ECOLE:

ECO industrial park network for the Alpine Regions Leveraging smart and Circular Economy

Transnational Validation Report

Deliverable D.2.3.1

Produced by

LP01 ZAI

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ECO industrial park network for the Alpine Regions **L**everaging smart and Circular **E**conomy

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Validation report through a peer review process, containing all pilots combined in a unique circular economy approach

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PROJECT PARTNERS

LP – Consorzio ZAI Interporto Quadrante Europa (IT): ZAI

PP 2 – Trieste Economic Development Agency (IT): COSELAG

PP 3 – Development agency Sora Ltd. (SI): RA Sora

PP 4 – Regional Development agency of the Ljubljana (SI): RRA-LUR

PP 5 – Energy and Innovation centre of WEIZ (AT): WEIZ

PP 6 – Wirtschaftsagentur Burgenland GmbH (AT): WAB

PP 7 – Landshut University of Applied Sciences (DE): TZE

PP 8 – Italienische Handelskammer München-Stuttgart (DE): ITALCAM

PP 9 – Grenoble-Alps Metropole (FR): GAM

PP10 – POLYMERIS (FR): POL

PP 11 – Lombardy Foundation for the Environment (IT): FLA

PP 12 – TUM International GmbH (DE): TUMint

ABBREVIATIONS USED

AF	Application Form
AP	Associated Partner
AS	Alpine Space
CM	Communication Manager
ECOLE	ECO industrial park network for the Alpine Regions Leveraging smart and Circular Economy
ERDF	European Regional Development Fund
EU	European Union
JS	Joint Secretary
KPI	Key Performance Indicators
LP	Lead partner
PP	Project Partner
TL	Task Leader
TPM	Transnational Project Meeting
WP	Work Package
WPL	Work Package Leader

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1. Introduction

The ECOLE project, "ECO Industrial Park Network for the Alpine Regions Leveraging Smart and Circular Economy," is a collaborative project aimed at transforming industrial parks into eco-industrial parks through the application of circular economy principles. By integrating sustainability into the operations of industrial parks across the Alpine region, the project aspires to create an environmentally, socially, and economically sustainable network of industrial ecosystems.

ECOLE focuses on three distinct thematic areas - Energy Materials & Circularity, Supply & Value Chains Resilience & Sustainability, EIP Governance, Local Symbiosis, and Circular Economy Knowledge & Transfer - each addressing a critical aspect of the transition. These three topics are addressed within the project through LABs, with industrial parks divided according to their focus areas, while the governance aspect is explored universally across all LABs.

This structured approach allows ECOLE to address multiple dimensions of sustainability, fostering collaboration, innovation, and knowledge-sharing among stakeholders across the Alpine region.

The project's pilot activities are designed to test and implement circular economy strategies in selected industrial parks, providing practical insights and scalable solutions. Through these pilot actions, ECOLE aims to demonstrate the feasibility and benefits of circular economy practices, laying the groundwork for broader adoption and long-term impact.

The "Transnational Validation Report" is a critical deliverable of Work Package 2 (WP2) and Act.2.3 Co-validate the pilot actions since it will co-validate and support the creation of a unique circular approach starting from the concept design, qualification and verification with the direct involvement of local Systemic Thinking Communities (STCs) and Systemic Thinking Communities network.

Simultaneously, it will get the inputs from the LABS and their transnational collaboration, where partners connect and work together across borders to address broader strategic goals.

This report summarizes the results of the co-validation of transnational pilot actions implemented within the ECOLE project.

Through a peer-review process and the direct involvement of local Systemic Thinking Communities (STCs) and their transnational network, this document outlines a circular approach developed by combining the outcomes of regional pilots.

It will provide a robust foundation for the replicability and transferability of the developed solutions, ensuring environmental, economic, and social benefits for the Alpine region, in alignment with the European Green Deal and macro-regional strategies.

2. Methodology and process

2.1 Co-validation approach

2.1.1. Peer Review process – methodology

Peer Review process: evaluation methodology in which experts, from different backgrounds with specific and complementary skills, review and evaluate the work or results of a project to ensure its quality, reliability and consistency with the set objectives. This approach is commonly used in academic, scientific, industrial, and research and innovation projects.

In the context of the **ECOLE** project, a **Peer Review** process is essential to validate and assess the effectiveness of projects supporting the transition of industrial parks into **Eco-Industrial Parks (EIPs)** through the **Circular Economy approach**. The **Peer Review framework** provides continuous feedback, identifies potential improvements, and supports best practices for EIP development in the Alpine region, reinforcing the systemic and integrated approach necessary for successful implementation.

The review group will consist of experts with multidisciplinary expertise – to ensure a balanced and thorough evaluation of the project. Experts have been selected by each including:

- **Specialists in circular economy** and environmental sustainability.
- **Experts in sustainable industrialization** and industrial park management.
- **Academics and researchers** in environmental sciences and engineering.
- **Institutional representatives and policymakers**.
- **Industrial stakeholders** involved in ecological transition.

The adoption of Peer Review in the ECOLE project offers numerous advantages:

- Greater reliability and transparency in evaluations and decisions.
- Optimization of transition strategies through evidence-based recommendations.
- Early identification of challenges and potential obstacles.
- Strengthened cooperation among stakeholders through structured dialogue.
- Increased replicability and transferability of solutions to other regional contexts.

This evaluation methodology ensures:

Figure 1: evaluation methodology

The implementation of the Peer Review process in the ECOLE project will follow a structured roadmap:

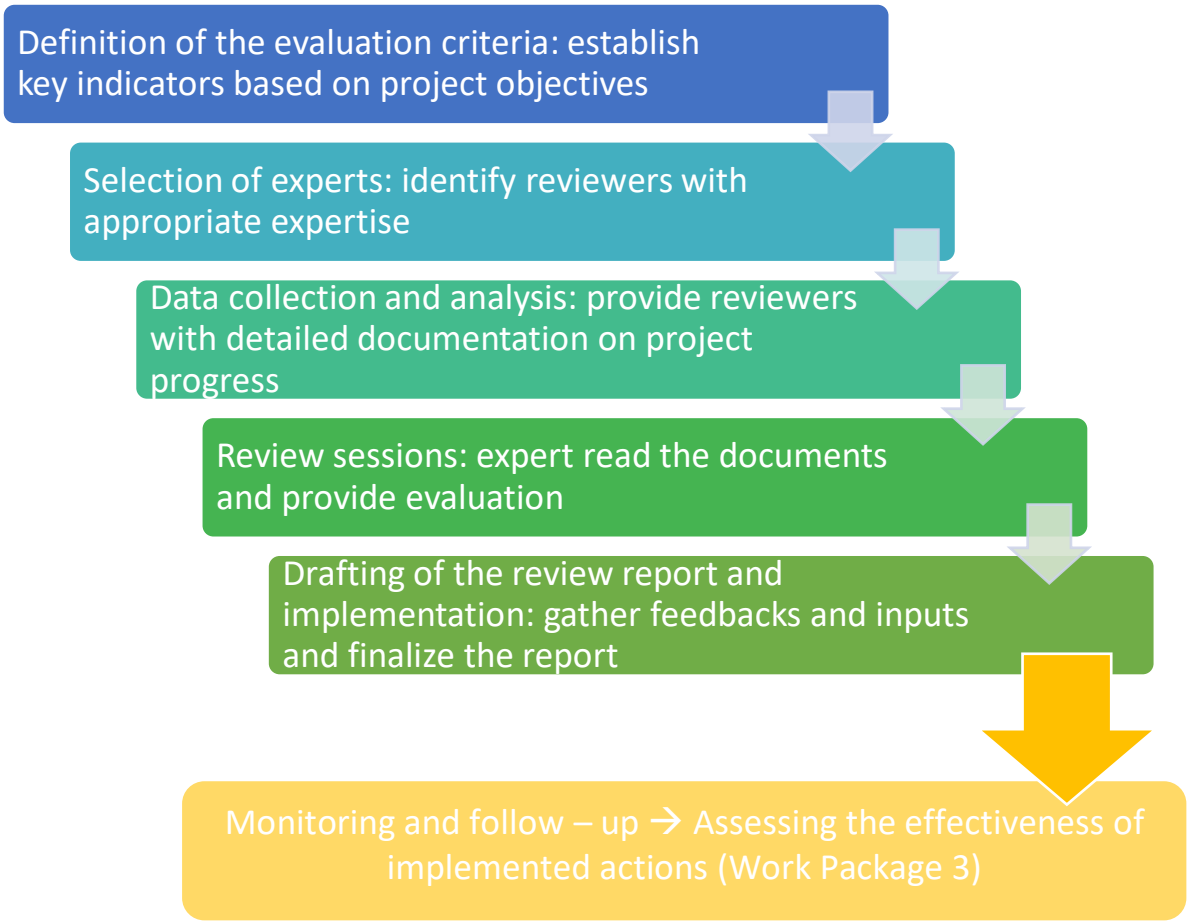

Figure 2: peer review process

2.1.2. Involvement of Local STCs and the Transnational STC Network

The Systemic Thinking Community Model (STCM) is a structured framework designed to foster coordination and engagement among diverse stakeholders in Eco-Industrial Parks (EIPs). It aims to enhance collaboration between industrial firms, local communities, policymakers, and knowledge institutions to facilitate the successful transformation of traditional industrial parks into sustainable, circular ecosystems.

STCM is essential for EIPs because it integrates diverse perspectives, aligns interests, and enables co-benefits that support industrial symbiosis. The model ensures that material flows, resource-sharing, and waste reduction strategies are optimized through collective decision-making. By strengthening communication and stakeholder engagement, STCM helps EIPs achieve their sustainability goals while also contributing to regional economic and environmental resilience.

Key Functions of STCs in EIPs involve enhancing coordination to facilitate structured engagement among different actors to align interests and create synergies, knowledge sharing to act as hubs for exchanging best practices and innovative circular economy solutions, supporting Industrial Symbiosis to foster collaboration, and enabling businesses to share resources, reduce waste, and optimize

material flows and policy and governance integration to provide insights into regulatory frameworks, ensuring alignment with sustainability goals at regional and European levels.

In the framework of the ECOLE project partners formed 10 local Systemic Thinking Communities (STCs) at the 10 pilot sites and performed the working sessions aimed at integrating circular economy solutions in industrial parks. The sessions addressed action plans, pilot technologies, and procedures to enhance cost efficiency, environmental sustainability, and social benefits. STCM provided a structured and collaborative framework to improve the performance of EIPs in partner territories. It ensured stakeholder engagement, resource optimization, and knowledge exchange by fostering synergies across industries, local communities, policymakers, and academia. This model was essential for both existing industrial parks (brownfield transformations) and new sustainable developments (greenfield projects), ensuring deep integration of circular economy strategies.

Systemic Thinking Community working sessions findings

Main objectives of the working sessions collected by the ECOLE partners:

- Transformation of Industrial Parks into Eco-Industrial Parks: reducing environmental impact through the adoption of circular economy practices;
- Optimizing resource use through waste recycling and sustainable materials management.
- Promotion of renewable energy: installing photovoltaic systems, producing biogas, and using renewable energy sources to reduce the carbon footprint.
- Development of systemic collaboration models through the creation of a Community Model (STCM) to foster cooperation between businesses, public institutions, and local communities.
- Innovation in industrial processes: experimenting with innovative technologies for waste reuse (e.g., producing biodiesel from used oils and digestate from biogas plants).
- Development of an it tool: developing an IT tool to monitor the energy input and output of the industrial area of Trieste.
- Promotion of a renewable energy community: encouraging the creation of a renewable energy community within the industrial park.
- Fostering business collaboration: promoting cooperation between companies to enhance environmental sustainability and reduce greenhouse gas (GHG) emissions.
- Assessment of excess heat potential: evaluating the technical and economic potential for using excess heat in four industrial parks.
- Identification of synergies: identifying synergies between companies for the use of residual heat in production processes or for public applications.
- Municipal engagement: involving municipalities to attract future users interested in heat recovery.
- Strengthening industrial park governance: enhancing governance in the southern industrial park and creating synergies between businesses.
- Promotion of circular economy initiatives: promoting circular economy through shared projects between businesses and local institutions.
- Implementation of sustainable transportation solutions: implementing sustainable transportation solutions for park employees.

Participants:

Organization	Implementations
Private companies and SMEs	• JATA EMONA, KOTO, VOKASNAGA for waste management and biogas production. • HHLA PLT and Trieste Trasporti, Local Energy Agency of Gorenjska, ENEKOM – Energy Consulting Institute.
Public Entities and Local Authorities	• Ministries, municipal and regional authorities playing a central role in project regulation and co-financing. • ARERA, Port Network Authority of the Eastern Adriatic Sea, Friuli Venezia Giulia Region. • Service providers: TERNA, AcegasApsAmga, Hera, SIOT, Grenoble Alpes Métropole, Grenoble Chamber of Commerce and Industry.
Research Institutions and Universities	• Collaboration with academic institutions to develop new technologies and provide technical support. • University of Trieste, Polytechnic University of Milan, Sincrotrone
Civil Society Organizations	• Engagement of local communities and citizens in waste separation and sustainable waste management programs. • Local Competitiveness Clusters: Vegepolys Valley, Tenerrdis, CIMES, Axelera.

Table 1: STCM working session participants

2.3 Analysis method

Walk-through for technological tests: detailed and systematic exploration of the technologies implemented in the pilot projects in order to evaluate their operation, efficiency and effectiveness under real conditions (Act. 2.2)

LAB A & LAB B overview

	Industrial Park Name	Pilot Activity Name	Main Focus	Key Actions	Challenges	Expected Benefits	
LAB A: Energy, Materials & Circularity							
1	Marangona Area ZAI	Sustainable energy community system in Marangona Area	Application of circular economy principles and renewable energy solutions	Energy demand study, feasibility analysis, stakeholder engagement	Resistance from companies, bureaucratic hurdles, data availability issues	Increased use of renewable energy, reduced emissions, enhanced collaboration among industrial stakeholders	LAB C: Eco-Industrial Park Governance, Local Symbiosis, and Circular Economy Knowledge Transfer
2	Trieste Industrial Zone COSELAG	IT Platform for Energy Demand and Waste Sharing	Development of an IT platform for waste and energy data sharing	Development of IT platform, integration of industrial data, stakeholder cooperation	Data fragmentation, stakeholder resistance, interoperability of IT systems	Improved data management, increased industrial symbiosis, better resource efficiency	
3	Industrial zones Železniki, Trata, Žiri, Todraž (Gorenja vas) RA Sora	Study of excess heat potential in the Škofjeloško area	Evaluation of excess heat potential and its utilization	Survey and study on excess heat, stakeholder engagement, proposal of development options	Lack of management in industrial zones, reluctance of companies to share data, identifying viable heat reuse options	Identification of viable heat reuse opportunities, improved energy efficiency, stronger collaboration among companies	
4	CRAISS Industrial Park WEIZ	Implementation of Energy related activities at the Industrial Park CRAISS	Integration of renewable energy, energy storage, and biodiversity projects	Installation of PV panels, energy storage systems, sustainable transport infrastructure	Technical challenges in energy storage, funding constraints, integration of different technologies	Reduced carbon footprint, enhanced energy resilience, biodiversity improvement	
5	Siemens Technopark TZE	Sustainable energy system at Siemens Technopark	Implementation of sustainable energy and monitoring solutions	Implementation of photovoltaic panels, storage solutions, energy monitoring systems	Aging infrastructure, financial investment hesitation, implementation of modern energy solutions	Higher energy efficiency, cost savings, sustainability improvements	
6	Veyziat industrial park (part of Plastics Vallée) POLYMERIS	Eco-effectiveness and eco-efficiency through plastic waste recycling & recovery	Improvement of plastic waste management and recycling	Study on waste management, car-pooling initiative, urban planning for service integration	Lack of trust among companies, difficulty in engaging stakeholders, competition hindering collaboration	Higher plastic recycling rates, enhanced industrial cooperation, improved mobility solutions	

LAB B: Supply & Value Chain Resilience & Sustainability						
7	Economic and Business Zone (EBZ) Zalog	Community-Powered Biofuel Transformation	Circular biofuel production from edible waste oil	Stakeholder clustering, waste oil collection strategy, community engagement, pilot testing	Improved waste management, enhanced community involvement, biofuel production, circular economy adoption	Economic and Business Zone (EBZ) Zalog
8	Intercommunal Business Park S7-Node Rudersdorf	Advancing Energy Resilience through Circular Principles	Energy resilience and sustainability in industrial parks	Development of energy resilience consulting service, stakeholder engagement, technology evaluation	Increased adoption of renewable energy, improved energy efficiency, stronger industry resilience	Intercommunal Business Park S7-Node Rudersdorf
9	CleanTec Innovation Park, Hallstadt	Collaborative Research Platform	Research and innovation in clean technology	Establishment of research collaborations, branding and outreach, circular economy strategy development	Enhanced collaboration between industry and academia, fostering of clean technology solutions, innovation-driven growth	CleanTec Innovation Park, Hallstadt
10	South Industrial Park, Grenoble Alps	Enhancing Material Flow Dynamics	Industrial symbiosis and material flow optimization	Governance improvement, industrial symbiosis evaluation, stakeholder engagement, resource mapping	Improved governance structure, increased industrial collaborations, better resource efficiency, waste recovery	South Industrial Park, Grenoble Alps

Table 2: LAB A & LAB B overview

3. Results from the LABs – Pilot Actions

All LABs aim to position industrial parks as leaders in adopting circular economy principles. These principles underpin the transition from linear resource use (take-make-dispose) to restorative and regenerative systems that minimize waste, optimize resource use, and create sustainable economic models. The shared goals include reducing resource consumption and emissions, promoting renewable energy and sustainable practices, and enhancing collaboration to maximize resource efficiency.

