Towards Green and Circular Transformation in Industrial, Science, and Technology Parks

Identifying the Potential of Polish Parks and Disseminating Best Practices from Norway

Gdańsk 2024

Iceland Liechtenstein Norway grants
Norway grants

Working together for a green, competitive and inclusive Europe

Agencja Rozwoju Pomorza S.A.
Spółka Samorządu Województwa Pomorskiego

Uniwersytet Gdański
Centrum Zrównoważonego Rozwoju

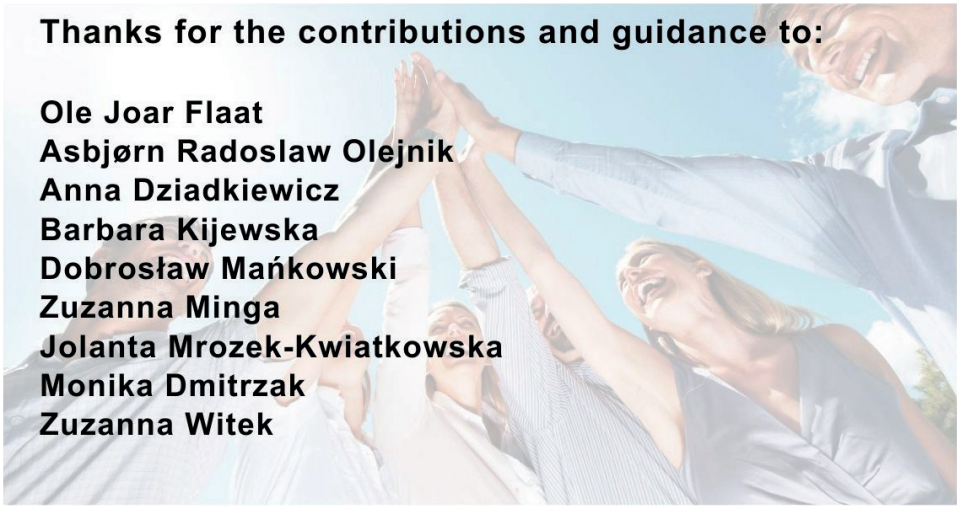
SKOGMO INDUSTRIPARK

Authors:

Anna Wojewnik-Filipkowska
Krzysztof Szczepaniak
Rafał Kowalski

Thanks for the contributions and guidance to:

Ole Joar Flaat
Asbjørn Radoslaw Olejnik
Anna Dziadkiewicz
Barbara Kijewska
Dobrosław Mańkowski
Zuzanna Minga
Jolanta Mrozek-Kwiatkowska
Monika Dmitrzak
Zuzanna Witek



Iceland Liechtenstein Norway grants

Working together for a green, competitive and inclusive Europe

Agencja Rozwoju Pomorza S.A.

Spółka Samorządu Województwa Pomorskiego

Uniwersytet Gdański Centrum Zrównoważonego Rozwoju

SKOGMO INDUSTRIPARK

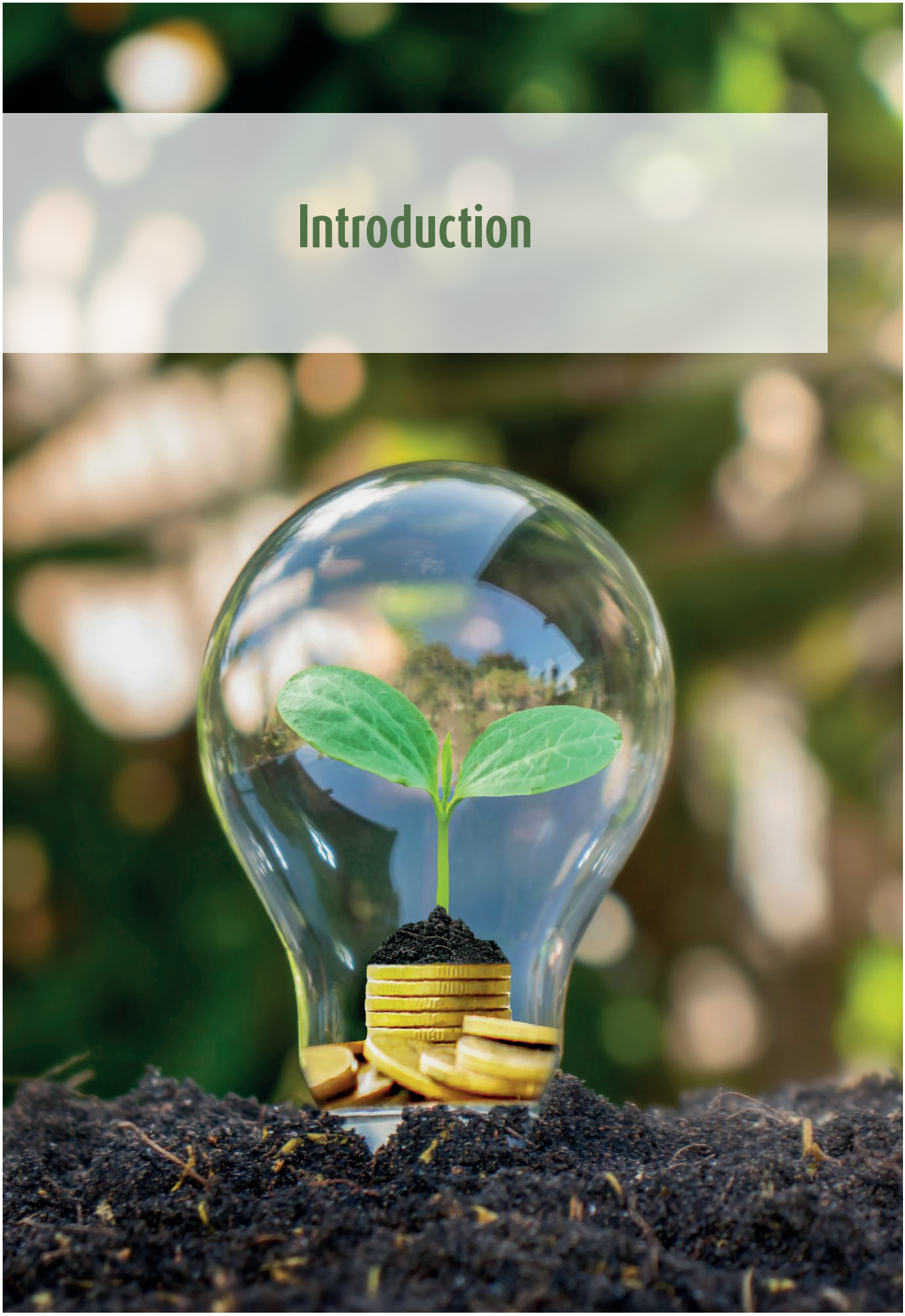
 ISBN 978-83-969991-5-3

The project ‘Polish-Norwegian way to the circular cooperation in industrial, science and technology parks (CIR-CO-WAY) benefits from a € 230,355 grant from Iceland, Liechtenstein and Norway through the EEA and Norway Grants under the Bilateral Cooperation Fund.

The aim of the CIR-CO-WAY project is to establish contacts and strengthen cooperation between Poland and Norway in the area of circular economy and green transformation, to support industrial, science and technology parks in implementing changes related to the circular economy (CE) both in their internal operations and in their relations with tenants, to increase the knowledge of companies that are members of the parks in the area of green transformation, CE and material flows.

Table of Contents

Introduction



Introduction

The study aims to present the results and conclusions of a comprehensive analysis of the methods and solutions employed in implementing the principles of the circular economy (CE) in industrial, science, and technology parks in Poland and Norway. The authors focus on identifying best practices, challenges and development perspectives regarding cooperation between parks in both countries in the context of sustainable development and circular transformation.

The study, which assesses the potential of Polish parks and the best practices of Norwegian parks, prepared to foster cooperation in the circular economy and material flow in parks, particularly addresses:

- the recognition of the scope of implementation of circular economy principles and green transformation in a group of companies located in and cooperating with parks;
- the analysis of the possibilities for park tenants to collaborate with other stakeholders in the area of material flow and the development of sustainable supply chains;
- the identification of procedures and processes supporting the circular economy and green transformation in practice;
- the recognition of various incentives (including non-financial) and sources of funding that support green and circular transformation in parks and the companies located within them;
- the identification of the potential of Polish parks to initiate and manage processes of green and circular transformation;
- the identification of best practices and practical tools used in the Skogmo Industripark in Norway.

The structure of the study comprises five sections, addressing the issues of the circular economy from the perspectives of strategic management, resource management, stakeholder cooperation, and financial and non-financial incentives. The first chapter introduces the concept of the circular economy and its significance for business parks. The second chapter is dedicated to the analysis of procedures and processes supporting CE and green transformation from the perspective of Polish parks, while the third chapter presents these issues from the tenants' perspective. The following section presents case studies and best practices from Norway. The study concludes with recommendations in the form of practical guidelines aimed at increasing the dynamics and scope of CE implementation in parks and the enterprises operating within them.

The methodology used in the preparation of this study combines both qualitative and quantitative methods. An analysis of strategic documents, industry reports and scientific literature on the circular economy in the context of business parks was conducted. Subsequently, survey research was carried out among park managers and tenants in Poland, supplemented by numerous in-depth interviews. For the analysis of Norwegian experiences, the case study method was employed. Additionally, benchmarking analysis and comparison methods were utilized.

Preliminary findings from the conducted research indicate a growing interest in implementing circular economy practices in both

Polish and Norwegian parks. However, their level of advancement and prioritization varies. Several similarities and differences have been identified, stemming from legal frameworks, economic conditions and the level of ecological awareness.

The key areas where potential for CE development in parks has been observed include:

- Efficient waste and resource management,
- Collaboration among tenants to reduce resource consumption, including energy,
- Innovative solutions in the fields of energy and water management,
- Education and awareness-building among employees and stakeholders.

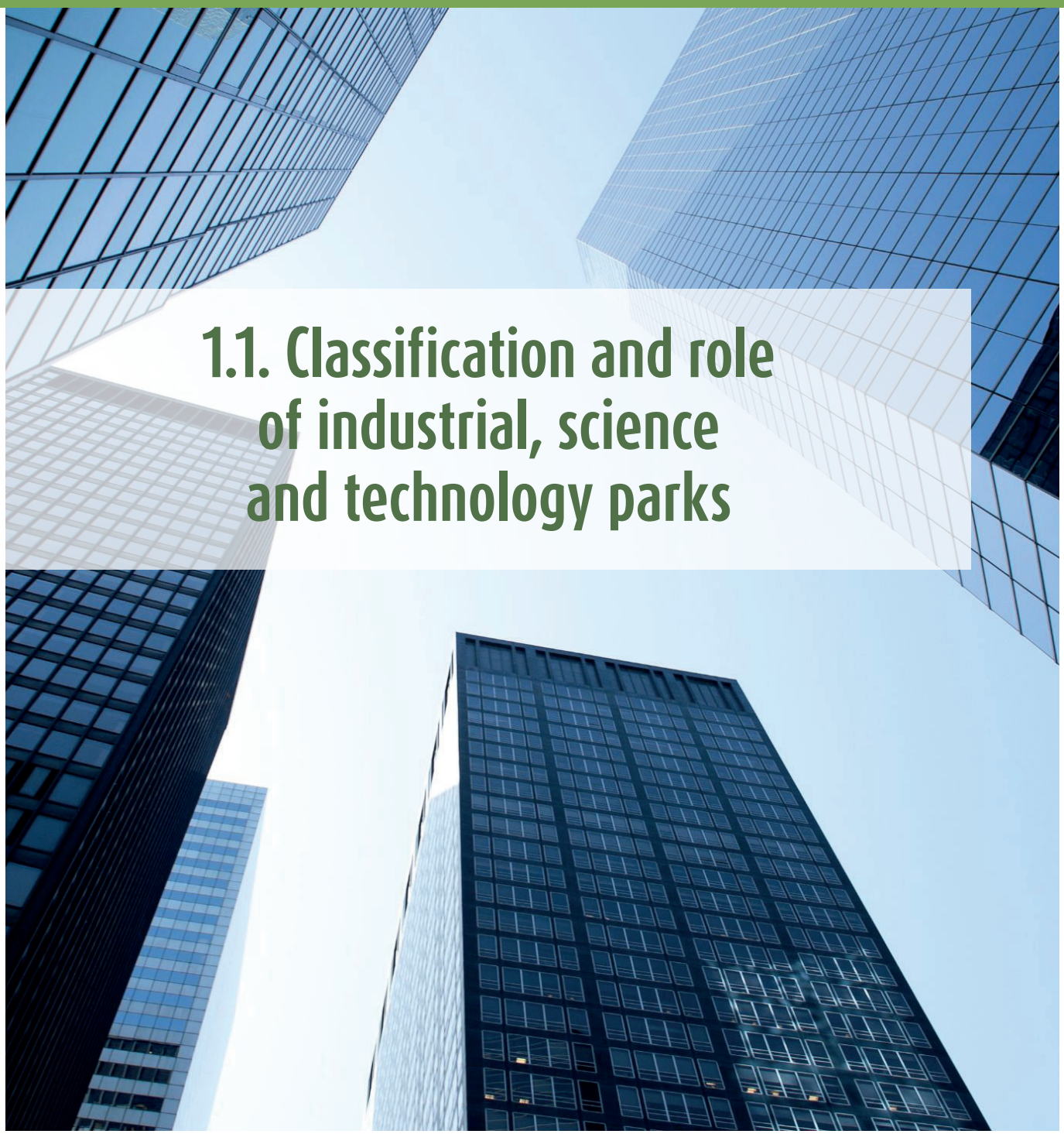
The study highlights the importance of a comprehensive approach to CE implementation, considering technological, organizational and social aspects. It emphasizes the need for creating appropriate incentives and support for tenants, as well as a communication platform to facilitate information exchange and collaboration.

A crucial element of the analysis is identifying opportunities for developing cooperation between parks in Poland and Norway. The study points to the potential for exchanging experiences, undertaking joint research and development projects, and forming international consortia for sustainable development and the circular economy.

Despite the fact that the conducted research focused on a predetermined and limited research group, this study provides a relatively comprehensive picture of the state of CE implementation in selected business parks in Poland and Norway, identifying key challenges, best practices and development opportunities. It serves as a foundation for further actions to promote and support circular business models, contributing to the sustainable development of industrial and technology parks in both countries.

The conclusions and recommendations presented in the study aim to support park managers in creating an environment conducive to green and circular transformation, while simultaneously increasing the attractiveness and competitiveness of business parks. The study also serves as a valuable source of information for policymakers, investors and researchers interested in the circular economy in the context of development of industrial, science, and technology parks.

1. Foundations and Framework for the Circular Economy in Industrial, Science and Technology Parks



1.1. Classification and role of industrial, science and technology parks

Polish organizations involved in entrepreneurial development, known as parks, are diverse in terms of their formal-organizational and legal structures. They operate as limited liability companies, joint-stock companies, public-private cooperatives, local government units, and university functional units. Typical shareholders or stakeholders include budgetary units of public administration, local government units, large companies, scientific institutions, and foundations. In the literature and documents of state agencies supporting the development of parks, there are many approaches to their characterization and division. The varied classification and nomenclature result not only from the lack of dedicated legislative frameworks regulating the organization of industrial, technology, and science parks, but also from growth factors and the social, cultural, and economic conditions of the region, which can attribute different origins to the parks.[1]

According to this criterion, Lecluyse et al. (2019) distinguish three categories of parks. The "science push" park emerges as a result of advances in science, generating new ideas, technologies, and solutions that can be brought to the market. "Market pull" refers to a situation where market demand or consumer needs stimulate innovation and product development. In this case, the market and consumers set the direction of development, and producers respond to their needs by establishing an appropriate type of park. "Interactive glocal flows" refers to the interactions between various entities and the flows of goods, services, information, or capital on both a global and local scale. This type of park evidences the complexity of modern economic networks, where local decisions and events can influence global phenomena and vice versa.

The primary task of parks is to stimulate the growth of the local economy by supporting entrepreneurship, innovation, and the diffusion of technology among the entities operating within the park. This means that parks play a crucial role in enhancing economic competitiveness. A practical division is the classification according to the park's activity profile. According to this classification, parks are divided into:[2]

- Industrial Parks – these relate to industry and large-scale production activities, thus requiring access to specialized real estate and infrastructure.

- Science Parks – these serve to initiate and develop innovative activities as well as support the creation of spin-off companies. The outcomes of activities and work may pertain exclusively to the prototype stage.
- Technology Parks – these are associated with modern technologies, technical solutions, and technological processes.
- Science and Technology Parks – these pertain to both science and modern technologies, combining scientific and technological aspects, where the production of innovative solutions is realized on an industrial scale.
- Industrial and Technology Parks – these encompass both industry and related production activities, as well as modern technologies, thereby combining production and technological elements.
- Business and Industrial Parks – these combine business and economic aspects with industrial and production activities.

Another classification is based on the criterion of owned fixed assets in the form of land

1 Lecluyse, L., Knockaert, M., Spithoven, A. (2019). The Contribution of Science Parks: A Literature Review and Future Research Agenda. *The Journal of Technology Transfer*, 44, pp. 559–595.

2 Waligóra, K. (2015). Parki naukowe, technologiczne i przemysłowe jako narzędzie wspierające potencjał innowacyjny polskiej gospodarki. In: Współczesne wyzwania rozwoju gospodarczego: polityka i kreacja potencjału. Cz. 1, Kreacja, innowacyjność, handel zagraniczny, red. Ewa Gruszewska (pp. 171–186). Wydawnictwo Uniwersytetu w Białymstoku, p. 179.

properties, i.e. investment plots.[3] It divides parks into those that possess investment plots and those that do not.

From the perspective of the primary role of parks, which is to support the development of innovation and entrepreneurship, and additionally considering environmental protection and infrastructure for companies, alongside the aforementioned parks, there also exist:[4]

- Incubators (technological, entrepreneurial) – centres supporting the development of innovative technology firms by offering office/production space, advisory services, training, and facilitating access to financing and networks;
- Business Incubators – entities enabling the initiation of business activities by providing infrastructure, advisory services, and training for budding entrepreneurs;
- Technology Transfer Centres – units mediating in the commercialization of scientific research results and the transfer of modern technologies between the scientific community and the economy;
- Technoparks – areas that bring together high-tech companies, research and development centres, and business support institutions, facilitating the flow of knowledge, innovation, and new technologies;
- Business Parks – Designated investment areas with technical and service infrastructure, intended for companies from various industries, often with tax preferences;
- Ecological Parks (Ecoparks) – economic areas combining industrial, scientific, and service activities with the principles of sustainable development, eco-innovations, and environmentally friendly technologies.

The division and types of parks vary not only in Poland, but also globally. Furthermore, dynamic changes in the global economy drive the evolution of parks. Three generations of park initiatives can be distinguished.[5]

First-generation parks are designed for companies located on or near university and research institution campuses to create a commercial focus for research. These parks offer specialized areas tailored to business needs based on new technologies. Their proximity to research units aims to bridge the gap between science and business by accelerating the processes of knowledge transfer and commercialization. Income from the infrastructure is to ensure a park's financial self-sufficiency, and the dynamic development of a business park is a sign of the modernity of the university and the region. The Poznań Science and Technology Park is the first Polish park of this type. It was established in 1995 as part of the statutory activities of the Foundation of the University of Economics in Poznań.

The second generation of parks involves their strengthening and broad availability of business support services. The diversification of services has led to the specialization of parks: ICT (Information and Communication Technology) parks (e.g. the Małopolski Information Technology Park within the Kraków Technology Park), bioparks (e.g. the Gdańsk Science and

3 Waligóra, K. (2015). Parki naukowe, technologiczne i przemysłowe jako narzędzie wspierające potencjał innowacyjny polskiej gospodarki. In Współczesne wyzwania rozwoju gospodarczego: polityka i kreacja potencjału. Cz. 1, Kreacja, innowacyjność, handel zagraniczny, red. Ewa Gruszewska (pp. 171–186). Wydawnictwo Uniwersytetu w Białymstoku, p. 183.

4 UNIDO (2021). *A New Generation of Science and Technology Parks, UNIDO's Strategic Approach to Fostering Innovation and Technology for Inclusive and Sustainable Industrial Development*, https://hub.unido.org/sites/default/files/publications/Publication_%20New%20Generation%20of%20STI%20parks_2021.pdf, p. 17; UN ESCAP (2019). *Establishing Science and Technology Parks: A Reference Guidebook for Policymakers in Asia and the Pacific*, https://www.unescap.org/sites/default/files/Guidebook_Final.pdf, p. 4; Leitão, J., Pereira, D., Gonçalves, Â. (2022). Business Incubators, Accelerators, and Performance of Technology-Based Ventures: A Systematic Literature Review. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(1), 46, p. 1.

5 Hansson, F., Husted, K., Vestergaard, J. (2005). Second Generation Science Parks: From Structural Holes Jockeys to Social Capital Catalysts of the Knowledge Society. *Technovation*, 25(9), pp. 1039–1049.

Technology Park), and media parks (e.g. MMC Brainville). Second-generation parks, therefore, offer services and facilities tailored to the specific goals of a particular industry. An important element of these parks is incubation programmes and a focus on creating new enterprises, often within the context of regional structural policy.

On the other hand, the concept of third-generation parks is based on integration with the challenges facing the development of cities and regions. They enable the transformation of large post-industrial urban areas into innovative and modern city districts. Parks become centres of specific cooperation networks and integrate regional innovation systems.

Since park initiatives are closely linked to the development of innovation, due to their diversity, parks, understood as a type of economic zone, are classified according to their level of innovativeness. Due to the increasing potential for innovation and development over time, yet more categories of park initiatives are distinguished.

PICTURE 1. TYPES OF PARK INITIATIVES BY DEGREE OF INNOVATION ACCORDING TO UNIDO

Source: own elaboration based on UNIDO (2021), A new generation of science and technology parks, UNIDO's strategic approach to fostering innovation and technology for Inclusive and Sustainable Industrial Development, https://hub.unido.org/sites/default/files/publications/Publication_%20New%20Generation%20of%20STI%20parks_2021.pdf, p. 17.

The aforementioned categories of parks indicate that they evolve in parallel with economic development. Industrial parks emerged in place of large, closed-down industrial plants or were created from local industrial enterprises that collaborated to some extent. Subsequently, industrial parks transformed into special economic zones to enable the development of enterprises and attract more companies to the area (see Fig. 1). In some countries, such as China,[6] the initiation and organization of special zones were primarily aimed at attracting foreign direct investment (FDI). The transfer of technologies that were previously unavailable in those regions facilitated the development of economic innovation.

The next stage was the evolution and transformation of Special Economic Zones into eco-industrial parks. This type of park was popular in Germany. Research from 2014 indicates that in Germany there were 40 eco-parks out of 206 parks in European countries.[7] An example from Poland is the Industrial and Technological Park Ecopark in Piekary Śląskie. Another type of park, considering the degree of innovativeness, is the science and technology park. This is one of the more advanced forms of parks, distinguished by collaboration between science and business, and the transfer, creation and development of technology. The last currently known type of economic zones, essentially successors to science and technology parks, are Areas of Innovation – innovation districts and entire technology towns, such as the famous Silicon Valley. The activities of Areas of Innovation mainly involve providing services and infrastructure (including real estate) for conducting business and research-and-development activities.

6 Oleksiuk, A. (2009). Konkurencyjność regionów a parki technologiczne i klastry przemysłowe. Oficyna Wydawnicza" Branta", p. 95

7 Massard, G., Jacquat, O., Zürcher, D. (2014). *International Survey on Eco-Innovation Parks: Learning from Experiences on the Spatial Dimension of Eco-Innovation*. FOEN, p. 21.

In Norway, compared to Poland, there are fewer parks (around 20) related to science, technology, and industry (PARP indicates that there are 77 industrial and technology parks in Poland).[8] Most of these are industrial parks and innovation centres. Among the Norwegian parks, two technology parks can also be distinguished – the Kongsberg Technology Park and EGGEMOEN Aviation & Technology Park; the capital of Norway, Oslo, hosts a science park – Forskningsparken – the Oslo Science Park.

Statistics on parks worldwide are collected by the IASP (International Association of Science Parks and Areas of Innovation). The IASP collects data for entities classified as STPs (Science, Technology and Research Parks) and AOIs (Areas of Innovation). According to the IASP data,[9] there are approximately 450 STPs and AOIs operating in Europe, housing around 80,000 companies (an average of about 180 companies per park). Among these parks, 210 STPs and AOIs are members of the IASP, which include 45,000 companies, as well as a significant number of research institutes, technology centres, business incubators and accelerators (as of 2020). The number of parks has increased significantly, as previous data from 2013 showed 366 STPs in Europe (EU). The number of parks worldwide, however, is difficult to estimate.[10]

European science and technology parks (STPs and AOIs) are considered an important part of local innovation ecosystems. They mainly collaborate with SMEs and startups, whose activities and development are knowledge-based. These parks are also valuable partners for investors looking for places for foreign direct investment (FDI), especially those involving high technologies. They also serve as magnets attracting talent and are a factor in fostering innovation openness.

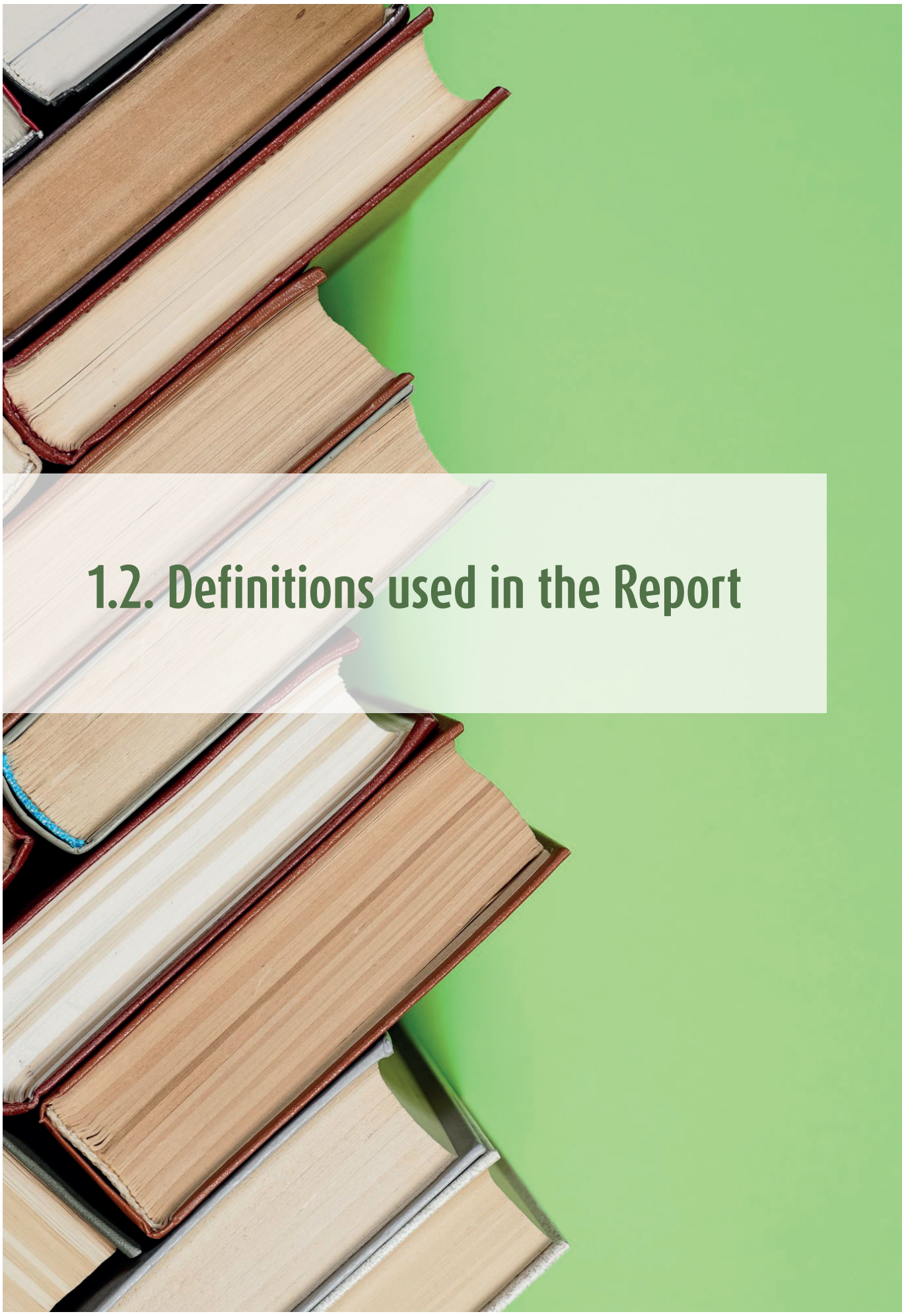
The most popular sector present in the parks (STPs) according to the IASP was the ICT sector (over 63% of STPs/AOIs). The next most prominent sector was biotechnology, with a share of over 36%, followed by software engineering (28%) and the energy sector (26%). The AI (artificial intelligence) sector is also becoming significant, being present in 21% of STPs/AOIs. Among the companies surveyed by the IASP, the majority are local and national firms, followed by regional and, to a lesser extent, international firms.

