



## ECOLE:

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

# Guideline for Circular economy principles in Eco-Industrial parks in the Alps: pilot actions report

**O 2.1 Pilot actions developed jointly and implemented in projects**

*Produced by PP04 RRA LUR*





Document Details	
Project acronym	ECOLE
Project title	ECO industrial park network for the Alpine Regions Leveraging smart and Circular Economy
Project ID	ASP0100091
Project budget	€ 2,591,200.00
Action	Co-implement & co-assess complementary pilot actions
Deliverable	Deliverable
Due date	2025.04
Delivery date	2025.04
Dissemination	PPs
Partner in charge	PP04 RRA LUR
Author(s)	Tina Pezdirc Nograšek

Short Description
<b>This document provides information and strategies of implemented actions for Eco-Industrial Parks.</b>

Dissemination level		
PU	Public	
PP	Restricted to other programme participants	X
RE	Restricted to a group specified by the consortium	
CO	Confidential, only for members of the consortium	

Revision history			
Version	Date	Author	Organization
V1.0	27 <sup>th</sup> February 2025	Tina Pezdirc Nograšek	RRA LUR
V2.0	31 <sup>th</sup> March 2025	Tina Pezdirc Nograšek	RRA LUR
Final Document	10 <sup>th</sup> April 2025	Tina Pezdirc Nograšek	RRA LUR



The document has been prepared by the project partners of the Interreg Alpine Space project ECOLE. This project is co-funded by the European Union through the Interreg Alpine Space programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

## 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 urban region (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): TUM int

## ABBREVIATIONS USED

ECOLE	ECO industrial park network for the Alpine Regions Leveraging smart and Circular Economy
CE	Circular Economy
IP	Industrial Park
EIP	Eco-Industrial Park
STCM	Systemic Thinking Community Model
STC	Systemic Thinking Community
CBA	Cost-Benefit analysis
MCA	Multi-Criteria Analysis
KPI	Key Performance Indicators
AG	Action Groups
PP	Project Partner
EU	European Union



## INDEX

1. Introduction .....	5
2. Circular Economy: Definition and key principles applied to Eco-Industrial parks .....	6
3. Regulatory framework and relevant European strategies.....	10
4. Eco-industrial parks framework: Definition and key benefits .....	11
5. Governance of Eco-Industrial parks: Importance and models .....	12
6. Systemic Thinking Community Model (STCM) and its importance for EIPs .....	15
6.1. Systemic Thinking Community working sessions findings .....	16
7. LAB framework and strategic focus .....	21
8. Overview of the implementation process .....	22
9. Innovative tools for Eco-Industrial park transformation .....	23
10. Common KPIs .....	27
11. Advancing Circular economy in Industrial parks: Solutions from the ECOLE.....	30
pilot project.....	30
11. Lessons learned from ECOLE pilot projects .....	35
12. Policy recommendations & scalability .....	38
13. Synthetic roadmap for implementing the ECOLE model in other Alpine .....	39
regions.....	39
14. Conclusion.....	44
15. Annexes.....	45



## 2. Circular Economy: Definition and key principles applied to Eco-Industrial parks

The Circular Economy (CE) is an economic model aimed at eliminating waste, maximizing resource efficiency, and maintaining the value of materials through continuous use. Unlike the traditional linear economy, CE focuses on restorative and regenerative processes. The Ellen MacArthur Foundation (EMF) defines CE as an industrial system that replaces the concept of "end of life" with restoration, prioritizing renewable energy, non-toxic materials, and innovative product design to minimize waste. Preston (2012) expands this by emphasizing resource transformation, where waste from one company becomes a valuable input for another, promoting reuse, repair, and upgrading instead of disposal. Kirchherr et al. (2017) further define CE as an economic system operating at micro (businesses, consumers), meso (industrial clusters), and macro (regions, nations) levels, aiming for sustainable development, environmental quality, economic prosperity, and social equity.

A widely accepted framework within CE is the "butterfly diagram" introduced by EMF in 2013, which illustrates two main cycles. The technical cycle ensures the continuous circulation of materials through reuse, repair, remanufacturing, and recycling, while the biological cycle returns biodegradable materials to the biosphere, fostering natural regeneration.

According to Webster (2015), CE creates value by prioritizing repair and maintenance over recycling, extending product lifecycles, cascading material use across industries, and ensuring high-quality resource recovery.

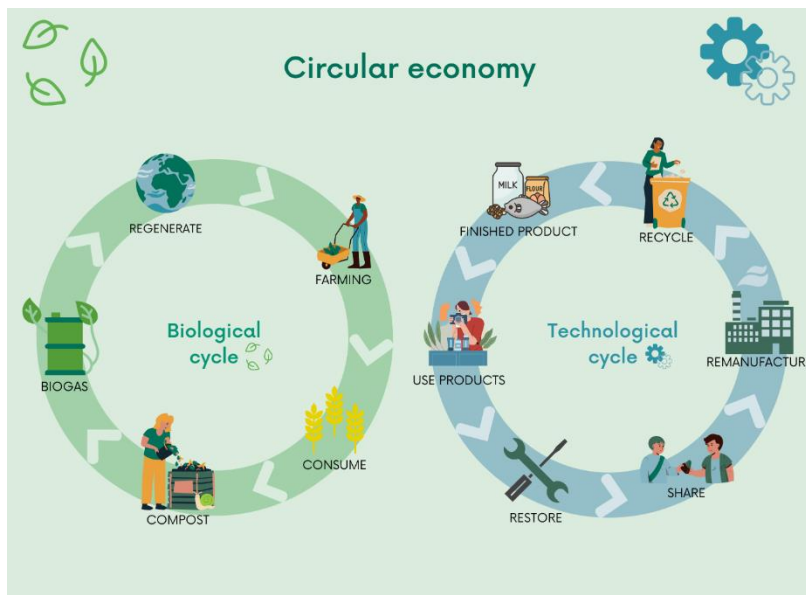


Figure 1: Biological and Technical cycle by EMAF (ECOLE infographic)

CE principles are commonly structured around the 3Rs—Reduction, Reuse, and Recycling, later expanded to the 4Rs with Recovery, focusing on material extraction and energy recovery from waste. Kirchherr et al. (2017) further introduced 10Rs, adding Refuse (eliminating unnecessary materials), Rethink (enhancing product utility), Repair (prolonging product use), Refurbish (upgrading products), Remanufacture (reprocessing components), Repurpose (using materials for new functions), and Re-mine (recovering materials from landfills). While some of these principles apply more to consumers (refuse, reuse, repair), others are essential for manufacturing and production processes (remanufacture, refurbish, repurpose).