Recognizing the diversity of industrial parks across the Alpine region, the LABs employ flexible frameworks adaptable to local contexts. Each LAB facilitates tailored solutions while maintaining alignment with the overarching vision of transforming industrial parks into eco-industrial parks. Strategies include addressing unique challenges and opportunities at each pilot site, designing interventions that balance local needs with transnational goals, and encouraging cross-sectoral collaboration to integrate diverse perspectives and expertise.

All LABs emphasize the critical role of stakeholder involvement in driving transformation. From local communities and businesses to academic institutions and policymakers, stakeholders are integral to ensuring the successful implementation of circular economy principles. Actions focus on building relationships and fostering trust among stakeholders, hosting workshops, roundtables, and training sessions to align objectives, and ensuring transparency and inclusivity in decision-making processes.

The unified vision of the LABs is to establish a network of eco-industrial parks that serve as benchmarks for circular economy practices. LABs share a commitment to rigorous evaluation and the dissemination of scalable solutions by providing predefined Key Performance Indicators (KPIs) to measure success, lessons learned to inform future implementations and strategies for transferring knowledge and practices to new contexts.

By working collaboratively and leveraging their unique strengths, the LABs form a cohesive framework for achieving impactful and enduring change in industrial ecosystems.

3.1. LAB A Materials, Energy, and Circularity

- LP ZAI – Marangona Area
- PP02 COSELAG – Trieste Industrial Park
- PP03 RA SORA - Industrial zones Železniki, Trata, Žiri, Todraž (Gorenja vas)
- PP05 WEIZ - CRAISS Industrial Park
- PP07 TZE - Siemens Technopark
- PP10 POLYMERIS - Veyziat industrial park (part of Plastics vallée)

The "Energy Materials & Circularity" theme is highly relevant, addressing the growing awareness of the importance of sustainable energy sources and eco-friendly industrial practices, essential to tackle current environmental challenges. "Energy materials" refer to substances used in the production and conversion of energy, often focusing on advanced and innovative materials that enhance efficiency and reduce the environmental impact of energy technologies. "Circularity" pertains to a resource management approach where the life cycle of materials is optimized, promoting reuse, recycling, and

waste reduction. In an industrial context, it aims to create closed-loop systems where minimizing waste becomes crucial.

In summary, the incorporation of energy efficiency measures, particularly the "reuse principle" and "re-think principle," enriches the collaborative efforts of both LABs. This not only amplifies research potential but also contributes to shaping an interdisciplinary, innovation-oriented approach necessary to address complex challenges such as sustainable energy and circularity. There are a couple of central themes that align with the overarching focus of the Energy Materials and Circularity LAB, and these are: IP Internetworking, Industrial Symbiosis.

The shift from traditional industrial parks to eco-industrial parks represents a critical evolution in sustainable urban and industrial planning. Central to this transformation is the application of Circular Economy (CE) principles, which challenge the linear paradigm of "take-make-dispose" and advocate for a restorative approach to resource management and utilization.

Within the context of the "Energy materials and circularity LAB," the role of CE principles cannot be understated. Partners LP, PP02, PP03, PP05, PP07 and PP10 are engaged in rigorous exploration and application of these principles. Their concerted efforts and interdisciplinary collaborations aim to provide empirical insights and frameworks for the successful transition of industrial parks into eco-sustainable entities.

LAB A's Strategic Goals evaluation

LAB A’s strategic goals are tailored to the individual contributions of each partner. LP ZAI is working towards establishing an energy community and a governance structure to enhance stakeholder collaboration and promote circular economy practices. PP02 COSELAG, operating under regional legislation, plans to develop an IT platform to enable energy demand and waste-sharing among stakeholders, fostering industrial symbiosis. PP03 RA Sora focuses on introducing a governance structure that represents industrial park tenants and the municipality while addressing waste heat recovery as a key resource.

In Weiz, PP05 has already established the Wirtschaftsraum Weiz-St. Ruprecht, represented stakeholders and actively promoted renewable energy and waste heat utilization within the industrial community. PP07 TZE leverages its park management structure to strengthen collaboration among tenants and plans to implement energy efficiency measures, including waste heat recovery. Finally, PP10 POLYMERIS is dedicated to creating a collaborative waste management system that recovers energy and materials, while also promoting best practices in circular economy principles.

Together, these partners contribute to LAB A’s overarching goals of fostering stakeholder collaboration, enhancing resource efficiency, and reducing environmental impact in industrial ecosystems.

The evaluation highlights significant variation in the development and implementation of governance structures, which poses a key barrier to advancing LAB A’s strategic goals. Establishing formal governance frameworks is critical for coordinating activities, engaging stakeholders, and driving the systemic transformation of industrial parks.

While progress has been made in stakeholder collaboration, waste management, and knowledge transfer, the following areas require further development to fully align with circular economy principles:

- **Governance Frameworks**: develop and implement governance structures that represent all IP stakeholders, including tenants, municipalities, and public authorities.
- **Stakeholder Engagement**: foster stronger connections with local authorities and community representatives to ensure inclusivity and regional alignment.
- **Waste-to-Resource Models**: expand and standardize waste recovery and recycling systems across all pilot sites, with a focus on achieving zero-waste objectives.
- **Knowledge Sharing and Training**: organize regular workshops, share best practices, and develop educational resources to build capacity and drive innovation.
- **Resource Optimization**: enhance methodologies for energy efficiency, material flow optimization, and industrial symbiosis across all partners.

3.2. LAB B Resilience and Sustainability of Value Chain

- PP04 RRA LUR - Economic and Business Zone (EBZ), Zalog
- PP06 WAB - Rudersdorf EIP
- PP08 ITALCAM - CleanTech Innovation Park, Hallstadt
- PP09 GAM - South Industrial Park, Grenoble Alps

In today's rapidly changing global landscape, two principals have emerged as vital for business and community success: resilience and sustainability. Resilience refers to the ability of a system, community, or business to anticipate, adapt to, and recover from disturbances, ensuring its continued function. Sustainability, on the other hand, underscores the importance of meeting the needs of the present without compromising the ability of future generations to meet their own needs. In the context of value and supply chains, integrating these two principles ensures that operations are both environmentally responsible and adaptable to unforeseen challenges.

Value and supply chains represent the interconnected stages through which products or services move from their origin to the end consumer. In these chains, resilience signifies the ability to anticipate, cope with, and recover from disturbances, whether they be sudden supply shocks, technological disruptions, or geopolitical shifts. A resilient value and supply chain is adaptive and agile, ensuring that product or service delivery is not severely hampered by these disruptions.

However, the LAB challenges the traditional notion of these chains. Instead of solely focusing on the linear progression of goods and services, the partner's pilot projects emphasize the importance of fostering relationships among various actors. This nuanced perspective understands that the essence of a successful, adaptive, and sustainable chain lies not just in the flow of products, but in the strength and flexibility of connections between its stakeholders.

Industrial parks, often seen as mere conglomerations of businesses, are re-envisioned as dynamic networks, businesses don't just co-exist; they collaborate, share resources, and co-innovate. Such collaborative environments amplify resilience as the LAB partners can quickly lean on each other in times of disruptions, ensuring that a challenge faced by one becomes a shared responsibility of all.

Moreover, these networks foster sustainability. Shared practices, technologies, or waste management initiatives can lead to larger-scale sustainable outcomes than isolated efforts. An eco-industrial park,

for instance, doesn't just house businesses; it represents a collaborative effort towards sustainable industrial growth.

In essence, while the classical understanding of value and supply chains focuses on the movement of products, the initiatives of LAB's pilot projects underscore the movement and evolution of relationships. LAB recognizes that in today's interconnected world, it is the quality of these relationships, rather than just the quality of products, that determines the resilience and sustainability of value and supply chains.

Building relationships & networks: both resilience and sustainability in supply and value chains are bolstered by strong relationships and networks. A well-connected network can facilitate rapid responses to disruptions and provide alternative solutions. Similarly, sustainability initiatives often require collaboration across various actors in the chain, from suppliers to end-users. By fostering strong ties with, for instance, universities, research institutions, and other companies (as seen in the pilots of PP06, PP08, and PP09), industrial parks can share best practices, jointly invest in sustainable technologies, and develop mutual aid protocols for crises.

Industrial Park networks: industrial parks, being hubs of innovation and production, are often at the forefront of both resilience and sustainability challenges. In an interconnected industrial network, if one entity faces supply disruptions, it can lean on its relationships within the park or wider network to find alternative sources or solutions, thus ensuring continuity. From a sustainability standpoint, shared resources, technology, or waste management practices (like the emphasis in PP04's waste-to-biodiesel initiative) in an industrial park network can lead to larger-scale sustainable outcomes than isolated efforts.

For value and supply chains, **resilience ensures flow continuity during challenges**, while **sustainability guarantees that this flow is responsible and future-proof**. By focusing on building relationships and networks, especially in industrial park settings, entities can significantly enhance both these attributes, driving collective growth and shared prosperity.

Within the context of the "Supply & Value Chains Resilience & Sustainability LAB," the role of CE principles presents an important focus. Partners PP04, PP06, PP08, and PP09 are engaged in exploration and application of these principles. Their efforts and interdisciplinary collaborations aim to provide empirical insights and frameworks for the successful transition of industrial parks into eco-sustainable entities.

LAB B's evaluation of strategic goals highlights both collective achievements and areas requiring further development among its partners. **PP04** demonstrates strengths in stakeholder engagement and aligning its actions with circular economy principles. However, the absence of a defined governance structure poses significant challenges in coordinating efforts and aligning with broader strategic objectives. In contrast, **PP06** integrates renewable energy principles within its pilot projects, showcasing a strong commitment to sustainability and resilience, yet it still requires refinement of its governance model to better involve and represent stakeholders. **PP08** excels in knowledge sharing and establishing collaborative research platforms, effectively engaging stakeholders across diverse sectors, but it also needs to further develop governance structures and advance strategies for material efficiency. **PP09** stands out in optimizing material flows and enhancing industrial symbiosis within its

pilot site, though its governance framework requires strengthening, particularly in involving local public authorities and fostering better community representation.

A key insight from the evaluation is the variation in governance structures across LAB B pilot sites, with some partners lacking such structures altogether. The absence of a governance structure significantly hampers the effective operation of EIPs, as it serves as a foundational precondition for coordinating activities, engaging tenants and local communities, and driving systemic progress. Therefore, all partners must prioritize the establishment of governance frameworks tailored to the unique needs of their pilot sites. This will ensure better alignment with circular economy principles and support the long-term sustainability of EIPs.

Across LAB B, significant progress has been made in fostering stakeholder collaboration and integrating circular economy principles into pilot projects. Collectively, partners have demonstrated their ability to collaborate effectively, share knowledge, and innovate within their respective contexts. Nonetheless, the evaluation underscores the need for expanded efforts in the following areas:

- Enhanced **stakeholder engagement**, particularly with local public authorities, to ensure inclusivity and alignment with regional needs.
- Broader adoption of **digital tools** to improve resource tracking, transparency, and process optimization.
- Further development of methodologies to advance **material flow efficiency** and inter-industrial symbiosis.
- **Establishing governance structures** to coordinate efforts effectively, engage all stakeholders, and enable EIPs to function optimally.

3.3. LAB C Governance and Local Symbiosis

- PP11 FLA
- PP12 TUM

The Governance Lab (LAB C) is designed as a common platform to analyze and improve governance models in ECOLE industrial parks. The goal is to build a network of forward-thinking, collaborative, and sustainability-oriented industrial parks. LAB C facilitates the comparison of different governance models, identifying best practices and weaknesses to support the transition to a circular economy.

LAB C aims to enhance governance in industrial parks through a structured approach that includes:

- **Assessment of current governance structures in ECOLE parks**
- **Identification of weaknesses and areas for improvement**
- **Knowledge-sharing platforms and collaborative workshops**
- **Continuous performance monitoring through specific Key Performance Indicators (KPIs)**

Key principles of LAB C include:

- **Diverse governance models**: governance systems do not need to be identical across all ECOLE pilot parks.
- **Collaboration and knowledge exchange**: industrial parks can improve by learning from each other.

- **Common vision with flexibility**: LAB C helps define governance benchmarks without imposing rigid structures.
- **Measurable impact**: governance analysis aims to drive tangible improvements in circular economy performance.

The current state of governance in the ECOLE industrial parks shows significant variations. Four main governance models have been identified:

- **Lack of structured governance**: management is left to individual companies, with limited involvement from local authorities.
- **Public statutory body**: a governance entity is established through legislation, with a mandate to develop the park.
- **Corporate private governance**: a profit-driven entity manages the industrial park.
- **Mixed public-private model**: a public entity oversees overall management, while a private company develops the industrial area.

In many ECOLE industrial parks, weak governance structures hinder the implementation of common sustainability and circular economy strategies. LAB C seeks to address this gap by providing tools for governance improvement.

Benchmarking governance models

A comparative study was conducted on four exemplary governance models in industrial parks. These case studies illustrate different approaches to governance, highlighting how effective structures can facilitate the transition to a circular economy. For a more detailed description see D2.1.3 Concept on EIP governance, local symbiosis & circular economy (CE) knowledge & transfer – chapter 5

- **Macrolotto di Prato (Italy)**: focused on water resource management and industrial symbiosis in the textile sector.
- **Ulsan Mipo and Onsan Industrial Park (South Korea)**: Centralized management with strong public involvement to tackle environmental challenges.
- **Industrial Park Malambo (Colombia)**: a private model integrating advanced infrastructure services and social development initiatives.
- **East London Industrial Development Zone (South Africa)**: a public-sector-led approach supporting companies in innovation and sustainability.

The ECOLE project has developed a **governance performance assessment tool** based on **Key Performance Indicators (KPIs)** to evaluate and enhance the governance of industrial parks (IPs). This tool is designed to provide a structured method for assessing the effectiveness of governance structures, stakeholder involvement, and management approaches in supporting the transition to **Eco-Industrial Parks (EIPs)**.