In this study, selected science, technology, and industrial parks from Poland and Norway are the subject of research, and they will be referred to by the acronym ISTP (Industry, Science, and Technology Parks).

8 Polska Agencja Inwestycji i Handlu, https://www.paih.gov.pl/dlaczego_polska/zachety_inwestycyjne/parki_przemyslowe_i_technologiczne/ [access 15.05.2024]

9 Strengthening the European Innovation Ecosystem via the enhanced involvement of STPs and AOIs, April 2020, Malaga. IASP - International Association of Science Parks and Areas of Innovation, p. 2

10 UNIDO (2021). *A New Generation of Science and Technology Parks, UNIDO's Strategic Approach to Fostering Innovation and Technology for Inclusive and Sustainable Industrial Development*, https://hub.unido.org/sites/default/files/publications/Publication_%20New%20Generation%20of%20STI%20parks_2021.pdf, p. 17.



1.2. Definitions used in the Report

Polish legislation defined the concepts of industrial parks and technology parks in the Act on financial support for investments of 20 March 2002 (Journal of Laws 2002 No. 41, item 363). This Act was repealed on 24 November 2017, pursuant to Article 88 of the Act on supporting new investments of 10 May 2018 (Journal of Laws 2018, item 1162).

The definitions of parks contained in the Act lost their binding force with the repeal of the Act. Currently, issues concerning industrial and technology parks are regulated by other legal acts, including the Act on Special Economic Zones. However, these regulations do not provide definitions of industrial or technology parks. Thus, in this context, entities managing these parks no longer have legal support for defining their status and nature of activity, which can lead to interpretative problems and discrepancies in understanding these concepts by various institutions and public administration bodies. The lack of definitions can also hinder the precise determination of the operating principles and requirements for such entities, resulting in legal uncertainty for entrepreneurs operating in industrial and technology parks.

Polish legal regulations do not define science parks either. The Polish Agency for Enterprise Development (PARP), based on a study from 1975, indicates that the concept of "technology park" customarily includes various types of entities, including research parks, science parks, research and development parks, science and technology parks, industrial and technology parks, and technopoles.[1]

The lack of a formal definition, however, can have certain advantages, such as increased flexibility in operations, which are no longer rigidly defined by law. This also facilitates adaptation to changing market and technological conditions without the need to amend the law, potentially providing better operating conditions for parks and the entities within them by allowing any regulations in lower-level acts to be refined.

Technology parks are diverse entities, which results from industry profiles, management systems, scales of operation, regional conditions, etc. With regard to science parks, it is important whether the park was established in the vicinity of a higher education institution and serves as a "bridge" between science and business or was initiated by local government or business support institutions. Therefore, science parks (research parks) are created by academic communities. They are strongly connected to specific universities and focused on supporting the commercialization of research conducted at these universities. In contrast, technopoles are created by public authorities, bringing together stakeholders from the local innovation environment, aimed at attracting external investors and concentrating research potential in the region.

In summary, for the purposes of this study, a distinction is made between industrial parks, technology parks, and science parks – although, in practice, the latter may combine functions of supporting entrepreneurship (technology parks) and strong ties with the scientific community (science parks). Therefore, the report adopts the following terms:

- **Industrial Parks** – these are parks with a distinctly industrial profile, focused on activities related to attracting investors and providing them with the necessary infrastructure to conduct business activities;
- **Technology Parks** – established on the initiative of local governments or business support institutions, these parks support the development of entrepreneurship and concentrate the research potential of the region;

1 Matusiak, K.B. (1975). *Parki technologiczne. Instytucjonalne wspieranie przedsiębiorczości, procesów innowacyjnych i rozwoju regionalnego*. Fundacja Inkubator. Za: Fabrowska, P., Kozdęba, D., Mackiewicz, M. i in. (2008). *Benchmarking parków technologicznych w Polsce, Wyniki badania (2008)*. Polska Agencja Rozwoju Przedsiębiorczości, p. 7.

- **Science Parks** (formally classified as technology parks) – these parks carry out tasks related to the transfer of knowledge from science to business.

Regardless of the formal nomenclature and classification into a specific category of parks, each park has an individual character that stems from its location and surroundings, i.e., social, cultural, and economic conditions, as well as available growth factors. Thus, the initiatives undertaken by the parks are a consequence of the specifics of the local scientific and business environment; they reflect the form of the economy, industrial traditions, and cultural conditions of entrepreneurship in a given region or country.

1.3. Assumptions for a circular economy and green transition – procedures and processes

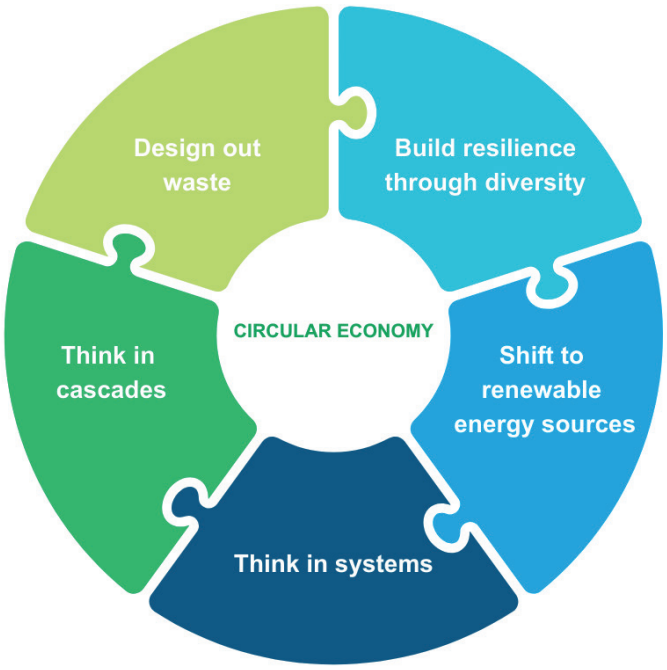
The circular economy (CE) is a concept focused on minimizing waste by maximizing the use of resources in cyclical production loops. Specifically, CE involves eliminating waste and reducing negative environmental impacts through the design, manufacture, and use of products and materials in a way that allows them to be safely reused, dismantled, recovered, recycled, or subjected to other forms of processing.

Green economy is a broader concept that encompasses not only aspects of the circular economy in production and waste management, but also sustainable management of natural resources, environmental protection, efficient use of energy, reduction of greenhouse gases, promotion of clean transportation, and economic development based on the principles of sustainable development and social benefits. Consequently, "green transformation" is a change in the way of production and service provision towards green economy, requiring the implementation of, among other things, the principles of the circular economy. Therefore, the circular economy is a tool of green transformation.

The procedures and processes of the circular economy particularly include (Figure 2):[1]

- **"Design out waste"** – waste does not exist when the biological and technical components of a product are designed to fit into biological or technical material cycles intended for reintegration, regeneration, disassembly, or reuse for other purposes;
- **"Build resilience through diversity"** – modularity, versatility, and adaptability are traits to be prioritized in an uncertain and rapidly changing world. Production systems should be flexible, allowing the use of a wide variety of inputs. Diverse systems are more resilient to external shocks than systems designed solely for efficiency;
- **"Shift to renewable energy sources"** – ultimately, systems should be powered by renewable energy, which is achievable thanks to the reduced threshold energy levels required by a regenerating circular economy;
- **"Think in systems"** – the ability to understand how parts influence one another within the whole, and the relationship of the whole to its parts, is crucial. Elements are considered in relation to their environmental and social context;
- **"Think in cascades"** – moving materials through the system as many times as possible through cascading them into different uses.

PICTURE 2. THE PRINCIPLES OF A CIRCULAR ECONOMY



Source: own elaboration.

Therefore, the implementation of the circular economy particularly involves:[2]

- **reducing the use of raw materials**, i.e. delivering greater value with fewer materials. This results in the protection of natural resources and the reduction of erosion of natural ecosystems;

1 Ellen MacArthur Foundation (2013), Towards the Circular Economy Vol.2: opportunities for the Consumer Goods Sector, Ellen MacArthur Foundation Report, pp. 26–28.

2 Pichlak, M. (2018), Gospodarka o obiegu zamkniętym model koncepcyjny. Ekonomista, 3, pp. 340–341.

- **reducing pollution levels** (including indirect emissions) – this is achieved, among other things, by using renewable energy sources, which is also related to energy efficiency;
- **increasing the durability of resources** by extending their lifespan (the time during which they can generate value). This results in more sustainable resource utilization and substitution between renewable and non-renewable resources (e.g. using renewable energy sources);
- **reducing the generation of solid waste and safely disposing of waste**;
- **reducing material losses** (and energy losses) through recovery and recycling processes of products and materials via reverse flows. Such actions will enable the implementation of closed-loop material flows, where processed products and materials become inputs in subsequent production processes.

Key processes in implementing the circular economy are related to reducing the use of natural resources and emissions of pollutants to minimize the negative impact on the natural environment. The reduction of pollutant emissions is particularly associated with the transition to low-emission energy sources, including renewable energy sources (RES). The use of RES increases energy efficiency by reducing transmission losses and decreasing the negative environmental impact, which translates into savings and improved economic balance. Solar and wind energy are constantly renewable energy sources, enhancing supply security and energy independence. Finally, RES do not generate greenhouse gas emissions or other pollutants, contributing to improved macro-scale energy efficiency by reducing negative environmental impacts. Moreover, CE involves maximizing the use of raw materials and waste, including those generated during the production of energy from RES, aligning with the idea of a closed-loop material cycle.

The idea of a closed-loop system particularly concerns the limited resource of water. The dynamically increasing demand for water in Europe over the last 50 years, due to population growth and other economic or climatic processes, has led to a general reduction in renewable water resources per capita by 24% across Europe. As a result, approximately 100 million people in Europe experience problems related to water scarcity. According to data from the European Environment Agency, economic activity in Europe consumes about 243,000 cubic hectometres of water annually, with most of this water (over 140,000 cubic hectometres) returning to the environment, often in a polluted state, including contamination by chemicals.[3] Therefore, the multiple uses of water within technological and operational processes, i.e. actions aimed at closing the water cycle, also become a key process in CE.

The closed-loop system within CE also involves minimizing or eliminating waste. Actions in this area include reducing waste as by-products of production and operational processes, limiting the consumption of raw materials necessary for production through their efficient use, and reusing production residues.

In the areas related to the implementation of the circular economy, namely energy efficiency, resources, and waste management, one can distinguish the following key processes and procedures (Table 1).

3 European Environment Agency, https://www.eea.europa.eu/pl/sygna142y/sygnaly-2018/infografika/zuzycie-wody-w-europie/view [access on 18.05.2024]

TABLE 1.KEY PROCESSES AND PROCEDURES
IN IMPLEMENTING THE CIRCULAR ECONOMY

ENERGY EFFICIENCY	WATER CYCLE CLOSURE	WASTE MANAGEMENT
• Solar Energy (Photovoltaics) • Wind Energy • Geothermal Energy • Hydropower • Biomass • Heat and Cold Conversion	• Water Recycling (Greywater Management) • Water Filtration • Water Treatment Plants • Water Disinfection • Rainwater Harvesting • Rainwater Storage • Drip Irrigation Systems • Green Roof Technologies • Wastewater Treatment Plants	• Reducing Waste Generation • Lean Manufacturing • Zero Waste Strategies • Product Reuse • Safe Disposal • Lifecycle Extension • Ecodesign (Ecological Design)

Source: own elaboration.

Overall, the implementation of circular economy (CE) principles can be achieved through the adoption of an appropriate business model. A business model is a long-term operational concept of an enterprise, defining how it generates revenue and profits by delivering unique value. It is a plan that outlines how a company intends to utilize its resources and competencies to gain and maintain a competitive advantage in the market. CE business models modify the linear flow of products from raw material to waste, reducing negative impacts on the environment and society. They particularly focus on closing material loops, extending product life cycles, sharing resources, and using renewable energy sources (Table 2).

Implementing business models based on circular economy (CE) principles requires close collaboration with various stakeholder groups. This is crucial from a strategic management perspective, as the transition to CE impacts the entire operation of the company and its environment. Therefore, transitioning to a circular model requires the engagement of employees at all levels – from management to frontline workers. Changes in organizational culture, training, and the implementation of new processes, which require effective communication, are necessary. Good relations with public administration regarding legal regulations, waste collection systems, and infrastructure, as well as good relations with local communities, where parks play special roles in knowledge exchange, education and entrepreneurial development, also facilitate the implementation of CE.

In summary, CE, as a key element and tool for the transition to a green economy, enabling the closure of material loops and the reduction of negative environmental impacts, is related to many areas of management/functioning of a given entity and functionally related entities. CE goals are connected to:

- **Strategic Management**: implementing CE (especially as a business model) can be considered a tool for implementing a sustainable development strategy for the entity. Implementing CE as a business model requires a thoughtful design of production and management processes to minimize waste and maximize the reuse of raw materials. An element of strategic management and strategy implementation, including CE, is the use

TABLE 2. EXAMPLES OF BUSINESS MODELS OF CIRCULAR ECONOMY

No.	Model Name	Description
1.	Rental and Service Model	Instead of selling a product, the company offers it as a rental or service. The customer pays for the use of the product, and the company retains ownership and responsibility for the product's lifecycle, including repairs, refurbishment, and eventual recycling.
2.	Closed-Loop Material Model	Products are designed so that their materials and components can be easily recovered and then used to produce new products after the end of their lifecycle. The material loop is closed and continuously utilized.
3.	Pay-per-Use and Recycling Model	Customers pay not only for the product but also for its use (e.g. printing fee) and for subsequent recycling or disposal after use.
4.	Product-as-a-Service (PaaS) Model	Customers do not buy the product, but they pay for access to it in the form of a subscription or usage fee. The company retains ownership of the product and responsibility for its lifecycle.
5.	Regenerative Model	Products are designed to be easily regenerated, repaired, and upgraded, extending their lifecycle and reducing the demand for new resources.
6.	Secondary Raw Materials Return Model	Products are designed for easy recovery of secondary raw materials after use, which can then be used to produce new products.
7.	Leasing with Buyback Option Model	The customer leases the product for a specified period, and after the lease term, can either purchase it or return it to the company for reuse or recycling.
8.	Upcycling Model	Unused products or waste materials are processed and transformed into new products of higher value and quality.
9.	Sharing Model	Products are shared among many users instead of being individually owned, increasing their utilization and reducing the demand for new resources.

Source: own elaboration based on: Atasu, A., Dumas, C., Van Wassenhove, L. N., The Circular Business Models, Harvard Business Review, July-August 202, https://hbr.org/2021/07/the-circular-business-model [access on 15.05.2024]

of indicators that allow measuring progress in strategy implementation, evaluating the effectiveness of implemented solutions, adjusting actions, and communicating with stakeholders;

- **Resource Management**: the key idea of CE is to minimize pollution emissions and treat waste as raw materials for reuse, which reduces the consumption of natural resources such as water, energy, and raw materials;
- **Stakeholder Collaboration**: transitioning to CE requires cooperation among various entities in the value chain, such as manufacturers, consumers, recyclers, public authorities, and local communities, to achieve the coordination of material and raw material flows necessary to close the loop;
- **Financial Incentives**: the implementation of CE can be supported by various instruments, such as aid programmes, tax incentives and regulatory incentives.

Transitioning to a circular economy system is one of the objectives of EU policy.[4] Poland, as a member state, also participates in this policy.

4 Political guidelines of the Commission 2019-2024, https://commission.europa.eu/strategy-and-policy/priorities-2019-2024_en [access: 12.05.2024]

1.4. Objective of the Report

The purpose of this study is to present the results of research on the potential of Polish industrial, science and technology parks (ISTPs) and the best Norwegian practices in circular economy and material flow in parks. Specifically, the aim of the Report is to:

- identify the extent to which circular economy and green transformation principles are being implemented by companies located in parks and collaborating with the park;
- analyse the possibilities for park tenants to collaborate with other stakeholders in the areas of material flow and building sustainable supply chains;
- examine the procedures and processes that support the circular economy and green transformation in practice;
- identify various incentives (including non-financial) and sources of funding that support green and circular transformation in parks and the companies located within them;
- identify the potential of Polish parks to initiate, animate, and manage the processes of green and circular transformation;
- identify the best Norwegian practices and practical tools used in the Skogmo Industripark.

The aforementioned objectives can be grouped into four key areas representing the current practices, challenges, and potential related to the circular economy and material flow in parks, in park management, and among their tenants in the following areas:

1. Strategic Management (including the implementation of CE business models).
2. Resource Management (water, energy, raw materials, pollution emissions).
3. Collaboration with Stakeholders in CE (including communication and education).
4. Financial and Non-Financial Incentives Supporting CE and Green Transformation in Industrial, Science and Technology Parks.

The specific objectives of the Report and the key areas determined its structure. Following the introduction (Chapter 1), the research results are presented, divided into the four areas of strategic management, resource management, stakeholder collaboration, and financial and non-financial incentives, from the perspective of parks (Chapter 2) and from the perspective of tenants in Poland (Chapter 3), as well as the research findings relevant to the Skogmo Industripark in Norway and its tenants (Chapter 4). The Report concludes with recommendations, challenges, and conclusions (Chapter 5).

1.5. Research methodology

The overarching approach to the research was the benchmarking method, a modern management tool for organizations.[1] This study uses horizontal benchmarking, which involves identifying best practices that enable success in a specific industry or area of activity. Identifying best practices (so-called benchmarks) requires analysing both the internal and external processes of organizations, including relationships with stakeholders. In this case, the essence of the analysis is to track management methods and mechanisms to identify optimal solutions.

Benchmarking allowed the presentation of selected Polish parks and their tenants against the Skogmo Industripark in Norway and its tenants. The review of existing data, survey questionnaires, in-depth interviews, and expert observation provided a basis for presenting the current practices, challenges, and potential related to the circular economy and material flow in parks, both in the management process of the parks and among their tenants. This information is valuable not only for the parks and tenants studied but also for entities that did not participate in the study, as it enables organizational improvement.

Preliminary research was conducted using the method of secondary data analysis,[2] i.e. critical analysis of the literature, available studies and legal acts. In particular, data from the latest national and international studies in the aforementioned areas of parks and the circular economy, industry reports such as those from the Polish Agency for Enterprise Development (PARP), the Polish Investment and Trade Agency, Statistical Yearbooks of Statistics Poland and other publications from Statistics Poland, information from the Public Information Bulletin, and indicated websites were utilized. This part of the research serves as the starting point, justification and background for the planned proper research (both quantitative and qualitative) of the parks and their tenants.

The proper research was conducted using:

- the diagnostic survey method, utilizing a questionnaire;
- social research methods involving participant observation, direct observation, and informal interviews;
- social research methods utilizing individual interviews and dyads.

Two questionnaires with questions were prepared. The first was directed to individuals representing entities managing the park; the second – to representatives of park tenants. The questionnaires consisted of closed, semi-open and open questions, specifically tailored for parks (38 questions) and their tenants (27 questions), including demographic questions. The sample selection for the study was purposeful and non-random. The survey was conducted using the CAWI (Computer Assisted Web Interview) technique, which allowed respondents to provide answers electronically. The "ebadania.pl" domain was used to collect the data. The research results were processed in a Microsoft Excel spreadsheet.

In the period from November 2023 to January 2024, the questionnaires were verified, and the survey was conducted among selected representatives of the parks. The questionnaires were sent to 46 parks in Poland via email, while the questionnaires for the tenants were distributed through the park management. The questionnaires could be completed between January 2024 and February 2024. The survey

1 Benchmarking was used by PARP, among others, in cyclical studies concerning technology parks, e.g. Hołub-Iwan J., Olczak B., Cheba K. (2012), Benchmarking parków technologicznych w Polsce edycja 2012, Polska Agencja Rozwoju Przedsiębiorczości, Warszawa.

2 Secondary data analysis was used by PARP, among others, in studies of sustainable production models:: Anuszewska I., Mazur A., Podlejska K., Jackiewicz A., Rudnicki R. (2011), Wzorce zrównoważonej produkcji (WPZ) – propozycja rozwiązań systemowych wspierających wdrażanie WZP w MSP, Raport z analizy danych zastanych h, Polska Agencja Rozwoju Przedsiębiorczości, Warszawa.

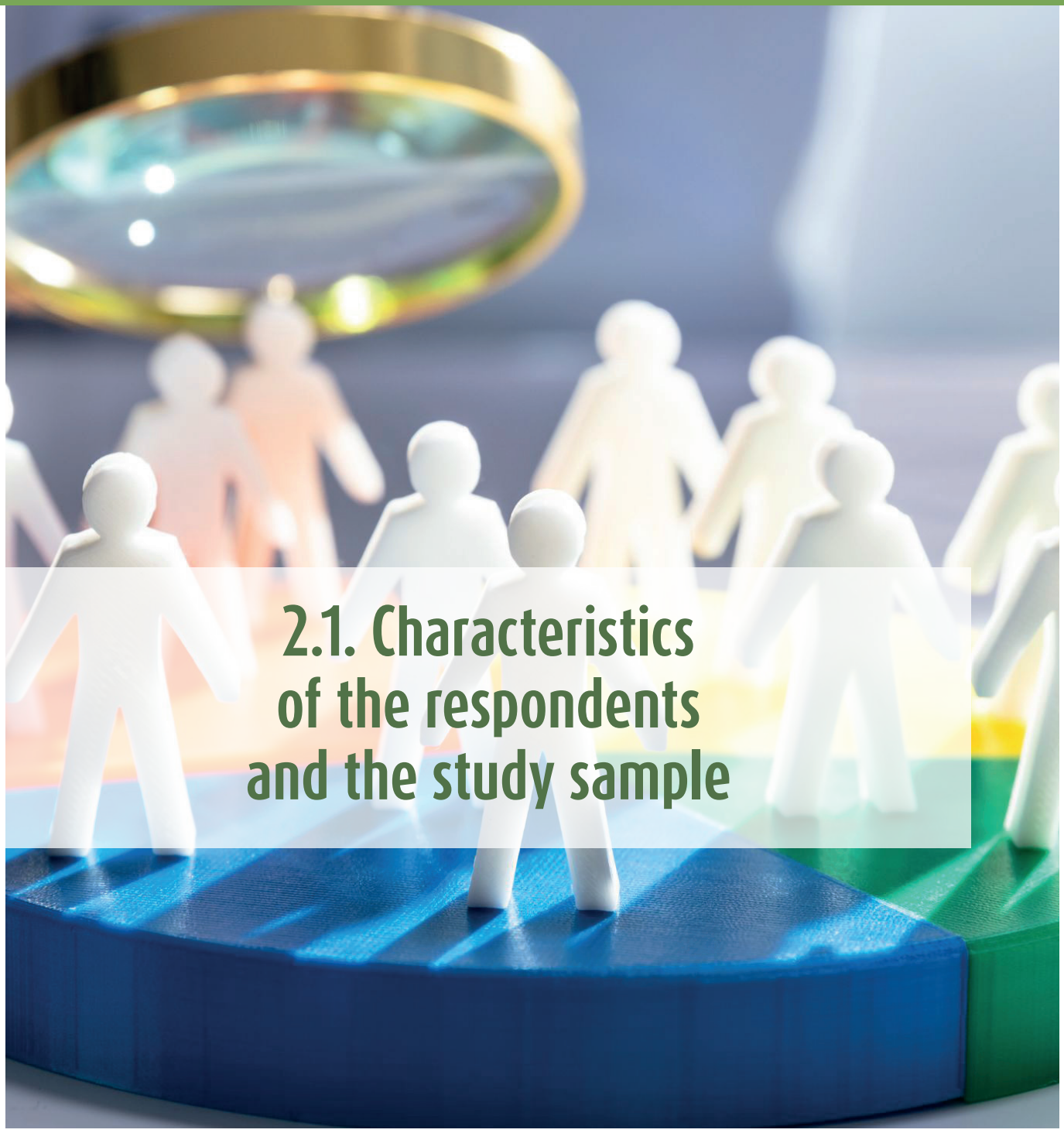
was accompanied by telephone monitoring. As a result of the conducted survey, 12 correctly completed questionnaires were collected from the parks (yielding a 26% response rate) and 46 from the tenants. The survey results were analysed in descriptive, tabular and graphical forms (using charts).

Participant observation and informal interviews took place during a 5-day study visit to the Skogmo Industripark in Norway for representatives of the Polish parks (about 12 people) and experts. The visit took place from February 27 to March 2, 2024.

In-depth individual interviews (6) and dyads (2) with representatives of the Polish parks were conducted from April 29 to May 13, 2024.

The research results were used in the Report and to organize workshops aimed at strengthening the innovative competencies of park employees and tenants in the area of the circular economy.

2. Identification of Procedures and Processes to Support a Circular Economy and Green Transformation – the Perspective of Industrial and Technology Parks in Poland



2.1. Characteristics of the respondents and the study sample

The study covered various types of science and technology parks, industrial parks and business incubators, classified as SIT (science, industry, technology) parks. These organisations were characterised by a diverse period of activity, ranging from recently established to those operating for nearly three decades.

Half of the parks included in the study had the attribute "technology" in their names, indicating their scientific and technological nature. The remaining parks, despite having different names, also had characteristics typical of science and technology parks, such as the presence of tenants conducting research and development work and collaborating with upper education institutions. One of the parks had the term "industrial" in its name, which was associated with making investment land available for production and industrial activities. Another operated as an "incubator", offering space to tenants in a manner characteristic of technology parks. The parks had been in operation for 11-29 years since their establishment, as at the end of 2023.

There are 756 tenants located in the studied parks (an average of 63 entities per park – that is fewer than the European average of approximately 180 entities). The surface area of parks (real estate of office and investment character) totalled approximately 238 ha (an average of 19.8 ha per park).

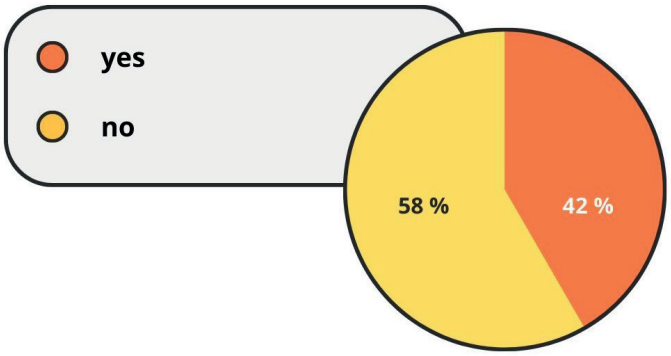
The questions in the survey questionnaire were answered by persons responsible for the management of parks at various levels, including those holding the following positions: president, board representative, chief operating officer, manager, management specialist.

The respondents answering the survey questionnaire addressed to the tenants were their representatives available at the time.

2.2. Strategic management

Procedures and processes that support the implementation of the circular economy are carried out at an operational level, in day-to-day operations, while their implementation should result from the strategy adopted by the organisation. Therefore, respondents were first asked whether a park has circular economy written into its strategy. The results of the study show that 5 parks have CE in their strategy (approximately 40%). The remainder of the respondents answered that parks had not incorporated CE principles into their development strategy (or other strategy) (Figure 1).

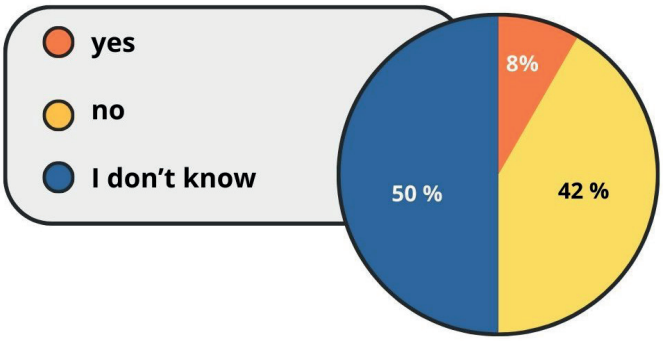
FIGURE 1. DOES THE PARK HAVE A CIRCULAR ECONOMY WRITTEN INTO ITS STRATEGY?



Source: own elaboration.