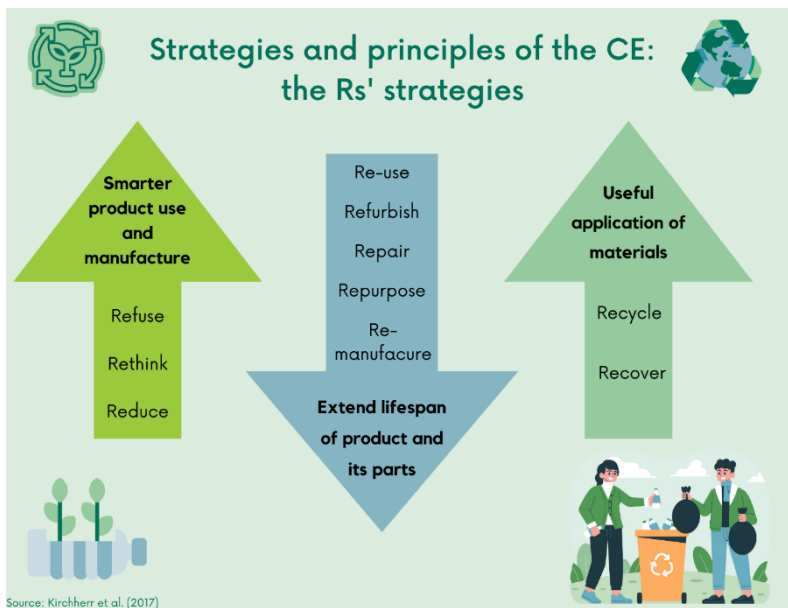


Figure 2: Rs' strategies by Kircher, 2017

**Dual application of CE principles in:**

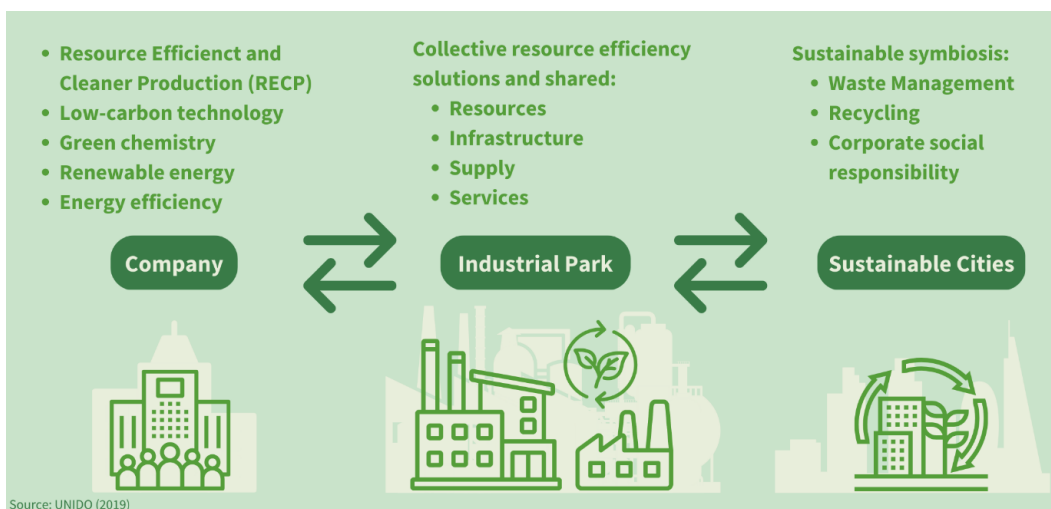
Single enterprises action area		EIP action area
<p><i>some non-exhaustive examples:</i></p> <ul style="list-style-type: none"> <li>Renewable energy supply, renewable thermal supply, hazardous waste</li> </ul>	Reduce	<p><i>some non-exhaustive examples:</i></p> <ul style="list-style-type: none"> <li>Rate of achievement of energy targets, water targets and waste reduction targets</li> </ul>
<ul style="list-style-type: none"> <li>Circular packaging, LCA studies</li> </ul>	Rethink	<ul style="list-style-type: none"> <li>Circular strategy, natural capital pressure studies</li> </ul>
<ul style="list-style-type: none"> <li>Product innovation, process innovation and digital innovation</li> </ul>	Innovate	<ul style="list-style-type: none"> <li>Joining Innovation Network and land monitoring systems</li> </ul>
<ul style="list-style-type: none"> <li>Water recovery, destination of waste, water recovery, circular design</li> </ul>	Revalue	<ul style="list-style-type: none"> <li>Energetic symbiosis, water recovery, destination of waste</li> </ul>
	Collaborate	<ul style="list-style-type: none"> <li>Supply chain management systems, industrial symbiosis, joining a network</li> </ul>
	Regenerate	<ul style="list-style-type: none"> <li>Participation in regeneration projects, regenerative cultivation</li> </ul>
<ul style="list-style-type: none"> <li>Employee incentives on regeneration, circular skills, internal training</li> </ul>	Inclusiveness	<ul style="list-style-type: none"> <li>Well-being local communities, local suppliers</li> </ul>

Source: Frey et al. (2020)



Figure 3: Dual application of CE principles in single company and EIP area

The circular economy is closely linked to industrial ecology and industrial symbiosis. Industrial ecology analyzes material and energy flows within industrial systems, aiming for "zero discharges" through recycling. Industrial symbiosis, a subset of industrial ecology, fosters collaboration between firms to exchange materials, water, energy, and by-products, leveraging geographic proximity for mutual benefits. This synergy enhances resource efficiency, reduces waste, and creates economic and social value beyond individual firm actions.



Source: UNIDO (2019)

Figure 4: Industrial-urban symbiosis, 2019

To effectively implement CE, Suárez-Eiroa et al. (2019) highlight additional strategic actions, including aligning resource inputs with natural regeneration rates, minimizing waste outputs, closing resource loops, maintaining resource value through recirculation, reducing material consumption, integrating eco-design, and fostering education for CE. The transition to CE demands a systemic and holistic approach, requiring collaboration across industries and societal engagement. It represents a paradigm shift, encouraging businesses and individuals to rethink production and consumption patterns to create a sustainable, low-waste future.

Webster (2015) identifies key principles that drive value creation within CE. The effectiveness of the inner circle emphasizes that repairing and maintaining products retains their value better than recycling. Extending product life cycles maximizes their use while reducing resource consumption. Cascading use refers to repurposing materials across industries, such as using cotton clothing first as second-hand apparel, then as upholstery filling, and eventually as insulation. Finally, using pure inputs ensures high-quality recycled materials, improving efficiency and prolonging product longevity. Supported by Cradle to Cradle and System Thinking approaches, CE aims to preserve the value of material flows through innovation, design, and strategic management.



The application of the principles of the circular economy to industrial parks is very important to consider the rational use of resources and the application of circularity principles. Mainly the areas of attention concern the exploitation of water resources and related discharges, energy supply and the use of renewable sources, the containment of waste production and its management.

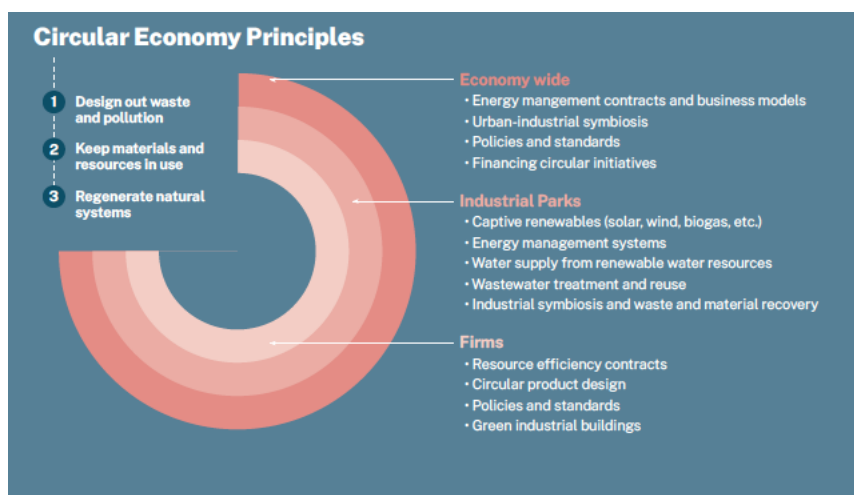


Figure 5: EIPs and circular principles, World Bank

To make circular actions effective within companies and in industrial parks, however, innovative approaches are needed for the application of new technologies and the adoption of revised business models. The sustainable path of an industrial park requires a series of useful strategies to develop the circular economy. Such strategies shall need to apply a systemic approach that also takes into account relevant relationships with all stakeholders in the area. It is by considering such relationships that circularity is promoted and enforced on the territory. The principles of circularity, according to different sources, cover, in several ways, all possible implementable strategies. Starting from these principles, and for each strategy, it will be possible to identify indicators for measuring the circularity performance of a company or group of companies. They must also make it possible to trace the development trajectory towards improvement of circularity performance based on reference benchmarks or objectives that the organization aims to achieve.