Purpose and objectives of the governance performance tool

The tool was created to:

- **Identify strengths and weaknesses** in governance across ECOLE industrial parks.
- **Establish benchmarks** for effective governance structures.
- **Facilitate knowledge exchange** among partners by providing a common evaluation framework.

- **Guide improvements** in governance by offering specific recommendations based on KPIs.
- **Support decision-making** for industrial park operators, policymakers, and stakeholders

Governance model in the pilot sites

PP	Industrial Park	Country	ECOLE's IPs Governance	General Management of the Industrial Area	Nature of the Governance of the IPs	Governance Structure
P9	Grenoble	France	No Governance	Not organised industrial settlement	Private and no governance; each company is independent	Voluntary association of some companies for the development of the industrial area
P6	Businessparks Burgenland	Austria	No Governance	Not organised industrial settlement	Private and no governance; each company is independent	Not existing
P10	Veyziat Industrial Park	France	No Governance	Not organised industrial settlement	Private and no governance; each company is independent	Not existing
P3	Industrial Zone: Trata, Todraz, Ziri, Alples	Slovenia	No Governance	Not organised industrial settlement	Private and no governance; each company is independent	Not existing
P4	EBZ Zalog	Slovenia	No Governance	Not organised industrial settlement	Private and no governance; each company is independent	Not existing
P5	Energy and Innovation Centre of WEIZ	Austria	No Governance	Not organised industrial settlement	Private and no governance; each company is independent	Not existing
P7	Siemens Technopark	Germany	Corporate Governance	Organised industrial settlement	Private governance: Siemens Real Estate	Corporate Real Estate Management Siemens
P8	The Cleantech Innovation Park in Hallstadt	Germany	Corporate Governance	Organised industrial settlement	Public and private	Managing Director
LP	Consorzio ZAI	Italy	Statutory Body	Organised industrial settlement	Public	Board of Directors and Chairman, Managing Director, Auditor and Supervisory Board
P2	COSELAG-Consorzio di Sviluppo Economico Locale dell'area Giuliana	Italy	Statutory Body	Organised industrial settlement	Public	Consortium assembly, Board of Directors and Chairman, General Director, Auditor and Supervisory Board

Table 3: Governance model in the pilot sites

3.3.1. Structure of the Governance Performance Tool

The assessment tool evaluates governance performance across **three main categories**, which align with international standards such as **UNIDO's International Framework for Eco-Industrial Parks**.

Park management services

- Presence of a **well-defined park management entity**.
- Degree of involvement of **local public authorities** in governance.
- Representation of **tenant companies** in the governance structure.
- Number of meetings held per year between the governing body and tenants.
- Governance structure's ability to provide services such as infrastructure management, waste collection, security, and training.

Monitoring and risk management

- Existence of a **monitoring system** for evaluating governance performance.
- Identification of **critical risks** within the park.
- Frequency of performance monitoring (every six months or annually).
- Climate risk assessment and mitigation strategies.
- Compliance with local and national **environmental regulations**.

Strategic planning and park design

- Development of a **master plan** that integrates circular economy principles.
- Long-term sustainability **objectives** incorporated into governance strategies.
- Inclusion of guidelines for **resource efficiency, waste management, and industrial symbiosis**.
- Adoption of **digital tools and data-driven decision-making** for governance improvements.

Each industrial park participating in the ECOLE project was required to complete a self-assessment using the governance performance tool. This involved:

- **Data collection** – gathering information on governance practices, stakeholder involvement, and compliance with sustainability targets.
- **Scoring system** – each kpi was assigned a weighted score, enabling the comparison of governance effectiveness across different parks.
- **Benchmarking** – parks were categorized into three performance levels based on their total scores:
  - **High-performing parks (Very Good Governance)**
  - **Moderate-performing parks (Needs Improvement)**
  - **Low-performing parks (Poor Governance)**
- **Action plan development** – based on the assessment results, each park received recommendations on how to enhance governance structures, improve stakeholder engagement, and implement best practices for sustainability.

Key findings and outcomes

- The majority of industrial parks scored in the "Needs Improvement" category, indicating that governance structures must be strengthened to support sustainability and circular economy goals.

- Only two parks demonstrated "Very Good Governance," serving as models for best practices.
- Monitoring and risk management emerged as the weakest area, with most parks lacking systematic risk identification and mitigation strategies.
- Strategic planning and sustainability integration were identified as key areas requiring improvement. Many parks lack a clear roadmap for integrating circular economy principles.
- The assessment tool provided a foundation for continuous improvement, allowing industrial parks to track their governance evolution over time and make data-driven decisions for enhancing sustainability performance.

Next steps for governance improvement

The governance performance tool is designed to be a **living framework**, allowing for periodic updates and refinements based on evolving needs and new insights. Moving forward, the ECOLE project recommends:

- **Capacity building** – conducting training sessions and workshops to enhance governance competencies among industrial park managers.
- **Stakeholder collaboration** – strengthening partnerships between industrial parks, public authorities, businesses, and research institutions.
- **Integration of digital tools** – leveraging smart governance platforms and real-time data analytics for monitoring performance.
- **Policy advocacy** – engaging with policymakers to establish **regulatory frameworks** that support sustainable industrial park governance.
- **Ongoing performance monitoring** – using the assessment tool annually to track improvements and adjust strategies accordingly.

In conclusion, effective governance is a key driver for successful EIP development. LAB C has identified that:

- Most ECOLE industrial parks need stronger governance to support the circular transition.
- Implementing structured KPIs can guide companies in improving their performance.
- Promoting a sustainability culture through stakeholder collaboration is essential.

3.4. Key Performance Indicators (KPIs) and effectiveness evaluation LAB A & LAB B

Each pilot site in **LAB A (Energy Materials & Circularity)** implemented and measured KPIs to assess progress in transitioning to eco-industrial parks.

1. **Marangona Industrial Park (Verona)**
   - Energy Renewable Coverage: Increase the share of renewable energy used within the park.
   - Stakeholder Engagement: Engage local stakeholders, including public and private entities, to ensure project success.
2. **Trieste Industrial Park**
   - KPI 1 - Creation of an IT Platform: Successfully implemented to manage energy demand and waste production.
   - KPI 2 - Number of Users of the IT Platform: 8 users initially, with plans for expansion.
3. **Škofjeloško area**

- Number of companies included analysis - at least 1 per IP (among 4 IPs).
- Number of Municipalities we engage in the project - at least 1.
- Proposal of the minimum viable quantity of excess heat that is profitable for further usage
- At least 3 examples of good practices about the usage of excess heat in Slovenia and the countries of the ECOLE consortium

4. **CRAISS Industrial Park**
   - Implementation of Energy Investments: Targets met for PV plants (1,780 kW), electrical storage, and green infrastructure.
   - CO_2 Reduction Measurement: Implemented a KNX metering system to calculate emissions reductions.
5. **Siemens Technopark**
   - PV Potential Realization: Identified the potential for 2 MW of solar energy integration.
   - Energy Monitoring System Implementation: Introduced a system to track and optimize energy and water use.
6. **Le Veyziat Industrial Park**
   - Waste Management KPIs: Contacted plastics companies to analyze waste streams and identified two recyclers.
   - Mobility KPIs: Introduced a regional carpooling application (Mov'ici), though promotion required more effort.

KPIs for **LAB B (Supply & Value Chains Resilience & Sustainability)** focused on supply chain resilience, industrial symbiosis, and governance structures.

1. **EBZ Zalog**
   - Stakeholder Engagement: Fully achieved through workshops and forums.
   - Waste Management Plan Implementation: Successfully prepared but faces technical/logistical challenges.
   - Community Engagement Strategy: Developed strategies for effective public outreach.
2. **Rudersdorf EIP**
   - Consulting Service Established: Created for energy resilience support.
   - Stakeholder Roundtable & Recommendations: Conducted interviews but faced bureaucratic challenges in implementation.
3. **Park Hallstadt**
   - Collaboration Initiatives: Launched networking events and stakeholder partnerships.
   - Branding & Outreach KPIs: Successfully increased visibility and engagement.
   - Circular Economy Framework Implementation: Pending due to ongoing park construction.
4. **South Industrial Park, Grenoble Alps** Industrial Synergy KPIs: Engaged 24 companies in workshops and identified 45 synergies.
   - Governance Structure KPIs: Park organization strengthened but faced delays in hiring staff.
   - Waste Recovery & Industrial Ecology: Ongoing efforts to implement new waste recovery solutions.

Economic KPIs LAB A and LAB B

		PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10
Economic EIP Prerequisites ("must have for EIPS")		Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer
Employment generation	Park management entity has plans to generate specific numbers and types of jobs (including diversity and inclusiveness) in line with government targets.	No	No	No	No	Yes	No	Yes	No	No	Yes
Local business & SME promotion	Park management entity allows and promotes the establishment of SMEs that provide services and add value to park residents.	No	No	No	No	Yes	No	Yes	Yes	No	No
Economic value creation	A market demand and feasibility study, supported by a business plan, for specific "green" infrastructure and service offerings has been undertaken to justify planning and implementation in the industrial park.	Yes	No	No	No	Yes	Yes	Yes	No	No	No
	Tracked by the park management entity, the industrial park fulfils relevant government targets, including domestic, foreign direct investment, and tax revenues.	No	No	No	No	Yes	No	No	No	No	No
Perfomance Indicators		Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer
Employment generation	At least 60% of total workers employed in industrial park live within daily commuting distance.	Not applicable	Not applicable	Not applicable	> 60%	> 60%	Not applicable	> 60%	Not applicable	> 60%	Not applicable
Local business & SME promotion	At least 25% of resident firms use local suppliers or service providers for at least 80 percent of their total procurement value.	Not applicable	>25%	Not applicable	15%-19%	>25%	Not applicable	Not applicable	Not applicable	20%-25%	15%-19%
Economic value creation	On average, the occupancy rate of space available for resident firms was >50% over the last 5 years.	Not applicable	<20%	Not applicable	>50%	<20%	Not applicable	<20%	Not applicable	>50%	<20%

Table 4: Economic KPIs LAB A and LAB B

Environmental KPIs LAB A and LAB B

		PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10
Environmental EIP Prerequisites ("must have for EIPs")		Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer
Management and monitoring	Park management entity operates an environmental / energy management system in line with internationally certified standards, monitoring park performance and supporting resident firms in the maintenance of their own firm-level management systems.	No	No	No	No	Yes	No	Yes	No	No	No
Energy	Supporting programs and documents are in place to improve the energy efficiency of resident firms, especially for the top 50 percent of major energy-consuming businesses in the park.	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	No
	An industrial heat recovery strategy is in place to investigate opportunities for heat and energy recovery for the major energy-consuming firms in the park. (Typically, these are firms that individually consume at least 10-20 percent of total firm level energy consumption).	No	No	No	No	No	Yes	Yes	No	No	No
Water	Park management entity or tenants have demonstrable plans and (preferably) prior documented evidence to increase water reuse in the short and medium term. This would be achieved by either reuse of industrial effluents, or by rainwater/storm water collection.	No	No	No	No	No	No	Yes	No	No	Yes
Climate change and the natural environment	A program is established to monitor, mitigate and/or minimize GHG emissions, such as carbon dioxide (CO_2), methane (CH_4), nitrogen oxide (NO_x), and so on. There is clear evidence of steps taken to introduce mitigation activities.	No	No	No	Yes	Yes	Yes	No	No	Yes	No
	The park management entity has a plan in place to assess operational environmental impacts, and aims to limit the impact on prioritized local ecosystem	No	Yes	No	No	Yes	No	Yes	No	No	Yes
Performance Indicators		Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer
Management and monitoring	At least 40% of resident firms (with more than 250 employees) have an environmental / energy management system in place that is in line with internationally certified standards.	Not applicable	Not applicable	>40%	>40%	>40%	Not applicable	>40%	Not applicable	>40%	30% - 40%
Energy	At least 90% of combined park facilities and firm-level energy consumption have metering and monitoring systems in place.	Not applicable	<50%	>90%	<50%	>90%	Not applicable	>90%	Not applicable	>90%	50% - 59%
	Total renewable energy use in the industrial park over the total energy consumption.	Not applicable	60% -69%	<50%	<50%	50% - 59%	Not applicable	50% - 59%	Not applicable	<50%	60% -69%
Water	At least 95% of industrial wastewater generated by industrial park and resident firms is treated to appropriate environmental standards.	Not applicable	<50%	Not applicable	>95%	Not applicable	Not applicable	>95%	Not applicable	>95%	50% - 64%
	At least 50% of total industrial wastewater from firms in the park is reused responsibly within or outside the industrial park.	Not applicable	<20%	Not applicable	>50%	Not applicable	Not applicable	>50%	Not applicable	<20%	<20%
Climate change and the natural environment	At least 5% of open space in the park is used for native flora and fauna.	Not applicable	<5%	Not applicable	>5%	>5%	>5%	>5%	Not applicable	>5%	<5%
	At least 50% of firms in park have pollution prevention and emission reduction strategies to reduce the intensity and mass flow of pollution/emission release beyond national regulations.	Not applicable	30% - 39%	Not applicable	40% - 50%	40% - 50%	Not applicable	40% - 50%	Not applicable	<20%	30% - 39%
Waste and material use	At least 20% of solid waste generated by firms is reused by other firms, neighbouring communities, or municipalities.	Not applicable	10% - 14%	Not applicable	>20%	>20%	Not applicable	>20%	Not applicable	<10%	10% - 14%
	100% of firms in park appropriately handle, store, transport and dispose of toxic and hazardous materials.	Not applicable	100%	Not applicable	100%	100%	Not applicable	100%	Not applicable	100%	100%
	Less than 50% of wastes generated by firms in the industrial park goes to landfills.	Not applicable	Not applicable	Not applicable	<50%	Not applicable	Not applicable	Not applicable	Not applicable	<50%	Not applicable

Table 5: Environmental KPIs LAB A and LAB B

Social KPIs LAB A and LAB B

		PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10
Social EIP Prerequisites ("must have for EIPs")		Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer
Social management systems	Dedicated personnel exist (as part of the park management entity) to plan and manage social quality standards.	Yes	Yes	No	No	Yes	No	No	No	No	Yes
Social infrastructure	Essential primary social infrastructure has been adequately provided in the site master plan, and is fully operational in the park.	No	No	No	No	Yes	No	No	No	No	No
Local community outreach	The park management entity organizes 1 or more outreach activities.	Yes	Yes	No	No	Yes	No	No	No	Yes	Yes
Performance indicators		Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer	Answer
Social management systems	At least 75% of all firms in the industrial park (with more than 250 employees) have a wellfunctioning OH&S (Occupational Health & Safety) management system in place.	Not applicable	<30%	Not applicable	>75%	>75%	Not applicable	>75%	Not applicable	>75%	Not applicable
	At least 75% of all firms in the industrial park (with more than 250 employees) have a code of conduct system in place to deal with grievances.	Not applicable	<30%	Not applicable	>75%	>75%	Not applicable	>75%	Not applicable	<30%	<30%
	At least 75% of all firms in the industrial park (with more than 250 employees) have a harassment prevention and response system in place.	Not applicable	>75%	Not applicable	<30%	>75%	Not applicable	>75%	Not applicable	>75%	>75%
Social infrastructure	75% of all firms in the industrial park have a program for skills/vocational training and	Not applicable	60% - 75%	Not applicable	>75%	>75%	Not applicable	>75%	Not applicable	>75%	60% - 75%
	At least 20% of female workforce benefit from available supporting infrastructure/programs for skills development.	Not applicable	>20%	Not applicable	>20%	>20%	Not applicable	<10%	Not applicable	10% - 14%	>20%

Table 6: Social KPIs LAB A and LAB B

3.5. Lessons Learned from LAB A

Marangona Industrial Park (Verona) – LP ZAI

- Gradual stakeholder engagement: establishing early and continuous dialogue with businesses and local authorities was crucial to overcoming initial resistance.
- Real-time monitoring: installing energy monitoring systems from the start would have improved resource optimization.
- Public-private cooperation: bureaucratic complexity highlighted the need for ongoing coordination with local authorities.