The implementation of CE principles is linked to sustainability goals. So, respondents were asked if the park is committed to meeting the stated sustainability objectives of the circular economy. One respondent gave a positive answer, indicating knowledge/awareness of the links between CE and sustainability principles, and half did not know the answer to this question. According to the remaining five respondents, the parks they manage are not committed to sustainability goals as an overriding concept in CE (Figure 2).

FIGURE 2. IS THE PARK COMMITTED TO MEETING SPECIFIC SUSTAINABILITY TARGETS FOR A CIRCULAR ECONOMY?

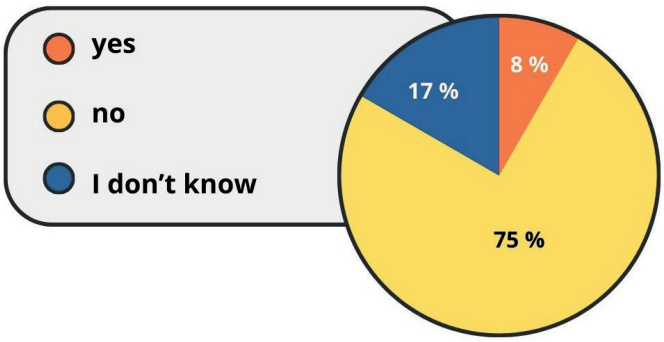


Source: own elaboration.

The answers obtained above indicate a relatively low awareness of the need to implement CE principles and thus commitment to the principles of sustainable development. The lack of CE in the strategy, which is the basic tool of strategic management, implies a lack of consideration of the requirements to adapt to the changing environment and thus a lack of use of CE as a tool for building competitive advantage. One of the factors of effective management is the process of information exchange between all decision-making levels in the organisation, their coordination, participation and involvement. On the one hand, the lack of knowledge of the commitment to the principles of sustainable development indicates deficiencies in this area. On the other hand, it represents an opportunity that parks can use to build a competitive advantage of their own, for their tenants and the region.

To support the formulation, implementation and monitoring of the CE strategy, an employee/person responsible for the development of the CE strategy in a given organisation is designated. Respondents were therefore asked whether there was a position in the park responsible for developing (practical) CE activities in the park's own operations (Figure 3).

FIGURE 3. IS THERE A POSITION IN THE PARK RESPONSIBLE FOR THE DEVELOPMENT OF (PRACTICAL) CE ACTIVITIES IN THE PARK'S OWN OPERATIONS?



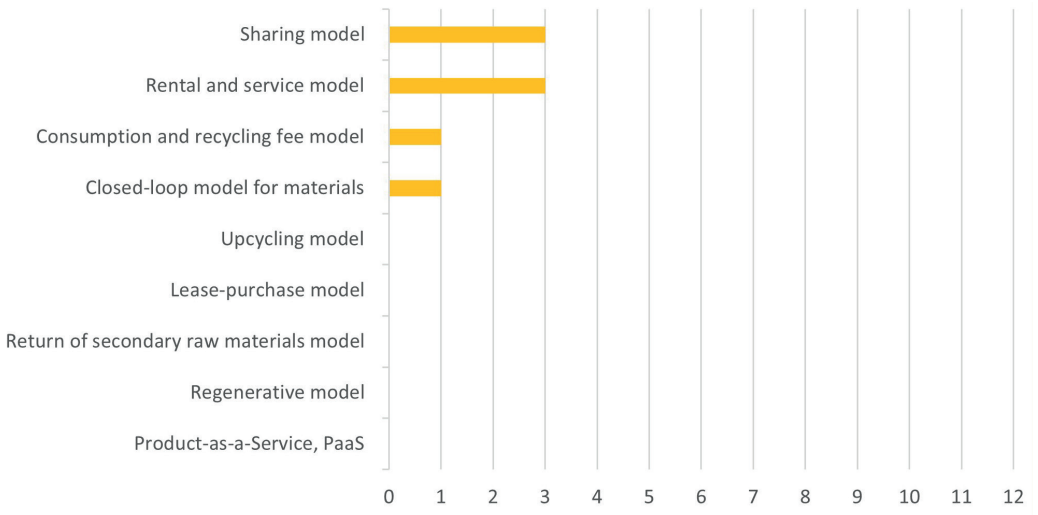
Source: own elaboration.

Only one park has a person responsible for CE both in the park's own operations and in relations with tenants/the environment. This position is present in the longest operating park, which may indicate that as a park and its operations grow, the management recognises the need for such a position. The other respondents either do not know if there is a dedicated person designated for CE activities or, as indicated by the majority of responses, there is no such position in the parks – indicating a high potential for change in this area.

In the next step, the respondents were asked whether the park promotes the implementation of a specific CE business model among its tenants. These models move away from the traditional linear "take – produce – consume – throw away" model, which generates waste and negatively impacts the environment and society. CE business models are based on closing material cycles by reusing raw materials and components. They also extend the life cycle of products through solutions such as repair, refurbishment and upgrading. In addition, they promote resource sharing between multiple users and the use of renewable energy in production processes. Considering the models listed, the respondents (they could choose more than one model) indicated promoting the rental and service model and the sharing model three times; the closed-loop model for materials and the consumption and recycling fee model was indicated once. The responses to this question suggest the implementation of CE in single activities rather than comprehensive business models, and/or a lack of familiarity with/ability to apply such a comprehensive approach (Figure 4, Figure 5).

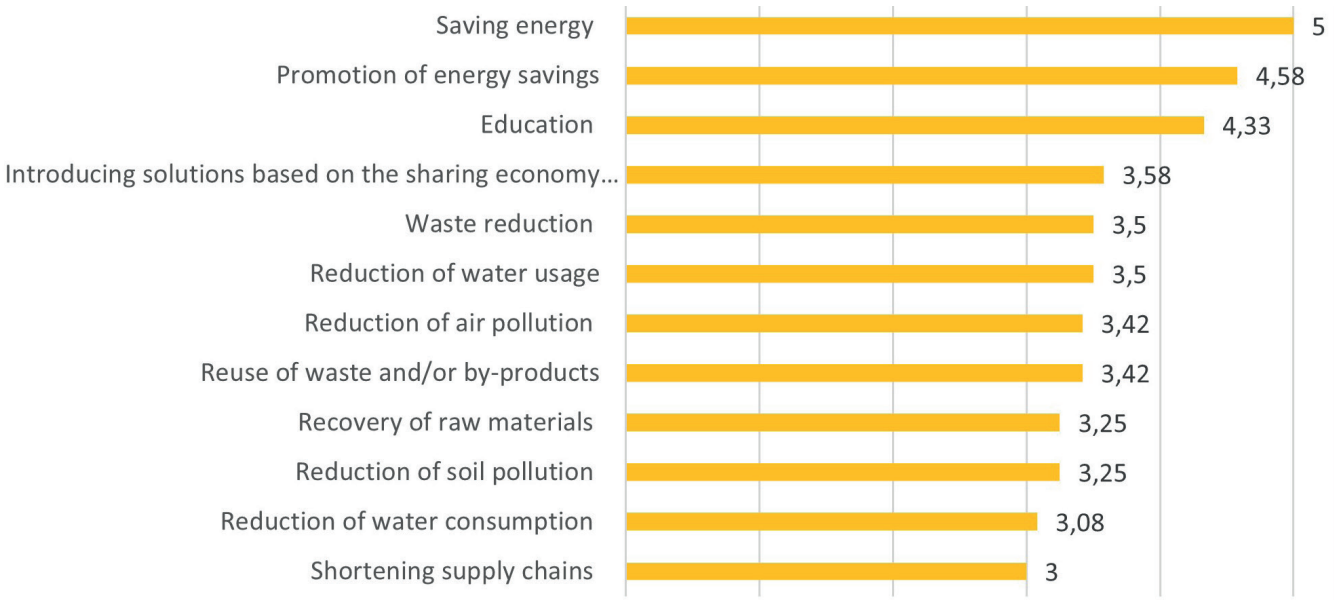
In total, the use of CE business models was indicated by five out of 12 respondents, which means that the remaining parks do not promote any CE models to their tenants. Thus, five

FIGURE 4. WHICH CE BUSINESS MODELS DOES THE PARK PROMOTE TO ITS TENANTS?



Source: own elaboration.

FIGURE 5. RELEVANCE OF SELECTED PRACTICES/PROCESSES FOR CE IMPLEMENTATION IN PARKS



Scale: 1-no importance, 2-not very important, 3-neutral, 4-important, 5-very important.

Source: own elaboration.

respondents made a total of eight indications – one park indicated that it promotes as many as three models to its tenants at the same time (sharing model, service rental model, consumption and recycling fee model), which – considering the other responses – distinguishes the park in terms of promoting CE models.

Next, the respondents were asked about the park's implementation of investments in innovative solutions that help accelerate the transition to circular economy. Such activities are undertaken by eight of 12 parks (66%). At the same time, such investments relating directly to solutions for buildings were declared by four out of 12 respondents. In the responses they mentioned the following investments :

- supporting the consumption of post-production waste,
- resource-saving solutions,
- water and sewage microinstallations,
- intelligent heat management systems,
- photovoltaic panel installations,
- equipment of the park' building with devices increasing energy efficiency.

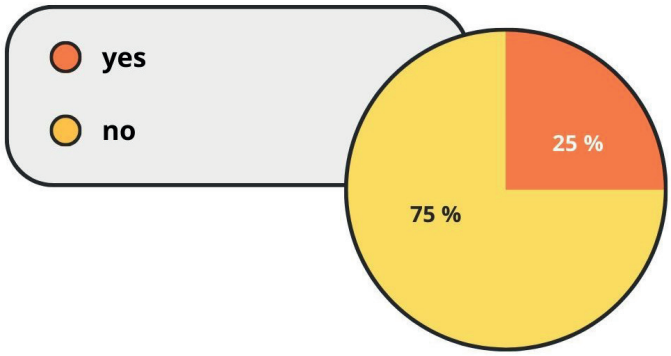
Next, respondents were asked how relevant the selected CE solutions and technologies were to the achievement of CE objectives. Using ratings on a scale of 1 (not important) to 5 (very important), based on the respondents' answers, a group of very important and moderately important CE practices for parks can be identified (Figure 5).

All the respondents (100%) indicated energy saving as a very important activity, while promoting energy efficiency was important or very important for almost 92% of the respondents surveyed (only one respondent rated this practice as neutral). Education was indicated as an important action by eight respondents and neutral for the rest. Shortening supply chains and reducing water pollution were, on average, indicated by the respondents as the least important of all the listed actions.

Effective implementation of a circular economy strategy, whether through comprehensive business models or selected CE-compliant actions, requires the formulation and use of indicators to assess the current state, monitor progress,

correct actions and communicate with stakeholders. The respondents were therefore asked whether, and what tools and indicators, the park uses to assess its progress in terms of the circular economy (Figure 6, Figure 7).

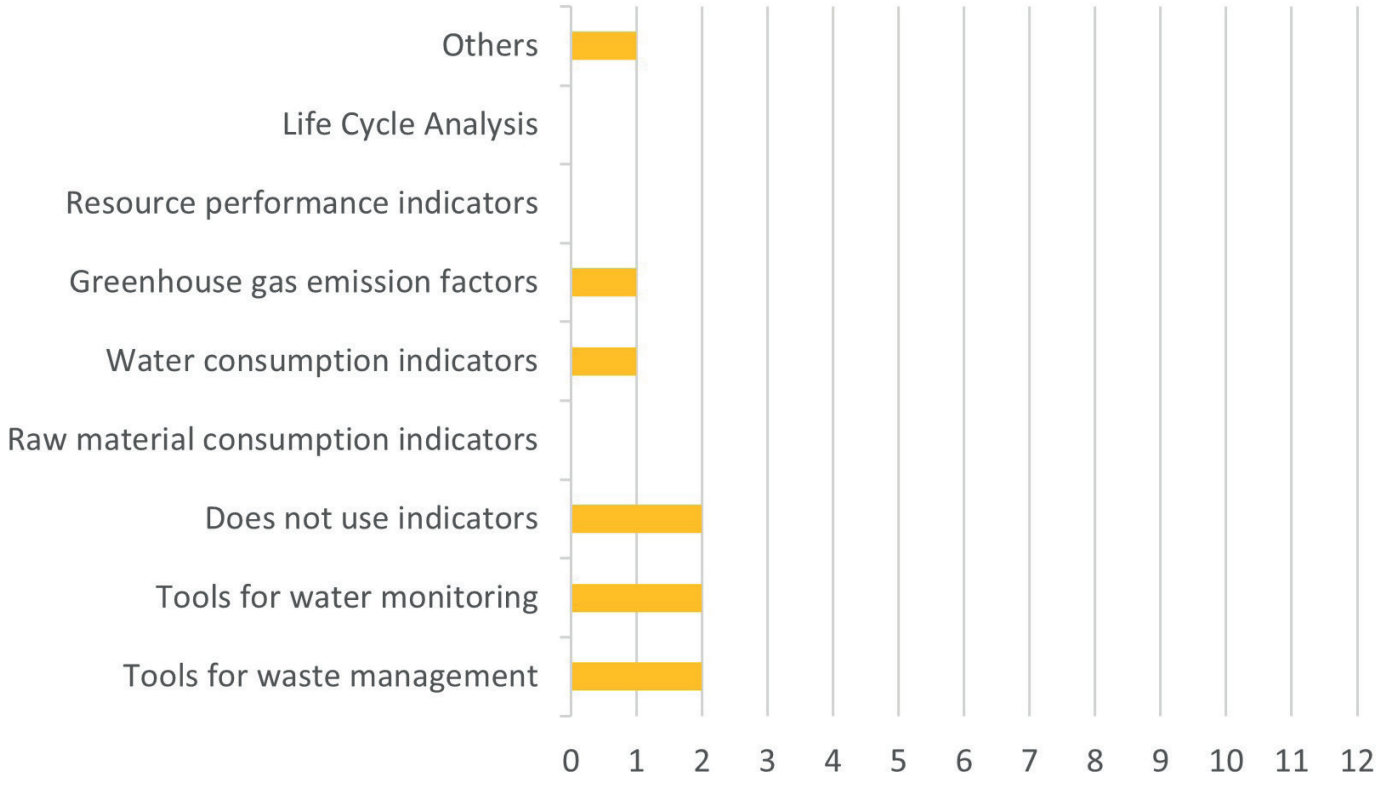
FIGURE 6. DOES THE PARK USE TOOLS AND INDICATORS TO EVALUATE ITS PROGRESS IN TERMS OF THE CIRCULAR ECONOMY?



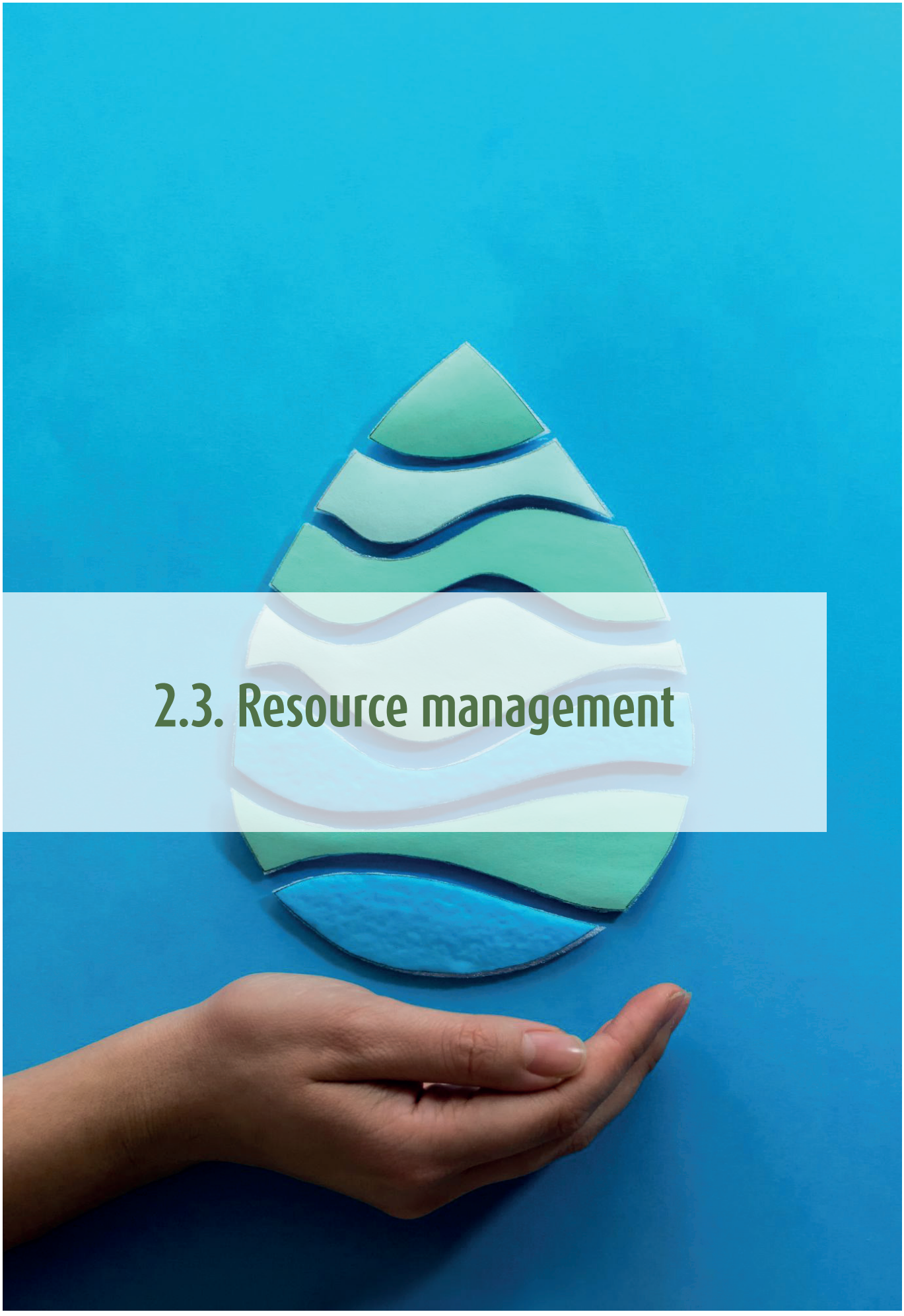
Source: own elaboration.

Only three out of nine parks measure progress in the implementation of CE. Thus, most of the parks surveyed are not able to determine the results, dynamics and scale of progress, and consequently do not have the capacity to manage these processes. Under "others", one respondent indicated energy consumption indicators and water consumption.

FIGURE 7. WHAT TOOLS AND INDICATORS DOES THE PARK USE TO ASSESS ITS PROGRESS TOWARDS A CIRCULAR ECONOMY?



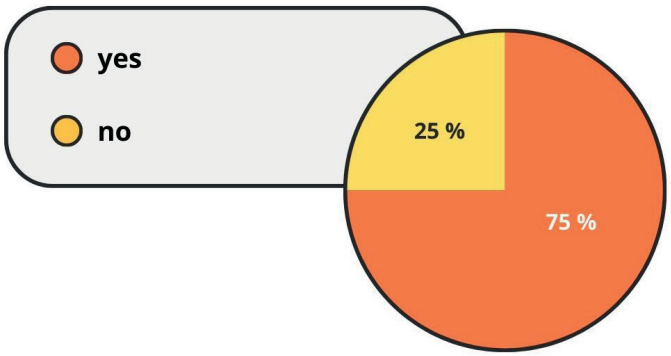
Source: own elaboration.



2.3. Resource management

The ircular economy and renewable energy sources are closely linked. Renewable energy sources (RES), such as solar, wind or geothermal energy, are a key element of CE, enabling energy production in a sustainable way, independent of fossil fuels, with reduced waste generation and improved energy efficiency. Respondents were therefore asked about the use of RES in parks (Figure 8).

FIGURE 8. DOES THE PARK USE RENEWABLE ENERGY SOURCES?

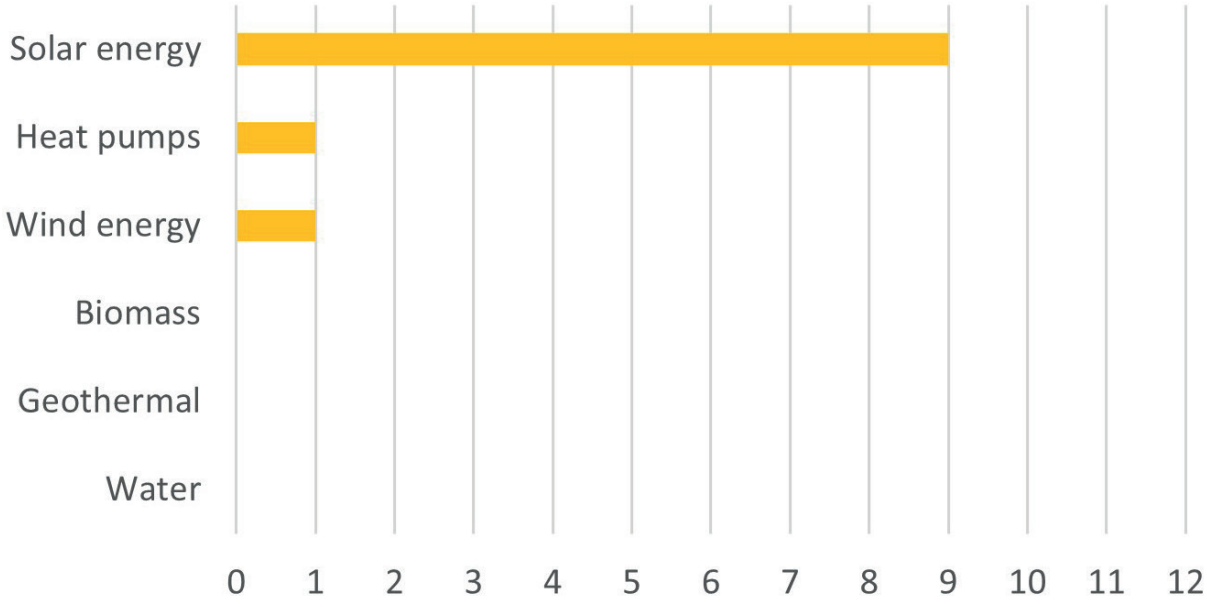


Source: own elaboration.

RES systems are used by nine out of the 12 parks surveyed (75%) and these are photovoltaic panels. One respondent, in addition to panels, indicated the use of air-to-air heat pumps and geothermal sources. Other RES sources were not indicated by the respondents. No RES solutions are used in three parks. Although the use of water requires a suitable location, i.e. proximity to and the possibility of developing surface watercourses, e.g. rivers, the reasons for the lack of use of other RES solutions require further research (Figure 9).

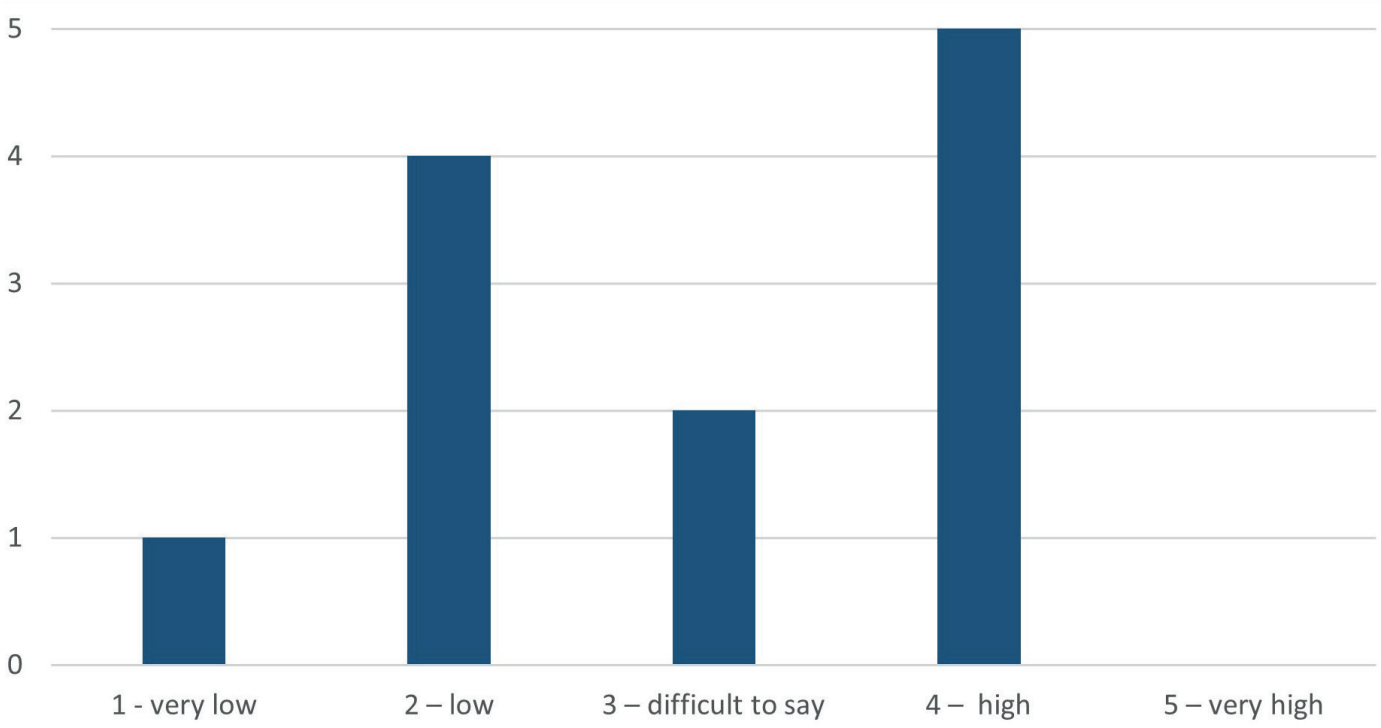
The respondents were also asked for their opinion (using a scale from 1-less important to 5-very important) at what level the park uses energy from renewable sources (Figure 10).

FIGURE 9. WHAT RENEWABLE ENERGY SOURCES DOES THE PARK USE?



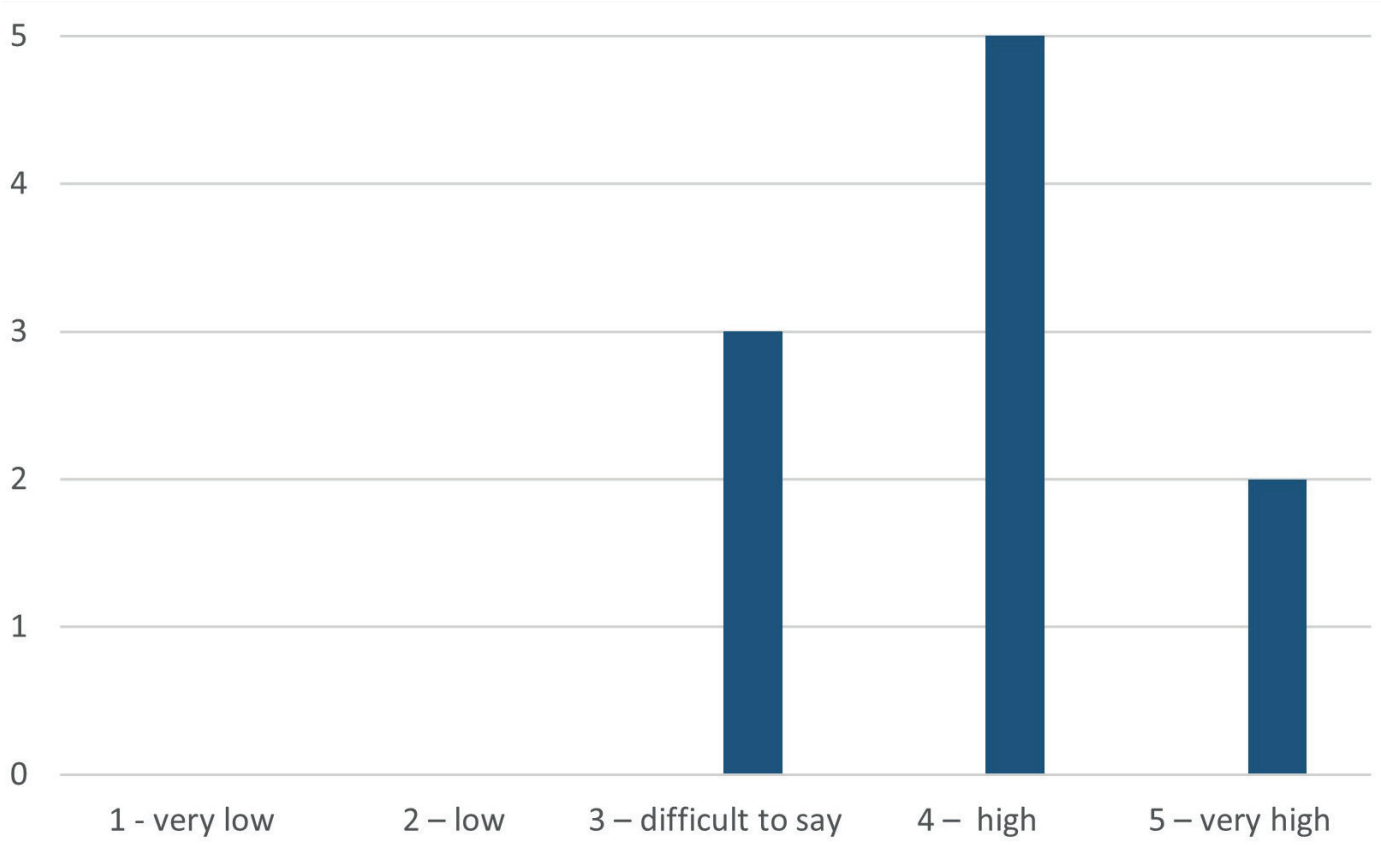
Source: own elaboration.