[See Annex 1: Strategies and principles to develop CE.](#)



### 3. Regulatory framework and relevant European strategies

The Circular Economy (CE) has been progressively integrated into European policies, initially focusing on waste management and recycling. Over time, the EU's approach has expanded towards a systemic and resource-efficient model, emphasizing closing material cycles and optimizing the entire supply chain—from procurement and design to production, distribution, use, and end-of-life.

The European Union (EU) has gradually strengthened its policy framework for circularity. In 2014, the European Commission introduced the Communication "Towards a Circular Economy: A Programme for a Zero Waste Europe," providing a strategic framework for fostering circularity. The following year, the "Circular Economy Package" was released, containing policies aimed at transitioning economic and social systems towards circularity. In 2018, the EU reinforced these efforts with four new circular economy directives, setting clear targets for waste reduction and recycling, along with the European Strategy for Plastics in the Circular Economy, which set 2030 as the target year for recycling all plastic packaging. The momentum continued in 2020, when the EU adopted the New Circular Economy Action Plan, a key pillar of the European Green Deal, reinforcing circular principles across industries and economies.

The EU's current CE strategy strongly incorporates system thinking and design approaches influenced by Performance Economics and Cradle to Cradle principles. This shift marks a departure from traditional waste management policies, which focused mainly on end-of-life treatment, towards a more holistic product lifecycle approach. The Directive 2008/98/EC, particularly Article 4, aligns closely with the 4Rs principle, establishing a waste hierarchy prioritizing prevention, preparation for reuse, recycling, other recovery (e.g., energy recovery), and disposal. Member States are required to implement this hierarchy based on the best possible environmental outcomes.

European CE policies are not only regional initiatives but also align with global sustainability frameworks, particularly Agenda 2030. The United Nations Sustainable Development Goals (SDGs) provide a comprehensive framework within which CE contributes to environmental, economic, and social sustainability. Specifically, CE plays a key role in achieving SDG 12 (Responsible Consumption and Production) by promoting resource efficiency, waste reduction, and sustainable supply chains. It also supports SDG 9 (Industry, Innovation, and Infrastructure) by fostering industrial symbiosis and technological innovation, as well as SDG 13 (Climate Action) by reducing carbon emissions through improved material cycles and waste prevention. By minimizing resource extraction and waste generation while promoting reuse, recycling, and regeneration, CE helps foster long-term sustainability and resilience. The European Green Deal and related policies reflect this global commitment, reinforcing CE as a key driver of sustainable development in Europe and beyond.

At the regional level, CE principles are integrated into Alpine governance structures, aligning with broader European climate and sustainability goals. The Alpine Convention, through its Alpine System of Objectives, has set 2050 climate targets to improve resource efficiency, reduce raw material



exploitation, and expand renewable energy sources. The 2020 Green Economy in the Alpine Region document further highlights circular economy initiatives and projects aimed at enhancing sustainability in the region.

Within the EUSALP program, several Action Groups (AGs) have conducted analyses on circularity-related issues. While these strategic documents do not specifically address the transformation of industrial parks into circular models, they explore circular supply chains, which are crucial for promoting sustainability in the Alpine region. This connection between CE principles, regional policies, and sustainable supply chain development highlights the broader effort to integrate circularity into industrial and economic systems across Europe.

#### 4. Eco-industrial parks framework: Definition and key benefits

Eco-Industrial Parks (EIPs) are industrial zones designed to integrate environmental sustainability, economic efficiency, and social responsibility. The concept, originating in the 1960s, focuses on industrial symbiosis, where businesses collaborate to optimize resource use, minimize waste, and enhance efficiency. Unlike traditional industrial parks, EIPs prioritize circular economy principles, ensuring that waste from one business becomes a resource for another, thus reducing environmental impact and promoting sustainable industrial development.

EIPs contribute to sustainability by improving resource efficiency, lowering emissions, and minimizing waste generation. They foster economic advantages, such as reducing operational costs, enhancing productivity, and supporting innovation-driven growth. Additionally, they strengthen social well-being by creating stable jobs, improving labor conditions, and promoting skill development through vocational training and knowledge exchange.

The evolution of EIPs has been driven by stricter environmental regulations, advances in technology, and a shift toward decoupling economic growth from resource extraction. They are categorized as either greenfield developments, built from the ground up with sustainability integrated into their design, or brownfield transformations, which retrofit existing industrial zones to improve environmental performance. Both models require coordinated efforts among stakeholders, including businesses, policymakers, research institutions, and community organizations, to ensure long-term viability and positive regional impact.

A key feature of EIPs is industrial symbiosis, where companies share utilities, services, and by-products, leading to mutual benefits such as energy recovery, water reuse, and material exchange. Advanced technologies, including waste-to-energy systems, sustainable water management, and renewable energy sources, further enhance their efficiency.



To successfully implement and manage EIPs, strong governance structures, performance monitoring, and stakeholder collaboration are essential. By fostering synergies between industries, communities, and policymakers, EIPs serve as a model for sustainable industrial development, supporting both environmental protection and economic resilience.



see  
annex

[See Annex 2](#): Best practices of eco-industrial parks around the world and [Annex 3](#): Preconditions for success of Eco-Industrial parks.

## 5. Governance of Eco-Industrial parks: Importance and models

The goal of an eco-industrial park is to serve as community of businesses and organizations located within a common property whose members seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. Governance is at the heart of any successful enterprise, especially in the field of EIPs, where the convergence of sustainability, industry, and community underscores the critical role of effective management structures. At its core, governance within EIPs encapsulates the mechanisms, policies, and frameworks that guide decision-making, operations, and collaborations among stakeholders. Governance basically refers to the system of decision-making, coordination, and management that ensures the effective and sustainable operation of the park. It involves the development and implementation of policies, regulations, and collaborative processes that guide the interactions among various stakeholders, such as businesses, government bodies, local communities, and environmental organizations.

Through an extensive and detailed research, a partial goal of ECOLE project is to emphasize the intrinsic link between sound governance models and the overall development and performance of EIPs by analyzing the Governance models of the ten industrial parks of the project. It highlights the critical role that Governance plays in promoting sustainable practices, fostering innovation, mitigating environmental impact, and driving economic growth within these specialized industrial ecosystems. It also identifies the various Governance models tailored to meet the different needs and objectives of diverse EIPs.

The importance of a well-structured governance is threefold:

- The presence of a governing entity in place is important to support various administrative issues and development functions. At the same time, a governing body ensures a better coordination when multiple parties have relationships with the firms on the settlement. This



is true when large industrial complexes have to deal with multiple stakeholders such as government, local authorities, municipalities, development agencies, investors and NGOs. The benefit to have a single point of contact is fundamental to have a coordinated management of all the interest at stake.

- A governing body is fundamental to formulate an integrated development plan. This is true for the planning and executions of activities on the industrial settlement such as land preparation (if talking about greenfield), infrastructure setting, facilities, utilities. The governing body is necessary to become a developer or master planner of the various activities. Eventually, a governing body is the sourcing and managing of funds in order to finance the various activities necessary to develop the industrial area such as infrastructure development and facilities in and around the industrial settlement. At the same time, the governing body is necessary for requesting or raising funds to finance infrastructures and facility projects. Having a sound governing entity can also bring strong marketing capability and focused promotional strategies to attract investors.
- A well-structured governance body is critical for ensuring an effective transformation of the industrial parks by applying sustainable practises. Implementing transformative measures towards circularity, for example, requires a high level of coordination, alignment of interests across stakeholders, extensive sharing of information and data, and coordinating action to harness benefits from industrial symbiosis. Without a well-functioning and highly invested governance body, such actions can only be limited.