Industrial Park Trieste - COSELAG

- Overcoming data fragmentation: the creation of an IT platform improved the collection and management of resource and waste data.
- Initial resistance from companies: early and transparent stakeholder involvement increased project acceptance.
- Importance of awareness events: informative sessions and open days were key to encouraging platform use and strengthening collaboration.

Škofjeloško area (Slovenia) – RA SORA

- Lack of governing body for industrial zones that would act as a focal point for gathering the information on energy needs and excesses and connect the supplies and the demand.
- Representatives from municipalities and the companies that we included in the project all agree on importance of waste heat management and are all interested in findings of the ECOLE project and future steps.
- Based on the survey we found out that there is potential for utilizing excess heat in the area. As part of the project, a basic assessment of the possibilities for utilizing the of excess heat in the surrounding area was made.

- The lack of communication between the municipalities and companies that can lead to poor decision making, for example in the case of spatial planning. We estimate that in the case of larger infrastructure projects, more intersectoral coordination is needed. We suggest regular meetings (for example, once a year) with key representatives of municipalities (energy department) and companies within the STC.

CRAISS Industrial Park (Austria) - WEIZ

- Municipal collaboration: the joint effort between Weiz and St. Ruprecht played a crucial role in successfully implementing circular economy initiatives.
- Sustainability requirements for businesses: setting clear environmental criteria for new businesses helped reduce the overall environmental impact.
- Early monitoring: implementing energy monitoring systems from the beginning would have improved resource efficiency.

Siemens Technopark (Germany) - TZE

- Involving multiple stakeholders: collaborating with public authorities and the local community would have improved the implementation of sustainability measures.
- Aging infrastructure: the presence of historical buildings created difficulties in installing new technologies, emphasizing the need for adaptable solutions.
- Early financial planning: economic constraints within companies made it difficult to adopt new technologies without adequate incentives.

Le Veyziat Industrial Park (France) - POLYMERIS

- Challenges in engaging companies: competition among businesses made collaboration difficult; an initial joint presentation of the project could have facilitated participation.
- Importance of European benchmarking: comparing practices with other industrial parks provided concrete examples of effective regulations and best practices.
- Promoting alternative mobility solutions: support from local authorities was crucial in encouraging carpooling and sustainable transportation infrastructure.

3.6. Lessons Learned from LAB B

EBZ Zalog, Slovenia RRA LUR

- Stakeholder engagement is critical: initial resistance from companies and the local community required structured dialogue platforms (workshops, forums) to build trust and encourage collaboration.
- Tailored communication strategies: effective engagement requires adapting communication to local contexts, addressing historical sensitivities, and using diverse communication channels.
- Robust resource and infrastructure planning: establishing a waste edible oil collection system faced logistical and regulatory challenges, highlighting the need for comprehensive pre-implementation planning.
- Innovative decision-making tools: customized Cost-Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA) helped prioritize actions and assess sustainability.

- Flexible implementation is essential: the ability to adjust strategies, reallocate resources, and revise timelines was key to overcoming unexpected challenges.
- Cross-sector collaboration drives success: partnerships with businesses, academic institutions, and policymakers enhanced knowledge exchange and resource optimization.

Rudersdorf, Austria - WAB

- Financial incentives and simplified bureaucracy are key drivers: companies are more likely to adopt energy-resilient technologies if financial support is accessible and regulatory processes are straightforward.
- Sustainability provides a strategic advantage: businesses recognize the reputational and economic benefits of integrating renewable energy systems.
- Personalized advisory services are effective: one-on-one consultations and tailored guidance improve adoption rates of energy-efficient technologies.
- Hybrid solutions are crucial for energy-intensive industries: combining renewable energy with traditional systems ensures reliability and efficiency.
- Awareness and education are needed: many businesses lack a full understanding of the long-term cost implications of not implementing energy resilience measures.

CleanTech Innovation Park, Hallstadt - ITALCAM

- Timing and readiness are crucial: implementing circular economy initiatives requires an existing ecosystem of operational stakeholders, which was missing as the park was still under construction.
- Proactive knowledge gathering: engaging with methodologies from LAB B workshops provided a strategic framework for future circular economy integration.
- Preemptive stakeholder engagement is vital: early alignment on shared sustainability goals would have improved the transition process.
- Flexible planning ensures smoother transitions: adapting plans to evolving construction phases would have facilitated better integration of sustainability practices.

South Industrial Park, Grenoble Alps - GAM

- Stakeholder engagement is essential: motivated actors should be engaged first to build momentum and encourage broader participation.
- Trust takes time to build: without formal governance, incremental trust-building through small actions is necessary before implementing large-scale projects.
- Economic considerations must be prioritized: data on financial impacts and cost savings would have helped convince local actors to invest in circular economy initiatives.
- Measuring impact is challenging but necessary: establishing clear metrics to track environmental benefits remains a difficulty but is essential for demonstrating the value of circular economy efforts.

3.7. Key Lessons Learned Across the ECOLE Project

- Early stakeholder involvement: the success of circular economy initiatives depends on engaging businesses, public authorities, and local communities from the outset.

- Continuous monitoring and reliable data: data collection tools and energy management systems should be integrated from the beginning to enhance effectiveness.
- Cross-regional collaboration: sharing experiences between different industrial parks helped identify scalable and replicable solutions (see table below).
- Adaptability to local conditions: strategies must be flexible to accommodate the unique needs of each pilot site and ensure concrete results.
- Regulatory and financial support: economic incentives and regulatory simplifications are essential to drive the transition toward a circular economy.
- Clear governance structures improve efficiency: industrial parks with well-defined governance frameworks were more successful in coordinating activities and aligning stakeholders.
- Flexible and adaptable strategies are needed: unforeseen challenges require adjustments in timelines, resources, and methodologies to maintain project momentum.
- Financial and regulatory support is critical: simplified subsidy applications and clear financial incentives encourage wider adoption of sustainability initiatives.
- Knowledge sharing fosters success: cross-regional collaboration and information exchange among industrial parks enabled partners to identify scalable solutions.
- Impact measurement should be prioritized: establishing clear KPIs and tracking metrics helps demonstrate the effectiveness of circular economy initiatives.
-

	Cross-Collaboration Opportunities Among LABs			
	Areas of expertise	**available expertise by partners**	**needed expertise by partners**	**coverage of the exchange of expertise in LABs**
1	Business models for renewable energy integration	PP06	PP07 (PP09) PP10, PP08	LAB A, LAB B
2	Digital platforms to manage waste streams/resources	PP10	PP02, PP09	LAB A, LAB B
3	Best practices on governance (installation of park management)	PP05, PP11, PP12	PP03, PP04	LAB A, LAB B, LAB C
4	Subsidies and funding available for EIPs	PP01, PP06	PP04, PP09	LAB A, LAB B
5	Waste heat utilization	PP09	PP03, PP07	LAB A, LAB B
6	Advisory service for economic sustainability (Cost-benefit analysis)	PP01	PP03, PP04, PP09	LAB A, LAB B
7	Best practices for using by-products as raw material (example on IP for chemical industries)	PP09 PP10		LAB B
8	Best practice of efficient public transportation (Greenfield planning)	PP01		LAB A
9	Digital technologies/visualization of data (Smart city platforms, etc.)			
10	Best practice on community involvement	PP04, PP08	PP03	LAB A, LAB B
11	Consulting services for energy-oriented circularity into IPs	PP06	PP03	LAB A, LAB B
12	Promoting sustainable mobility in IP	PP03	PP04	LAB A, LAB B

Table 7: Cross-Collaboration Opportunities Among LABs

4. Creation of a unified Circular Approach

4.1 Principles, integrated guidelines and technological frameworks

The transition to **Eco-Industrial Parks (EIPs)** in the Alpine region is a crucial step in achieving sustainability, economic efficiency, and social cohesion. This transformation is grounded in circular economy principles, industrial symbiosis, and integrated governance models, ensuring resource efficiency and environmental responsibility.

Circular Economy and industrial symbiosis

Circular Economy (CE) is a systemic approach aimed at eliminating waste, keeping products and materials in use, and regenerating natural systems. In the context of **industrial symbiosis**, companies work together by exchanging materials, energy, water, and by-products, optimizing resource use and reducing costs. This collaboration fosters competitiveness and sustainability across industrial clusters

Main benefits derived from EIPs

EIPs provide **multi-dimensional benefits**, enhancing environmental sustainability, economic resilience, and social well-being. These include:

- **Environmental:** reduced emissions, efficient waste management, and resource conservation.
- **Economic:** lower operational costs, increased productivity, and new revenue streams through by-product valorization.
- **Social:** job creation, improved community relations, and enhanced well-being through sustainable infrastructures

Key Stakeholders in EIP development

A successful EIP requires engagement from diverse stakeholders, including:

- **Park operators and management** – responsible for governance and infrastructure development.
- **Industrial tenants** – key players in resource exchange and sustainability initiatives.
- **Local municipalities and regional authorities** – enablers of policy alignment and regulatory compliance.
- **Financial institutions and investors** – providers of funding for green initiatives.
- **Research institutions and innovation hubs** – facilitators of technological advancement

Preconditions for success

To qualify as an EIP, an industrial zone must meet stringent **performance indicators**, including:

Environmental standards: renewable energy adoption, efficient waste treatment, and water recycling.

Economic viability: competitive cost structures and return on investment for companies.

Social sustainability: compliance with labor rights, workplace safety, and community engagement

For an EIP to function effectively, the following conditions must be met:

- **Regulatory support**: clear policies promoting circular economy models.

- **Infrastructure readiness**: availability of shared utilities and waste treatment facilities.
- **Stakeholder collaboration**: Strong governance structures ensuring multi-sector engagement.
- **Technology integration**: smart data management systems for real-time monitoring and optimization

European policies on the Circular Economy

The European Union has developed comprehensive policies to support CE and EIPs, mainly including:

- **EU Circular Economy Action Plan (2020)** – defines legislative and financial support mechanisms.
- **Industrial Emissions Directive** – regulates pollution control in industrial zones.
- **Green Deal Strategy** – aims for climate neutrality through sustainable industry transformation

The Policy Cycle as a guiding process

The implementation of EIPs follows a **policy cycle model**, ensuring continuous improvement through:

- **Issue identification and data collection** – understanding challenges and setting priorities.
- **Policy formulation** – developing regulatory frameworks.
- **Stakeholder engagement** – fostering collaboration across industries and governance bodies.
- **Implementation and monitoring** – deploying initiatives and assessing their impact

Urban–Industrial symbiosis

Urban-industrial symbiosis extends EIP benefits beyond industrial parks, creating synergies with surrounding **urban and rural communities**. This integration enables:

- Shared energy and water management**.**
- Municipal waste-to-resource conversion**.**
- Enhanced logistics and transportation network

The **adoption of a unified circular economy approach** for EIPs in the Alpine region is critical for ensuring sustainability, economic resilience, and regional competitiveness. By fostering **industrial symbiosis, integrated governance, and technology-driven solutions**, the Alpine region can serve as a benchmark for **sustainable industrial development** in Europe and beyond.

5. Transnational validation

5.1. Peer Review results

The Peer Review process involved 18 experts with multidisciplinary backgrounds, including specialists in circular economy, institutional representatives, experts in sustainable industrialization, academics, and other relevant stakeholders. This comprehensive approach provided an in-depth evaluation of the effectiveness, innovation, and replicability of the ECOLE pilot actions across diverse Alpine industrial contexts.

Key findings from the review include:

- **Most structured pilots**: the best-organized and impactful pilots were identified as Trieste (PP02 COSELAG), EBZ Zalog (PP04 RRA LUR), CRAISS (PP05 WEIZ), and Siemens Technopark (PP07 TZE), mainly due to more defined governance structures and innovative technological tools.
- **Innovative aspects**: digital platforms and IT tools enabling real-time energy and waste data management, the ECOLE Toolkit for cost-benefit and multi-criteria analysis, the Systemic Thinking Community Model (STCM) for participatory stakeholder engagement, and tangible energy innovations such as waste heat recovery and energy communities were highlighted.
- **Alignment with global and EU frameworks**: most experts agreed that ECOLE's actions align well with major sustainability policies like the European Green Deal and Circular Economy Action Plan.
- **Stakeholder engagement**: engagement was generally adequate, supported by transnational workshops and participatory approaches, though some pilots experienced low participation and challenges due to lack of stable management structures.
- **Crucial role of key actors**: industrial tenants, especially large companies, public institutions, park management bodies, policymakers, and academic institutions were pivotal for project success.
- **Identified barriers**: key obstacles include absence of stable financial partners, weak park management structures, complex regulatory frameworks, and cultural resistance to collaboration.
- **Governance challenges**: governance models across pilot sites were varied and often insufficient to coordinate circular economy initiatives effectively, underscoring the need for structured and stable management frameworks.
- **Methodologies and tools**: the ECOLE Toolkit (CBA and MCA) and the STCM model were recognized as robust, scalable, and adaptable tools that support informed decision-making even in less technically skilled contexts.
- **Challenges and opportunities**: issues with data availability and quality, stakeholder resistance, and infrastructural limitations were noted, alongside emerging opportunities for new synergies, enhanced cooperation, and increased interest from research institutions.

The Peer Review confirms that ECOLE has developed a solid, innovative, and well-aligned approach with European policies, demonstrating significant potential for scalability and replication. **However, full success depends on establishing effective governance structures, simplifying regulatory frameworks, increasing stakeholder engagement, and securing adequate financial support.**

In the table below the Peer Review results.