FIGURE 10. AT WHAT LEVEL DO YOU THINK THE PARK USES ENERGY FROM RENEWABLE SOURCES?



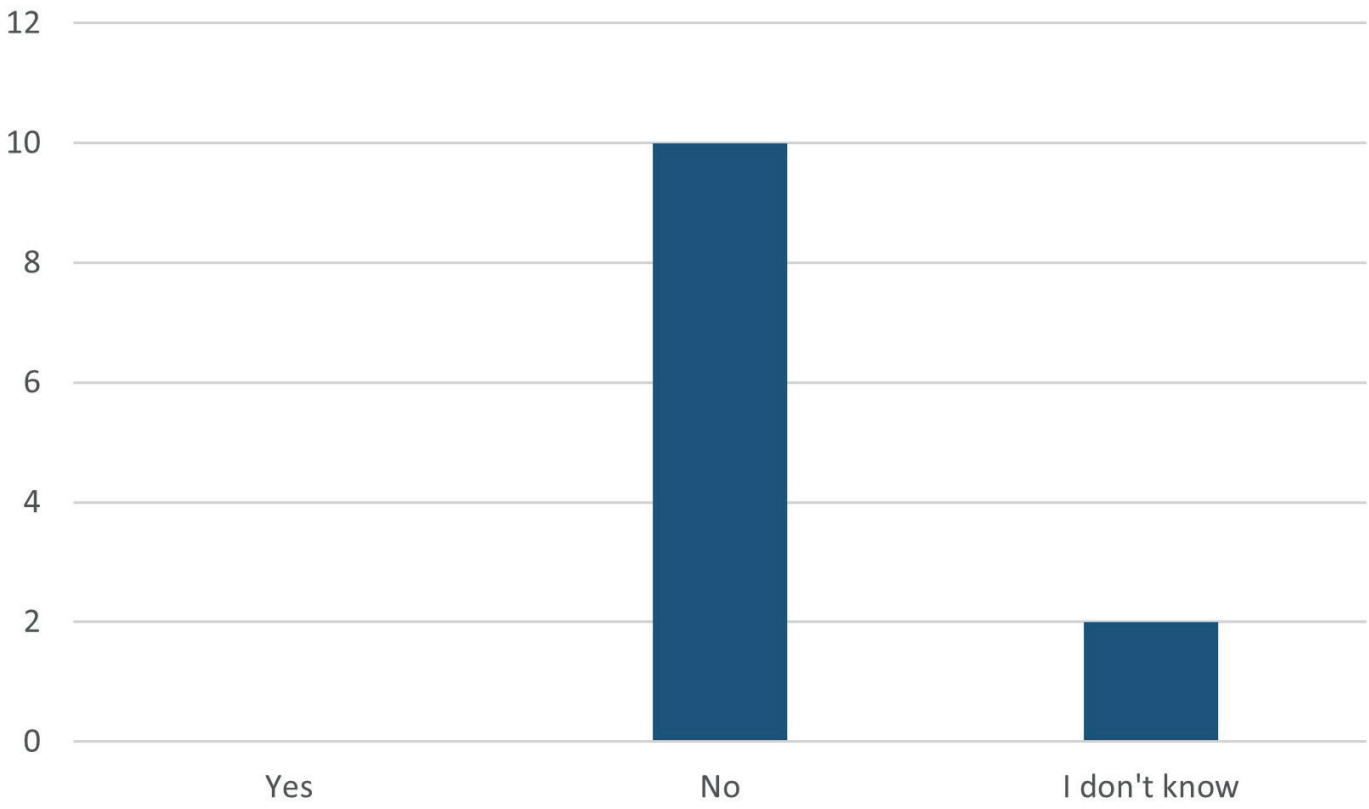
Source: own elaboration.

FIGURE 11. AT WHAT LEVEL DO YOU THINK THE PARK IS COMMITTED TO IMPROVING/ACHIEVING ENERGY EFFICIENCY?



Source: own elaboration.

FIGURE 12. DOES THE PARK HAVE SOLUTIONS FOR CLOSING THE WATER CYCLE?



Source: own elaboration.

In the opinion of the respondents, five out of 12 parks use RES at a high level. An average opinion of 2.91 together with only three RES sources indicated in the answer to the previous question lead to the conclusion that there is potential for the use of RES in parks that the respondents are aware of.

Thus, the respondents were next asked at what level in their opinion (using a scale from 1-not important to 5-very important), the park is committed to improving/achieving energy efficiency (Figure 11).

A rating of 3.92 on a scale of 1 to 5 means that on average the parks rate this commitment well. The use of energy-efficient technologies in buildings and equipment is common only in the context of the use of photovoltaic panels (in eight out of 12 parks). Other, previously unused technologies represent undoubted potential in this respect. The parks studied therefore not only have a "reserve" to increase the level of RES use in order to obtain some energy from renewable sources and thus meet the objectives related to the implementation of CE, but are also involved in activities related to improving energy efficiency.

The respondents were then asked questions about other resources the economical management of which fits into the assumptions and processes of CE implementation. The respondents were asked about the operation of solutions in the park for closing the water cycle (Figure 12).

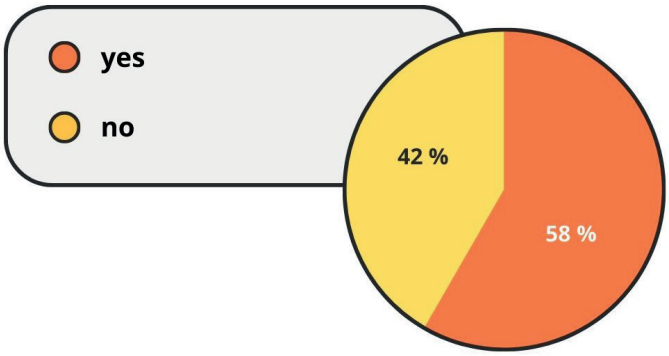
Most parks, according to the respondents (10 out of 12 parks), do not have solutions that make it possible to close the water cycle, either in the facilities (building properties) or as part of the technological processes carried out

on their premises. The respondents of the other two parks had no knowledge in this respect. Thus, the procedure for closing the water cycle is generally not used, so the potential to implement the mentioned as well as other solutions within the water cycle closure is high in the surveyed parks. The survey questionnaire indicated the following possibilities:

- water recycling (grey water management),
- water filtration,
- water purification plants,
- water disinfection,
- rainwater harvesting,
- rainwater storage,
- drip irrigation systems,
- green roof technologies,
- wastewater treatment plant construction,
- life cycle analysis,
- education.

The closed loop also applies to waste management processes. The respondents were asked about optimising material consumption (reduction / reuse / recyclables, etc.) to reduce the amount of waste generated in the park (Figure 13).

FIGURE 13. DOES THE PARK OPTIMISE THE USE OF MATERIALS TO REDUCE THE AMOUNT OF WASTE GENERATED IN ITS OPERATIONS?



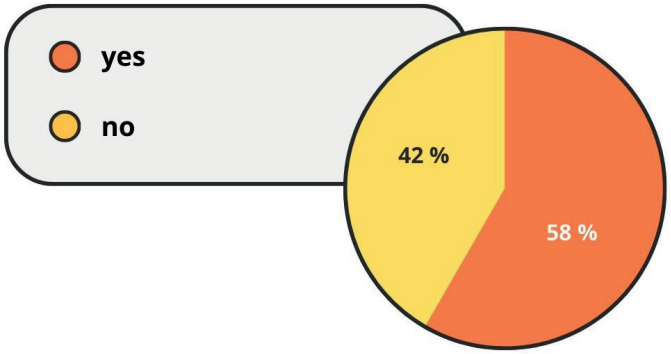
Source: own elaboration.

The majority (seven out of 12 parks) carry out optimisation activities in the consumption of materials and raw materials. Thus, as in the case of water, the lack of action in this area means that the potential that exists in the parks and the areas they manage is significant but untapped. This potential is all the greater in that even the parks that are already implementing solutions in, for example, minimising waste or extending the life cycle of products, can achieve better results by developing innovations in this area.

2.4. Cooperation with stakeholders

Successful transformation towards a circular economy depends on the involvement of different stakeholder groups. Implementing CE changes and principles in a park requires good relationships based on trust and shared sustainability goals, which in turn is conditioned by effective communication and involvement. Thus, the respondents were initially asked whether parks engage their tenants in CE initiatives (Figure 14).

FIGURE 14. DOES THE PARK INVOLVE ITS TENANTS IN CIRCULAR ECONOMY INITIATIVES?



Source: own elaboration.

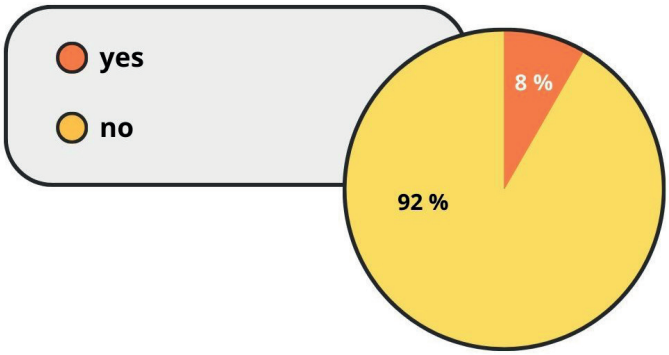
More than half of the parks, according to the respondents' answers (seven out of 12), engage in initiatives related to CE. As examples of the initiatives, the respondents mentioned informational and educational events, as well as initiatives in the form of specific solutions supporting CE:

- conferences (e.g. annual ECO ON conference at the GPNT in Gdansk, dedicated to eco-efficient technologies);
- trainings, meetings, webinars,
- interactive container for clothes collection,
- containers for segregated waste.

In other words, more than half of the parks surveyed, through the organisation of various interesting initiatives, play an important role in both informing about, moderating and engaging in the dissemination of CE principles. The potential to engage tenants is high, as both the parks that are already active in this area and those that are not yet, can inspire each other to implement similar activities and thus fill the gap in their activities.

Education and information initiatives are not only related to promoting CE, but are also a tool to inform tenants that the park can support them in CE. The respondents were therefore asked whether, to their knowledge, tenants come to the park with problems/challenges in implementing circular economy practices (Figure 15).

FIGURE 15. TO YOUR KNOWLEDGE, DO TENANTS COME TO THE PARK WITH PROBLEMS/CHALLENGES IN IMPLEMENTING CIRCULAR ECONOMY PRACTICES?

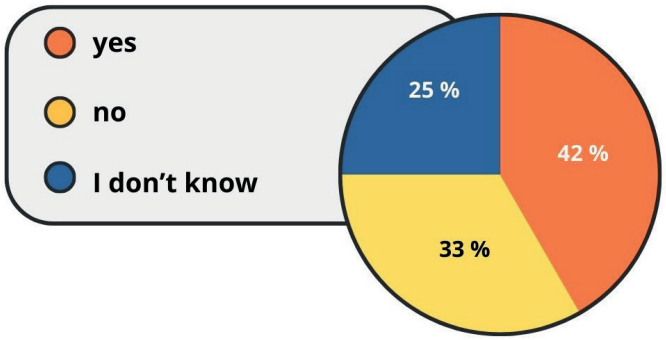


Source: own elaboration.

Only one respondent indicated that a tenant reported problems – in this case regarding high electricity prices. A possible reason for this situation is the low level of monitoring of CE progress (only three out of 12 entities use selected indicators and monitoring tools). At the same time, five out of 12 respondents indicated that the park takes action in response to problems/challenges in CE reported by the park tenants (Figure 16).

Thus, regardless of the lack of supporting management tools (tools and indicators for monitoring progress in CE), there is initiative on the part of parks – some parks are proactive in addressing tenant reports of problems/issues related to CE.

FIGURE 16. IN YOUR EXPERIENCE, DOES THE PARK ACT IN RESPONSE TO PROBLEMS/ CHALLENGES IN THE CONTEXT OF CE REPORTED BY THE PARK TENANTS?



Source: own elaboration.

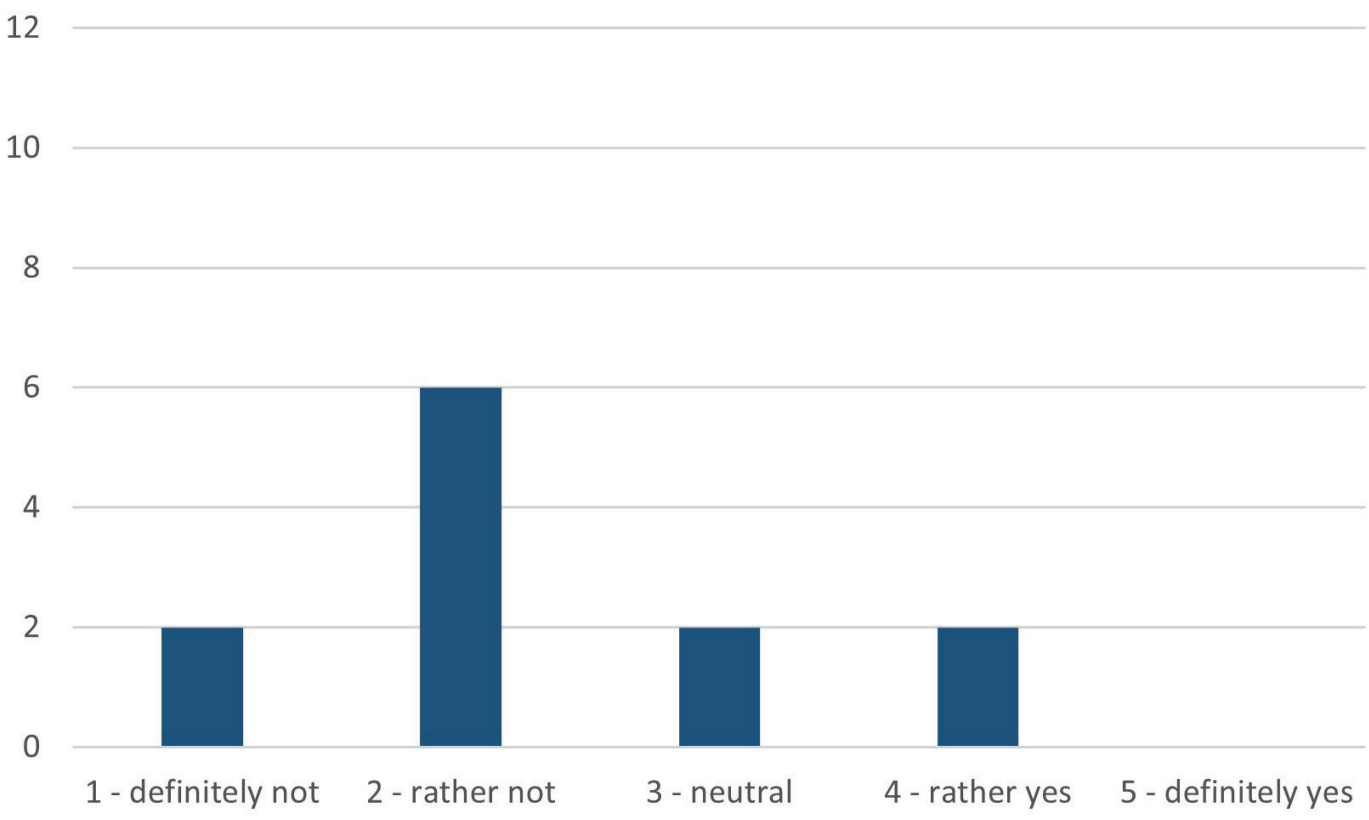
The respondents were also asked whether, in their opinion, the park has a tenant selection policy regarding the manner and scope in which CE practices are implemented (Figure 17).

An average response score of 2.33 indicates that the parks are not guided in their tenant selection policy by their CE experience. As a follow-up, the respondents were asked what sectors of business (looking at tenant selection) were and are particularly important, taking into consideration CE activities within the park. The respondents mentioned the following sectors:

- energy and eco-energy,
- RES and sustainable technologies,
- recycling, upcycling and waste management,
- innovation and environmental sector,
- food production,
- lighting manufacturing,
- automotive,
- chemicals.

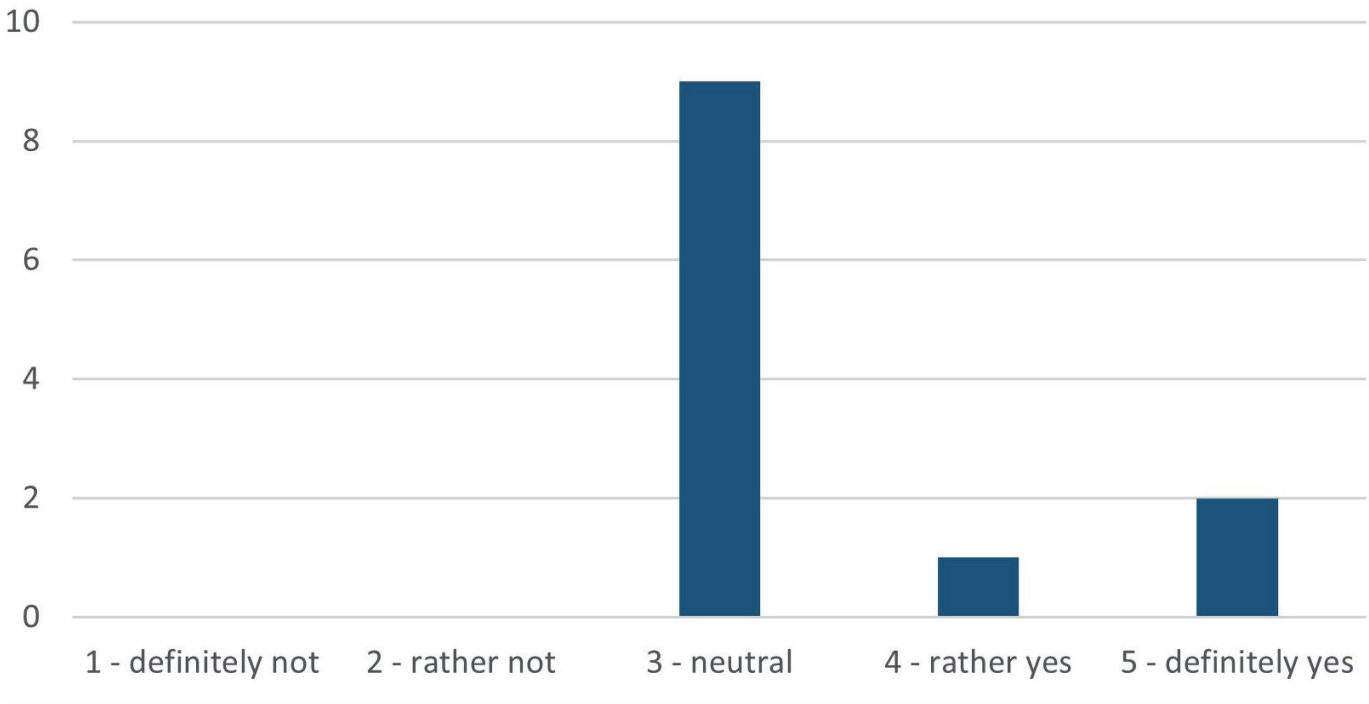
The responses were dominated by sectors related to environmental protection and energy

FIGURE 17. TO WHAT EXTENT DO YOU THINK THE PARK HAS A TENANT SELECTION POLICY TAKING INTO CONSIDERATION HOW AND TO WHAT EXTENT CE PRACTICES ARE IMPLEMENTED?



Source: own elaboration.

FIGURE 18. CAN A PARK'S COMMITMENT TO DEVELOPING A CIRCULAR ECONOMY ATTRACT NEW TENANTS?



Source: own elaboration.

(renewable). At the same time, five parks did not answer the question or wrote "not applicable" or pointed to the specific nature of the park, referring to their tenants and indicating that they are small entities that generate mainly municipal waste.

A park's relationship with stakeholders in implementing CE also applies to potential tenants. Given the need to meet sustainability goals as well as the potential that parks have to accommodate additional tenants, the respondents were asked whether a park's commitment to the development of a circular economy can attract new tenants (Figure 18).

The average rating of 3.42 for the question on the effectiveness of a park's commitment to CE in attracting new tenants indicates that the respondents consider this a rather neutral factor. At the same time, none of the respondents indicated negative responses, and two responses were strongly supportive of the importance of a park's commitment to CE to attracting new tenants, so CE-related criteria are treated at least neutrally.

Next, the respondents were asked about marketing/promotional activities on the part of a park that are/would be the most effective in attracting a CE-directed tenant. The respondents mentioned:

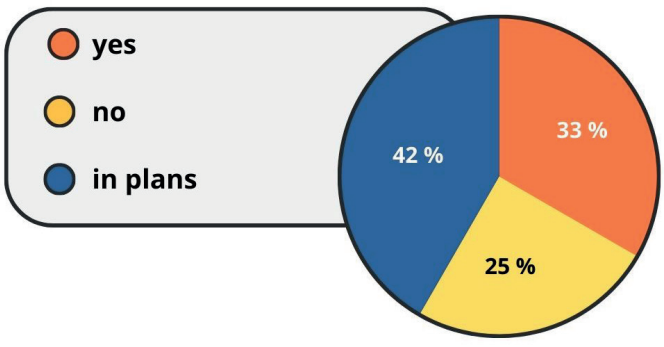
- an incubation project for startups implementing a product/service within CE,
- promotion of CE in relation to tenants from the broadly defined sectors of chemistry, biotechnology, environmental protection,
- promotion of acceleration for CE-oriented tenants,
- waste segregation,
- bicycle racks, promotion of public transport,
- flower meadows in green areas,
- printing on recycled paper and reducing the production of advertising gadgets,
- abandoning plastic and PET packaging at events,
- use of solar panels,
- use of photocell lighting in common areas,
- promotion of good practices,
- thematic competitions,
- social media marketing campaign,
- promotional spots,

- webinars, training, information meetings,
- possibility of interacting with the local research community in the sphere of CE.

The indicated activities can be divided into three types: actions targeting projects/tenants whose activities are directly related to environmental protection, selected activities in line with/implementing CE, and information and education activities. The respondents also indicated that only in one park is there a dedicated position/person responsible for developing (practical) CE activities in relation to the environment/stakeholders/tenants.

Park stakeholders include entities from the closer and further environment. A park plays an ancillary role to them, promoting innovation, entrepreneurial attitudes, as well as CE principles. The respondents were therefore asked whether, in their opinion, the park collaborates with other organisations in order to promote the circular economy at a regional or national level (Figure 19).

FIGURE 19. DOES THE PARK COLLABORATE WITH OTHER ORGANISATIONS TO PROMOTE THE CIRCULAR ECONOMY AT A REGIONAL OR NATIONAL LEVEL?

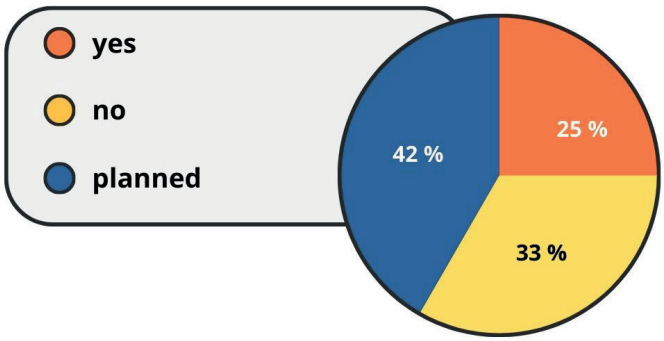


Source: own elaboration.

Such cooperation is carried out by four out of 12 parks and five are planning to do so. To date, the parks cooperate with such institutions as: European Digital Innovation Hubs (EDIH) – especially those focused on CE, city halls, marshal's offices and government administration – in thematic areas related to CE. The cooperation takes different forms, starting with the implementation of joint programmes, through the organisation of conferences or participation in teams promoting CE and joint information platforms.

Next, the respondents were asked whether the park initiates cooperation with local authorities within the scope of the circular economy (Figure 20).

FIGURE 20. DOES THE PARK INITIATE COOPERATION WITH LOCAL AUTHORITIES WITHIN THE CIRCULAR ECONOMY?



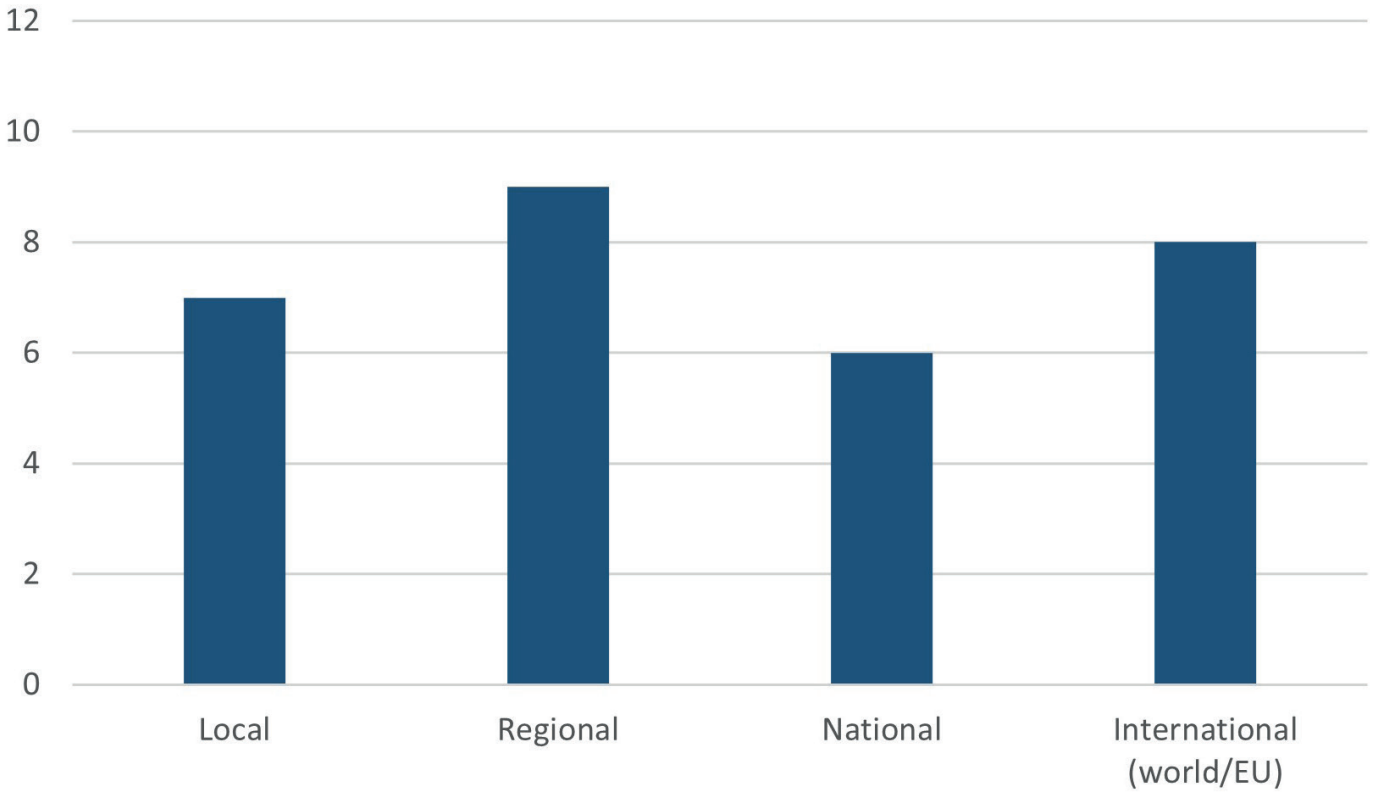
Source: own elaboration.