As far as the governance structure of an industrial park is concerned, this can take on different connotations based on international experiences in this area. In general, we can consider four cases:

1. **No governance:** this is the most common case and concerns the marginal role played by public bodies. These are involved in the planning processes of industrial sites that can be redeveloped (brownfield) or provide for new production facilities on virgin land and/or used for agricultural practices (greenfield). In this case, the role of the local public body and, where it exists, of the economic development agencies of the territory are characterized by territorial planning but without entering into the merits of the management of the activities of individual companies nor, even less, of setting targets and circular economy objectives within the industrial site.
2. **Statutory Body:** this is the case where the governing body is established through a legislative act (national, regional) that also define the powers. Usually, this body has the mandate to develop and administer the park.
3. **Corporation:** this is the case where a profit-driven entity is created to develop and administer an industrial settlement. It is established through a companies act.
4. **Combination of Statutory Body and Corporation:** in this fourth model the statutory body and a corporation are set up together. The public representatives of this model can be local authorities, municipalities, development agencies. The Statutory Body has the aim to administer the Park and to protect the public bodies interests. The corporation may have the



duty to develop the land, to attract the investors and new tenants. The land could be owned by the local municipalities/authorities, sold to each single tenants or owned and managed by the corporation.

Assessment of Governance Models

To assess the governance differences among Ecole Industrial Parks (IPs), a set of key performance indicators (KPIs) was developed, primarily based on UNIDO’s International Framework for Eco-Industrial Parks. These indicators were refined in consultation with project partners to measure the state of development and implementation across the IPs.

The analysis first examined park management structures and the services provided to tenants, focusing on the presence of a management body, engagement with local authorities and stakeholders, and the level of tenant representation in governance. Another key aspect was the park’s ability to plan and implement circular economy and sustainability goals.

Additionally, the study evaluated property and infrastructure management, including the provision of utilities, capacity building, and knowledge exchange. Lastly, the role of the managing body in monitoring, risk management, and climate resilience was highlighted as essential for sustainable industrial park operations.

Park Management Services	Park Management Entity	A well-defined park management entity exists?	Monitoring performance and risks	Critical risks are identified and defined in a list
		Involvement of local public authorities in the governance structure of the IP		Monitoring performance of the critical risks is done every 6 months
		Degree of decision-making influence on the governance by local authorities		All tenant firms are aware of the critical risks within the park and the monitoring process
		Degree of representation of all the tenants in the IP governance structure, committee, or existing organization structure of companies/tenants	Climate risk assessment	Climate change risks are identified and defined in a list
		Number of meetings to present IP’s strategies with all the tenants in a year		Monitoring procedures for prevention and disaster preparedness are established
		Number of meetings within the ECOLE project related to stakeholders’ engagement and park management		Monitoring performance of the climate change risks is done every 6 months
		Board member numbers	Information on applicable regulations and standards	Mitigation strategies are identified and shared with tenant firms
		Extent of board member expertise in circularity/sustainability		Local and national regulations and standards related to sustainability/circularity are integrated in the Master Plan of the IP and communicated to the tenant firms
		Diversity of board directors in terms of background, sector, gender, etc.	Monitoring procedures are established to evaluate the compliance of the regulations and standards	
	Park property, common infrastructure, and services	The park management entity manages the land use of the IP, including plot allotments and re-allotments	Planning and park design	Master plan development
If the answer above is “No”, is the local authority or the municipality in charge of land management?				
Waste collection areas and services, and utilities are available for tenants				
Presence of security and emergency response services and facilities				
Presence of capacity building and knowledge exchange activities and services (e.g. networking, training courses, educational opportunities also related to sustainability)				



Figure 6: KPIs used to evaluate the governance models of the 10 IPs in ECOLE.



[See Annex 4: Table 1. Governance models of the 10 IPs in ECOLE.](#)

## 6. Systemic Thinking Community Model (STCM) and its importance for EIPs

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.

One of the most important tools that enable STCM is the policy cycle model, which provides a structured and iterative approach for decision-making, stakeholder engagement, and governance within EIPs. This model ensures that industrial parks continuously evolve through assessment, implementation, and refinement of circular economy strategies.

A crucial component of this model is the Systemic Thinking Community (STC), which acts as a collaborative network facilitating the practical implementation of circular economy principles. STCs bring together key stakeholders to coordinate efforts, exchange best practices, and drive industrial symbiosis within EIPs. It serves as a platform for dialogue, coordination, and shared decision-making, enabling industrial parks to transition toward sustainable, resource-efficient, and low-carbon models. Through structured working sessions, STCs support the transition of traditional industrial parks into sustainable, resource-efficient ecosystems, ensuring alignment with regional and European sustainability goals.

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.

### 6.1. Systemic Thinking Community working sessions findings

Findings have been collected till December 2024. At the end of the project the chapter will be updated with the other STCM-WSs that will be organized during the last year of the project - 2025

#### Main objectives of the STCM working sessions

- 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: Creating a Systemic Thinking 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

Private Companies and SMEs:

JATA EMONA, KOTO, 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.

### Main Topics of the 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

- 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.

### Lessons Learned

- 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).

## Evaluations

- 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.



[See Annex 5](#): The Policy cycle as a guiding model and [Annex 6](#) Understanding stakeholder and planning engagement and [Annex XXX](#) Stakeholder mapping template

### LAB framework and strategic focus

As part of the ECOLE project, three LABs were established as key mechanisms to facilitate the transition of industrial parks across the Alpine region into eco-industrial parks (EIPs). While each LAB operates within a distinct thematic area, they share a common vision and foundational principles aimed at fostering collaboration, innovation, and knowledge exchange. Collectively, they contribute to a transnational network that advances sustainability and resilience in industrial ecosystems.

The three LABs address the following core themes: LAB A focuses on Energy, Materials & Circularity, LAB B examines Supply & Value Chain Resilience & Sustainability, while LAB C is dedicated to Eco-Industrial Park Governance, Local Symbiosis, and Circular Economy Knowledge Transfer (see Section 5). Recognizing the diversity of industrial parks across the Alpine region, the LABs employ flexible, context-specific frameworks, ensuring that strategies are tailored to local conditions while maintaining alignment with overarching sustainability objectives. This approach allows for the integration of site-specific challenges and opportunities within a broader transnational framework.

A defining feature of the LABs is their workshop-based methodology, which provides a structured environment for continuous engagement and stakeholder collaboration. This model ensures cross-disciplinary exchange, fostering the integration of diverse perspectives essential for comprehensive problem-solving and the development of scalable circular economy strategies. Through this participatory approach, LABs optimize resource utilization, enhance energy and material efficiency, and strengthen knowledge-sharing networks.



The six workshops conducted within the ECOLE project played a pivotal role in shaping the LABs' contributions. They facilitated cross-collaboration, governance enhancement, pilot implementation assessment, strategic goal refinement, cost-benefit evaluation, and transnational knowledge-sharing. By addressing stakeholder engagement barriers, governance challenges, and resource constraints, the LABs developed innovative tools, governance models, and circular economy solutions applicable across industrial parks. The final workshop emphasized the importance of systemic thinking, adaptive governance, and collective problem-solving in ensuring the long-term sustainability of EIPs. Through these initiatives, the LABs have established a robust foundation for the continued integration of circular economy principles within industrial parks across the Alpine region.



See [Annex 7](#): Roadmap for ensuring the operations of the LABs and [Annex 8](#): Cross-collaboration opportunities among LABs.