Peer Reviews	Results
	General information
Type of expertise:	• Specialists in circular economy and environmental sustainability: 3 • Institutional representatives and policymakers: 3 • Experts in sustainable industrialization and industrial park management: 3 • Academics and researchers in environmental sciences and engineering: 4 • Others expertise related to Circular Economy, Sustainability and Industrial Symbiosis: 5
Which LAB (LAB A, LAB B, LAB C) did you attend and/or contribute to?	• LAB A: 9 • LAB B: 6 • LAB C: 3
Which ECOLE Pilot do you consider the best structured, and why?	According to the Peer Review results, the most structured ECOLE pilots are: • PP02 COSELAG: Industrial Park Trieste, Italy, • PP04 RRA LUR: EBZ Zalog, Slovenia • PP05 WEIZ: CRAISS Industrial Park, Austria • PP07 TZE: Siemens Technopark, Germany)
What aspects of the ECOLE Pilot do you find most innovative?	Most innovative aspects: 1. Digital platforms and IT tools: development of digital platforms for industrial symbiosis, particularly for real-time exchange of energy and waste data among companies within industrial parks. Notable examples include: • Platforms for matching supply and demand (e.g., in Trieste). • ACTIF, tested by PP09, for mapping synergies and enabling resource/waste exchanges. • User-driven platform development, ensuring that tools are tailored to actual operational needs. 2. ECOLE Toolkit and decision-making approaches: the ECOLE Toolkit stands out for its user-friendliness and strategic utility, especially: • Integration of Cost-Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA). • Accessibility for non-technical users. • Progress-tracking mechanisms (e.g., task completion rates) that encourage continuous engagement and action. 3. Systemic Thinking Community Model (STCM): the introduction and application of the Systemic Thinking Community Model (STCM) enabled: • Cross-sectoral collaboration and stakeholder engagement. • Integration of both technical and participatory components. • A strategic framework to build community support and systemic change. 4. Energy synergies and physical innovations: some pilots implemented concrete energy-related innovations, such as: • Waste heat recovery systems (in Austria and Slovenia). • Hybrid energy storage solutions (e.g., Johann-Storage at CRAISS). • Photovoltaic installations and refueling stations (e.g., by PP5), indicating a move beyond planning into tangible investments. 5. Sustainability criteria and park governance: pilots adopted clear sustainability criteria for new entrants in industrial parks, ensuring alignment with circular principles from the outset and introducing structured management models for greenfield development. **6. Transnational and participatory approach:** a core strength of the project was the structured involvement of stakeholders, both local and transnational, through:

	• Co-design of action plans. • Sharing of good practices tailored to regional contexts.
Do you think the project pilots (and more in general ECOLE project) aligns with global and European sustainability frameworks, such as the **EU Green Deal** and the **Circular Economy Action Plan**	Most of the experts agree on the alignment of ECOLE within global and European sustainability frameworks, in particular to the: • European Green Deal • EU Strategy for a Circular Economy • Sustainable Industry Action Plan • European Sustainability Framework • SDGs
Stakeholder engagement and governance evaluation	
Do you think stakeholder engagement during the pilot's development (working session) was **adequate and effective**?	Most respondents considered stakeholder engagement to be generally adequate and effective, especially due to: • The organization of six transnational LAB workshops focusing on governance, implementation, cost-benefit analysis, and lessons learned. • The use of a participatory approach in developing the ECOLE Toolkit and during local working sessions tailored to individual pilots. • The application of the Systemic Thinking Community Model (STCM) which facilitated meaningful and strategic interactions. While the overall engagement was appreciated, effectiveness varied between pilots, due to: • Lack of park management structures, which hindered coordination and continuity. • Low interest from companies or slow-moving stakeholders (e.g., in Grenoble). • Underdeveloped industrial parks, such as Rudersdorf, which lacked a critical mass of engaged tenants. • Some respondents felt that engagement could have been deeper and more sustained.
Which key actors (*industries, public institutions, policymakers*) played a **crucial role** in the project's success?	1. Industries and industrial park tenants: aonsistent theme among responses is the central role of industries, particularly large tenants, in ensuring the effectiveness of pilot actions. Several responses emphasized that without active industrial involvement, the project could not have succeeded**.** 2. Public institutions and local authorities: local and regional public institutions played a facilitative and enabling role, particularly by: • Coordinating stakeholders and aligning interests (e.g., ZAI Consortium, RRA LUR, Grenoble-Alpes Métropole). • Offering governance and policy support, including mandates and regulatory innovation (e.g., solar energy regulations in Slovenia). • Leading or participating in infrastructure upgrades and community engagement efforts. 3. Park management structures: Park managers and industrial park consortia emerged as key operational actors, especially in: • Coordinating site-specific pilot implementation. • Facilitating cooperation between businesses and public entities. • Ensuring that interventions were aligned with site governance and infrastructure realities. 4. Policy makers and decision-makers: policy makers at various levels (municipal, regional, national) were essential in: • Supporting the regulatory environment for the pilots. • Translating project lessons into policy frameworks. • Enabling scaling and transferability beyond the pilot sites. 5. Academic and research institutions: research actors contributed valuable technical expertise and scientific validation, with examples including: • TUMint, FLA, TZE – for technology and governance. • Universities such as Bamberg (PP08) – for innovation challenges and knowledge sharing. **6.** Collaborative ecosystems**:** the project thrived on the collaboration between actors, with many responses highlighting that:

	• Success was a result of multi-actor cooperation across sectors and scales. • Bottom-up stakeholder involvement, as promoted by the Systemic Thinking Community Model (STCM), was particularly impactful.
Were there any **stakeholders missing** that could have contributed significantly to the project?	1. Financial institutions and investors: the absence of stable financial partners (banks, green funds, investors) was considered a limitation for scaling and long-term sustainability. 2. Industrial Park management entities: many reviewers pointed out that dedicated industrial park managers were either absent or not clearly defined in several pilots. 3. Policymakers and regulators: some responses also mentioned the need for waste management regulators and energy authorities to facilitate implementation and compliance. 4. Technical and research stakeholders: this absence may have limited innovation depth and scientific validation of some pilot activities. 5. Community and civil society actors **6.** Other potentially valuable contributors: energy providers and regional energy agencies, who could support integration into regional transition strategies. Recyclers, SMEs, and employees within companies, whose operational insights are essential for practical implementation.
How did different stakeholders (*industrial tenants, policymakers, researchers*) influence **decision-making and technology implementation**?	1. Industrial tenants: industrial tenants were seen as key decision-makers in the actual implementation of technologies and circular economy solutions 2. Policymakers and local authorities: their influence was particularly important in aligning industrial park development with long-term environmental and economic policy 3. Researchers and technical experts: technical centres (e.g., Centre Technique Industriel de la Plasturgie) conducted field research to identify sector-specific needs and pass them on to public actors. **4.** Collaborative and iterative processes: Systemic Thinking Community Models and LABs, where stakeholders co-designed actions and shared responsibilities. Workshops and feedback sessions where tenants, researchers, and authorities co-shaped pilot designs and regulatory alignment.
In your opinion, what were the most effective **incentives** for stakeholder involvement?	• Financial Incentives and Economic Benefits • Knowledge Transfer and Technical Support • Collaborative Platforms and Networking • Strategic and Social Value
Did the project create **new synergies** between public and private actors that did not exist before?	1. Widespread creation of new synergies**:** the majority of respondents confirmed the creation of new synergies between public and private actors, noting that ECOLE played a catalytic role in fostering: • Collaborative platforms, including technical working tables and energy communities. • New partnerships across sectors, such as between municipalities and industries, waste operators, research institutions, and technical clusters. 2. Notable examples from pilot sites **3.** Mechanisms enabling cooperation: the project enabled cooperation through: • Systemic Thinking Communities (STC) and stakeholder workshops, which provided structured environments for exchange. • Pilot activities that required cross-sector coordination, prompting actors to work together in new configurations. • Park management frameworks, which brought public institutions and private tenants into closer operational alignment. 4. Strategic impact of public-private collaboration**:** the creation of these synergies is seen as key to: • strengthening industrial symbiosis and innovation. • Enabling shared infrastructure and investment models. • Accelerating the transition to a circular economy at both site and regional levels.
How do you assess the governance	• Diverse and uneven governance structures

models adopted in the pilot actions in terms of resource management and circular transition?	• The governance models adopted across the ECOLE pilot actions were highly varied, reflecting national contexts and local park conditions. • Impact on resource management and circularity • Strengths and weaknesses identified • Several governance models showed promising early-stage potential • Key challenges and observations • Recommendations and insights
Do you think the project facilitated effective interdisciplinary dialogue? Which additional fields should be integrated?	ECOLE project successfully facilitated interdisciplinary dialogue, particularly: • Through LAB workshops, where cross-sector collaboration (e.g., between urban planners, engineers, and public authorities) was evident. • Via the Systemic Thinking Community Model (STCM), which enabled diverse stakeholders to engage in collective reflection and solution design. • Across project phases, including pilot development and transnational partner meetings, fostering a shared language and mutual learning. • Several reviewers highlighted that this dialogue was foundational to the project's methodology and instrumental in supporting the transition to Eco-Industrial Parks. Additional fields suggested: • Strengths in Dialogue and Collaboration • Gaps and Opportunities for Broader Integration • Contextual Depth and Holistic Integration
Validation of methodologies and tools	
Do you consider the methodologies adopted **robust and replicable** in other industrial contexts?	Most respondents confirmed that the methodologies developed within ECOLE are robust, scalable, and replicable across other industrial park contexts. This is especially true for: • The ECOLE Toolkit, which includes Cost-Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA) components. • The Systemic Thinking Community Model (STCM), which facilitates structured stakeholder engagement. These tools were praised for their modular and adaptable design, making them usable in a variety of local and national contexts. While broadly positive, some reviewers emphasized that replicability is conditional upon: • Presence of actual synergies within industrial parks; without them, implementation becomes superficial and symbolic. • Support from consulting or intermediary organizations, especially to enhance economic rigor or customize tools. • Availability of baseline data and metrics to measure impact—data gaps (e.g., PP09) can limit tool effectiveness. • Regulatory alignment, as local and national policies can vary widely and may support or hinder implementation.
What were the strengths and weaknesses of the **Systemic Thinking Community Model (STCM)** developed within ECOLE and the working session with local Stakeholders?	Strengths of the STCM: • Fostering Collaboration and Inclusivity • Structured and Participatory Approach • Holistic and Systemic Perspective • Trust Building and Relationship Formation Weaknesses of the STCM: • Lack of Operational Structure and Governance • Time and Resource Intensive • Motivation and Engagement Challenges • Context-Specific Limitations • Risk of Imbalance or Theoretical Dominance Recommendations • Formalize governance and continuity mechanisms to ensure long-term community durability post-project. • Enhance usability and facilitation guidelines for STCM tools.

	• Involve financial experts and industrial park managers more directly to ensure economic viability and operational follow-through. • Tailor stakeholder engagement formats to better accommodate confidentiality concerns and limited availability.

Which elements of the **ECOLE Toolkit** were most useful in supporting the implementation of pilot actions?	• Multi-Criteria Analysis (MCA) and Cost-Benefit Analysis (CBA) tools
	The MCA and CBA templates were among the most frequently cited components for their effectiveness in:
	  • Structuring decision-making around technology choices, energy efficiency, and waste management.
	  • Providing a comprehensive assessment of gaps and priorities within industrial parks.
	  • Helping
	• Self-assessment and circularity checklists
	• Progress tracking and kpi reporting
	• Stakeholder engagement and governance tools
	• Practical tools for energy and waste management
	• Flexibility and customization

Was a **Cost-Benefit Analysis (CBA)** or **Multi-Criteria Analysis (MCA)** applied? If so, what were the key findings?	Most pilot sites applied either Cost-Benefit Analysis (CBA), Multi-Criteria Analysis (MCA), or both, as part of their decision-making processes. These tools were embedded in the ECOLE Toolkit and used to assess circular economy interventions, particularly related to: • Renewable energy investments (e.g., solar PV and energy storage). • Waste-to-energy and heat recovery technologies. • Governance priorities and strategic planning in industrial parks. Key Findings from Cost-Benefit Analyses (CBA) • Economic viability: CBA was instrumental in demonstrating the financial attractiveness of interventions like solar energy systems, particularly where public subsidies were available (e.g., PP04, PP5). • Long-term value: although some technologies (e.g., waste heat recovery) required higher initial investments, they offered positive long-term returns, especially under stable regulatory and market conditions. • Complementary benefits: the analysis revealed that economic sustainability alone was insufficient; circular initiatives also needed to deliver environmental and social value to justify investment decisions. Key Findings from Multi-Criteria Analyses (MCA) • Multi-dimensional evaluation: MCA allowed pilots to assess solutions using technical, environmental, governance, and social criteria, helping align actions with broader sustainability goals. • strategic prioritization: the tool was used to rank and select circular strategies, guide local decision-makers, and identify next steps within pilot sites (e.g., PP06, PP7). • Capacity building: MCA offered a framework for industry actors with limited baseline data or readiness, supporting staged improvements and compliance with upcoming policies (e.g., digital product passports). • Influence on planning: results from MCA were often used to influence park management priorities and action roadmaps.
Did the data collection and monitoring tools effectively measure progress toward circular economy goals?	Data collection and monitoring tools contributed meaningfully to measuring circular economy progress within the pilot sites. However, the effectiveness was often partial, and varied based on: • Data availability and quality. • The degree of tool adoption and iteration. • The presence (or absence) of supporting digital infrastructure.
What were the most effective **Key Performance Indicators (KPIs)** used in the pilots?	Environmental KPIs: • CO_2 emissions reduction per intervention: widely used and crucial for evaluating environmental impact (e.g., PP5, PP8). • Energy consumption and renewable energy share: used to measure improvements in energy efficiency and transition to renewables (e.g., PP1, PP4, PP5).

	• Material reuse and recycling rates**:** key to tracking industrial symbiosis and circularity progress.
	• Waste diverted or reused (e.g., tons of waste diverted – PP04, PP9).
	• Energy self-sufficiency ratios and waste heat utilization metrics (e.g., PP6, PP8).
	Economic KPIs:
	• Cost savings from resource and energy synergies (e.g., PP09).
	• Economic value creation: including return on investment and resource productivity.
	• Sustainable employment generation and new business installations (e.g., PP8).
	Social and organizational KPIs**:**
	• Stakeholder engagement metrics:
	  ○ Number and diversity of engaged companies or institutions (e.g., PP2, PP3, PP4).
	  ○ Number of workshops, agreements, or collaboration platforms activated.
	• Community participation rates and outreach success (e.g., PP04).
	• Quality of industrial symbiosis partnerships.
	Operational KPIs**:**
	• Resource use intensity: Input/output per unit of production.
	• Waste-to-resource conversion rates**.**
	• Energy and water monitoring parameters for continuous improvement and adaptive management.

Are there **additional metrics** you think should be included in future impact assessments?	The inclusion of new and more diversified metrics in future ECOLE-related or similar impact assessments would complement existing KPIs by offering deeper insights into social, environmental, economic, and digital dimensions of circular transitions: • Biodiversity indicators • Water circularity rates • Lifecycle-based carbon accounting • Digital maturity levels • Implementation rates of monitoring systems • Supply chain circularity indicators: • Job creation in circular economy sectors. • Gender inclusion and workforce upskilling • Community engagement levels • Behavioral change metrics • Energy resilience indicators: • Long-term financial return (ROI) • Carbon intensity of operations
Identifying challenges and areas of improvement	
What were the main **challenges** encountered during project pilots' implementation?	Data availability and quality: • Insufficient baseline data, particularly on waste streams, energy flows, and circularity indicators. • Data fragmentation and inconsistency, hindering monitoring and decision-making processes. • Reluctance to share sensitive information, especially from industrial stakeholders concerned about confidentiality (e.g., waste production/recycling volumes). • Difficulties in extracting and structuring data from stakeholders due to lack of standardized reporting formats. Stakeholder engagement and resistance: • Low readiness among stakeholders in some regions to engage in systemic, collaborative processes. • Resistance to change, especially in companies without immediate financial or regulatory incentives. • Lack of time and resources from SMEs to actively participate in workshops or planning activities.

	• Trust issues, with several stakeholders skeptical about the tangible outcomes of participation, due to perceived past inaction.
	Governance and coordination gaps:
	• Many pilot sites faced the absence of structured governance models within their industrial parks, leading to:
	  ○ Fragmented responsibilities
	  ○ Limited coordination between actors
	  ○ Delays in decision-making
	• Difficulty in aligning stakeholders under a common strategic vision, especially in greenfield areas lacking anchor tenants or mature infrastructure.
	Technical and infrastructure limitations:
	• Aging infrastructure in some brownfield parks limited the feasibility of implementing advanced energy or waste solutions.
	• Challenges in deploying renewable energy systems and ICT tools for circularity due to:
	  ○ Technical barriers
	  ○ Compatibility issues
	  ○ High initial investment costs
	Regulatory and administrative complexity:
	• Complex and fragmented regulatory frameworks, particularly affecting:
	  ○ Industrial symbiosis initiatives
	  ○ Renewable energy projects
	• Delays in permitting and approvals, which slowed down the implementation pace.
	• Lack of clarity on future regulations, making it harder to justify upfront investments or long-term planning.
	Transnational coordination and contextual differences:
	• Challenges in harmonizing approaches across diverse regional and national contexts within the Alpine Space.
	• Varying levels of maturity of industrial parks and local ecosystems affected replication and comparability.
	• Limited resources to address the specific needs of each location in a tailored manner.