For example, the Kraków Technology Park is participating in the Climate Package Council of the Kraków City Hall in a project concerning the creation of the Positive Energy District (PED) and the Małopolska Regional Group for the Development of Hydrogen Technologies. The Elbląg Technology Park is involved in a project called Green Up, Sztum Circular Economy, EPT Demonstratorium, related to the CE concept. A park from Olsztyn participates in an initiative in the form of an Energy Cluster bringing together units of the Olsztyn Municipality. These examples demonstrate the diverse opportunities of cooperation with local authorities.

Finally, the respondents were asked about the range of the park's activities in terms of relations with various external entities (Figure 21).

The respondents could indicate several answers to this question. They most often indicated regional coverage, followed by international, local and national coverage.

FIGURE 21. THE RANGE OF THE PARK'S ACTIVITIES WITHIN THE SCOPE OF ITS RELATIONS WITH VARIOUS EXTERNAL ENTITIES

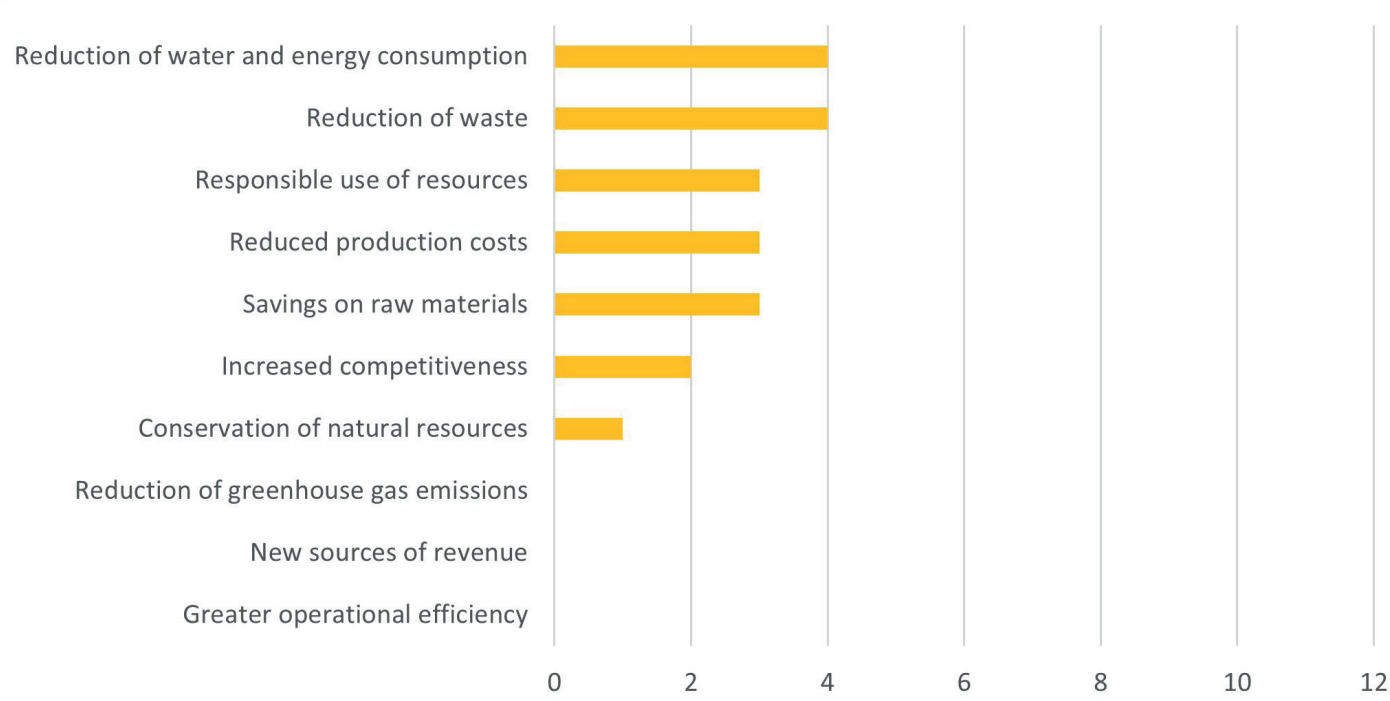


Source: own elaboration.

2.5. Financial and non-financial incentives

The implementation of CE business models brings numerous benefits from their implementation, both for the companies themselves but also for the environment. The respondents were asked for their opinion on the existence of these benefits for tenants implementing CE principles (Figure 22).

FIGURE 22. WHAT ARE THE FINANCIAL AND ENVIRONMENTAL BENEFITS FOR PARK TENANTS THAT IMPLEMENT BUSINESS MODELS BASED ON THE CIRCULAR ECONOMY?

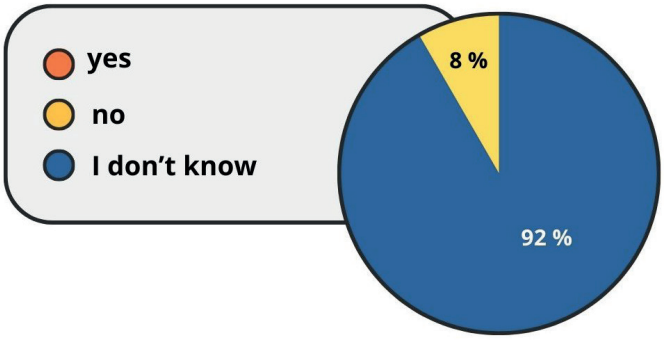


Source: own elaboration.

The respondents, given the opportunity to select multiple answers, most often cited the benefits of reduced waste and reduced water and energy consumption. This benefit directly contributes to lower operating costs, which is the main motivation for the interest in CE solutions. Three respondents pointed to a further three benefits: responsible use of resources, reduced production costs and saving of raw materials. Increased competitiveness was only indicated twice and environmental protection – once. Thus, in the opinion of the respondents, the implementation of CE principles is not a key determinant of company success. Not a single indication was given to suggested benefits related to increased operational efficiency, new sources of revenue or reduction of greenhouse gas emissions. At the same time, five out of 12 respondents indicated that tenants implementing CE business models do not benefit in any way, either financially or even environmentally. There is a huge potential in this area related to the need to make tenants aware that CE procedures are not only about cost savings, but also about the potential of revenues realised through higher competitiveness, a better image and access to "green" financing.

Since, in the opinion of the respondents, the application of CE principles is not associated with financial benefits, the question was asked whether the park offers programmes of financial support or tax relief for tenants implementing CE solutions (Figure 23).

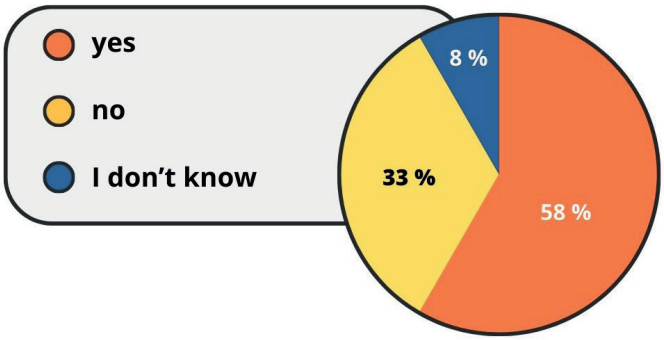
FIGURE 23. DOES THE PARK OFFER PROGRAMMES OF FINANCIAL SUPPORT OR TAX RELIEF FOR TENANTS IMPLEMENTING CE SOLUTIONS?



Source: own elaboration.

The parks analysed do not offer direct financial support to tenants implementing CE. However, they do offer support of a non-financial nature – mainly education and information support, which could indirectly allow tenants to realise financial benefits (Figure 24).

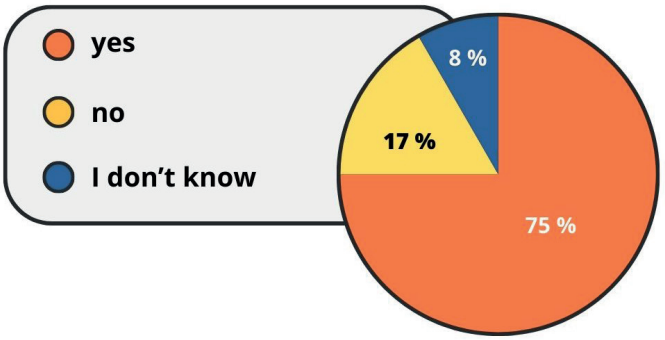
FIGURE 24. DOES THE PARK OFFER SUBSTANTIVE SUPPORT IN TERMS OF THE CIRCULAR ECONOMY FOR ITS TENANTS?



Source: own elaboration.

Content-related support, although not directly related to financial benefits, is aimed at supporting activities that may ultimately bring such benefits. For example, raising awareness of CE processes and related business models, relates not only to spending on environmental infrastructure, but is associated with generating savings, improving the image and increasing entrepreneurship, which ultimately translates into tangible financial benefits. Among activities of an educational nature, parks organise training for tenants (Figure 25).

FIGURE 25. DOES THE PARK ORGANISE EVENTS OR TRAINING ON THE CIRCULAR ECONOMY?

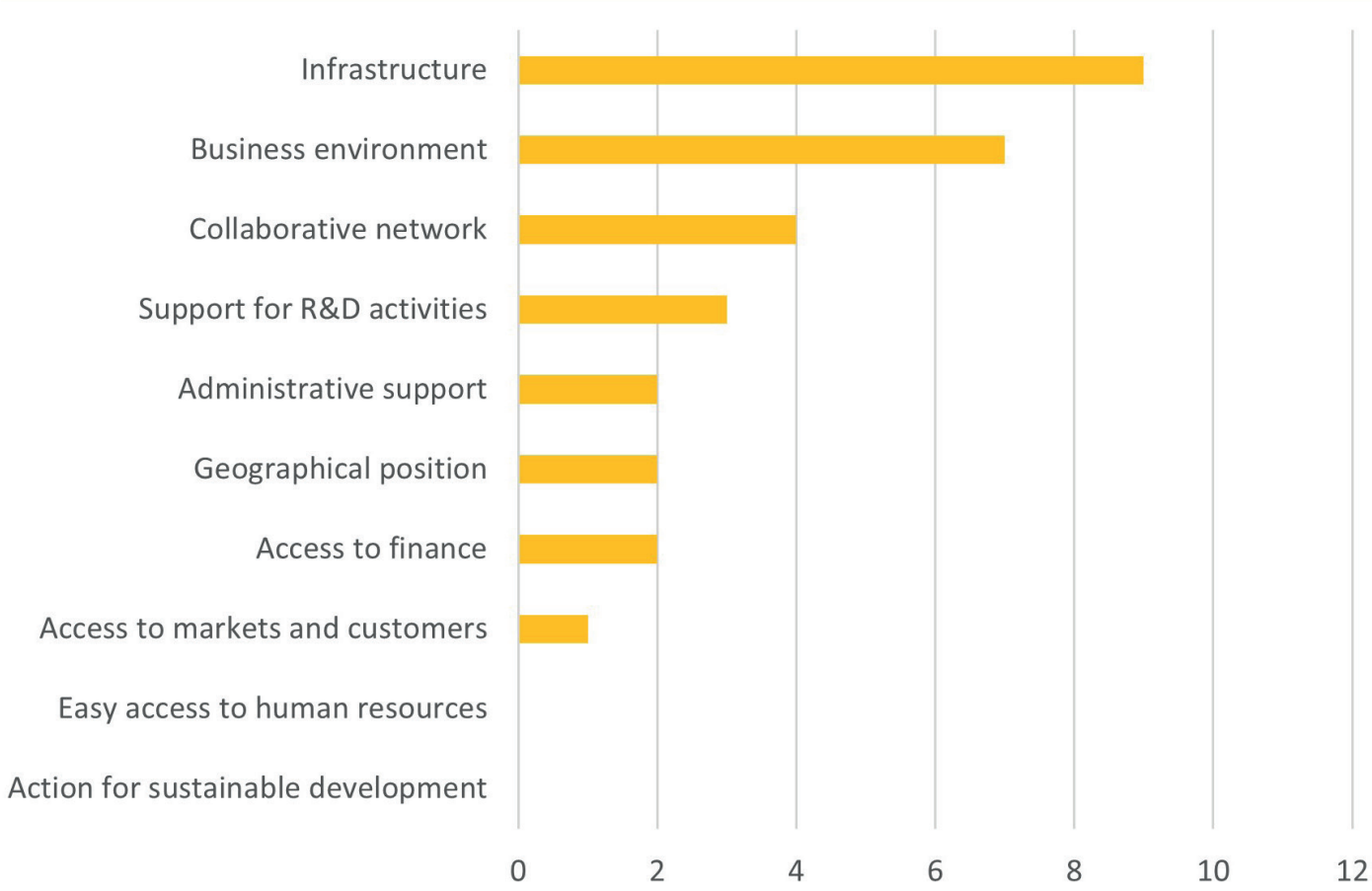


Source: own elaboration.

The respondents indicated that nine out of 12 parks organise CE training for tenants. Events, training and otherwise, can be the park's advantage for a current or future tenant, as they increase the competitiveness of the tenant. The respondents were therefore asked what they thought was the greatest advantage for tenants (Figure 26).

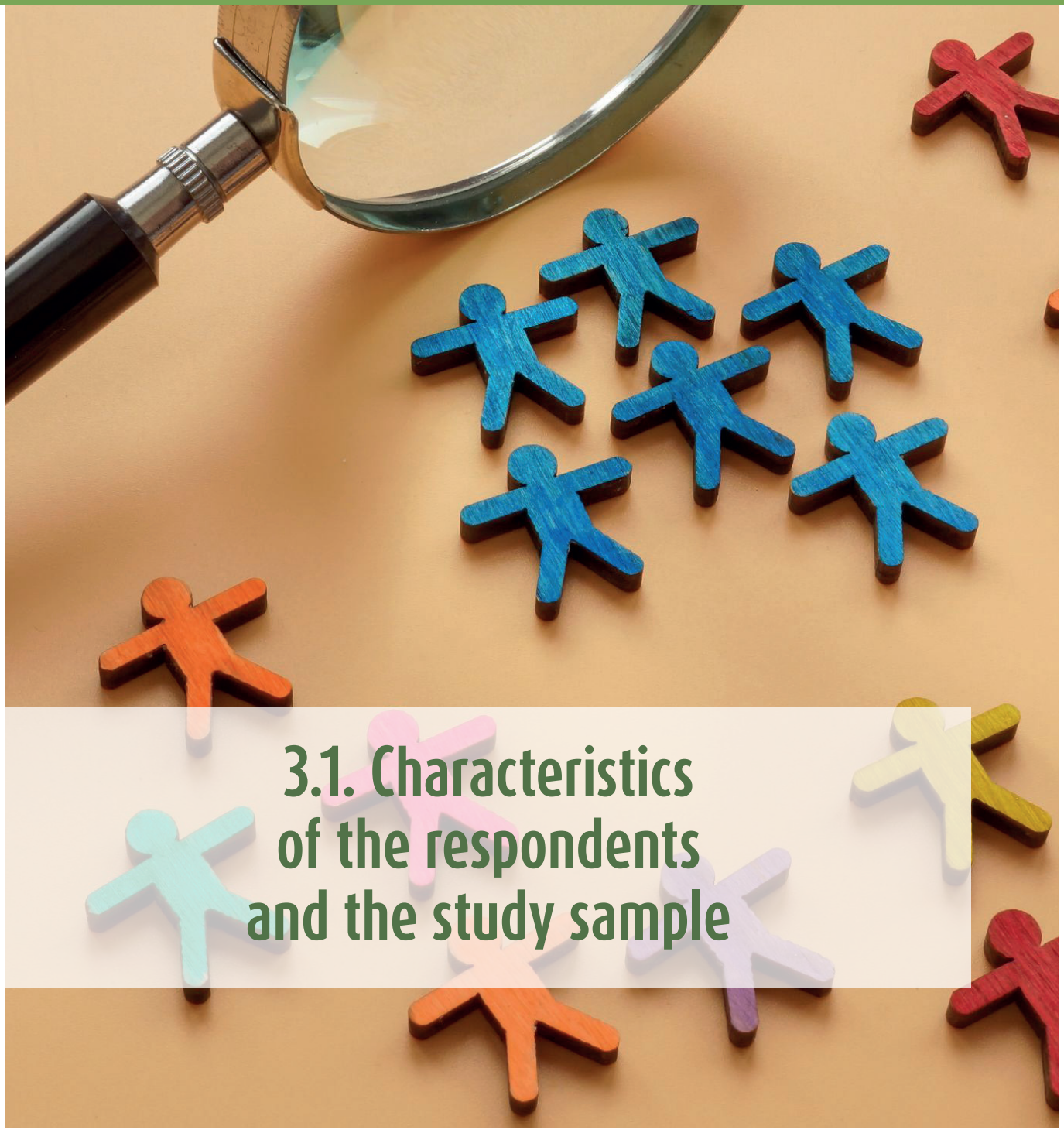
The respondents, who on average indicated three factors each, most frequently indicated infrastructure and business environment. They were followed by collaborative network and support for R&D activities. Administrative support, geographical position and access to finance were indicated twice; access to markets and customers was indicated once. The respondents were given the opportunity to indicate "other" factors – but there were no such indications. The lack of indications for sustainability, among others, is noteworthy. Thus, at the current level of awareness of sustainability, this aspect is not, in the opinion of the respondents, a key advantage of the park.

FIGURE 26. WHAT IS THE PARK'S GREATEST ASSET FOR TENANTS?



Source: own elaboration.

3. Recognition of Procedures and Processes to Support the Circular Economy and Green Transformation – the Tenants' Perspective

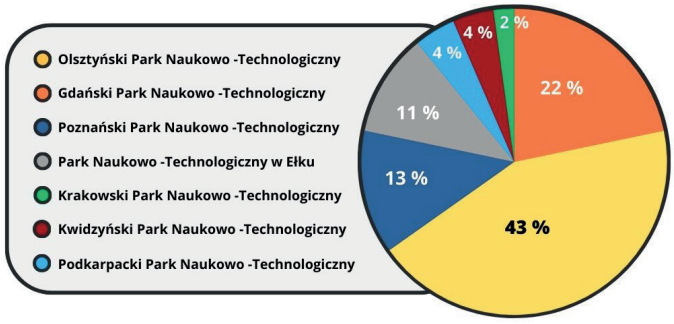


3.1. Characteristics of the respondents and the study sample

A questionnaire survey addressed to tenants was completed by the respondents representing residents of seven science and technology parks classified as SIT (science, industry, technology) parks. The parks are in various parts of Poland; both parks and tenants are diverse in many respects, in particular in terms of the period of activity and the subject (industry) of activity. The words "tenants" or "respondents" will hereinafter refer to tenants participating in the study.

In the Olsztyn Science and Technology Park (OPNT) (20 respondents) and in the Poznań Science and Technology Park (PPNT) (6 respondents) there is significant industry diversity. There are companies from many different sectors. In the Gdansk Science and Technology Park (GPNT) (10 respondents) tenants are mainly IT, marketing and other companies operating mainly in leased office space and laboratories. In the Science and Technology Park in Ełk (5 respondents) companies represent the IT, energy and transport sectors. Podkarpacki Park Naukowo-Technologiczny and Kwidzyński Park Przemysłowo-Technologiczny were represented by two tenants each. The last analysed location is the Kraków Technology Park (KPT), where answers were provided by one tenant from the automotive industry, characterised by a large scale of operations. From the seven above-mentioned parks, correctly filled-in questionnaires were obtained from 46 tenants (Figure 27).

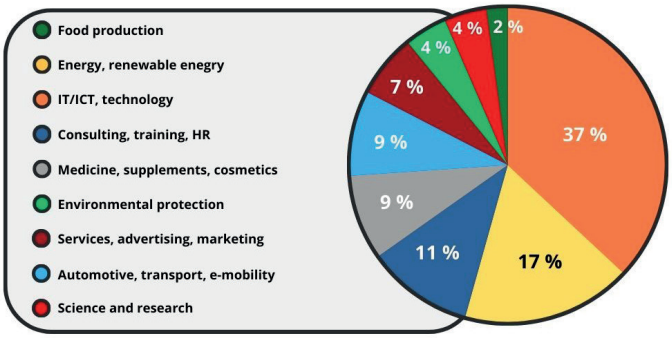
FIGURE 27. STRUCTURE OF TENANTS BY LOCATION



Source: own elaboration.

More than half of the companies surveyed (25 companies, 54%) are in two sectors: IT/ICT and the energy sector, which is indicative of the leading trends in the business of science, industry and technology parks. The next largest sector of tenants participating in the survey is the "consulting, training, HR" sector (5 companies, 11%). This is followed by "medicine, supplements, cosmetics" and the "automotive, transport and e-mobility" sector (4 surveyed companies each – 9%). Three representatives of the "services" sector, two representatives of the "environmental protection" sector and the "science and research" industry should also be mentioned. Only one entity was involved in the food production industry. The structure of the tenants participating in the survey indicates a significant concentration in the IT sector, i.e. activities carried out in an office space. Industries requiring specialised premises were less frequently represented in the study, which results from both the specifics of the parks and the tenants themselves (Figure 28).

FIGURE 28. SECTOR STRUCTURE OF TENANTS

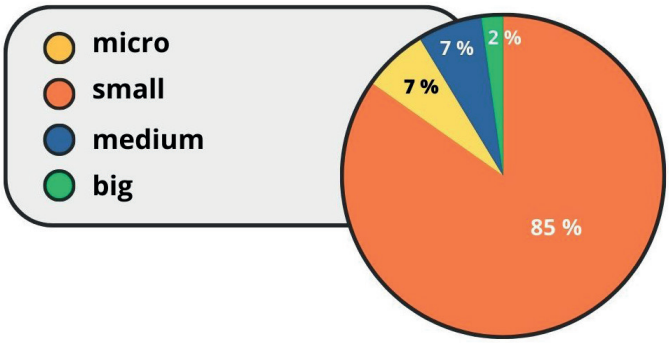


Source: own elaboration.

The largest proportion of the participants in the survey are microcompanies (39, nearly 85%). Three companies (6.5%) are medium-sized companies, and three companies are small and one is large. The tenants from the GPNT who took part in the survey represented exclusively microcompanies, the tenants from the PPNT are representatives of micro, small and medium companies, while one company from the

KPT is a large enterprise. The largest number of microcompanies that took part in the survey came from Olsztyn (Figure 29).

FIGURE 29. STRUCTURE OF TENANTS BY SIZE



Source: own elaboration.

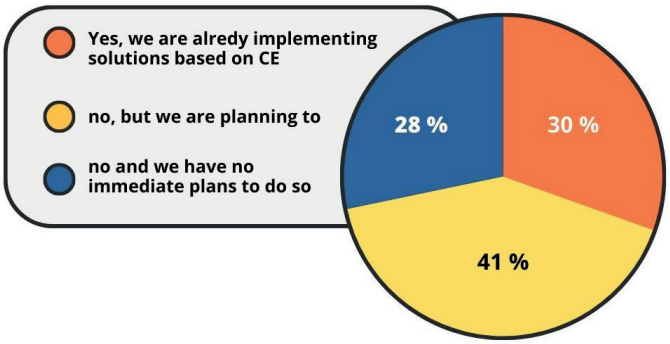
The age structure of the parks' tenants varies. The shortest-operating companies are in Gdansk – the average age of tenants in the GPNT is nearly 3.5 years. The longest-established companies are in Poznan – the average age of tenants in the PSTP is over 21 years, which results from the fact that the PPNT itself was established in 1994, so it is 30 years old. In the Kwidzyn park, the average age of tenants is 18.5 years. The average tenant from the Kraków park is about 7 years old. The average age of tenants from the park in Elk is nearly 10 years. Tenants in the Podkarpackie park have an average age of 6.5 years, and those located in the park in Olsztyn have an average age of 5.5 years. The average age of all the surveyed tenants from the analysed locations is just over 8 years.

3.2. Strategic management

In the context of strategic management, the implementation of circular economy principles should be part of the long-term planning and development of companies. An analysis of tenants' attitudes towards the implementation of CE practices makes it possible to assess the degree of awareness and readiness of organisations to adapt to changing market and regulatory conditions. Even a survey of selected tenants provides valuable information on the current status and future plans for implementing circular economy solutions, which has important implications for the formulation of overall strategies for both tenants and parks as a whole.

Fourteen respondents (30%) positively answered the question whether the tenant is implementing or intends to implement circular economy practices. Nineteen (41%) companies answered that they are not currently implementing them, but are planning to do so; thirteen (28%) – that they are not implementing them and are not planning to do so. Thus, it can be concluded that as many as 70% of responding tenants are not currently implementing CE practices, while this percentage will be decreasing due to both planned implementations and current trends (Figure 30).

FIGURE 30. IS YOUR COMPANY IMPLEMENTING OR PLANNING TO IMPLEMENT CLOSED-LOOP ECONOMY PRACTICES?

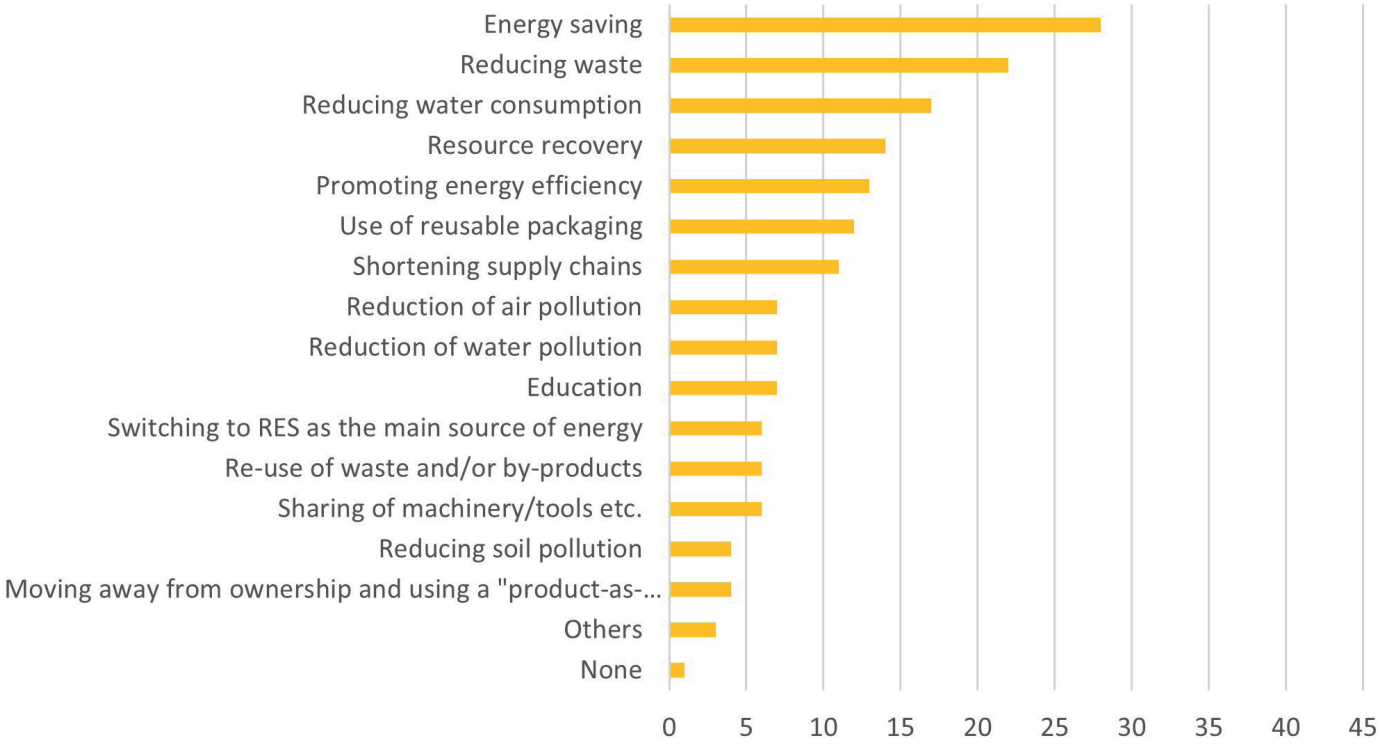


Source: own elaboration.

3.3. Resource management

An analysis of specific actions taken by tenants within the circular economy makes it possible to assess the degree of sophistication and prioritisation of various aspects of sustainable resource management. A survey of tenants makes it possible to identify the solutions most frequently used (Figure 31).