## 8. Overview of the implementation process

The implementation process for the project follows a structured approach to embedding CE principles within EIPs across the Alpine region. It includes key steps designed to facilitate knowledge transfer, pilot testing, and large-scale adoption of CE strategies.

The first step involves defining a common understanding and framework for EIPs and the circular economy approach. This stage includes benchmarking studies on governance, economic, and environmental factors influencing industrial parks. A systemic thinking community (STC) model tailored to the Alpine region was established, setting the foundation for knowledge-sharing networks.

The second step focuses on on-the-ground testing of CE principles through pilot actions in selected industrial parks, based on the action plans prepared by the partners. These pilot actions explore various themes, including energy and material circularity, governance, local symbiosis, value chain resilience, and sustainability. The goal is to demonstrate the applicability of CE principles and refine methodologies through practical implementation. Once pilot actions are implemented, the next step involves validation and co-assessment of results. This step ensures that the strategies tested during the pilot phase are viable and can be scaled. A transnational peer review process consolidates the lessons learned, while digital publications and video documentation share key findings.

The final step will be the dissemination and scaling, where validated solutions will be integrated into governance structures and policy recommendations. This includes re-evaluating and updating action plans for industrial parks based on pilot experiences. A set of solutions tailored for EIPs, including

toolkits and guidelines, will be developed to support broader adoption. Additionally, industry stakeholders, policymakers, and private sector entities receive targeted recommendations to embed circular economy principles into their strategic frameworks.

Through this structured process, the project aims to accelerate the transition towards circular industrial ecosystems, ensuring long-term sustainability and resilience in Alpine EIPs.

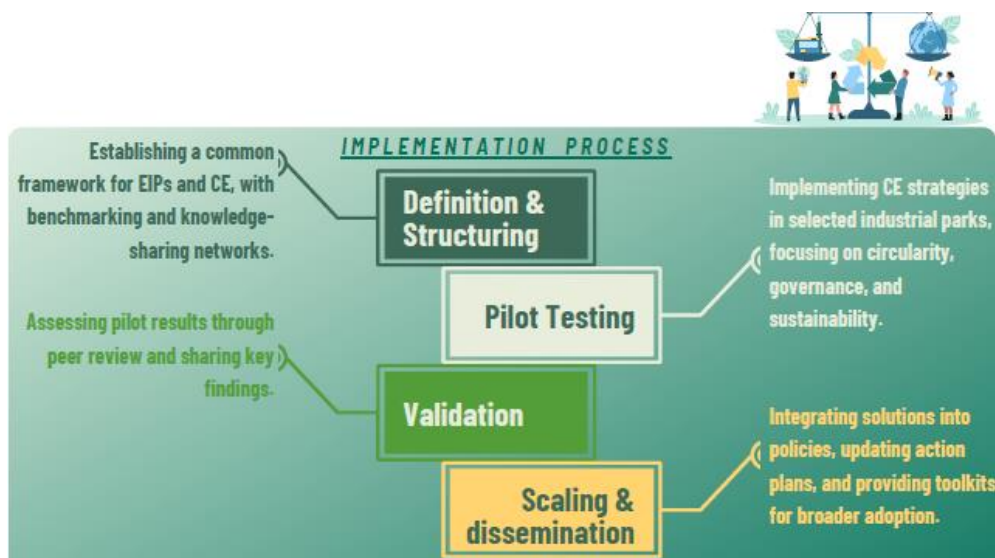


Figure 7: Implementation process (Ecole infographic)

## 9. Innovative tools for Eco-Industrial park transformation

The toolkit developed by the ECOLE group is specifically designed to facilitate non-technical users in understanding the process of transitioning their industrial park into an eco-industrial park. It primarily focuses on two key aspects: technology and communication.

General users typically possess foundational knowledge about their industrial park, such as its geographical location and total area. Utilizing this information, the tool provides an initial roadmap for transition, which may include adopting renewable energy sources or implementing an efficient waste management system. At this stage, users can explore various options and proceed accordingly. Subsequently, a preliminary financial assessment is generated based on available data, enabling users to make informed decisions through Cost-Benefit Analysis.

The next stage of the toolkit involves dedicated sheets for each potential solution, structured using Multi-Criteria Analysis. For instance, if a user selects the option of integrating renewable energy, a detailed sheet outlines the necessary steps for various energy generation methods. A key feature of the tool is a progress tracking mechanism, where users can mark tasks as completed using a checkbox. This generates a completion rate, thereby encouraging continued engagement and fostering a more sustainable industrial park.

From a communication perspective, the transition process requires effective coordination with various stakeholders, including park management, government agencies, and other relevant entities. The toolkit is designed to guide users through structured communication procedures, ensuring clarity and trust-building. This, in turn, enhances the efficiency and success rate of the eco-industrial park transition.

The Toolkit, tested across various industrial parks, demonstrates significant potential for facilitating a faster understanding based on knowledge and communication. The results indicate that there are a few technological aspects that need to be incorporated into the toolkit, which will be addressed in future versions. This is due to the fact that each industrial park, located in different regions, specializes in distinct areas and faces unique challenges.



Figure 8: Facilitating the transition to ECO-Industrial Parks (Own made image)

The use of the toolkit simplifies the understanding of the approach and the possible pathways for transition. The tested toolkit has proven to be beneficial in providing users with the necessary knowledge to address transition-related issues such as stakeholder management, waste management, regional economic strengthening, symbiotic relationships, and the identification of resource streams.

Testing serves multiple purposes:

Validation: To confirm that the tools meet the requirements of the action plans and deliver measurable outcomes, such as waste reduction, energy efficiency improvements, or economic benefits.





clearer guidance on prioritizing **multi-criteria sheets**, enhanced visualization of progress tracking, and better integration of financial feasibility assessments. While the step-by-step methodology was well-received, some users indicated a need for additional sector-specific case studies, improved digital support, and more hands-on training materials.

The pilots underscored the **importance of stakeholder engagement and institutional support** in successfully leveraging the toolkit. Future iterations should incorporate more interactive elements, refined sector-specific recommendations, and case-based learning modules to improve accessibility and adoption. Strengthening digital functionalities and offering tailored advisory support can further enhance the toolkit's long-term impact.

Overall, the toolkit has **proven** to be a **valuable instrument** for accelerating sustainability initiatives and strengthening supply chain resilience. With further refinements based on real-world applications, it has the potential to become a cornerstone for organizations pursuing sustainability-driven innovation.

The toolkit developed within the project has been instrumental in structuring sustainability efforts within industrial parks. It provides a well-defined methodology for assessing stakeholder engagement, waste management, renewable energy adoption, and governance structures. The feedback from various pilot implementations highlights its effectiveness in guiding transition strategies, identifying gaps, and facilitating informed decision-making. While the toolkit effectively supports circular economy adoption, areas for refinement include clearer guidance on prioritizing multi-criteria sheets, enhanced visualization of progress tracking, and better integration of financial feasibility assessments. Overall, the toolkit has proven to be a valuable instrument for accelerating sustainability initiatives and strengthening supply chain resilience.



[See Annex 9: ECOLE toolkit.](#)



## 10. Common KPIs

During the development of the LABs for the transition to EIPs, it became crucial to assess the initial conditions of the 10 project partners in three key areas: economic, social, and environmental. To facilitate this, an evaluation form was designed to measure KIPs within these areas, guided by a framework adapted from UNIDO to address the specific profiles and needs of the project partners. This framework categorizes a list of essential prerequisites an industrial park must fulfill to qualify as an EIP, along with various performance indicators.