What **barriers** still need to be overcome to improve the transition towards sustainable industrial parks?	Regulatory and policy barriers: • Regulatory fragmentation across national, regional, and local levels creates uncertainty and complexity for implementation. • Lack of harmonized standards and legal definitions for eco-industrial parks and circular economy practices. • Frequent policy changes or unclear timelines (immediate vs. deferred enforcement) create confusion among stakeholders. • Absence of supportive regulations such as simplified permitting for circular initiatives or incentives for industrial symbiosis. Economic and financial constraints: • Insufficient financial incentives, subsidies, or grants to motivate investment in circular solutions. • High upfront costs for renewable energy, resource monitoring, and waste valorization technologies are prohibitive for many SMEs. • Limited access to funding, especially for small tenants lacking the capacity to prepare complex project proposals. • Low economic visibility of the long-term benefits of circular practices reduces interest and urgency. Governance and management gaps: • Lack of structured and long-term governance models in many industrial parks impedes strategic planning. • Absence of a dedicated park management entity to coordinate efforts and ensure follow-up beyond pilot phases. • Fragmented stakeholder responsibilities prevent coherent action across energy, waste, infrastructure, and logistics domains. Stakeholder engagement challenges:

	• Low engagement levels from businesses, often due to lack of awareness, time, or perceived relevance. • Cultural resistance to collaboration, particularly between companies operating in similar sectors who view each other as competitors. • Limited understanding of circular economy benefits and unfamiliarity with new collaborative business models. Technological and infrastructural limitations: • Insufficient digitalization of parks, especially regarding real-time monitoring systems and data-driven decision-making tools. • Infrastructural inadequacy, particularly in older or brownfield industrial zones, makes upgrading costly and complex. • Lack of scalable and context-specific technological solutions, especially for complex waste streams or energy integration. Awareness and cultural resistance: • Low awareness of circular economy concepts among local authorities, SMEs, and the broader community. • Skepticism about the practical feasibility or profitability of circular practices. • Lack of visible success stories and benchmarking platforms to motivate action and peer learning. Systemic and coordination issues: • Absence of shared platforms for publishing and benchmarking sustainability performance across parks. • Insufficient cross-sectoral collaboration, limiting the development of synergies with other value chains (e.g., agriculture, housing, logistics). • Underutilization of industrial symbiosis potential due to missing matchmaking mechanisms or shared planning tools.
Do you think the **current regulatory framework** facilitates or hinders the replicability of the solutions tested in the pilots?	The current regulatory framework mostly hinders the replicability of ECOLE pilot solutions. Key regulatory barriers: • Complex permitting processes for shared infrastructure, waste exchange, and renewable energy. • Fragmented regulations across national and local levels, not tailored to eco-industrial park needs. • Unclear roles or legal status for industrial park managers and coordinating bodies. • Lack of economic incentives, with recycled materials often more expensive than raw ones, and landfilling cheaper than recycling. • Rigid waste management laws that complicate reuse, material sharing, and industrial symbiosis. There is a need for regulatory harmonization**,** streamlined procedures**,** legal recognition of sustainable industrial parks, and stronger incentives to support circular economy solutions.
What strategies could be implemented to **overcome regulatory barriers**?	To enable replicability and acceleration of circular economy practices in industrial parks, regulatory frameworks must become simpler, clearer, more supportive, and better aligned with the realities of industrial ecosystems. Strategies suggested: 1. Legal and institutional reforms: • Develop dedicated legal frameworks for Eco-Industrial Parks (EIPs) at national or regional levels. • Promote harmonization of regulations across countries and sectors to avoid fragmentation. • Define clear legal roles for park managers and coordinating bodies. 2. Administrative simplification: • Introduce “one-stop shops” or fast-track permitting for circular economy (CE) initiatives. • Pilot pre-authorized zones for testing industrial symbiosis and green innovation. • Use “living labs” as regulatory sandboxes for experimentation.

	3. Economic incentives: • Create tax credits, grants, or green investment schemes to support circular solutions. • Encourage Extended Producer Responsibility (EPR) systems and financial incentives for shared infrastructure. 4. Capacity building and engagement: • Train public officials and regulators to understand circular economy principles and support implementation. • Establish public-private governance models to jointly manage resources and utilities. • Strengthen stakeholder engagement in regulatory reform processes. 5. Policy advocacy and strategic dialogue: • Align national frameworks with EU policies (e.g., Green Deal). • Conduct evidence-based lobbying using results from pilots to influence legislation. • Promote cross-sectoral collaboration between industry, municipalities, and research institutions
What were the main **lessons learned** from the pilot actions?	The ECOLE pilots demonstrated that multi-level governance, early engagement, digital infrastructure, and economic viability are key for circular transition success. Long-term replication will depend on embedding these lessons into policy, financing, and industrial culture. Main lessons learned are**:** 1. Local adaptation is essential: • Tailored approaches proved far more effective than one-size-fits-all models. Success depended on adapting circular economy strategies to: ○ Industrial typologies ○ Governance frameworks ○ Geographical and socio-economic contexts 2. Early and inclusive stakeholder engagement: • Engaging companies, municipalities, park operators, and communities from the start was critical. • Transparent communication built trust and buy-in, particularly in challenging contexts (e.g., PP04 biofuel in Slovenia). • Cross-sectoral collaboration, including academia and civil society, strengthened impact and innovation. 3. The role of governance: • Formal governance structures (or the lack thereof) were a recurring success/failure factor. • Pilots with clear management bodies progressed faster. • The need for institutional continuity post-project was highlighted. 4. Digitalization and data-driven decisions: • Digital platforms enabled resource sharing, monitoring, and transparency. • Success depended on data availability, stakeholder digital readiness, and system interoperability. • KPIs and real-time monitoring tools supported more strategic, measurable action. 5. Economic framing and incentives: • Pilots that framed solutions in financial terms (e.g., ROI, subsidies) gained faster industry engagement. • Cost-saving narratives and green investment support encouraged uptake, particularly among SMEs. 6. Pilot testing and scalability: • Pilots served as low-risk environments to test circular models. • Results underscored the value of: ○ Flexible project timelines ○ Clear sustainability goals ○ Structured learning and replication tools (e.g., MCA/CBA, STCM)

	7. Communication and knowledge sharing: • Clear long-term visioning, scenario planning, and storytelling facilitated alignment. • Cross-border learning enriched pilots, revealing approaches not previously tested locally.
Which **elements** of the pilot actions do you find most **innovative and strategic** for successful replication?	1. Digital innovation and IT platforms: • Real-time IT platforms for sharing energy and waste data (e.g. ACTIF): enabled industrial symbiosis by matching resources and needs among companies. • Digital tools with modular design: adaptable to local contexts and regulatory frameworks. • User-friendly interfaces encouraged participation by non-experts and SMEs. 2. Energy communities and infrastructure: • Creation of decentralized energy communities: enabled joint renewable energy investments and reduced dependency on external supply. • Hybrid energy storage systems and low-emission vehicle infrastructure (e.g. EV/truck charging stations) addressed both sustainability and operational needs. • Legally mandated renewables (e.g. solar panels on new buildings in Slovenia) stood out as policy-driven innovation. 3. Governance and planning models: • STCM – Systemic Thinking Community Model: promoted participatory governance, stakeholder trust, and shared ownership of initiatives. • Integration of circularity KPIs into industrial development plans and park management protocols. • Public-private cooperation models empowered intermediary institutions and park managers to lead the transition. 4. Practical, low-tech circular solutions: • Shared waste collection hubs and reuse of industrial by-products provided cost-effective, high-impact interventions. • Closed-loop waste management systems and co-designed logistics routes supported local synergies. • Environmental standards for new tenants ensured long-term alignment with circular goals. 5. Social and community integration: • Community co-creation models (e.g. waste-to-biofuel projects with residents) enhanced legitimacy and fostered local buy-in. • Stakeholder engagement through workshops and STCM built networks that outlived the project phase.
What **gaps** should be addressed to ensure the success and scalability of the developed solutions?	**1.** Financial and funding gaps: • Lack of long-term funding mechanisms for circular infrastructure and park operations. • Limited financial tools for SMEs, such as green guarantees, to de-risk investments. • No sustainable business models to maintain actions post-project. **2.** Governance and policy alignment: • Missing formal governance structures for industrial park management. • Need for legal recognition of Eco-Industrial Parks within national/regional frameworks. • Weak integration into urban and regional planning and lack of policy continuity. • Poor alignment between local, national, and EU policy instruments. **3.** Data and IT system limitations: • Data fragmentation and lack of interoperability across stakeholders and digital tools. • Absence of standardized KPIs to evaluate circular performance consistently. • Insufficient cybersecurity and privacy protocols for shared IT platforms.

	4. Technical and capacity gaps: • Insufficient training and technical skills, especially among SMEs and park managers. • Low stakeholder engagement due to lack of understanding of benefits or usability. • Limited scalability planning and adaptability to diverse park configurations. 5. Cultural and procedural barriers: • Resistance to change remains a key obstacle.
Were there any **unexpected challenges or opportunities** that emerged during the pilot phase?	Unexpected challenges: • Data confidentiality concerns: some companies hesitated to share data due to competition fears or lack of trust, limiting early engagement. • Low initial stakeholder engagement: in some regions, stakeholder mobilization was slower than expected, revealing resistance to change and gaps in understanding circular economy concepts. • External economic and structural factors: • Energy price volatility and supply chain disruptions impacted the feasibility of planned investments. • Construction delays in greenfield parks (e.g., Cleantech Park, PP06) misaligned with project timelines. • Existing companies prioritized core business over sustainability due to sector-specific pressures (e.g., automotive industry). Unexpected opportunities: • New synergies and business models: • Integrating energy and waste solutions led to novel ideas, such as reusing heat for nearby public buildings. • Community dialogue in PP04 triggered the expansion of bike-sharing and other co-benefits. • Enhanced collaboration: • Informal stakeholder networks emerged, fostering new partnerships beyond the original project scope. • Universities and research centers showed unexpected interest, leading to further cooperation opportunities. • Greater policy and community interest: • Economic downturns (e.g., in PP09) boosted interest in cost-saving circular practices. • Transparent communication strategies increased community support. • Technology and learning opportunities • Challenges in data handling pointed to the need for AI and Machine Learning integration. • Skills gaps exposed the necessity of targeted training and upskilling initiatives.
Impact and scalability of solutions	
Do you think the pilot actions had a **positive impact on industrial park governance**?	Pilot actions contributed significantly to improving governance in industrial parks, with some variation based on local context and implementation depth: • Creation or strengthening of park management structures • Improved stakeholder collaboration • Increased awareness and institutional Learning • Limitations and variability
Can the **technologies implemented in the pilots** be easily adapted to other industrial contexts? If so, what factors facilitate this adaptability?	Many technologies tested in the pilots are highly adaptable to other industrial contexts, especially when supported by enabling conditions. technologies with high replication potential • Digital platforms for resource tracking and industrial symbiosis • Renewable energy systems (e.g., solar PV, heat pumps) • Waste heat recovery and energy storage solutions • Monitoring tools **for** circular economy indicators Key enabling factors**:**

	• Governance structures: existence of park management entities or intermediaries facilitates coordination and implementation. • Infrastructure readiness: basic infrastructure such as grid access, data networks, and monitoring systems is crucial. • Stakeholder engagement: willingness of companies to collaborate, share data, and invest jointly is essential. • Policy and financial support: incentives, feed-in tariffs, and regulatory alignment accelerate adoption and long-term policy stability is critical for capital-intensive technologies. • Workforce and skills: Presence of a skilled labor force supports implementation and maintenance of advanced solutions.
Which **technologies** developed in the project do you consider most **promising for broader adoption**?	Digital resource exchange platforms: • Strengths: promote industrial symbiosis, are scalable and cost-effective, and facilitate cross-company collaboration. Smart monitoring and metering systems: • Benefits: provide precise data for decision-making, efficiency gains, and sustainability reporting. Photovoltaic (PV) and battery storage systems: • Strengths: effective for shared or decentralized energy production within parks. Waste heat recovery systems: • Use case: particularly relevant in multi-tenant industrial parks or co-located factories. • impact: reduces energy waste and operational costs, and enhances circularity. Decentralized biofuel / biogas / biomass units: • Target: agro-industrial and rural industrial parks. • Advantage: valorizes organic waste streams and reduces reliance on fossil fuels.
What role did **digitalization and smart technologies** play in improving circular economy implementation?	Real-Time monitoring and data management: • Enabled continuous tracking of resource consumption (e.g., energy, water), waste generation, and emissions. • Provided accurate data for performance metrics (KPIs), enabling ongoing optimization and informed decision-making. Industrial symbiosis and resource exchange: • Platforms like ACTIF (PP09) allowed companies to identify and exploit waste-to-resource synergies. • Facilitated digital matchmaking for waste reuse and shared service models. Stakeholder engagement and coordination: • Improved transparency and communication between businesses, municipalities, and service providers. • Supported collaborative planning through shared digital platforms and real-time information flows. Process optimization and innovation: • Tools helped optimize energy and logistics operations. • Enabled new business models such as predictive maintenance (e.g., QR codes on products) and product life-cycle extension.

What is the potential for integrating **renewable energy sources** into industrial parks based on the findings from the pilots?	Proven technologies and positive outcomes:
	• Solar PV systems emerged as the most widely applicable solution, especially:
	  ○ In brownfield redevelopments.
	  ○ Where national or regional mandates (e.g., Slovenia's legal requirement) boosted implementation.
	• Heat pumps and waste heat recovery were found feasible and impactful, particularly in multi-tenant settings.
	• Biogas systems showed promise in parks with organic waste streams, offering synergy between waste and energy sectors.
	Economic viability:
	• Many pilots reported positive results from Cost-Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA).

	• Subsidies and grants (e.g., Slovenia's Eco Fund) significantly improved payback periods, making investments more attractive. Key Enablers for successful integration: • Shared infrastructure models, such as energy communities and collective energy storage, are gaining traction. • The existence of grid connections, available space (e.g., rooftops, parking lots), and management bodies facilitates deployment. • Access to soft loans, policy incentives, and supportive regulations was repeatedly highlighted as a decisive factor. Context-specific considerations: • Wind energy faced regulatory and technical constraints, being feasible only in select locations. • Hydrogen was considered aspirational: pilots showed technical interest, but infrastructure and partnerships were not yet in place. • Integration success varied depending on site typology (greenfield vs. brownfield), local planning norms, and stakeholder engagement.
What **communication and dissemination strategies** could be adopted to enhance the scalability of the solutions?	To enhance scalability, ECOLE should adopt a multi-level communication strategy that blends technical clarity, participatory engagement, real-time digital tools, and institutional alignment. Sharing results in ways that are both informative and inspiring—while equipping stakeholders with actionable resources—will be essential for expanding circular economy practices across the Alpine Space and beyond. Tools suggested: • Toolkit-based and tangible communication • Stakeholder engagement platforms • Digital communication channels • Institutional and policy-level dissemination • Capacity building and education • Tailored messaging and targeted outreach
How do you think the project could attract **further investment and funding** to expand its impact?	Build a strong investment case: • Demonstrate measurable impacts from the pilot actions (e.g., ROI, energy savings, CO_2 reduction, job creation). • Develop a business case library and standardized financial models tailored to different industrial park types. • Highlight the de-risking achieved during pilots to reassure prospective investors. Leverage public-private partnerships PPP: • Structure public-private investment vehicles (e.g., joint ventures, blended finance schemes). • Encourage co-investment by industrial tenants in return for long-term benefits (e.g., solar power cost savings). • Use tiered membership models offering park tenants differentiated services linked to infrastructure investments. Align with EU and National Funding Instruments: • Position ECOLE within key EU frameworks: • *Horizon Europe*, *Green Deal*, *Innovation Fund*, *Just Transition Fund*, *LIFE Programme* • Align with *National Recovery and Resilience Plans* and *ERDF Operational Programmes* • Leverage platforms such as the Circular Cities and Regions Initiative (CCRI) for visibility and matchmaking. Emphasize Circular and Climate Finance Potential: • Engage green investment bodies, regional development banks, and climate finance mechanisms. • Create impact investment portfolios that align with ESG, SDG, and low-carbon objectives. • Promote carbon offset opportunities, renewable deployment, and circular cost savings as core selling points. Strategic communication and visibility: • Highlight success stories through professional communication campaigns.