FIGURE 31. WHAT PRACTICES IN THE CONTEXT OF A CIRCULAR ECONOMY DOES YOUR COMPANY IMPLEMENT OR INTEND TO IMPLEMENT AS PART OF ITS OPERATIONS?

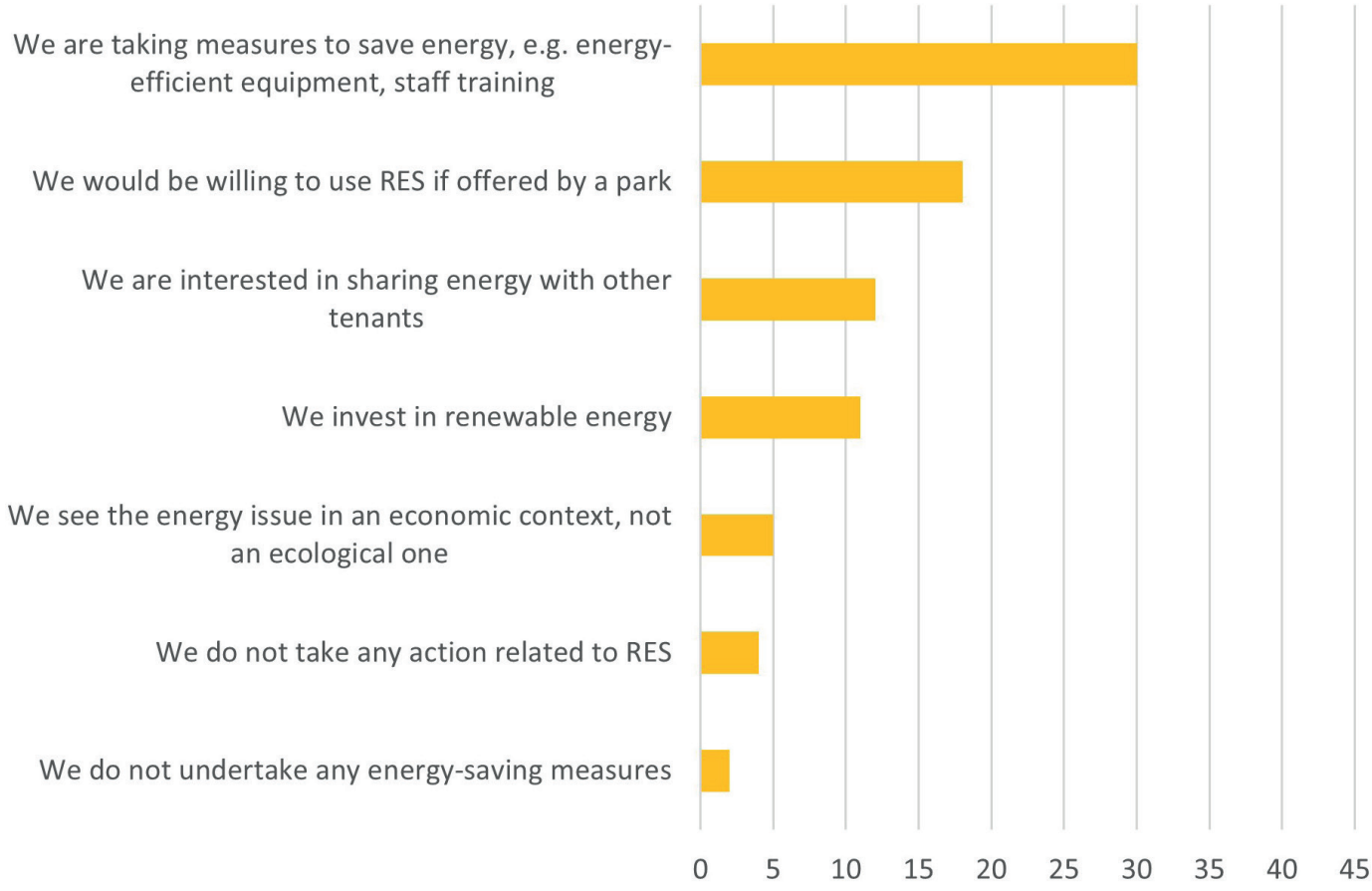


Source: own elaboration.

In this question, the tenants were able to indicate multiple answers. Out of 167 total responses, the largest number related to actions in energy savings and waste reduction (28 and 22 responses, respectively – corresponding to 61% and 41% of respondents). These two areas therefore represent the most popular circular economy practices. This is followed by reducing water consumption (17 out of 46 companies – 37%) and recovering raw materials (14 out of 46 companies – 30%). Promoting energy efficiency and the use of reusable packaging (13 and 12 responses 26% and 28% of tenants, respectively) are other areas in which the tenants are relatively active. Less than a quarter of the responses are related to shortening supply chains (11 responses). These solutions are slightly more difficult to implement, which may be the reason for the fewer responses. Other measures received fewer responses, which may also be due to the lack of relevance of the practice to the business. Not every company surveyed pollutes water and soil or generates significant amounts of recyclable waste.

In the context of business energy efficiency, the analysis of companies' attitudes towards energy provides valuable information on energy awareness, the energy-saving measures taken and the willingness to implement renewable energy solutions. The results of the survey allow an assessment of the degree of tenant engagement with energy issues and the identification of potential areas for further development and collaboration within the SIT park ecosystem. The respondents were asked about their approach to a key resource, namely energy (Figure 32).

FIGURE 32. WHICH OF THE FOLLOWING STATEMENTS BEST ILLUSTRATES YOUR COMPANY'S APPROACH TO ENERGY?

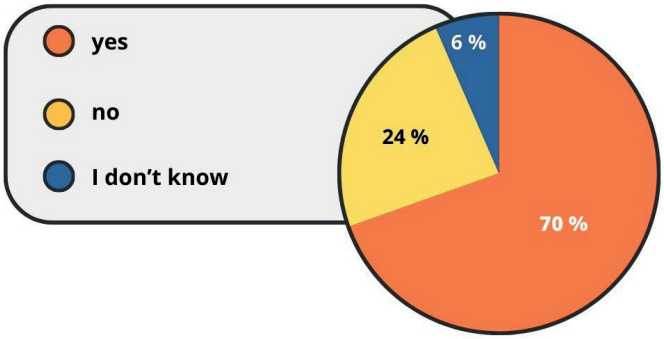


Source: own elaboration.

The largest number of responses – 30 – was given for activities in the form of staff training or purchase of energy-efficient equipment. The companies surveyed would be willing to use RES if the park in which they are located offered this possibility (18 responses). Slightly fewer, 12, indicated that they were interested in sharing energy in cooperation with other tenants. These responses indicate that companies in the parks mostly want to act or are acting to save energy. The next answer was given by 11 out of 46 respondents investing in renewable energy. Five indications were given to the answer referring to energy as an economic rather than an environmental problem. Only two respondents do not take any action regarding energy savings. The general approach of the respondents therefore indicates that energy issues are being taken into account. This issue is important to many respondents, some of whom are already taking energy-saving measures.

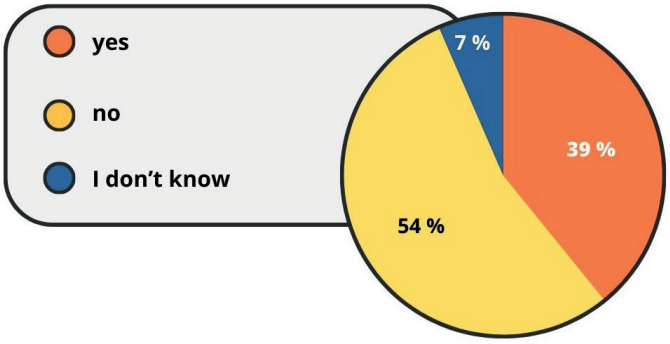
While energy saving is a key element in the green transformation, an equally important aspect is the optimisation of material consumption. Efficient management of material resources not only contributes to reducing operating costs, but also has a direct impact on reducing waste generation. In this context, companies are increasingly focusing on strategies such as the minimisation of raw material consumption, the reuse of materials and the integration of secondary raw materials into production processes as a further step towards a circular economy. The respondents were therefore asked about waste management (Figure 33).

FIGURE 33. DOES YOUR COMPANY OPTIMISE THE USE OF MATERIALS (REDUCTION / REUSE / RECYCLABLE MATERIALS, ETC.) TO REDUCE THE AMOUNT OF WASTE GENERATED IN THE COMPANY?



Source: own elaboration.

FIGURE 34.DOES YOUR COMPANY ANALYSE ITS SUPPLY CHAIN IN THE CONTEXT OF ENVIRONMENTAL MEASURES AND CLOSING THE RAW MATERIAL CYCLE?



Source: own elaboration.

As many as 32 respondents (almost 70%) optimise material consumption and only 11 respondents (about 23%) do not. This distribution of responses demonstrates the relatively high awareness of materials saving, their wise management and reuse or use of recyclable raw materials. Although a significant proportion of the respondents are IT companies or work with a small amount of materials, it is significant that, taken together, their combined involvement in optimisation processes can already make a significant contribution to reducing waste generated in parks.

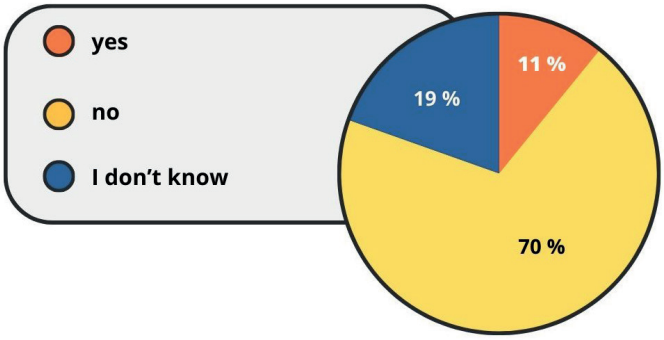
In terms of resource management, the respondents were also asked about analysing the supply chain in an environmental context and closing the raw material cycle (Figure 34).

Supply chain analyses are carried out by 18 out of 46 companies analysed (39%), while according to 25 indications (54%) no such analyses are carried out in the companies' operations. Three company representatives do not know if this type of analysis is performed in their company (7%). Supply chain analysis is a key tool for understanding and optimising relationships with stakeholders, especially suppliers, which translates into efficiency, sustainability and competitiveness of the entire supply chain.

3.4. Cooperation with stakeholders

Suppliers are one of the most important stakeholders in the supply chain. Their actions directly affect the quality, cost and timeliness of supply, which translates into the efficiency of the entire chain. Companies are increasingly requiring their suppliers to adhere to certain environmental and social standards, and supply chain analytics enables the monitoring and enforcement of these standards. The respondents were asked about this in the following question (Figure 35).

FIGURE 35. DOES YOUR COMPANY REQUIRE ITS SUPPLIERS TO ALSO IMPLEMENT CIRCULAR ECONOMY PRACTICES?

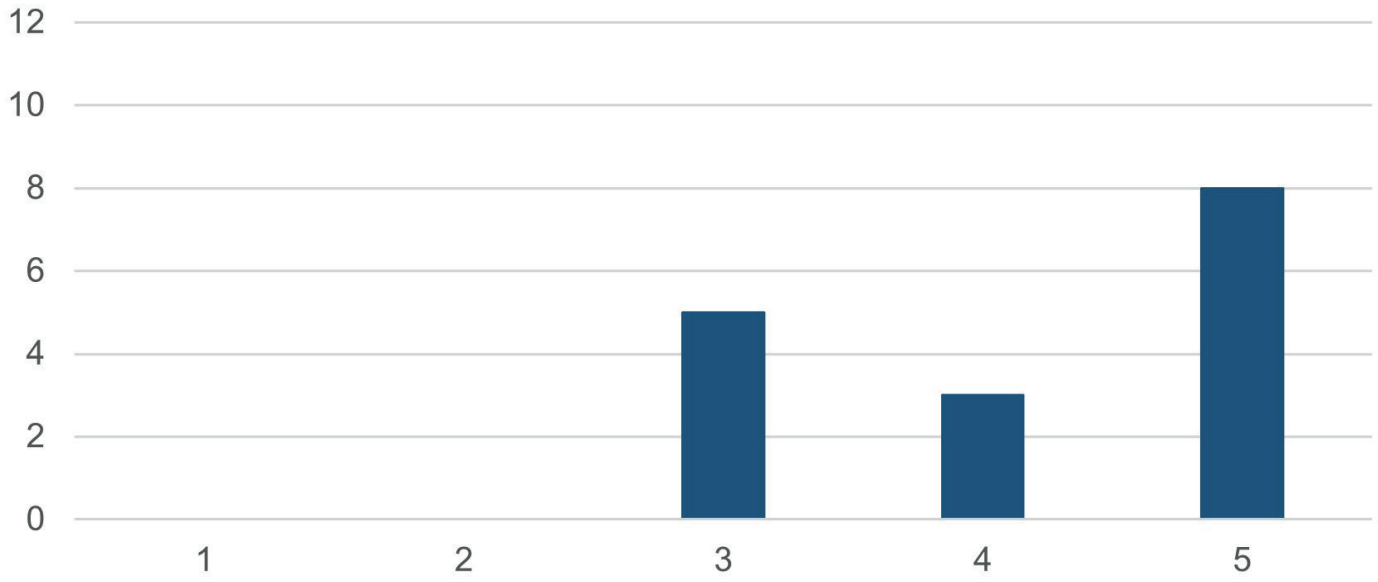


Source: own elaboration.

While 18 (40%) out of 46 respondents analyse their supply chain (Figure 33), only 5 (10%) require their suppliers to implement CE practices in their processes. Nine representatives of the companies surveyed were unsure whether such requirements exist in their company, and 32 out of 46 (close to 70%) respondents do not require CE practices to be implemented by suppliers. This situation indicates some potential for increased involvement in supplier analysis.

The analysis of supply chain and other CE practices is not only limited to relationships with external suppliers, but can also include potential synergies and opportunities for collaboration between park tenants. By examining the interconnectedness and complementary activities of different companies within the park, opportunities to shorten supply chains through local partnerships and resource sharing can be identified. This internal analysis can lead to process optimisation, cost reduction and a smaller carbon footprint, while also strengthening the local business ecosystem. Thus, collaboration between companies

FIGURE 36. HOW WOULD YOU RATE (ON A SCALE OF 1 TO 5) THE COLLABORATION WITH OTHER TENANTS OF THE TECHNOLOGY PARK TO CREATE CLOSED RESOURCE CIRCUITS IN TERMS OF ITS FREQUENCY?



Scale: 1-without significance, 2-poor, 3-neutral, 4-good, 5-very good.

Source: own elaboration.

operating within a single park plays a key role in creating closed raw material circuits. Analysing the frequency and quality of such collaborations provides valuable information on the potential and effectiveness of implementing CE practices at the local business ecosystem level. To assess the sophistication and effectiveness of CE collaborations, which may have important implications for the development of resource management strategies and the promotion of sustainable development practices in parks, the respondents were asked to rate the above collaborations (Figure 36).

In the context of the frequency of cooperation with other tenants of the park, in most cases the respondents rated cooperation with stakeholders as very good (8 indications). A further three ratings were good. This makes a total of 11 out of 46 respondents who speak positively about cooperation with other tenants in terms of closing the resource cycle. Five respondents commented neutrally on the frequency of this cooperation, while the remaining companies did not answer this question. The lack of response may mean that there is no such cooperation or that they are not competent to answer in this regard.

4. Best Management Practices in Circular Economy at the Skogmo Industripark in Norway

4.1. Business organisation and strategy at the Skogmo Industripark

The Skogmo Industripark is an industrial park located in the town of Overhalla, Norway. In 2024, the park is owned by 20 organizations, including local municipalities and enterprises, while an additional 37 enterprises use the park's space and infrastructure as tenants, and are also members of the park. For the past 15 years, Skogmo has supported its members in developing technologies, employee competencies, and business scale. Currently, more than 860 employees work within the park, and the turnover of the over 50 companies located there exceeds 3 billion euros annually.

The Skogmo Industripark provides favourable conditions for starting a new business and ensures competitiveness and attractiveness for all companies located in the park. A crucial factor for success is the genuine cooperation among all enterprises, which support each other daily on the path to success, share problems, knowledge, and jointly seek effective solutions to emerging challenges. Park members have access to courses and development programmes that meet their needs, such as digitization and sustainable development. The implemented strategy has resulted in a noticeable increase in sales of products and services, the execution of new investment projects, technological progress, and a reduction in negative environmental impact.

At the Skogmo Industripark, a systematic approach is taken to generate ideas, seek solutions, and secure funding for so-called "pre-projects" (in Norwegian: *Førprosjekt*), which are used to assess the utility and feasibility of innovative ideas. Support for enterprises located in the park is provided by the Project Leader. This position is often held by an experienced university employee. In the case of Skogmo, the supporting institution is the Norwegian University of Science and Technology[1] (NTNU) in Trondheim and the foundation established by this university, SINTEF.[2] The tasks of the Project Leader include:

Development of innovative solution concepts in cooperation with the park's stakeholders;

- Preparation of "pre-projects" that receive funding from Norwegian innovation funds, enabling the assessment of their effectiveness and feasibility;
- Preparation of full-scale projects (Norwegian: *hoved prosjekt*) for innovation development for the park management and its shareholders or cooperating companies;
- Initiating and developing project consortia, which involves seeking partners among research and development institutions and businesses willing to implement joint projects for innovation development;
- Developing a proactive stance of the park by signing letters of intent used to implement projects in collaboration with the NTNU, SINTEF, and other entities. The role of the project leader is to identify and establish contact with interested enterprises within the park, initiate and then coordinate the collaboration, and provide support in terms of substantive and financial aspects of the project. The starting point often involves the participation of a park representative (project leader) at trade fairs and industry events, conferences, and workshops organized by universities or other entities, both domestically and abroad. Establishing collaborations and networking directly during meetings or using attendance lists, phone numbers, and email addresses provided by the organizers of research and implementation meetings and business events.

It is important to note that in Norway the funds used to implement innovative projects are managed by two institutions. The first is

1 Norwegian University of Science and Technology, https://www.ntnu.edu/ [access on 12.05.2024]

2 SINTEF, https://www.sintef.no/en/ [access on 12.05.2024]

Innovation Norway, which funds projects up to 50% of the budget in cash. The remaining 50% must be provided by the company itself, typically in the form of employee work hours dedicated to the project. The second source of innovation funding is the Research Council of Norway (Norges forskningsråd).[3] This entity aims to benefit society by conducting, utilizing, and sharing research results, contributing to the restructuring of the Norwegian economy and increased engagement in achieving sustainable development goals.

At the Skogmo Industripark, great importance is attached to environmental respect and achieving sustainable development goals. According to the management of Skogmo, sustainable development means living and working without wasting resources and materials (Norwegian: "itj sløs" – don't waste, Norwegian dialect: Trøndersk), so that future generations can meet their needs. In practice, this means ensuring the economic growth of member companies, while considering the interests of employees and the environment. Therefore, Skogmo has developed a competence programme in sustainable development and provides support from an in-house specialist who helps companies identify and implement climate accounting principles. Assistance also includes process mapping and the use of tools from Klimapartnerne,[4] of which Skogmo is a member.

The park's management board, if necessary, can also help companies obtain environmental certificates related to reducing greenhouse gas emissions, calculating emissions in buildings, sustainable procurement or preparing and implementing a sustainable development strategy. This includes identifying areas related to the UN Sustainable Development Goals,[5] planning for long-term and short-term goals, helping to map suppliers and material flows, and supporting communication and visualization of progress towards these goals.

Similar to its approach to sustainable development, the Skogmo Industripark is committed to providing digital competencies to its members. Skogmo's goal is for member companies to possess knowledge and use available digital tools. The quality of products and services is becoming increasingly important, and by having control over company processes, operations can be optimized, and the final product delivered more quickly. Skogmo organizes appropriate workshops for its members and ensures close cooperation with relevant partners, such as Digital Norway.[6]

The park's management understands that ensuring a supply of high-quality human capital is essential for business development. Access to a sufficient number of employees with the right skills is a challenge today and will be an even greater challenge in the coming years. The Skogmo Industripark, along with its member companies, is an attractive place to work. Nevertheless, it continually promotes job offers through various channels to increase their visibility and reach. These actions aim to ensure that companies located in the park are known to young people, students, and job seekers. Maintaining constant contact with educational institutions is also crucial. Several times a year, Skogmo is visited by future employees, such as students and primary school pupils. This allows them to get to know the companies, job positions, and the park itself, which, thanks to its extensive structure, has much to offer future employees from Norway and abroad. Skogmo is present wherever future employees can be found, especially at innovation fairs, technology events, and meetings dedicated to specific professional groups.

3 The Research Council of Norway, https://www.forskningsradet.no/en/ [access on 12.05.2024]

4 Klimapartnerne, https://www.klimapartnere.no/ [access on 12.05.2024]

5 United Nations, https://sdgs.un.org/ [access on 12.05.2024]

6 Digital Norway, https://digitalnorway.com/ [access on 12.05.2024]

The strength of the park's management lies in its genuine understanding of the needs of employees working within the park. From the beginning of its existence, it has been a provider and organizer of various courses and certifications. The most frequently offered courses are in the fields of construction and transportation, which are also available to people who are not members of the park. An important support for park members is the willingness and ability to organize courses that meet the individual requirements and needs of the various entrepreneurs located in the park.

One example is the development of skills in preparing Life Cycle Assessment (LCA) reports on CO2 emissions. At the Skogmo Industripark, the project leader initiates and conducts LCA training for employees of companies located in the park. In this way, Overhall Hus, a company producing prefabricated components for assembling wooden houses, collects and provides information on the carbon footprint in the catalogue of houses for sale. A similar solution is used by Overhall Fjøs, a company that comprehensively designs and builds facilities for animal husbandry. Overhalla Betongbygg, a leader in the production of building materials and ecological concrete, also provides its clients with documentation on the carbon footprint of its products, calculated according to the LCA methodology.

The park is also open to cooperation with the local community. For the Skogmo Industripark, the exchange of experiences and the ability to share specialized knowledge between companies and industries is very important. Therefore, joint breakfasts are organized at Skogmo for park employees to create a space for exchanging knowledge and experience, as well as to facilitate informal contacts between younger and older employees. In this way, everyone can be heard and benefit from belonging to the park community.

Surveys conducted among businesses operating in the Skogmo Industripark, along with in-depth interviews carried out during individual meetings as part of the project, identified 10 best practices that can be classified as implementing circular economy principles. For each best practice identified in a company operating within the park or cooperating with the park, the environmental context of the activity, the challenge related to the intention to implement circular economy principles, and the way in which the company's goals were achieved are presented.

4.2. Water mist systems for fire extinguishing

Sustainable Development Goal 6 – Clean water and sanitation

Sustainable Development Goal 12 – Responsible consumption and production

Company

Grannes VVS AS, Norway,
www: https://www.bademiljo.no/finn-rorlegger-og-butikk/trondelag/grannes-vvs-as/

Background

Water is a resource that is theoretically abundant. However, due to salinization, pollution, and increasingly frequent cases of significant groundwater level reductions in Europe and other regions of the world,[1] it is necessary to take actions aimed at protecting drinking water resources and reducing its use in industrial production. Every entity (an individual or a company) can undertake more or less effective initiatives in this direction. One such action taken by enterprises is the development of water recycling methods, i.e. reusing water in production processes.

In clusters of enterprises such as industrial parks, it is important to ensure appropriate fire protection and systems capable of effectively combating fires. These systems also use large amounts of water. Therefore, innovative solutions, such as water mist, should be considered. Mist consists of very small water droplets. The excellent fire suppression ability of water mist is based on evaporation: when small droplets of water mist turn into steam, a large amount of energy is absorbed from the fire. This makes water mist an excellent choice for fire protection.[2] Water mist combats fire in three ways, each affecting the three elements of the "fire triangle," which consists of oxygen, heat and fuel. Using water mist leads to a significant reduction in water consumption during firefighting, which is an important achievement in such systems.

Challenge

Water is a limited resource, and its consumption needs to be reduced. During rescue operations in buildings and areas affected by fire, there are numerous difficulties in supplying and transporting sufficient water for firefighting purposes. Therefore, it seems useful and necessary to replace traditional solutions with water mist systems.

Proposed solution

Architects and entrepreneurs most commonly use sprinkler systems in buildings. Implementing new solutions capable of generating water mist during firefighting requires appropriate knowledge and experience. With this knowledge and experience, these systems will become more common in new buildings.

Grannes VVS AS is carrying out a project in collaboration with the research and development unit SINTEF, which conducts relevant research and provides reliable knowledge about the possibilities of using water mist on a larger scale.

1 Ladányi, Z., Deák, Á., Rakonczai, J. (2010). The Effect of Aridification on Dry and Wet Habitats of Illancs Microregion, SW Great Hungarian Plain, Hungary. *Acta Geographica Debrecina Landscape & Environment series*, 4(1), pp. 11–22.

2 Marioff, https://www.marioff.com/en/water-mist/water-mist-fire-protection-in-brief/ [access on 12.05.2024]

4.3. Reuse of Water in Concrete Production

Sustainable Development Goal 6 – Clean water and sanitation

Sustainable Development Goal 12 – Responsible consumption and production

Companies

Skogmo Industripark: Norway;
www: https://skogmoindustripark.no/

Overhalla Betongbygg, Norway;
www: https://overhallabetongbygg.no/

PHARMAQ, Norway;
www: https://www.pharmaq.com/en

Industry / sector

Construction sector – production of concrete elements; pharmaceutical sector – production of fish vaccines

Background

Both presented enterprises operate within the Skogmo Industripark. PHARMAQ is a world-leading company in the field of vaccines and innovations targeted at the aquaculture sector and is part of Zoetis, the world's leading animal health company. PHARMAQ employs approximately 375 people, and its products are sold in Europe, North and South America, and Asia. On the other hand, Overhalla Betongbygg (OBB) produces and supplies prefabricated concrete elements and steel structures to customers in the construction and building industry.

Challenge

A strategic challenge identified by the management of the Skogmo Industripark is the reduction of water consumption due to the immense importance of this resource for the environment and future generations. The main source of this strategic element is the high water consumption by companies located in the Park, primarily representing the construction industry. For example, the production of concrete at Overhalla Betongbygg requires large amounts of water, both in technological processes and in the cleaning and washing of equipment used during the production of concrete structural elements.

Overhalla Betongbygg produces approximately 300 tons of concrete per day. On average, 7% of the concrete is water, which means 21 tons of water are needed daily, or about 5,000 tons annually. A critical point for the park occurred in the summer of 2023, when there was an insufficient amount of water to maintain the company's production at an average annual level. Consequently, production was reduced for a period, resulting in measurable financial losses.

Overhalla Betongbygg is not the only significant water consumer in the Skogmo Industripark. Other significant users of this resource include Pharmaq, Namdal Plast og Betong, and other enterprises. For the park's management, the high water consumption, as well as the fact that it is potable water, poses a serious burden and challenge. Therefore, a solution was sought that would enable and significantly increase the multiple use of "grey" water within a closed production loop.

Proposed solution

The reuse of water from production in the Skogmo Industripark has become an important component of the park's strategy. The effects of implementing actions based on the adopted strategy are as follows:

Overhalla Betongbygg: Currently, about 25% of the water used in production can be reused. This applies to water used for cleaning the concrete mixer. This means that approximately 5-6 tons of potable water, which was previously lost irretrievably, are saved daily.

Research Initiated: Research has begun to prepare solutions that will allow the use of wastewater from Pharmaq for concrete production at Overhalla Betongbygg. Through this cooperation between companies located in the park, it will be possible to save additional tons of water each year. The quality requirements of OBB were used to compare with the quality measurements conducted by Pharmaq to determine suitability. Successful test results will allow further development of the adopted concept in managing water consumption within the park.

Overhalla Betongbygg: The company has created possibilities for the multiple reuse of water used in the grinding (slip-forming) of concrete during the production of structural elements. This initiative also brings real savings in the water used in the production process.

The sound concept of reducing water consumption at the Skogmo Industripark will bring tangible benefits to the environment and achieve financial effects. Using wastewater from some companies for technological processes in other companies will reduce the pressure on the ecosystem, which is a long-term strategic goal of Skogmo.

4.4. From food waste to biofuels and soil improvement

Sustainable Development Goal 9 – Innovation, industry and infrastructure

Sustainable Development Goal 15 – Life on land

Company

Circular Values Cluster (Civac), Norway;
www: https://civac.no/

Background

The Circular Values Cluster (Civac) is a public-private industrial network based on membership, dedicated to advancing the circular economy. Its 26 members encompass SMEs, start-ups, and larger industrial enterprises specializing in waste management and recycling, wood processing, plastic upcycling, as well as investors and public authorities committed to achieving their climate objectives. Civac's primary goal is to develop new circular value chains using recycled resources and innovative technologies, thereby enabling participating companies to create value in novel ways and enhance their market competitiveness. To attain these objectives, Civac actively fosters the growth of SMEs and other stakeholders by facilitating networking opportunities and promoting cross-industry knowledge exchange.