The primary purpose of this evaluation form is to establish a baseline and a reference point for monitoring progress as the action plans of the ECOLE project are implemented. It also enables partners to share insights on diverse topics, fostering innovation and cross-border collaboration. For instance, a project partner struggling to meet a particular prerequisite can seek and receive advice from another who has successfully met the requirement. Moreover, this tool was developed to be used and adapted to the industrial park's needs even after the completion of the ECOLE project.

The evaluation form is designed for intuitive use, with responses for each KPI color-coded in shades of red and green. Red indicates that a prerequisite or KPI has not been met, while green signifies successful implementation. This color-coding system makes it easy to interpret the results and understand each project partner's current status, enhancing the monitoring process's overall effectiveness.

**Economic KPIs** focus on financial performance, cost efficiency, and resource optimization, assessing how well partners manage their supply chains and enhance financial resilience.

**Environmental KPIs** measure efforts toward sustainability, such as waste reduction, energy efficiency, and carbon footprint management.

**Social KPIs** emphasize stakeholder engagement, labor practices, community involvement, and knowledge transfer, reflecting the integration of inclusivity and collaboration in achieving circular economy goals.

		INDUSTRIAL PARK
<b>EIP Prerequisites ("must have for EIPS")</b>		Answer
Employment generation	Park management entity has plans to generate specific numbers and types of jobs (including	No
Local business & SME promotion	Park management entity allows and promotes the establishment of SMEs that provide services and add value to park residents.	Yes
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.	No
	Tracked by the park management entity, the industrial park fulfils relevant government targets, including domestic, foreign direct investment, and	No
<b>Performance Indicators</b>		Answer



Figure 10: Table 2. Economic KPIs

		INDUSTRIAL PARK
<b>EIP Prerequisites ("must have for EIPs")</b>		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
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
	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
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
Climate change and the natural environment	A program is established to monitor, mitigate and/or minimize GHG emissions, such as carbon dioxide (CO <sub>2</sub> ), methane (CH <sub>4</sub> ), nitrogen oxide (NO <sub>x</sub> ), and so on. There is clear evidence of steps taken to introduce mitigation activities.	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 services.	No
<b>Performance Indicators</b>		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
Energy	At least 90% of combined park facilities and firm-level energy consumption have metering and monitoring systems in place.	<10%
	Total renewable energy use in the industrial park over the total energy consumption.	Not applicable
Water	At least 95% of industrial wastewater generated by industrial park and resident firms is treated to appropriate environmental standards.	>95%
	At least 50% of total industrial wastewater from firms in the park is reused responsibly within or outside the industrial park.	Not applicable
Climate change and the natural environment	At least 5% of open space in the park is used for native flora and fauna.	Not applicable
	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
Waste and material use	At least 20% of solid waste generated by firms is reused by other firms, neighbouring communities, or municipalities.	Not applicable
	100% of firms in park appropriately handle, store, transport and dispose of toxic and hazardous materials.	Not applicable
	Less than 50% of wastes generated by firms in the industrial park goes to landfills.	Not applicable

Figure 11: Table 3. Environmental KPIs



		INDUSTRIAL PARK
EIP Prerequisites ("must have for EIPs")		Answer
Social management systems	Dedicated personnel exist (as part of the park management entity) to plan and manage social quality standards.	No
Social infrastructure	Essential primary social infrastructure has been adequately provided in the site master plan, and is fully operational in the park.	Yes
Local community outreach	The park management entity organizes 1 or more outreach activities.	No
Performance indicators		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
	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.	>75%
	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
Social infrastructure	75% of all firms in the industrial park have a program for skills/vocational training and	45% - 59%
	At least 20% of female workforce benefit from available supporting infrastructure/programs for skills development.	Not applicable

Figure 12: Table 4. Social KPIs



[See Annex 10: ECOLE Common KPIs.](#)



## 11. Advancing Circular economy in Industrial parks: Solutions from the ECOLE pilot project

This chapter presents the pilot projects implemented by ten (10) partners collaborating within LAB A and LAB B, focusing on advancing circular economy principles and enhancing industrial park operations. The projects span diverse regions, each addressing unique challenges and opportunities in fostering sustainability, resource efficiency, stakeholder collaboration, and community engagement. Through innovative strategies, tailored tools, and shared experiences, these initiatives demonstrate practical approaches to transforming industrial parks into resilient, eco-industrial ecosystems, offering valuable insights for broader application.

### 1. Marangona Area ZAI (Verona, Italy)

**Solution:** Development of a **Sustainable energy community system**, including real-time energy demand analysis, renewable energy adoption (solar panels), and the creation of an energy community. Multi-Criteria Analysis (MCA) and Cost-Benefit Analysis (CBA) were applied to optimize energy solutions.

### 2. Trieste Industrial Zone COSELAG (Italy)

**Solution:** Implementation of an **IT platform for energy demand and waste sharing** to facilitate circular economy practices and industrial symbiosis. The platform enables data collection, improves waste management, and optimizes energy use. It also supports the Ecologically Equipped Production Areas (APEA) initiative.

### 3. Industrial Zones Železniki, Trata, Žiri, Todraž (Slovenia)

**Solution:** Conducted a **Study on excess heat potential in the Škofjeloško area**, identifying waste heat sources and potential consumers. The study aimed to optimize heat recovery and utilization within industrial zones.

### 4. Economic and Business Zone (EBZ) Zalog, Slovenia

**Solution:** Community-Powered Biofuel Transformation, focusing on circular waste management and industrial symbiosis. Key initiatives included clustering stakeholders in the waste management supply chain, **developing a waste management plan for edible waste oil collection and biofuel production**, and engaging the local community to foster collaboration and awareness. Testing strategies for waste reduction and optimizing resource use were also implemented.

### 5. CRAISS Industrial Park WEIZ (Austria)



**Solution:** Implementation of **Energy-related initiatives**, including photovoltaic (PV) installations, energy storage systems, sustainable transport infrastructure (EV refueling stations), and biodiversity enhancement projects like an insect hotel and green noise barriers.

#### 6. Intercommunal Business Park S7-Node Rudersdorf, Austria

**Solution: Advancing energy resilience through circular principles**, with the creation of a consulting service for energy resilience. The service included knowledge-building on energy efficiency, modular advisory services for companies, and feasibility tools for renewable energy projects such as PV installations and heat pumps. A technology roundtable was established to enhance stakeholder collaboration and knowledge transfer.

#### 7. Siemens Technopark TZE (Germany)

**Solution:** Development of a **Sustainable energy system**, including PV panel installations, energy storage solutions, and electric vehicle charging infrastructure. Focused on improving energy efficiency and circular economy principles within the industrial park.

#### 8. Cleantech Innovation Park (CTIP), Hallstadt, Germany

**Solution: Collaborative research platform**, transforming an industrial site into a sustainability-driven innovation hub. The park established an Innovation Center for R&D collaboration, launched networking and funding initiatives for startups and academic institutions, and implemented a circular economy framework through resource-sharing platforms. Branding and outreach efforts helped position the park as a leader in sustainable innovation.

#### 9. South Industrial Park, Grenoble Alps, France

**Solution: Enhancing material flow dynamics**, strengthening governance and fostering industrial symbiosis. The project evaluated and developed industrial synergies for resource efficiency, implemented a digital platform for tracking waste streams, and promoted financial mechanisms to accelerate sustainability transitions. Workshops and stakeholder engagement initiatives supported knowledge-sharing and circular economy practices.

#### 10. Veyziat Industrial Park (Plastics Vallée, France)

**Solution: Promotion of Eco-effectiveness and eco-efficiency through plastic waste recycling & recovery.** This involved implementing a common waste management system for SMEs in the plastics industry, introducing a carpooling initiative, and modifying local urban planning policies to support circular economy initiatives.