	• Engage stakeholders via open days, conferences, and policy roundtables to showcase outcomes. • Tailor communication to investor interests: e.g., stability, returns, and market opportunity. Innovation and technology integration: • Emphasize AI and data-driven solutions to monitor and optimize circular performance. • Highlight how digital tools enhance scalability and reduce operational risk, improving fundability. • Support monitoring systems and KPIs that track environmental, social, and financial performance.
Final recommendations	
What recommendations would you suggest to enhance the future impact of the ECOLE project?	Establish a permanent transnational platform: • Create a long-term European network or community of practice for Eco-Industrial Parks (EIPs), particularly in the Alpine Space, to facilitate continuous exchange of experiences, peer support, and joint project development. • Promote cross-border collaboration and replication of successful pilots under Interreg, Horizon Europe, or other EU programs. Strengthen and formalize governance models: • Consolidate the STCM and governance models into standard methodologies and publish policy briefs and best-practice guidelines. • Encourage the integration of these models into local and regional industrial planning frameworks and EU Green Deal-linked policies. • Develop transnational certification schemes (e.g., a "Circular Industrial Park Label") based on KPI systems to reward commitment and enable benchmarking. Expand training and knowledge sharing: • Launch EU-wide training programs to promote the uptake of the ECOLE Toolkit, especially among new parks and public authorities. • Strengthen partnerships with research and educational institutions to ensure continuous innovation and upskilling. • Disseminate results and lessons learned Ensure long-term monitoring and impact evaluation: • Develop and implement a long-term monitoring system for circular KPIs and progress tracking in participating parks. • Encourage the adoption of a shared sustainability reporting system at the park level, improving transparency and enabling aggregated insights. • Promote the use of emerging technologies like AI and Machine Learning for data-driven planning, financial modeling, and environmental assessment. Scale technological and methodological adoption: • Enhance scalability and adaptability of digital and operational tools by improving usability and flexibility across different industrial contexts. • Broaden toolkit functionality to include smart governance, digital maturity diagnostics, and industry-specific modules (e.g., water reuse, biodiversity indicators). Broaden stakeholder engagement: • Formalize multi-level stakeholder collaboration mechanisms including municipalities, industrial tenants, academia, and civil society. • Ensure diverse and continuous participation in governance and decision-making processes through recurring engagement forums. • Encourage joint sustainability planning between industrial parks and other sectors (housing, transport, agriculture). Secure financial sustainability: • Align with national and regional funding programs, and advocate for incentive schemes (e.g., green procurement, tax relief, dedicated investment funds). • Explore performance-based financing models (e.g., revolving funds tied to savings or impact metrics). • Facilitate public-private partnerships for infrastructure development and service provision. Enhance communication and policy advocacy:

	• Amplify the project's visibility through strategic communication and succinct messaging. • Share the challenges and limitations experienced across pilots to inform European policy revisions. • Develop a formal advocacy strategy to promote the inclusion of circular economy goals into EU and national industrial policies.
What additional actions could be taken to ensure the long-term sustainability of the developed solutions?	• Institutionalization of governance and management • Continuous monitoring and data systems • Financial sustainability and business models • Capacity building and knowledge retention • Stakeholder engagement and community integration • Transnational scaling and strategic linkages

How could the project further strengthen its **political, economic, and environmental impact**	Political impact – aligning policy and governance:
	• Align with national and EU climate, industrial, energy, and waste strategies, ensuring coherence with ongoing legislative frameworks.
	• Engage directly with policymakers at all levels, advocating for:
	  ○ Supportive regulation and recognition of Eco-Industrial Parks (EIPs).
	  ○ Inclusion of ECOLE methodologies in urban planning, energy strategies, and spatial plans.
	• Create a dedicated ECOLE Policy Task Force to:
	  ○ Standardize circular park regulations.
	  ○ Develop "fast-track" permitting systems.
	  ○ Promote cross-border working groups on circular industrial policy.
	• Actively disseminate evidence-based policy recommendations, using project data to influence decision-making and build political credibility.
	• Expand outreach through campaigns and public events, increasing awareness of the project's contribution to broader sustainability and resilience goals.
	Economic Impact – Demonstrating Viability and Driving Investment:
	• Quantify economic benefits such as cost savings, job creation, and innovation potential from circular economy actions.
	• Promote public-private partnerships and investment tools, including:
	  ○ Circular economy tax incentives.
	  ○ Green public procurement (GPP) quotas for public buyers.
	  ○ Circular industrial park investment indexes to track and promote sustainable business performance.
	• Use pilot success stories to showcase how circular solutions can be operationally and economically viable.
	• Strengthen ties with financial institutions and consultants to co-develop economic models that facilitate replication.
	• Develop scalable and transferable business models for circular industrial parks and resource management.
	Environmental Impact – Scaling and Monitoring Sustainability:
	• To maximize environmental contributions and outcomes:
	• Implement park-level environmental budgeting to track environmental impact at the operational scale.
	• Scale sustainable practices by replicating successful pilots in other regions and countries.
	• Promote tools such as:
	  ○ Material passports for infrastructure and assets.
	  ○ Adaptive reuse standards for brownfield and industrial sites.
	• Enhance monitoring and reporting with continuous data collection on:
	  ○ CO_2 emissions saved.
	  ○ Waste reduction and recycling rates.
	  ○ Biodiversity impacts.
	• Develop environmental certifications tailored to circular industrial ecosystems to support transparency and recognition.

What **follow-up actions** would you recommend for	For policymakers: **1.** Institutional and regulatory measures

stakeholders and policymakers?	• Recognize Eco-Industrial Parks (EIPs) as a formal planning category within urban and regional development frameworks. • Introduce circular park certification systems with tiered benefits and requirements. • Mandate material flow reporting for industrial parks to enhance transparency and monitoring. • Incorporate circular goals into regional development policies, including dedicating portions of funding (e.g., 5%) to circular initiatives. **2.** Policy and governance Innovation • Support multi-level governance platforms, uniting local governments, companies, and park operators in coordinated decision-making. • Simplify administrative procedures for shared energy and waste management to remove bureaucratic barriers to circular implementation. • Establish policy dialogues and replication incentives, including grants and formal policy recommendations derived from pilot learnings. **3.** Funding and technical Support • Create regional technical assistance hubs to support SMEs and park managers in deploying circular solutions. • Improve access to funding instruments, including EU funds and green finance. • Incentivize green public procurement (GPP) to stimulate market demand for sustainable products and services within industrial zones. For stakeholders and industrial actors: **1.** Capacity building and knowledge sharing • Institutionalize ECOLE tools within park operations (e.g., as part of standard procedures). • Appoint dedicated circular economy officers and conduct regular (e.g., biannual) stakeholder satisfaction surveys. • Invest in continuous training, particularly for circular tools like CBA/MCA and digital monitoring. • Promote peer learning, sectoral working groups, and resource-sharing platforms across industrial parks. **2.** Collaboration and community engagement • Foster collaborative platforms for aligning goals, sharing resources, and co-developing innovations. • Create community advisory boards and organize “open house” days to increase transparency and community buy-in. • Raise awareness on circularity, including its role in addressing European resource dependency and environmental risks. **4.** Operational improvements • Develop standardized toolkits derived from pilot actions for broader replication. • Implement internal carbon pricing systems and encourage material innovation to support sustainability objectives. • Track progress and impact through annual reviews and monitoring mechanisms.
What role should **education and training** play in ensuring the long-term success of circular economy initiatives in industrial parks?	Unanimous agreement among respondents that education and training are fundamental to the long-term success of circular economy initiatives in industrial parks. Their value extends across technical, organizational, cultural, and strategic dimensions: • Key Functions of Education and Training: • Building Technical Expertise and Operational Capacity • Fostering Systemic Thinking and Innovation • Supporting Continuous Learning and Adaptation • Raising Awareness and Shaping Mindsets Strategic Recommendations**:** • Training should be used to bridge gaps between policy and industry, translating strategic goals into operational actions.

	• It should be embedded into institutional frameworks to ensure continuity and support for circular transitions. • Future capacity-building strategies must emphasize both technical skills and mindset change, ensuring that circular economy becomes a sustained practice, not a one-time project.

Table 8: Peer Reviews questionnaires questions

5.2. Contributions from Systemic Thinking Community Sessions

Below a summary of the Reports that have been collected from the working sessions each partner has organized within its local stakeholders.

Main topics of the Systemic Community Working Sessions:

- Sustainable waste management: pilot projects for the recycling of used cooking oil and biogas production from organic waste; treatment of sewage sludge and management of animal waste.
- Energy efficiency and renewable sources: use of residual heat from industrial plants to provide heating for other companies; creation of renewable energy communities within industrial areas.
- Collaboration between businesses and institutions: partnerships between companies, public authorities, and universities to promote research and innovation in environmental sustainability; proposals for resource and service sharing between businesses to reduce costs and environmental impact.
- Digitalization and monitoring: development of it tools to monitor energy consumption, waste production, and potential synergies between companies.
- Introduction of new regulations on renewable energy use: discussion on the latest legislative developments aimed at fostering the use of renewable energy sources.
- Potential development of an industrial symbiosis networks: exploration of industrial symbiosis networks to facilitate resource sharing and collaborative practices among industries.
- Planning for future energy needs: implementation of on-shore power supply solutions in ports to meet future energy demands.
- Presentation of excess heat potential analysis results: discussion on the importance of managing residual heat and future collaborative opportunities.
- Exploring synergies between companies and local authorities: encouraging collaboration between businesses and municipalities for improved resource management.
- Strengthening industrial park governance: defining priority actions and improving governance within industrial parks to enhance coordination.
- Circular economy projects: collection and reuse of industrial waste and the management of residual heat within eco-industrial parks.
- Implementation of an online platform: facilitating collaboration between companies through a digital platform designed to enhance communication and cooperation.

Key conclusions of the Systemic Community Working Sessions:

- Positive effects of Public-Private Partnerships: the projects demonstrated that synergies between public entities, businesses, and universities enhance the effectiveness of sustainability strategies.
- Scalability of pilot models: initiatives launched in industrial parks can be replicated in other regions, contributing to the spread of circular economy practices.

- Need to overcome regulatory and financial barriers: large companies like KOTO face challenges in accessing funding, while SMEs require incentives to adopt green solutions.
- High motivation for shared projects: companies are motivated to participate in collaborative projects, especially to improve the image of the industrial park.
- crucial involvement of businesses and institutions: engaging more companies and institutions is essential for creating effective synergies.
- Strong interest in efficient heat management: both businesses and municipalities show a strong interest in managing excess heat effectively.
- Need for a coordinating body: establishing a central organization is necessary to facilitate information collection and collaboration among stakeholders.
- Strong Public-Private Cooperation: effective collaboration between public and private entities is crucial for improving energy efficiency.
- Replicable IT platform model: the IT platform developed can serve as a replicable model for other industrial parks.
- Active participant engagement: participants showed strong involvement, focusing on solutions that are scalable and replicable across different contexts.

Summary: lessons learned from the Systemic Community Working Sessions

- Several companies, such as JATA EMONA and VOKASNAGA, have highlighted innovative approaches to waste management. Examples include transforming manure into fertilizer and collecting used cooking oil for biodiesel production.
- Collaboration among stakeholders has proven essential for the success of pilot projects, fostering synergies between public entities, businesses, and local communities.
- COSELAG: The local community has shown significant interest in the circular economy and its application in industrial parks. Public-private collaboration is crucial for improving environmental performance and reducing greenhouse gas (GHG) emissions.
- Initiatives to install photovoltaic systems (e.g., JATA EMONA and KOTO) have emphasized the importance of reducing the carbon footprint through solar energy and energy efficiency improvements.
- Managing residual heat for industrial cooling has been discussed as an innovative solution to reduce energy waste.
- Difficulties have emerged in collecting data on the energy needs of residential buildings (RA SORA).
- The creation of Systemic Thinking Committee Models has facilitated stronger collaboration among different stakeholders (companies, public authorities, and universities) to promote the circular economy in eco-industrial parks.
- The lessons learned highlighted the need for stakeholder engagement strategies from the early stages of the project.
- A systemic approach has proven essential for creating effective synergies between businesses and institutions.
- Companies are motivated to participate in joint initiatives to improve the park's image and reduce environmental impact.

- The creation of an online platform to facilitate synergies between companies is considered a strategic element.
- The lack of a centralized governing body for industrial zones is seen as a barrier to collecting information on residual energy (RA SORA).

Summary: evaluations of the Systemic Community Working Sessions

- All participants expressed a high level of satisfaction with the organization of the workshops, with an average score of 5 out of 5 for session quality and interactivity.
- Topics such as **sustainable waste management**, **renewable energy production**, and **cross-sector collaboration** were met with great interest.
- In particular, pilot projects on **used cooking oil recycling** and **biogas production** garnered significant attention for their potential replicability.
- The synergies created between public entities, universities, and private companies were positively evaluated for their contribution to improving **environmental sustainability** and **operational efficiency**.
- Participants recognized the value of **cross-sector cooperation** as a key element in achieving decarbonization goals and reducing waste.
- Some reports suggested further discussion on financial aspects, such as **return on investment (ROI)** for green infrastructure projects.
- Improving communication between stakeholders was recommended to increase transparency and enhance the effectiveness of initiatives.
- Participants positively evaluated the organization of the sessions.
- Discussions highlighted the importance of an **IT platform** for sharing data on energy demand and waste production. The possibility of replicating the pilot project in other industrial parks in the region was confirmed.
- The working sessions were highly rated by participants.
- Companies expressed strong interest in collaborating with municipalities to harness the potential of **excess heat**.
- Participants called for joint meetings between businesses and local administrations to strengthen synergies.
- The workshops received positive feedback, with strong participant engagement. Industries requested further meetings to delve into specific topics and improve collaborations.
- The value of **online platforms** for managing industrial synergies was recognized.

5.3. Consolidation of the Circular Approach

The ECOLE project has demonstrated that a Circular Economy approach within Industrial Parks is feasible and beneficial through the implementation of transnational pilot actions. The consolidation of this approach requires an integrated strategy that harmonizes methodologies, best practices, and governance models identified in different pilot regions. This chapter outlines the key steps necessary

to solidify the circular economy model across industrial parks in the Alpine region, ensuring long-term sustainability and replicability.

The consolidation of the circular approach within the ECOLE project represents a significant step towards transforming industrial parks into sustainable ecosystems. By integrating resource optimization, governance models, and digital solutions, the project sets a strong foundation for long-term success. The next phase involves scaling these efforts and institutionalizing policies that ensure the widespread adoption of circular economy principles across the Alpine region.

Key elements of the circular approach

The circular approach developed within the ECOLE project is based on three fundamental pillars:

- **Resource optimization through industrial symbiosis**
  - Enhancing the exchange of materials, energy, and by-products among companies within industrial parks.
  - Implementing waste-to-resource strategies that minimize environmental impact and reduce operational costs.
  - Strengthening cross-sector collaborations to increase efficiency and resource recovery.
- **Governance and stakeholder engagement**
  - Establishing clear governance structures to facilitate decision-making and long-term management of circular economy initiatives.
  - Supporting the development of Systemic Thinking Communities (STCs) that promote knowledge sharing and best practice exchange among industry, local authorities, and research institutions.
  - Defining regulatory frameworks and policy recommendations to support circular economy transitions in industrial parks.
- **technological integration and digitalization**
  - Developing and implementing IT platforms/tool/model to monitor energy consumption, waste production, and industrial symbiosis opportunities.
  - Utilizing real-time data analytics to optimize resource flows and environmental performance.
  - Encouraging the adoption of renewable energy sources and energy efficiency solutions.