Challenge

Biomass derived from food waste holds significant potential that can be effectively harnessed to reduce the amount of residual waste destined for incineration. Transforming food waste into biogas through the process of anaerobic digestion can provide renewable energy and valuable organic fertilizers. Additionally, composting food waste contributes to the creation of high-quality compost, which enriches soils with nutrients, thereby reducing the need for chemical fertilizers. Consequently, biomass becomes a valuable resource that helps mitigate greenhouse gas emissions from incineration processes. At the same time, sustainable agriculture is supported, as part of the carbon dioxide used in agricultural production is offset. Utilizing these methods can also lower waste management costs and increase the efficiency of waste management systems.

Proposed solution

To improve biomass management, all residents of the municipality have been encouraged to collect food waste in separate containers. The food waste is transported to a biogas plant, where the biomass undergoes preliminary processing before the actual bioprocess. This process yields two main components: biogas, which can be used as biofuel, and compost, a soil improver used for agricultural purposes.

Results

The developed solution has resulted in a forward-looking process that aligns with both national and international environmental goals and requirements. The collection of food waste remains a challenge for municipalities worldwide. Currently, various types of bags are used in kitchens for food waste: paper, plastic, and biodegradable. Biodegradable bags are used in many regions of Norway, which may pose an additional challenge due to the presence of microplastics in bio-waste.

4.5. Waste management solutions for businesses

Sustainable Development Goal 13 – Climate action

Sustainable Development Goal 15 – Life on land

Company

Retura, Norway,
www: https://retura.no/

Industry / sector

Retura is a holding company, with its managing company, ReturaNT AS, being a member of the Skogmo Industripark. The organization provides cost-effective and environmentally friendly waste solutions for businesses, adhering to the principles of the circular economy. Retura encompasses a total of 24 companies, with annual revenues exceeding 200 million euros and employing several hundred workers. Retura's achievements are of great significance to the local community. Together with clients, suppliers and partners, Retura works daily towards a sustainable environment by ensuring:

- "zero waste" services for businesses and the public sector;
- implementation of efficient waste collection solutions;
- waste collection and transportation;
- checking, invoicing, and reporting in line with "green accounting" requirements.

Challenges

1. Recovery and Reuse of Wood
2. Sorting Waste at Building Demolition Sites

Every year, over 260,000 tons of pure wood are produced, which subsequently becomes waste and is almost in 100% subjected to energy recycling, meaning it is incinerated. This includes all types of wood (including construction wood) that could potentially meet other market needs. From an environmental protection standpoint, a better solution than incineration is to direct recovered wood towards reuse.

In collaboration with Innovation Norway and ReturaNT, the Skogmo Industripark established a pilot project aimed at mapping the possibilities of sorting used lumber, which could then find other practical and market applications instead of traditional incineration. The project gained knowledge and experience on how to practically avoid the issue of wood being sent for incineration. Additionally, it defined what the business model should be and the potential for wood reuse.

The project lasted several months and concluded in December 2020. The Skogmo Industripark assisted in managing the project, and during its course, cooperation agreements were signed with several relevant wood waste suppliers. These included construction contractors, building wholesalers, and craft workshops.

The key challenges of the project were formulated in the form of a list of questions:

- What can be recovered and sorted during demolition?
- What can be removed from the construction site?
- What can be recovered and sorted at a modular wooden house factory?
- What can be recovered and sorted by entities involved in wood sales?

Objectives

The conclusions of the project presented a list of actions necessary to ensure high-quality recovered wood:

- Mapping the quality of wood before planned building demolitions.
- Mapping the quantity of construction wood available for reuse.

- Identifying the best methods for sourcing and sorting the material.
- Identifying and mapping the market through synergy with other projects.

Proposed solution

Based on the assessment of the market of reclaimed wood from demolition, the material was divided into the following fractions:

1. Construction Wood Without Nails/Screws; minimum dimensions of 48x48 mm and larger, with a minimum length of 1 metre; free from paint or stain contamination
   - Collection using an 18m³ container.

2. Clean Wood free from paint/stain, but nails/screws are allowed. No dimension requirements. For example, pallets are an approved fraction.
   - Collection using a 10m³ container.

3. Surface-Treated Wood (Painted/Stained); nails/screws are allowed.
   - Collection using a 10m³ container.

ReturaNT places collection containers labelled according to the type of fraction and arranges the emptying schedule in agreement with the waste supplier. In collaboration with other entities, such as Moelven and Treteknisk, the registration and quality control of the collected wood designated for reuse in construction are carried out.

Results

Recovering wood during the demolition of buildings offers numerous utilitarian and environmental benefits. Reusing wood reduces the demand for new material, which leads to a decrease in tree felling and the conservation of forest resources. Wood recycling helps reduce the amount of construction waste sent to landfills, minimizing environmental impact and lowering waste management costs. Additionally, wood recovered from demolition can be used to produce new products, such as furniture or construction elements, promoting the implementation of circular economy principles in construction and industry. Using recovered wood also reduces greenhouse gas emissions associated with the production of new materials, contributing to the fight against climate change.

In Norway, recovering wood during the demolition of buildings is becoming increasingly common, yielding significant environmental and economic benefits. This is because approximately 30% of construction waste in Norway is wood, a substantial portion of which is recycled or reused. Detailed data indicates that over the past decade, about 150,000 tons of wood from building demolitions have been recovered and reused annually. This practice reduces the amount of waste sent to landfills, consequently lowering methane emissions – a potent greenhouse gas generated during the decomposition of organic waste in landfills.

4.6. Reuse of vehicle parts

Sustainable Development Goal 9 – Innovation, Industry, Infrastructure

Sustainable Development Goal 12 – Responsible consumption and production

Company

Bil1Din, Namdal Biloppguggeri, Norway; www: https://bil1din.no/

Industry

Car parts, recycling

Background

According to the United Nations Sustainable Development Goals, sustainable consumption and production involve achieving better and greater outcomes with fewer resources, ensuring that resources last longer. This approach also ensures a good quality of life for future generations. Reusing parts and components suitable for reuse is key to better utilizing materials and resources, as it effectively reduces the consumption of resources more than recycling or new production. The company Bil1Din has extensive experience in this field, as a family-owned business founded by Arne Brøndbo that has been operating since 1975. The aim of their operations is to give "new life" to used car parts. With modern tools, standardized processes, and access to a vast market for used car parts, Bil1Din has raised the bar in terms of both quality and the products offered.

Proposed solution

The company Bil1Din increases the professionalism of car dismantling each year through continuous improvement and ensuring high quality in all its processes. By doing so, Bil1Din ensures that used car parts become an environmentally friendly and obvious first choice for workshops, the insurance industry, and the general public.

The company is expanding in the following areas:

1. Car Parts Dismantling

   In the summer of 2021, Bil1Din opened Norway's most advanced car dismantling facility in Skage, Namdalen. Here, Bil1Din processes 3,000 vehicles annually and produces 30,000 high-quality used parts, which find buyers in the Norwegian automotive market. With a strong and ambitious team in both management and production, the company's goal is to continue meeting the high demand for used car parts from professional customers by providing high-quality parts that meet the needs and expectations of discerning clients. In this way, Bil1Din stimulates the growth of recycling and contributes to a greener planet for future generations.

2. High-Energy Battery Recycling

   In 2018, there were about 195,000 vehicles with high-energy batteries registered in Norway. It is estimated that by 2024, the number of electric, hybrid, and plug-in hybrid vehicles will exceed 500,000 units. The National Association of Car Importers, Autoretur AS, and Batteriretur AS already in 2016 established a company that developed a system for recycling high-energy batteries. Bil1Din's project laid the initial foundations for future collaboration in handling used (and often damaged) high-energy batteries.

3. Environmental Technology – Circular Economy

   The environmental technology and circular economy project is a pilot initiative launched by Namdal Bilopphuggeri AS (Bil1Din) to increase knowledge about the reuse and recycling of materials from recreational boats, caravans, campers, etc. The actions undertaken involve mapping and researching existing applications and seeking new uses for materials derived from the recycling of the aforementioned vessels and vehicles.

4.7. Reuse of building materials

Sustainable Development Goal 9 – Innovation, Industry, Infrastructure

Sustainable Development Goal 12 – Responsible consumption and production

Company

SIRK AS, Norway,
www: https://sirken.no/

Industry / sector

The Sirken project consists of an open-access auction of second-hand products mainly from the construction industry.

Background

As part of the Sirken project, the company provides the construction industry with a platform that facilitates the transformation of construction waste from demolitions into materials suitable for reuse in the market. This is beneficial for construction contractors, environmentally conscious market participants (the so-called green players), and end users. In 2020, the construction industry produced 2.14 million tons of waste. The industry disposes of this waste in the most economical way currently available, which is external waste management. Construction and the building industry account for 25% of all waste in Norway, according to waste accounts from the Central Bureau of Statistics. Experts believe the high level of waste is due to a lack of proper incentives and the imposition of direct responsibility on entities involved in construction and demolition projects. Consequently, a market gap has emerged, which the project's proponents aim to exploit, ultimately leading to a reduction in the construction industry's negative environmental impact and a decrease in the amount of unmanaged waste.

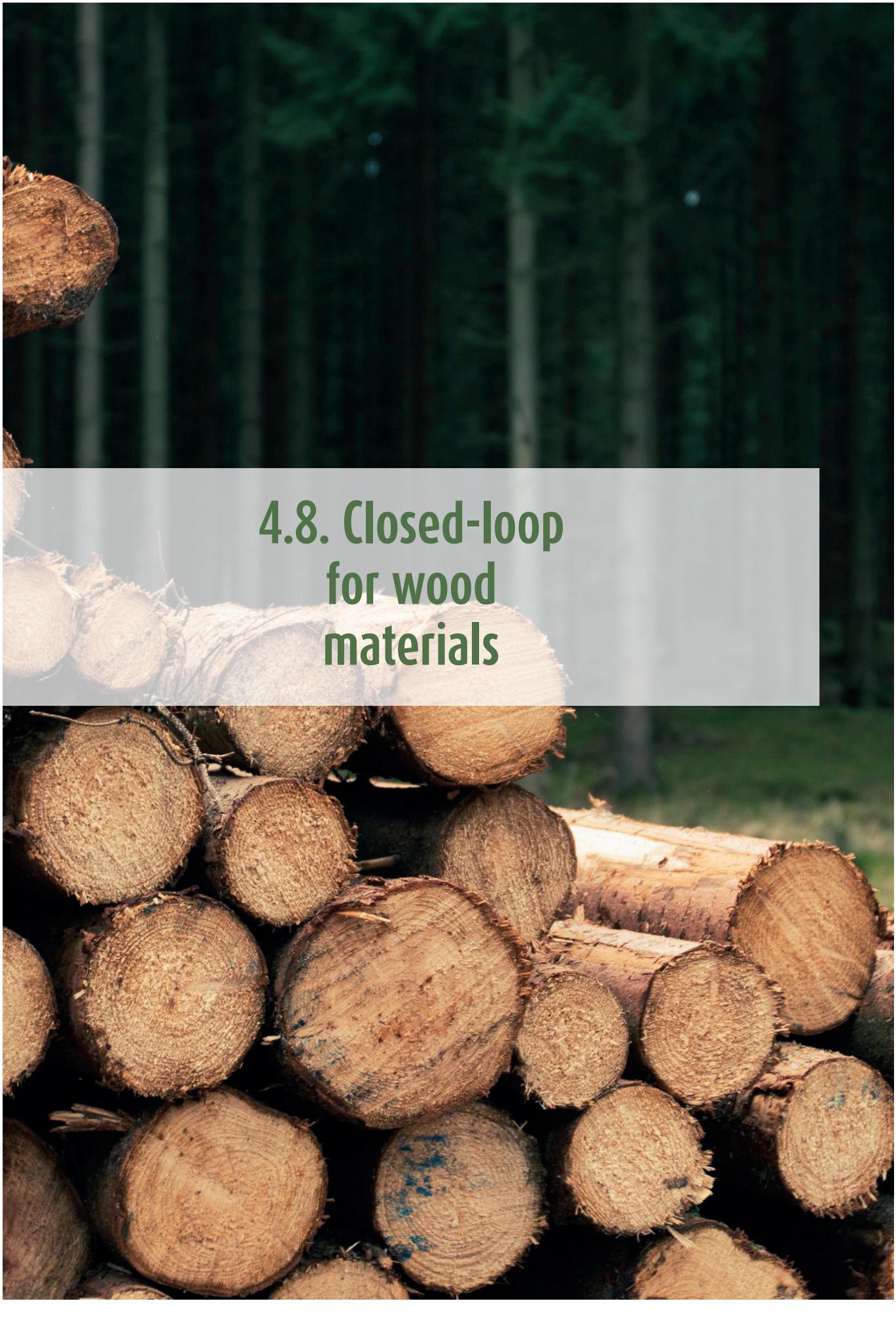
Proposed solution

The main goal of Sirken is to ensure that construction waste does not go directly to landfills, thereby extending its lifespan (recycling) by making it available on the secondary market. Sirken must actively collaborate with clients to achieve the highest possible level of resource and material reuse. An additional objective of the project is to prevent internal malfeasance by the client, ensuring that resources and material surpluses do not disappear unregistered from the client's projects. The company's aim is to protect the environment from unnecessary CO_2 emissions and the costs incurred by clients associated with traditional construction waste management methods.

Collaboration with the entity (client) offering material surpluses or construction waste involves Sirken signing an agreement to organize a collection point for the offered materials at a location agreed upon with the client. The materials will be collected in a self-service, aesthetically pleasing container provided by Sirken. The client is responsible for ensuring power supply for the Sirken store and a relatively flat storage area for the materials. It is also important that buyers of the materials have access to a gate allowing car entry. Sirken requires the area designated for the store to be approximately 50 m^2. If the client has a surplus of materials, they are obligated to register it via the form at www.sirken.no/varemottak. The surplus goods are placed on one of the Sirken-shop shelves. From that point, Sirken takes over responsibility for executing the sales process. Sirken handles the advertising and sale of the materials.

If items are not sold in the Sirken store, they revert to traditional waste management. Regardless of whether the transfer agreement includes a return to the client or disposal in a landfill, they are paid for via Sirken by the ordering entity based on the invoice amount. The client can then invoice Sirken for this

amount upon completion of the order. After the project concludes, a final report, including an LCA (Life Cycle Assessment) report on CO_2 emissions savings calculated based on the EPD (Environmental Product Declaration) of the surplus goods or an equivalent EPD of similar goods, can be sent to the client. This is an additional service that must be selected in the service agreement entered into with Sirken by the client.



4.8. Closed-loop for wood materials

Sustainable Development Goal 12 – Responsible consumption and production

Sustainable Development Goal 13 – Climate action

Company

NAMAS Vekst;
www: https://namas.no/

Background

NAMAS Vekst is an example of a Norwegian vocational rehabilitation company that assists individuals needing additional support in their daily work or help in securing regular employment. The support is provided to those who have "fallen out" of the labour market, are at risk of exclusion, or require a workplace adapted to their needs. The company's activities focus on enabling as many people as possible to quickly obtain permanent employment.

The company undertakes a variety of tasks, particularly those related to environmental protection. To carry out these tasks, it employs people affected by the problem of professional exclusion. One example of this type of activity is the organisation of a process for the use of wood waste and the use of closed-loop recycling.

Proposed solution

At the Skogmo Industripark, the companies Skogmo Bruk and Overhalla Hus operate in the wood industry, producing various wooden structures for both domestic and international markets. The wood scraps generated during production are collected and sent to Namas Vekst. At Namas Vekst, these scraps are sorted based on their suitability for further production processes. Some of the scraps are used to produce wooden crates useful in forestry operations. The produced crates are sent to Skogplanter Midt-Norge, where tree seedlings are

PICTURE 3. WOOD MATERIAL FLOW DIAGRAM

Source: own elaboration

placed in them and then sold to forest owners for reforestation of cleared forest areas. The forest owners plant the seedlings in early summer and return the crates for reuse. Subsequently, the wood from these forests is sold back to the same companies that supplied the waste used to produce the wooden crates, namely Skogmo Bruk and Overhalla Hus. This exemplifies the practical application of the circular economy concept based on the flow of wooden materials.

Partners

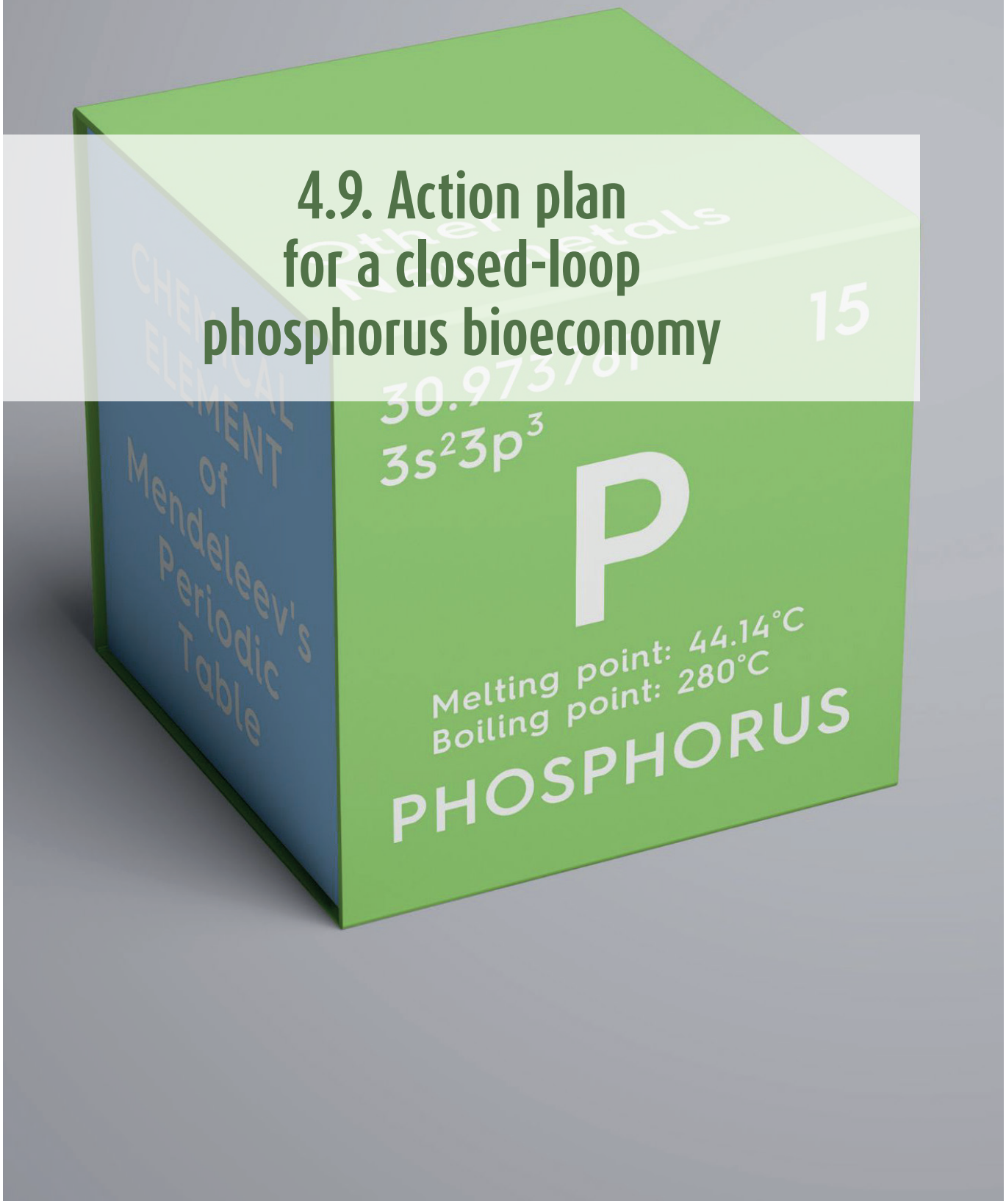
Skogplanter Midt-Norge: https://spmn.no/

Overhalla Hus: https://overhallahus.no/

Skogmo Bruk: https://www.skogmobruk.no/

Namas Vekst: https://namas.no/om-namas/

4.9. Action plan for a closed-loop phosphorus bioeconomy



Sustainable Development Goal 12 – Responsible consumption and production

Sustainable Development Goal 13 – Climate action

Entities

Norwegian University of Science and Technology (NTNU); www: https://www.ntnu.no/

Norwegian Institute of Bioeconomy Research (NIBIO); www: https://www.nibio.no/

Project MIND-P; www: https://mindp.indecol.no/?lang=en

Background

Phosphorus is one of the three key macronutrients and an important part of the bioeconomy, serving both as a fertilizer and a feed additive. It is also a known factor causing eutrophication in freshwater bodies and a potential contributor to eutrophication in marine waters. The use of phosphorus in agriculture and marine aquaculture leads to significant losses of phosphorus resources and can have negative environmental impacts. The MIND-P project (funded by the Norwegian Research Council) was launched to map the potential for more circular practices.

Challenge

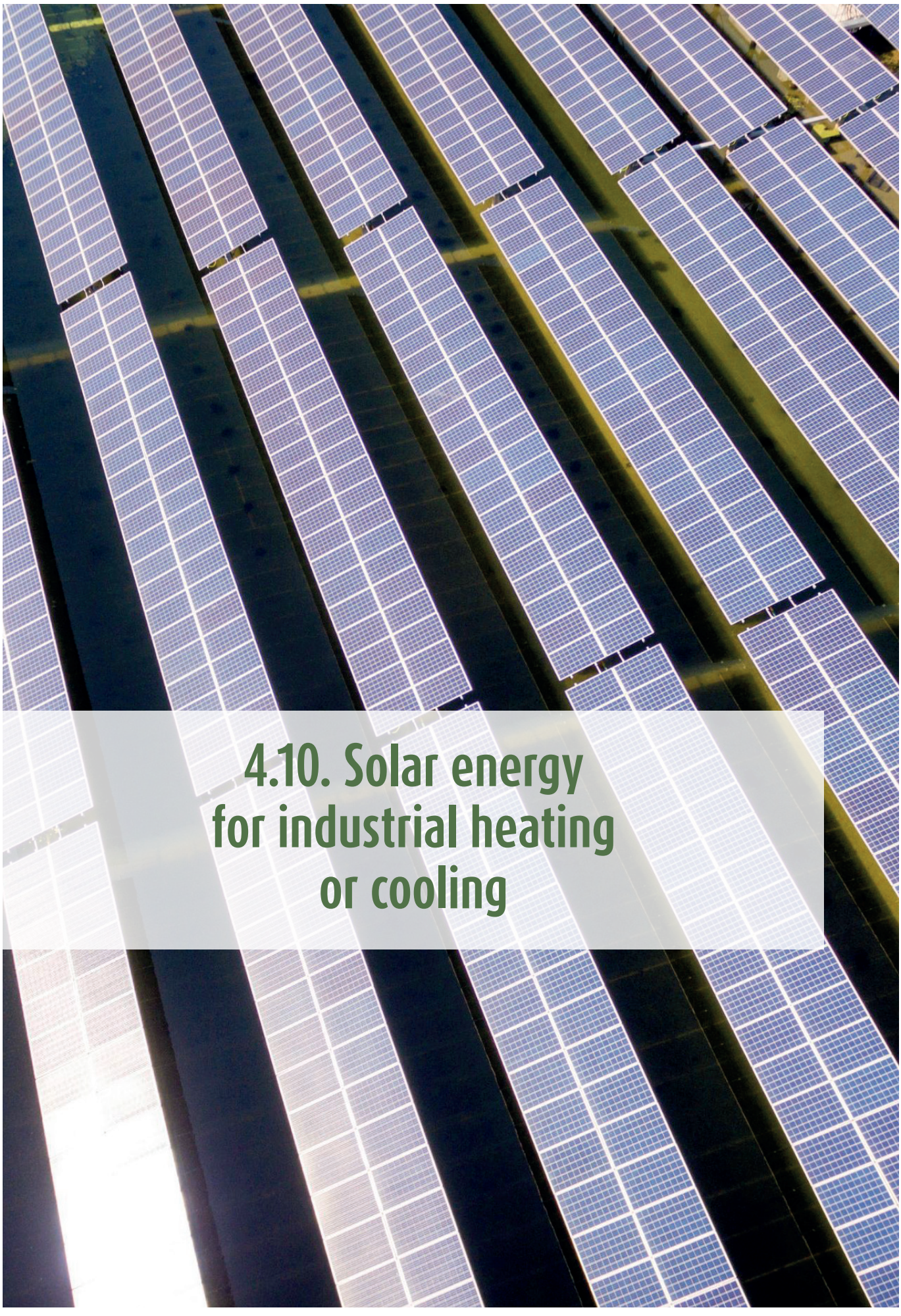
Phosphorus is used as an additive in fertilizers and fish feed, but both applications typically rely on mineral phosphorus derived from limited geological resources. Only a small fraction of the applied phosphorus reaches consumers' plates, while the rest is lost to the environment. A circular bioeconomy must find ways to recirculate phosphorus from manure and fish sediments, for example, into fertilizer production, while reducing the overuse of mineral phosphorus. This involves challenges related to mapping the supply of secondary sources, analysing phosphorus availability in secondary sources, and overcoming end-user resistance.

Proposed solution

Mapping phosphorus cycles in Norway was based on the methodological principles of Material Flow Analysis (MFA), utilizing available production statistics from both aquaculture and agriculture. The usefulness of secondary phosphorus sources was examined in both laboratory and field conditions, while social practices limiting the use of low-tech solutions were studied using qualitative research methods. In summary, the project aimed to create a roadmap towards a circular phosphorus bioeconomy, while engaging industry partners to take the initial steps.

Results and opportunities

The roadmap outlines possible and likely actions to improve phosphorus flow in Norway, revealing the potential to almost entirely eliminate the use of mineral phosphorus fertilizers in Norway. Phosphorus losses in the aquaculture sector require more advanced solutions to convert fish sediments into high-quality fertilizer and are more challenging to address.



4.10. Solar energy for industrial heating or cooling

Sustainable Development Goal 9 – Innovation, Industry, Infrastructure

Sustainable Development Goal 12 – Responsible Consumption and Production

Sustainable Development Goal 13 – Climate Action

Entity

Norwegian University of Science and Technology (NTNU); www: https://www.ntnu.no/

Background

As part of the strategic research area at the Department of Electrical Power Engineering at the NTNU in Trondheim, studies are being conducted on the utilization of solar energy. One of the main goals of Team Solar is to scale up the use of solar energy in the Scandinavian built environment. The team's primary tasks include investigating the potential of solar energy to provide heating and/or cooling in industrial processes. Many industrial processes require heating and/or cooling where the temperature does not exceed 100°C. The energy demand for such processes can be met by solar energy. The goal is to explore feasible options for implementing solar energy in these applications.

Companies, such as those in the Skogmo Industripark, can serve as case studies. Actual data from these companies will be useful for the success of the research. Upon completion of the study, the results and recommendations will be available to the companies. The companies will benefit from the research, as feasible options indicated by the results can be considered for future implementation.

Proposed solution

Industry utilizes hot water for processing its products. Some sectors use warm water from district heating networks, while others generate warm water using electricity or boilers.

A model consisting of energy sources, energy storage systems, and energy loads is used for system analysis. The study considers existing sources of electricity and fossil fuels, as well as alternative solar thermal collectors (SWC) and photovoltaics. The research also examines options for battery storage and thermal energy storage (TES). Based on hourly solar radiation data and hourly energy demand, various combinations of energy sources and energy storage sizes are simulated. The software TRNSYS is used for analysis and simulation.

The results of the study have not yet been published, but researchers are confident that they will be able to develop and propose efficient and feasible technical system solutions to end-users.

5. Recommendations, Challenges and Conclusions for the Managers of Industrial, Science and Technology Parks

5.1. Management strategies for industrial, science and technology parks

The conducted research indicates that in both Poland and Norway, the choice of the type and nature of a park (i.e. industrial, science, technology, or other hybrid forms) depends on various conditions related to the organizing entity and the social and economic environment. The establishment of a park can be considered part of the strategy of an organization, public authorities, universities, or an entity established to organize the park, such as a municipal association, foundation, or another legally permissible form. The decision is typically the result of a confluence of various interests and development plans, associated with defining long-term goals, action plans, and positioning and shaping the future role within the environment. On the tenant's side, the decision should result from the company's development strategy, the need for technology transfer, commercialization of research results, or the search for tools and methods for enterprise development.