Alpine Space

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
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

LAB C: Eco-Industrial Park Governance, Local Symbiosis, and Circular Economy Knowledge Transfer



Alpine Space

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	Improved governance structure, increased industrial collaborations, better	South Industrial Park, Grenoble Alps



				engagement, resource mapping	resource efficiency, waste recovery		
--	--	--	--	------------------------------	-------------------------------------	--	--

Table 5: Pilot activities in Industrial parks of the ECOLE project





### 3. Regulatory and bureaucratic hurdles

- Navigating permits and public authority approvals requires persistence and clear negotiation strategies.
- Public-private cooperation is complex and demands continuous dialogue with regulatory bodies.
- The complexity of funding mechanisms and bureaucratic processes can slow implementation.

### 4. Adoption of Circular Economy principles

- Resistance to new business models and circular practices is a significant barrier.
- Educating stakeholders about long-term economic and environmental benefits is necessary to drive adoption.
- The integration of circular economy practices is more successful when companies see clear economic incentives.

### 5. Challenges in the use of new technologies

- Integrating digital and smart technologies requires overcoming initial resistance and skill gaps among stakeholders.
- Ensuring compatibility and interoperability between different technological systems is a key challenge.
- High initial investment costs and uncertainty about long-term returns can slow adoption.
- A user-centered approach, including early-stage training and capacity building, improves technology acceptance and efficiency.

### 5. Technical and infrastructure challenges

- Renewable energy implementation faces hurdles such as old infrastructure, unsuitable building structures, and integration with existing systems.
- Flexibility in implementation plans is essential to adapt to unforeseen technical difficulties.
- Hybrid solutions (e.g., combining renewable energy with traditional systems) may be required for large-scale adoption.



## 6. Economic considerations and financial incentives

- Businesses prioritize cost savings and need clear financial incentives to adopt sustainability initiatives.
- Simplified subsidy application processes would encourage more widespread adoption of energy-efficient technologies.
- CO2 pricing and regulatory compliance create financial motivations for energy resilience measures.

## 7. Importance of pilot testing and demonstration

- Pilot projects help identify feasibility and optimize implementation strategies before full-scale deployment.
- Hands-on testing of tools and methodologies provides practical insights into their effectiveness.
- Lessons from pilot testing should be incorporated into future scalability plans.

## 8. Community involvement and awareness

- Local communities are often unfamiliar with industrial sustainability practices, requiring tailored awareness campaigns.
- Addressing historical tensions between industrial parks and residents fosters better collaboration.
- Events, open days, and educational initiatives improve public perception and support.

The ECOLE project has demonstrated the immense value of collaborative learning and practical experimentation in advancing circular economy principles within industrial parks. The ten pilot activities have not only tested innovative approaches but have also provided a wealth of knowledge on how industrial parks can navigate the complexities of sustainability transitions. Each pilot served as a real-world case study, revealing the importance of stakeholder engagement, data-driven decision-making, and adaptive governance.

Equally significant has been the role of cross-border collaboration within the LABs, where knowledge-sharing and joint problem-solving have enriched the project's outcomes. The transnational exchange



of ideas has strengthened the adaptability of circular economy strategies across diverse industrial contexts, reinforcing the need for flexible frameworks that cater to regional and sectoral specificities.

Ultimately, the ECOLE project has provided a robust foundation for future eco-industrial park transformations. By addressing key challenges, refining best practices, and fostering a culture of continuous learning, the project partners have laid the groundwork for sustainable industrial development that can be scaled and replicated across regions. The lessons learned will serve as a guiding reference for policymakers, industrial park managers, and businesses aiming to embrace circularity, resilience, and long-term sustainability in their operations.

## 12. Policy recommendations & scalability

Below a summary of the structure, main objectives and expected outcomes of the D2.3.1 Transnational pilot actions validation report that is under finalization.

The **ECOLE Transnational Validation Report** is part of the **ECOLE project** (ECO Industrial Park Network for the Alpine Regions Leveraging Smart and Circular Economy). The main objective of the project is to transform traditional industrial parks into **eco-industrial parks** by applying circular economy principles across the Alpine region.

### Key Objectives:

- **Environmental, Economic, and Social Benefits:** Reduce environmental impacts, promote sustainability, and improve economic opportunities in the Alpine region.
- **Knowledge Transfer:** Share best practices and innovative solutions among industrial parks through international collaboration.
- **Unified Circular Approach:** Develop a comprehensive framework that can be replicated in other regions, ensuring that pilot projects can serve as models for broader application.
- **Support Policy Development:** Offer recommendations for policymakers and industry stakeholders to help align local strategies with broader European objectives, such as the European Green Deal.

### Expected Outcomes:

- A set of validated guidelines and technological frameworks for circular economy implementation.
- Increased cooperation across borders to address environmental and economic challenges.
- Development of a transferable model for eco-industrial parks applicable across Europe.





Step	Objective	Key Actions	Challenges	Guidelines & Best Practices
1. Establish a Common Understanding & Framework Development	Define a strategic approach for transforming industrial parks into EIPs.	<ul style="list-style-type: none"> <li>- Conduct SWOT analysis to identify opportunities and barriers.</li> <li>- Develop a Systemic Thinking Community Model (STCM) for collaboration.</li> <li>- Define a governance framework for multi-stakeholder engagement.</li> <li>- Create an open transnational network for cross-regional knowledge exchange.</li> <li>- prepare the Action plan.</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of common understanding of circular economy principles.</li> <li>- Resistance to new governance models.</li> </ul>	<ul style="list-style-type: none"> <li>- Organize structured workshops to educate stakeholders.</li> <li>- Align governance structures with regional policies and EU funding.</li> </ul>
2. Stakeholder Engagement & Community Building	Foster collaboration among businesses, authorities, and communities.	<ul style="list-style-type: none"> <li>- Establish Local Systemic Thinking Communities (STCs).</li> <li>- Conduct LAB workshops to define priorities and strategies.</li> <li>- Implement a stakeholder mapping tool to identify key actors.</li> <li>- Develop a multi-channel communication strategy for transparency and trust-building.</li> </ul>	<ul style="list-style-type: none"> <li>- Low participation from businesses due to competition concerns.</li> <li>- Limited awareness of circular economy benefits among communities.</li> </ul>	<ul style="list-style-type: none"> <li>- Use digital technologies to improve collaboration.</li> <li>- Develop targeted communication campaigns to raise awareness.</li> </ul>
3. Digital Tools & Data-Driven Decision Making	Implement smart monitoring systems and	<ul style="list-style-type: none"> <li>- Develop IT platforms for resource-sharing and waste tracking.</li> </ul>	<ul style="list-style-type: none"> <li>- Resistance to data-sharing due to confidentiality concerns.</li> </ul>	<ul style="list-style-type: none"> <li>- Establish clear data-sharing agreements.</li> <li>- Provide training on</li> </ul>