Pathways for long-term implementation

To ensure that the circular approach established by ECOLE will be sustainable and scalable, the following actions are recommended:

- **Institutionalization of Circular Economy governance**
  - Developing regional and national policies that support circular industrial ecosystems.
  - Encouraging the creation of industrial park management bodies dedicated to circular economy practices.
- **Expansion and standardization of digital tools**
  - Implementing shared digital platforms to track and optimize resource exchanges.
  - Integrating monitoring systems that provide real-time insights for decision-makers.
- **Capacity building and knowledge transfer**

  - Conducting training programs and workshops to equip stakeholders with the necessary skills.
  - Establishing permanent knowledge-sharing hubs to facilitate ongoing collaboration among industrial parks.
- **Scaling up circular initiatives**
  - Expanding the most successful pilot initiatives to other industrial parks in the Alpine region and beyond.
  - Developing a replicability framework to guide new industrial parks in adopting circular economy principles.

6. Impact of pilot actions

6.1. Environmental, economic, and social benefits: results from the Act.1.2 (Toolkit)

ECOLE project is dedicated to expediting the transition towards a circular economy by providing a structured approach for stakeholders at various stages of implementation. A key component of this initiative is the development of a comprehensive toolkit designed to guide users through the necessary steps for adopting circular economy principles. Whether an entity is in the initial phase or has already embarked on the transition, the toolkit serves as a valuable resource to install the confidence in the process and encourage further efforts towards a more efficient and rapid transformation.

Toolkit in Act 1.2: integrated community and industrial engagement

The toolkit, particularly in Act 1.2, emphasizes the importance of integrating all segments of society, including local residents, municipal authorities, and companies within industrial parks. This holistic approach aims to foster coherence in understanding and implementing circular economy strategies. By engaging diverse stakeholders, the initiative ensures that all participants align with the planned methodologies and objectives, thereby facilitating a unified and structured transition process. A crucial aspect of the toolkit is its focus on renewable energy as a fundamental element of sustainability. By advocating for the adoption of renewable energy solutions, the initiative seeks to minimize environmental impact, enhance economic efficiency by reducing energy expenditures, and contribute to a cleaner and healthier environment for local communities.

Focus on waste management and the 5r strategy

Waste management is a pivotal area addressed in Act 1.2, with an emphasis on minimizing waste at the source and implementing the 5R strategy—Refuse, Reduce, Reuse, Repurpose, and Recycle. This methodology aligns with the European Union's Waste Framework Directive 2008/98/EC, which underscores the importance of waste prevention as a primary objective. The toolkit advocates for a hierarchical approach to waste management, prioritizing prevention, followed by reuse, recycling, recovery, and, as a last resort, safe disposal. The adoption of the 5R strategy not only reduces environmental impact but also extends the economic value chain, creating additional social benefits such as job creation and new product development. For instance, a Slovenian partner collaborates with a company that collects used household cooking oil and converts it into fuel for industrial heating applications. Similarly, in Grenoble, a facility has been established where local communities and industries can contribute waste materials, ranging from surplus agricultural produce to broken electronics. Within this facility, multiple enterprises specialize in repairing electronic devices and producing consumable goods such as jams from surplus agricultural produce. Such initiatives not only reduce waste generation but also extend product lifecycles, maximizing their value before they enter the recycling stage.

Empowering industrial parks for sustainable growth

The toolkit serves as a catalyst for the development of similar initiatives, enabling industrial parks to take a proactive role in minimizing value loss within the economic chain. By facilitating resource

optimization, waste reduction, and sustainability-driven economic strategies, the initiative ensure significant environmental benefits while simultaneously fostering economic growth and societal well-being. Through the implementation of these measures, industrial parks can play a critical role in driving the circular economy forward, enhancing long-term sustainability and resilience.

6.2. Knowledge transfer opportunities

Effective knowledge transfer is crucial for ensuring the scalability and sustainability of the Circular Economy under act 1.2. Following opportunities can help facilitate the exchange of best practices, innovation and expertise among all stake holders:

- **Establishing circular economy knowledge Hub:** creation of online and physical platform where business, Municipalities, and researchers can exchange best practices, case studies and technological innovation.
- **Industrial symbiosis network:** symbiosis network will facilitate the match making between industries that produce waste and those who can repurpose it, ensuring material circularity.
- **Workshops and seminars**: conducting regular training sessions for businesses, policymakers, and community members on implementing circular economy strategies.
- **Government-industry roundtables** – organizing regular dialogues between policymakers and industry leaders to discuss barriers, opportunities, and advancements in circular economy transitions.
- **Collaboration with research institutions** – engaging with universities and think tanks in studying and improving circular economy models, with findings shared across industrial and governmental stakeholders.
- **Cross-border knowledge exchange programs** – facilitating partnerships between European cities and industrial parks to share experiences and strategies.
- **EU-funded knowledge transfer initiatives** – leveraging european Union funding programs to support knowledge-sharing projects on circular economy transitions.

7. Conclusions and recommendations: towards WP3

7.1. Key considerations for regional policies and strategies

The transition to a circular and sustainable economy within industrial parks in the Alpine region requires a strategic and coordinated approach among Public Authorities, industrial stakeholders, and local communities. Regional policies must be designed to facilitate the transformation of industrial parks into eco-industrial parks (EIPs), fostering synergies among companies, optimizing resource use, and ensuring the scalability and replicability of successful solutions across different territories.

Below the key considerations for developing effective regional strategies are presented, highlighting some examples from ECOLE pilots and emphasizing the critical role of governance, financial support, and digitalization in creating resilient and sustainable industrial ecosystems.

Integrated approaches combining governance, digital tools, and multi-stakeholder collaboration

Pilots have showed a notable strength in integrating:

- Innovative governance models (e.g.,STCM, SHs involvement): these models demonstrate that they are effectively able to bring together industrial firms, municipalities, policymakers, and research institutions to collaboratively plan and implement circular strategies.
- Digital platforms for monitoring resource flows: these tools are essential for monitoring resource flows (energy, water, waste), supporting transparent communication, and enabling real-time data-driven decisions.
- Participatory processes involving both public and private actors: involving public and private actors foster trust, cooperation, and alignment of objectives, which are crucial for systemic industrial symbiosis and sustainability.

This integration could enable collaborative management of industrial parks, aligning energy, waste, and mobility strategies with shared decision-making. In the French pilot (PP09 GAM South Industrial Park, Grenoble Alps), the ACTIF digital platform was used to facilitate industrial symbiosis by matching waste and resource flows among local companies. The modular structure of the tool allowed for easy customization and was recognized as highly scalable.

Digitalization as a key enabler for circularity

Digital technologies have proven to be key factors in accelerating and enabling Circular Economy practices within Industrial Parks. They act as the backbone for efficient resource management, transparent communication, and continuous improvement. Digitalization played a crucial enabling role by:

- **Real-time monitoring and data collection:** digital sensors and IoT devices capture data on energy consumption, water usage, waste generation, and emissions in real time. This granular visibility allows stakeholders to pinpoint inefficiencies and identify opportunities for circular synergies quickly. For example, in the Slovenian pilot (PP04 Economic and Business Zone EBZ Zalog), digital monitoring revealed excess heat produced by manufacturing units, which was then redirected to heat nearby public buildings, reducing external energy demand.
- **Data-driven decision making:** beyond simple data collection, advanced analytics enable predictive modeling and optimization of resource flows. Digital platforms integrate

environmental, economic, and operational data, supporting scenario analysis and strategic planning. This was visible in the French pilot (PP09 South Industrial Park, Grenoble Alps), where the ACTIF platform used real-time data to match waste producers with users, creating symbiotic exchanges that lowered overall resource input.

- **Enhanced transparency and stakeholder engagement:** digital platforms provide shared dashboards accessible by multiple stakeholders, increasing transparency and trust. This fosters collaborative problem-solving and consensus building. The availability of clear, up-to-date information empowers park managers, companies, and regulators to make informed, timely decisions.
- **Continuous kpi tracking and reporting:** automation of performance monitoring facilitates regular reporting on circular economy indicators, making it easier to track progress and adjust policies or interventions. This leads to greater accountability and helps maintain momentum in long-term circular initiatives.
- **Enabler for new business models:** digital technologies facilitate innovative approaches such as product lifecycle management, predictive maintenance, and circular supply chain management, extending the life of materials and products.

Simplified evaluation tools for circular investments

Some partners successfully adapted complex tools such as Cost-Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA) into more user-friendly formats, allowing small and medium enterprises (SMEs) to make informed decisions about adopting circular practices, even with limited technical expertise.

- **Cost-Benefit Analysis (CBA):** it provides a quantitative assessment of the economic viability of circular investments by comparing upfront costs with expected savings and revenues. This straightforward approach demystifies financial decision-making and highlights the return on investment potential of circular technologies or processes.
- **Multi-Criteria Analysis (MCA):** it goes beyond economics by including environmental, social, and technical criteria, enabling a more holistic assessment. This helps stakeholders evaluate trade-offs and select options that best align with sustainability goals.
- **Adaptation to non-technical users:** these tools were tailored with simplified interfaces, guided workflows, and clear instructions to support SMEs and park managers who may lack specialized expertise. For instance, the Austrian pilot (PP06 WAB) used MCA/CBA templates to jointly evaluate investments in shared photovoltaic systems, allowing stakeholders to weigh environmental benefits alongside financial returns

Low-tech, high-impact solutions

Several simple but strategic solutions had a major impact on circularity and cooperation:

- **Shared waste collection hubs:** creating centralized points for collecting specialized or hazardous waste reduced costs, simplified logistics, and improved recycling rates. This approach enhanced circularity by enabling smaller firms to participate in joint waste management schemes that would be too costly individually.
- **Reuse of industrial by-products:** facilitating the reuse of residual materials within or between parks minimized waste generation and reduced demand for virgin resources. For example,

metal scraps or chemical by-products from one company were reused as inputs for others, closing material loops locally.

- **Co-designed logistics and transport optimization:** coordinated transport routes and shared logistics resources decreased emissions and costs. Grouping deliveries or pickups helped reduce vehicle usage and congestion.
- **Low-barrier implementation:** these low-tech solutions proved easier to implement quickly, making them ideal for parks with limited capital or technical capacity. They often serve as first steps toward deeper circular integration.
- **Social and community impact:** simple, visible initiatives fostered greater awareness and buy-in among local communities and stakeholders, building momentum for more complex projects.

Governance innovations for industrial park management

In many regions, the pilot actions addressed the lack of formal park management trying to:

- **Create or reinforce dedicated management bodies:** many pilot parks lacked formal governance, which led to fragmented responsibilities. ECOLE could help to establish or strengthen park management entities tasked with coordinating sustainability initiatives, overseeing resource sharing, and liaising with authorities and tenants. **Multi-stakeholder platforms and collaborative governance:** innovative governance models like the Systemic Thinking Community Model (STCM) are able to engage a broad range of actors — companies, local government, service providers, and research institutions — in co-creating circular strategies. This built trust, facilitated conflict resolution, and improved decision-making. In the French pilot (PP10 POLYMERIS Veyziat industrial park (part of Plastics Vallée), local authorities adopted new environmental technical requirements for incoming tenants, aligning park development with circular economy goals.
- **Formal and informal governance mechanisms:** they could help the creation of informal networks that evolved into structured governance bodies. These platforms enable shared planning of energy systems, waste management, and mobility solutions.
- **Environmental and social entry criteria for tenants:** parks could introduce sustainability requirements for new tenants, helping to institutionalize circular economy principles in admission policies.
- **Public-Private Partnerships (PPP):** PPP models are usually proposed to manage shared infrastructure and services, distributing costs and benefits equitably among stakeholders.
- **Adaptive and participatory governance:** pilots underscored the importance of flexible governance capable of evolving with technological and market changes, supported by ongoing stakeholder engagement.

7.2. Recommendations for policy makers and industrial stakeholders

Eco-industrial parks (EIPs) stand at the forefront of the transformation towards sustainable industrial practices, offering a model for sustainable industrial clusters where businesses, communities, and ecosystems coexist harmoniously. By integrating principles of circular economy, resource efficiency, and technological innovation, EIPs have the potential to significantly reduce environmental impacts while fostering economic growth and resilience.

However, the successful development and operation of EIPs require a well-structured framework to ensure that all stakeholders are aligned in their goals, and that long-term sustainability is achieved. A comprehensive set of **recommendations** is essential to guide the planning, design, and governance of these parks. Without such guidelines, efforts can become fragmented or misaligned, preventing the full potential of eco-industrial parks from being realized.

Policy recommendations for policymakers and industrial stakeholders must aim to ensure the long-term sustainability of eco-industrial parks by integrating innovative practices and collaborative strategies. The ECOLE project has demonstrated the importance of policies that promote industrial symbiosis, waste reduction, and resource efficiency.

This chapter outlines practical recommendations to improve industrial policies and governance frameworks, providing guidelines for stakeholder engagement and the development of sustainable growth models across key areas: governance and stakeholder collaboration, circular economy strategies, innovation and digitalization, financial and policy support, and scalability.

The recommendations presented in the table below are the result of the **D3.4.1. *A set of digital factsheets with recommendations* elaborated by PP11 FLA** within WP3 *Boosting the transition towards Eco Industrial Park, that also include the overall list of recommendations that have been provided by the partners and the experts within the Peer Review.*

The table below presents the main issues related to the potential implementation of scalable Industrial Parks. A questionnaire was distributed to project partners (PPs), who rated each proposed recommendation.

List of recommendations	
Governance and Stakeholder collaboration	**Score**
Establish a dedicated governance body – ensure a structured governance model, possibly through statutory bodies, corporations, or public-private partnerships.	High
Encourage multi stakeholder engagement – involve industries, local authorities, research institutions, and communities in decision mking process	High
Develop a Systemic Thinking Community Model (STCM) – foster collaboration between industrial firms, municipalities, and policymakers for continuous innovation and circular economy integration**.**	High
Create digital knowledge-sharing platforms - implement IT tools to enhance collaboration, monitor energy use, and track waste streams.	Medium
Circular Economy and sustainable strategies	**Score**
Encourage industrial symbiosis - promote shared resources, waste exchange, and energy co-usage between companies within industrial parks.	High
Adopt Circular Economy principles - develop eco-design and prioritize reuse, recycling, remanufacturing, repair and waste valorization within industrial operations.	High
Develop local circular supply chains - strengthen value chain resilience by sourcing locally and integrating secondary raw materials.	Medium
Promote sustainable waste management - implement systems for collecting, processing, and utilizing waste as a resource (e.g., biofuels, biogas).	Medium
Enhance water and energy efficiency - optimize water reuse, wastewater treatment, and energy recovery from industrial processes.	Medium
Encourage renewable energy adoption - Install photovoltaic systems, wind turbines, and biogas production units to reduce carbon footprints**.**	Medium
Innovation and digitalization	**Score**
Develop smart monitoring systems - use IoT-based platforms for real-time energy tracking and resource optimization.	Medium
Implement Cost-Benefit and Multi-Criteria analysis tools - support industries in assessing circular economy investments.	High

Use digital twins and ai for industrial optimization - simulate resource flows and predict efficiency improvements.	Low
Encourage Research and Development (R&D) – partner with universities and technology centers to develop innovative circular solutions	Medium
Financial and policy support	**Score**
Align EIP Development with EU Green Deal and CE Action Plan - Ensure compliance with European circular economy and sustainability policies.	High
Mobilize public and private funds - use financial instruments, incentives, and subsidies to foster EIP transformation.	High
Simplify regulatory frameworks - streamline bureaucratic processes to facilitate investment in eco-industrial transformation.	Medium
Establish Public Private Partnership PPP – Leverage joint investments for infrastructures, renewable energy projects, and waste management systems	Medium
Scalability and replicability	**Score**
Develop Standardized KPI frameworks - measure eip performance across economic, environmental, and social dimensions.	High
Create EIP certification and labeling schemes - introduce voluntary standards to recognize circular industrial parks.	High
Support knowledge transfer and training - organize cross-regional workshops and mentorship programs for EIP managers.	Medium
Foster international collaboration – exchange best practices with other regions to improve scalability	Medium

Table 9: List of recommendations

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