Alpine Space

Step	Objective	Key Actions	Challenges	Guidelines & Best Practices
	digital platforms to optimize resource use.	<ul style="list-style-type: none"> <li>- Standardize data collection for waste streams, energy use, and material flows.</li> <li>- Use appropriate tools (e.g. Cost-Benefit Analysis and Multi-Criteria Analysis) for impact assessment.</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of standardized digital infrastructure.</li> </ul>	<ul style="list-style-type: none"> <li>- sustainability monitoring tools.</li> </ul>
4. Technical Implementation & Circular Economy Adoption	Introduce circular economy solutions and renewable energy strategies.	<ul style="list-style-type: none"> <li>- Integrate renewable energy solutions (solar, biogas, waste heat recovery).</li> <li>- Optimize waste stream management through industrial symbiosis.</li> <li>- Implement eco-innovation labs to pilot new sustainable business models.</li> </ul>	<ul style="list-style-type: none"> <li>- High initial investment costs.</li> <li>- Complexity in integrating circular solutions into existing operations.</li> </ul>	<ul style="list-style-type: none"> <li>- Leverage public-private partnerships (PPPs) and EU funding.</li> <li>- Use phased implementation strategies to reduce risk.</li> </ul>
5. Governance, Regulatory Alignment & Policy Integration	Align governance structures with sustainability policies.	<ul style="list-style-type: none"> <li>- Establish a dedicated industrial park management body.</li> <li>- Ensure alignment with the EU Circular Economy Action Plan.</li> <li>- Implement incentive schemes to encourage sustainable business practices.</li> <li>- Develop long-term funding mechanisms.</li> </ul>	<ul style="list-style-type: none"> <li>- Regulatory complexities and bureaucratic hurdles.</li> <li>- Slow policy adaptation to circular economy models.</li> </ul>	<ul style="list-style-type: none"> <li>- Foster close collaboration with policymakers.</li> <li>- Advocate for policy incentives such as tax breaks for green businesses.</li> </ul>



Step	Objective	Key Actions	Challenges	Guidelines & Best Practices
6. Pilot Testing & Scalability	Validate strategies through pilot projects before scaling solutions.	<ul style="list-style-type: none"> <li>- Conduct pilot initiatives focusing on renewable energy, waste management, and industrial symbiosis.</li> <li>- Measure progress using Key Performance Indicators (KPIs).</li> <li>- Document and share best practices across transnational networks.</li> </ul>	<ul style="list-style-type: none"> <li>- Ensuring pilot projects address real-world industrial challenges.</li> <li>- Securing long-term commitment from stakeholders.</li> </ul>	<ul style="list-style-type: none"> <li>- Focus on practical applications that deliver economic and environmental benefits.</li> <li>- Develop scalability strategies to replicate best practices across multiple regions.</li> </ul>
7. Continuous Learning & Knowledge Transfer	Strengthen long-term learning mechanisms and regional collaboration.	<ul style="list-style-type: none"> <li>- Organize cross-border knowledge exchange programs.</li> <li>- Develop an EIP best-practices repository.</li> <li>- Conduct training sessions and policy dialogues to integrate lessons into future industrial park developments.</li> </ul>	<ul style="list-style-type: none"> <li>- Ensuring continuous engagement from industrial park stakeholders.</li> <li>- Managing knowledge transfer across regions with different levels of development.</li> </ul>	<ul style="list-style-type: none"> <li>- Create structured learning platforms (e.g., online knowledge hubs).</li> <li>- Establish mentorship programs for new industrial parks.</li> </ul>

Table 6: Key Steps for Transitioning Industrial Parks into Eco-Industrial Parks (EIPs)





## 14. Conclusion

The ECOLE project has successfully demonstrated the feasibility and benefits of implementing circular economy principles in industrial parks across the Alpine region. Through diverse pilot actions, stakeholders have explored innovative strategies for energy efficiency, resource optimization, waste valorization, and enhanced governance models, reinforcing the role of industrial parks as catalysts for sustainable regional development.

These guidelines, grounded in practical pilot experiences, ensure that the methodologies developed within ECOLE are not only effective but also transferable to other industrial parks within the Alpine Space and beyond.

The project has highlighted that stakeholder engagement, data-driven decision-making, and flexible governance structures are essential for successful circular economy adoption. By fostering cross-border collaboration through the LAB framework, ECOLE has created a scalable model that enables industrial parks to tailor circular economy solutions to their specific contexts while maintaining alignment with broader sustainability goals.

Moreover, the knowledge and best practices gained from the ECOLE project provide a replicable framework for policymakers, industrial park managers, and businesses aiming to transition towards eco-industrial parks. The project's emphasis on transnational cooperation and systemic thinking ensures that circular economy principles can be seamlessly adapted to diverse regulatory, economic, and industrial landscapes within the Alpine region.

Ultimately, ECOLE sets a strong foundation for future innovation and policy development, demonstrating that circular industrial ecosystems can enhance economic competitiveness, environmental responsibility, and social well-being. The insights gained will serve as actionable roadmaps for accelerating the circular transition of industrial parks across the Alpine Space and other European regions.



## 15. Annexes

Annex 1: Strategies and principles to develop CE

Annex 2: Best practices of Eco-Industrial parks around the world

Annex 3: Preconditions for the success of Eco-industrial parks

Annex 4: Table 1. Governance models of the 10 Ips in ECOLE

Annex 5: The policy cycle as a guiding process

Annex 6: Understanding stakeholders and planning engagement

Annex 7: Roadmap for ensuring the operations of the labs

Annex 8: Cross-collaboration opportunities among LABs

Annex 9: Ecole Toolkit

Annex 10: Common KPIs

## References

Kirchherr, J., Reike, D. and Hekkert, M. (2017), 'Conceptualizing the circular economy: An analysis of 114 definitions' *Resources, Conservation and Recycling*, Vol. 127, pp. 221-232, <https://doi.org/10.1016/j.resconrec.2017.09.005>.

Preston F. (2012), *A Global Redesign? Shaping the Circular Economy*, testo disponibile al sito: [https://www.chathamhouse.org/sites/default/files/public/Research/Energy%2C%20Environment%20and%20Development/bp0312\\_preston.pdf](https://www.chathamhouse.org/sites/default/files/public/Research/Energy%2C%20Environment%20and%20Development/bp0312_preston.pdf).

Suárez-Eiroa B., Fernández E., Méndez-Martínez G. and Soto-Oñate D. (2019), "Operational principles of circular economy for sustainable development: Linking theory and practice", *Journal of Cleaner Production*, 214: 952-961

Webster K. (2015), *The Circular Economy: A Wealth of flows*, EMF.

World Bank Group (2021), *Circular Economy in Industrial Parks*.

### Project documents

D.1.1.1: Benchmarking study on the circular economy approach in industrial parks, produced by TUM International GmbH in the frame of the ECOLE project

D.1.1.2: Paper on Eco Industrial Park (EIP) concept in the Alpine region, produced by FLA in the frame of the ECOLE project



D.1.3.2: Representative model of the systemic thinking community for circular economy in eco-industrial parks in the Alpine region, produced by TUM International GmbH in the frame of the ECOLE project

D.1.3.2: Transnational report on Local Systemic Thinking Communities working sessions, produced by ZAI in the frame of the ECOLE project

D1.4.1: Action plans for the Eco-Industrial Parks and their uptake of the circular economy approach, produced by TZE with the contribution of all partners in the frame of the ECOLE project

D2.1.1: Concept on energy materials & circularity, produced by ZAI with the contribution of partners: CONSELAG, RA SORA, WEIZ, TZE, POLYMERIS in the frame of the ECOLE project

D2.1.2: Concept on supply & value chains resilience & sustainability produced by RRA LUR with the contribution of partners: WAB, ITALCAM, GAM in the frame of the ECOLE project

D2.1.3: Concept on EIP governance, local symbiosis & circular economy (CE) knowledge & transfer produced by FLA in the frame of the ECOLE project

D.2.2.1: Energy-materials & circularity implementation report, produced by WEIZ in the frame of the ECOLE project

D.2.2.2: Supply, value chains resilience & sustainability implementation report, produced by RRA LUR in the frame of the ECOLE project

D.2.2.3: EIP governance & local symbiosis & circular economy knowledge & transfer produced by FLA in the frame of the ECOLE project

D.2.3.1: Transnational pilot actions validation report produced by ZAI in the frame of the ECOLE project

Images used in this document are sourced from the ECOLE project partners' archive and were also created as part of D.1.1.3 Infographics on the Eco-Industrial Park (EIP) concept and D.2.3.2 Digital publication with infographic on pilot results and lessons learned.