The type of park can also be seen as a component of the business model. Participation in an industrial, science, or technology park directly impacts the business model, defining revenue sources, relationships with partners, key resources, and activities. Thus, it is an element that describes how the business will be conducted and what will the source of profits be.

In summary, the choice of the type of park (industrial, science, technology, etc.) can be viewed both from the perspective of the organization's strategy and its business model, as this decision influences long-term goals, action plans, market positioning, as well as revenue generation and value creation methods. It is, therefore, an element of strategic planning and the pattern of actions of the organization.

The main findings regarding the recognition of the scope of implementation of circular economy (CE) and green transformation principles are as follows:

1. Integration in Development Strategies: Most industrial/science parks do not have circular economy principles embedded in their development strategies, indicating low awareness of the importance of this concept. Only 40% of parks have CE included in their strategy.
2. Tenant Practices: 70% of surveyed park tenants currently do not implement circular economy practices.
3. Sustainable Development Goals: Most parks, according to respondents, are not obliged to achieve sustainable development goals related to CE. The lack of knowledge about obligations to achieve sustainable development goals indicates insufficient communication and coordination of actions in this area.
4. Dedicated Roles: Only one park has a dedicated position responsible for the development of practical CE actions, suggesting a significant potential for organizational changes.
5. Promotion of CE Models: Few parks promote comprehensive business models based on CE among tenants, such as leasing and services, resource sharing, or closed-loop material cycles.
6. Investment in Innovation: 66% of parks are investing in innovative solutions supporting the transition to CE, such as waste utilization, resource saving, and renewable energy installations.
7. Key CE Principles: The most important CE principles being implemented in parks are energy saving, promoting energy efficiency, and education.
8. Measurement and Monitoring: Only a few parks use tools and indicators to assess progress in implementing CE, which hinders the monitoring and communication of achievements.

In summary, the implementation of circular economy principles in industrial parks is at an early stage. Effective implementation of CE in industrial/science parks requires a strategic approach, organizational changes, investments in innovation, stakeholder education,

and continuous monitoring of progress using appropriate measurement tools.

Based on the results of the conducted research, the following recommendations can be made:

1. Incorporate Circular Economy Principles: Parks should integrate circular economy (CE) principles into their development strategies, treating them as a source of competitive advantage.
2. Develop Long-Term Strategies: A long-term strategy for implementing CE in the park should include a gradual increase in the number of firms adopting CE practices.
3. Raise Awareness and Enhance Communication: It is necessary to raise awareness about the connections between CE and sustainable development goals, as well as to strengthen communication and coordination of actions in this area.
4. Establish Dedicated Roles: It is recommended to create dedicated positions or teams responsible for implementing CE practices in parks.
5. Promote Comprehensive CE Business Models: Parks should promote comprehensive CE-based business models among tenants, such as product-as-a-service, material recirculation, and resource sharing.
6. Continue Investing in CE Innovations: Investments in innovative CE solutions should continue, with particular emphasis on energy efficiency, waste management, and closing the loop of potable water used for technological purposes.
7. Conduct Regular Educational Activities: It is crucial to conduct regular educational and informational activities about the financial and non-financial benefits of implementing CE for parks and their tenants.
8. Develop a Monitoring System: Parks should develop and implement a system of indicators to measure progress, monitor and communicate achievements in the field of circular economy.

By adopting these recommendations, parks can enhance their strategic approaches, foster sustainable development, and achieve long-term benefits for themselves and their tenants.

5.2. Best practices in resource management

The use of renewable energy sources, water resource management actions, and waste management are key processes in implementing circular economy (CE), sustainable development, and the transition towards a more efficient and environmentally friendly economic model. The research has enabled the identification of procedures and processes that support the practical application of circular economy and green transformation.

The main findings regarding best practices in resource management are as follows:

1. Use of Renewable Energy Sources: The majority of parks (75%) utilize renewable energy sources, mainly in the form of photovoltaic panels. Only one park additionally uses heat pumps and geothermal sources, while other renewable sources such as wind or hydropower are not employed.
2. Renewable Energy Utilization: According to respondents, five out of 12 parks use renewable energy at a high level, but the average rating of 2.91 indicates potential for increasing the share of renewables. The widespread use of energy-efficient technologies, mainly photovoltaic panels, suggests potential for implementing other solutions.
3. Energy Efficiency Efforts: Parks are engaged in activities to improve energy efficiency, which was rated at an average level of 3.92 on a scale of 1 to 5.
4. Water Cycle Closure Solutions: The vast majority of parks (10 out of 12) do not have solutions that allow closing the water cycle, such as water recycling, rainwater harvesting and green roofs.
5. Material Use Optimization: Most parks (7 out of 12) undertake actions to optimize material use to reduce waste generation.
6. Supply Chain Environmental Analysis: 39% of surveyed tenants (18 out of 46) analyse their supply chain for ecological actions and closing the raw material loop, and only 10% (five out of 46) expect the same from their suppliers.

These findings highlight the current state and opportunities for improving resource management practices in industrial and science parks.

Based on the presented research findings, the following recommendations can be formulated:

1. Increase Utilization of Diverse Renewable Energy Sources: Science, Industrial, and Technology (SIT) parks should enhance the use of various renewable energy sources, such as wind energy, geothermal energy, and small-scale hydropower, to increase the share of renewables in the energy mix.
2. Invest in Advanced Energy-Efficient Technologies: Continue and expand investments in modern energy-efficient technologies beyond photovoltaic panels, targeting both buildings and processes.
3. Implement Comprehensive Water Cycle Solutions: It is essential to implement comprehensive solutions for closing the water cycle, such as water recycling, rainwater harvesting, irrigation systems, and green roofs.
4. Optimize Material and Resource Use: Parks should further develop actions to optimize the use of materials and resources to minimize waste generation.
5. Conduct Regular Educational and Informational Activities: Key to success is the regular conduct of educational and informational activities about the benefits of implementing renewable energy sources (RES), energy efficiency, and circular economy for parks and their tenants.
6. Develop and Implement Monitoring Systems: Develop and implement a system of indicators to measure progress, monitor and communicate achievements in the use of RES, energy efficiency, and circular economy practices.
7. Create a Resource and Material Exchange Platform: Establish a platform for resource and material exchange among tenants to shorten supply chains and increase the use of recyclable materials.

In summary, parks should intensify efforts to increase the share of renewable energy sources, improve energy efficiency, and implement circular economy solutions, with particular emphasis on water and waste management. Educating stakeholders and monitoring progress with appropriate indicators are also crucial for achieving these goals.

5.3. Cooperation with park stakeholders

Effective transformation towards a circular economy requires the involvement of various stakeholder groups, such as tenants, local authorities, non-governmental organizations, and local communities. Good relationships based on trust, shared sustainable development goals, and effective communication are crucial for the success of this process. In this context, the conducted research aimed to identify the potential of Polish parks to initiate and manage green and circular transformation processes and to assess the possibilities of park tenants collaborating with other stakeholders in material flows and building sustainable supply chains. The analysis of the results helped identify good practices and areas needing further action in stakeholder collaboration for the circular economy. Based on this, several recommendations were formulated to strengthen the role of parks as centres promoting and implementing CE principles in cooperation with their environment.

The main conclusions that can be drawn from the research results obtained are as follows:

1. Engagement in Circular Economy Initiatives: More than half of the parks involve their tenants in circular economy initiatives, such as conferences, training sessions, waste collection and segregation bins.
2. Energy Price Concerns: Only one park reported a tenant's complaint about high energy prices in the context of implementing CE practices.
3. Active Response to Tenant Challenges: Despite the lack of widespread use of monitoring tools, some parks actively respond to problems and challenges reported by tenants concerning CE practices.
4. Tenant Selection Policy: Parks do not apply tenant selection policies that consider experience in CE practices, although they indicate sectors related to sustainable development as desirable.
5. Attraction of New Tenants: The park's involvement in CE development is perceived as a neutral or positive factor in attracting new tenants.
6. Marketing and Promotional Activities: Parks propose various marketing and promotional activities aimed at attracting tenants focused on CE, ranging from informational campaigns to specific pro-environmental solutions.
7. Dedicated CE Role: Only one park has a dedicated position responsible for the development of practical CE actions in stakeholder relations.
8. Collaboration with Organizations: Some parks cooperate or plan to cooperate with other organizations to promote CE at regional or national levels. Few parks initiate cooperation with local authorities on CE.
9. Tenant Collaboration: 18 out of 46 surveyed tenants positively assess the frequency of collaboration with other tenants in implementing CE practices.

Based on the presented research results, the following recommendations can be formulated:

1. Intensify Tenant Engagement: Parks should intensify activities engaging tenants in circular economy (CE) initiatives, such as informational and educational events, competitions, and specific solutions supporting circular economy practices.
2. Implement Monitoring Systems: It is essential to implement monitoring systems and tools that enable the identification of tenant problems/challenges in CE and effective responses to them.
3. Develop Tenant Selection Policies: It is recommended to develop tenant selection policies that take into consideration their experience and commitment to implementing circular economy practices.
4. Active Marketing and Promotion: Parks should conduct active marketing and promotional activities, combining various forms of communication and specific solutions, to attract tenants oriented towards CE.
5. Create Dedicated CE Roles: Consider creating dedicated positions or teams responsible

for developing practical CE actions in stakeholder relations within the parks.

6. Strengthen Collaboration with Organizations: Establish and strengthen cooperation with other organizations, local and regional authorities to more effectively promote and implement circular economy practices.
7. Collaborate with Local Authorities: Parks should initiate and develop collaboration with local authorities in circular economy, engaging in initiatives, programmes, and projects for sustainable development.
8. Regular Educational Activities: Regularly conduct educational and informational activities aimed at tenants, stakeholders, and local communities concerning the benefits of implementing CE.
9. Supplier Evaluation and Certification: Introduce a system for evaluating and certifying suppliers based on their use of CE practices, encouraging tenants to choose sustainable business partners.

Effective engagement of stakeholders, including tenants, in implementing circular economy (CE) in parks requires coordinated actions encompassing active communication, collaboration with various entities, appropriate management tools, and a coherent policy for selecting and supporting CE-oriented tenants. The adoption of these recommendations will help parks better engage stakeholders, address challenges, and enhance their role as leaders in promoting and implementing circular economy practices. This approach will ensure sustainable growth and development, benefiting tenants, the local community, and the broader environment.

5.4. Financial and non-financial incentives

Implementing business models based on circular economy (CE) principles brings numerous benefits to companies and their surrounding environments. The research conducted among the parks aimed to identify various incentives (including non-financial) and funding sources supporting green and circular transformation in the parks and the companies located within them. The analysis of the results identified both positive aspects and areas requiring further action in promoting and supporting the circular economy. Based on this, a series of recommendations have been formulated to strengthen the role of parks as centres supporting sustainable development and innovation within the framework of CE.

The main conclusions formulated on the basis of the collected research material are the following:

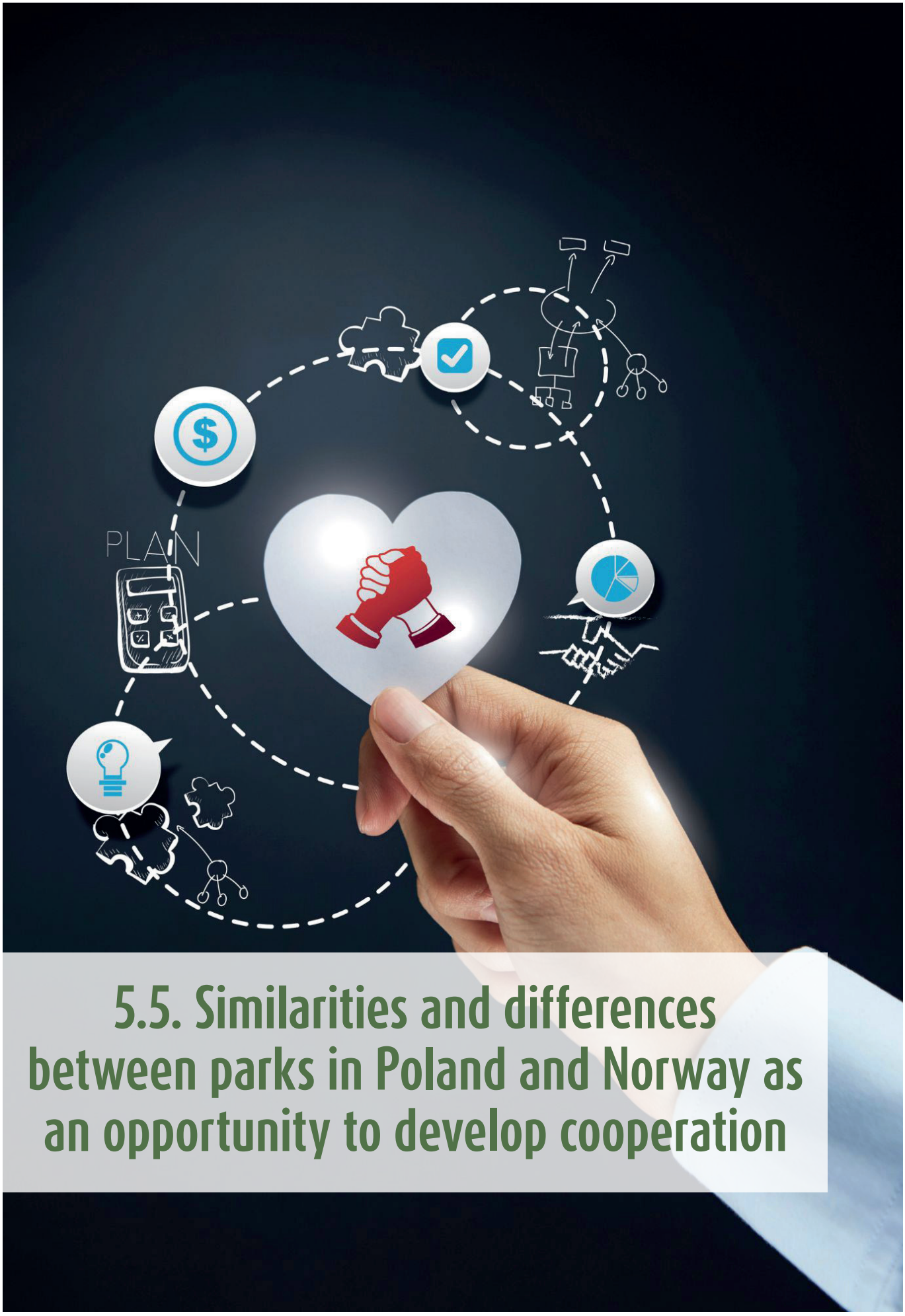
1. Common Benefits for Tenants: According to the respondents, the most frequently mentioned benefits for tenants implementing CE business models include waste reduction, reduced water and energy consumption, and lower operational costs.
2. Less Frequent Benefits: Benefits such as increased competitiveness, environmental protection, greater operational efficiency, new revenue sources and reduced greenhouse gas emissions were rarely mentioned or not indicated at all.
3. Perceived Lack of Benefits: As many as five out of 12 respondents stated that tenants implementing CE do not derive any financial or ecological benefits.
4. Lack of Direct Financial Support: Parks do not offer direct financial support or tax incentives for tenants implementing CE solutions.
5. Educational and Knowledge Support: The support provided by parks is primarily educational, in the form of trainings and events on CE. Nine out of 12 parks organize educational trainings and events related to the circular economy for their tenants.
6. Parks' Key Strengths: According to the respondents, the main strengths of the parks for tenants are infrastructure, business environment, collaboration network and support for R&D activities, rather than aspects related to sustainable development.
7. Interest in Energy Sharing: Based on tenants' responses, they are interested in energy sharing with other tenants, with 18 out of 46 expressing willingness to use renewable energy sources if offered by the park.

The conclusions of the research presented above allow the following recommendations to be identified:

1. Enhance Educational and Informational Efforts: Parks should intensify educational and informational activities, raising tenant awareness about the numerous financial, ecological, and competitive benefits of implementing circular economy (CE) business models.
2. Introduce Financial Support Programmes: Consider introducing financial support programmes, tax incentives or other incentives for tenants undertaking CE initiatives.
3. Leverage Park Strengths: Utilize park strengths such as infrastructure, business environment and collaboration networks to promote and facilitate the implementation of CE solutions among tenants.
4. Raise Awareness Among Park Managers: Increase awareness among park managers about the importance of sustainable development and CE as significant factors for tenant competitiveness and attractiveness.
5. Expand Training and Educational Events: Develop a robust offering of training and educational events on CE, engaging experts, consulting firms and tenants who have successfully implemented circular economy practices.
6. Collaborate with Financial and Governmental Institutions: Establish partnerships with financial institutions, non-governmental organizations and local government units to gather information on financial support opportunities for tenants implementing CE.

7. Regular Monitoring and Evaluation: Conduct regular monitoring and evaluation of the benefits of CE implementation by tenants to identify best practices and areas needing support.
8. Create Incentive Systems: Consider creating incentive and support systems for tenants implementing CE solutions, such as preferential lease terms or access to additional services.
9. Develop a Communication Platform: Create a communication platform for tenants to facilitate information exchange and collaboration in implementing CE practices.

Effective promotion and support for implementing circular economy business models among park tenants require comprehensive actions encompassing education, financial incentives, leveraging park strengths and close collaboration with various stakeholders for sustainable development. Implementing these recommendations will help park managers create an environment conducive to green and circular transformation, while simultaneously increasing the attractiveness and competitiveness of business parks.



5.5. Similarities and differences between parks in Poland and Norway as an opportunity to develop cooperation

The results of the survey research conducted in Poland and Norway, supplemented by numerous in-depth interviews, allowed to identify numerous similarities and differences in the circular economy (CE) practices among parks and entities located in science, industrial, and technology parks.

The main probable causes of the observed similarities and differences include the following factors:

1. Legal and Regulatory Frameworks:
   - Similarities: Both Poland and Norway are members of the European Economic Area (EEA), meaning that enterprises must comply with certain common EU regulations and directives regarding the circular economy and sustainable development. This leads to the implementation of similar principles and practices within industrial and science parks in both countries.
   - Differences: Despite the common EU regulations, specific implementations and enforcement of these regulations can vary depending on local policies, priorities and resources. For example, Norway may have stricter environmental protection regulations and more advanced support mechanisms for CE initiatives than Poland.

2. Business and Social Culture:
   - Similarities: In both countries, there is growing ecological awareness and a need for sustainable development, influencing the implementation of CE practices in industrial and technology parks. Shared European values and aspirations for sustainable development create similar motivations for CE implementation.
   - Differences: Norway, due to its natural resources, strong local economies and long tradition of sustainable resource management, has a more developed business culture regarding CE. Poland, on the other hand, as a developing country, focuses on economic growth dynamics, which leads to the necessity of considering certain compromises in the field of sustainable practices implementation.

3. Access to Technology and Innovation:
   - Similarities: Both countries invest in innovations and new technologies, which is crucial for the effective implementation of CE practices. Science and technology parks in Poland and Norway have access to the latest technological advancements and can use similar tools and methods.
   - Differences: Norway, with a higher level of technological development and greater access to capital, can more quickly and efficiently implement advanced technologies supporting CE. Despite significant progress, Poland may face greater financial and infrastructural barriers that slow down the implementation of innovative solutions.

The marked similarities and differences in circular economy between parks in Poland and Norway result from a combination of legal, cultural and technological factors. These three main reasons help to understand why, despite some common goals and regulatory frameworks, the specific approaches and levels of sophistication in CE implementation can differ significantly between the two countries.

Familiarizing oneself with the detailed research findings will enable a deeper assessment and drawing conclusions on potential areas for collaboration. Table 3 presents the attitudes of parks and their tenants towards CE divided into four areas:

- Implemented Solutions;
- Support from CE experts employed by the park;
- Obstacles in Implementing CE in the Park;
- Communication Difficulties Between the Park and Companies Regarding CE.

In the first analysed area concerning the solutions used in enterprises, it is noteworthy that both Polish and Norwegian entities aim to implement circular economy (CE) solutions. However, Norwegian entities have more tools to support these processes. Norwegian entities are also more advanced in implementing CE solutions, while Polish entities are at the initial stage of their implementation. Legal regulations in Poland regarding waste segregation serve as a good example of how to encourage tenants to adopt CE practices. Conversely, in Norway, which is more developed in this area, there are still some entrepreneurs who are not fully aware of the sustainability requirements imposed on them. Both countries practice educational activities related to sustainable development and circular economy, but as the research results indicate, more effort is still needed to achieve more durable effects.

The next area concerns the use of support from CE experts employed by the park. In Polish parks, this type of solution practically does not exist due to the lack of financial resources and managerial decisions in this regard. In Norway, it is common to create such positions. Individuals employed as CE experts and project leaders related to this field are successfully used in the daily management of the park and in initiating and directing innovative CE projects. Based on the experiences gained in the project, Poland should strive to develop an appropriate model for the functioning of such solutions based on the best Norwegian practices.

Low awareness, poor promotion of benefits, and a lack of regulations are the main obstacles in implementing CE goals in Poland. In contrast, the problem in Norway lies in insufficient resources, competencies, and a lack of unanimity among tenants regarding a common energy policy. The obstacles in Poland stem from a low level of awareness about the possible implementation of CE concepts and related business models.

Communication difficulties in Poland are primarily due to the mentality of entrepreneurs, who are mainly focused on achieving their own profits. Another significant factor is the belief in the minimal significance and negligible impact of individual enterprises on achieving global CE goals. In Norway, there is often a higher awareness of the negative impact of businesses on the environment, which is associated with a greater willingness to undertake projects in the area of the circular economy. Despite this significant difference compared to Polish entrepreneurs, the necessity of achieving high financial efficiency by CE projects is also highly valued in Norway. This is also the main reason for the abandonment of such ventures. This indicates the need for greater financial involvement from national and regional authorities to increase the number of projects in line with CE principles.

In summary, it should be noted that both Polish and Norwegian SIT parks are striving to implement the principles of the circular economy, which provides a solid foundation for further collaboration in sustainable development. Although Polish parks are at the initial stage of implementing CE solutions, they can benefit from the more developed tools and experiences of Norwegian parks. Norway, with its greater resources and advanced practices, can support Polish parks in the implementation of effective CE models. The shared goal of achieving sustainable development and similar values create a foundation for mutual complementarity and effective partnership.

Common challenges, such as energy security, the decreasing availability of many resources, the necessity of raising awareness and developing knowledge about available CE models, and the need to seek financial support sources, indicate the need for joint initiatives. These initiatives will help bring both countries closer to achieving the goals of common environmental policies. Both countries can also benefit from sharing experiences and best practices,

TABLE 3. SIMILARITIES AND DIFFERENCES BETWEEN PARKS AND THEIR TENANTS IN THE CONTEXT OF CE IN POLAND AND NORWAY.

Areas	Polish parks and their tenants versus CE	Norwegian park and its tenants versus CE
Implemented solutions	Most parks aim to implement circular economy (CE) solutions, although this depends on the decisions of the management board and the availability of funding, primarily from external sources. The majority of the surveyed parks are at the initial stage of implementing CE solutions. Solutions that are being implemented include those mandated by regulations, such as waste segregation, and those for which funding has been secured, such as photovoltaic panels. In most parks, educational activities related to CE are practiced, aiming to raise awareness among tenants and collaborating companies.	Most tenants (companies) in the Norwegian park want more circular changes. The park provides tools supporting CE, with one-third of tenants using tools offered by the Skogmo Industripark. Half of the tenants are aware of the legal requirements regarding CE, while only 16% are unaware of such requirements (the remainder have not analysed this issue in depth). Two-thirds of the tenants want to continue educating their staff and partners in the area of CE.
Support from CE experts employed by the park	In Poland, there is practically no designated person or position solely responsible for the area of circular economy (CE) in the parks, with only one park (out of several analysed) reporting the presence of such a position. So far, CE topics are handled by individuals or teams who also perform other tasks (it is not their primary responsibility). At present, there are no plans to establish such positions within the park's structure. This situation could change if funds for a project are secured or if there is a decision from the management board.	In the Norwegian Skogmo Industripark, there is a designated position for a CE officer responsible for collaboration with tenants in this area. The individual in this position acts as a liaison, cooperation organizer, support tools specialist, and educator.
Obstacles in implementing CE goals in the park	There is insufficient awareness, knowledge and education among park employees and tenants regarding CE. There are no benefits or incentives offered by the parks or the government/local authorities for companies to adopt CE practices. There are no mandatory regulations or requirements for companies imposed by either national law or park operational rules to implement CE practices.	Over 40% of companies do not see the potential in joint energy projects and do not support building energy independence in collaboration with the park and other tenants, indicating a lack of unanimity. Companies lack the resources and competencies, and many buildings are too old to install certain solutions, such as heat pumps. While water management efficiency is a problem in Skogmo, it is indicated as an issue by less than half of the companies.
Communication difficulties between the park and companies regarding CE solutions	There is a lack of interest from companies and a scarcity of grassroots initiatives in this area. Companies are primarily focused on achieving the goal of increasing profits. There is a belief that IT/ICT service companies either cannot implement CE solutions or that their impact is negligible. There are no ideas on how to communicate and highlight the benefits of CE solutions to companies.	75% of tenants want to implement changes in their companies to comply with CE and seek to exchange experiences and collaborate with other companies. 50% of company representatives state that their partners require evidence that their company operates in accordance with CE principles.

Source: own elaboration

which will help overcome barriers to CE implementation. The potential for Polish-Norwegian cooperation also includes the development of joint projects that can contribute to increasing ecological awareness and promoting innovative CE solutions, while simultaneously strengthening the competitiveness and attractiveness of SIT parks in both countries.

References

Anuszewska, I., Mazur, A., Podlejska, K., Jackiewicz, A., Rudnicki, R. (2011). *Wzorce zrównoważonej produkcji (WPZ) – propozycja rozwiązań systemowych wspierających wdrażanie WZP w MSP, Raport z analizy danych zastanych*. Polska Agencja Rozwoju Przedsiębiorczości.

Atasu, A., Dumas, C., Van Wassenhove, L.N. (2021). The Circular Business Models. *Harvard Business Review*, July–August, https://hbr.org/2021/07/the-circular-business-model.

Hołub-Iwan, J., Olczak, B., Cheba, K. (2012). *Benchmarking parków technologicznych w Polsce edycja 2012*. Polska Agencja Rozwoju Przedsiębiorczości.

Digital Norway, https://digitalnorway.com/.

Ellen MacArthur Foundation (2013). *Towards the Circular Economy*. Vol. 2: *Opportunities for the Consumer Goods Sector*. Ellen MacArthur Foundation Report.

European Environment Agency, https://www.eea.europa.eu/pl/sygna142y/sygnaly-2018/infografika/zuzycie-wody-w-europie/view.

Hansson, F., Husted, K., Vestergaard, J. (2005). Second Generation Science Parks: From Structural Holes Jockeys to Social Capital Catalysts of the Knowledge Society. *Technovation*, 25(9), pp. 1039–1049.

Klimapartnerne, https://www.klimapartnere.no/.

Ladányi, Z., Deák, Á., Rakonczai, J. (2010). The Effect of Aridification on Dry and Wet Habitats of Illancs Microregion, SW Great Hungarian Plain, Hungary. *Acta Geographica Debrecina Landscape & Environment series*, 4(1), pp. 11–22.

Lecluyse, L., Knockaert, M., Spithoven, A. (2019). The Contribution of Science Parks: A Literature Review and Future Research Agenda. *The Journal of Technology Transfer*, 44, pp. 559–595.

Leitão, J., Pereira, D., Gonçalves, Â. (2022). Business Incubators, Accelerators, and Performance of Technology-Based Ventures: A Systematic Literature Review. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(1), 46.

Marioff, https://www.marioff.com/en/water-mist/water-mist-fire-protection-in-brief/.

Massard, G., Jacquat, O., Zürcher, D. (2014). *International Survey on Eco-Innovation Parks: Learning from Experiences on the Spatial Dimension of Eco-Innovation*. FOEN.

Matusiak, K.B. (1975). *Parki technologiczne. Instytucjonalne wspieranie przedsiębiorczości, procesów innowacyjnych i rozwoju regionalnego. Fundacja Inkubator*.

Norwegian University of Science and Technology, https://www.ntnu.edu/.

Oleksiuk, A. (2009). *Konkurencyjność regionów a parki technologiczne i klastry przemysłowe*. Oficyna Wydawnicza „Branta".

Pichlak, M. (2018). Gospodarka o obiegu zamkniętym model koncepcyjny. *Ekonomista*, 3, s. 340–341.

Political guidelines of the Commission 2019–2024, https://commission.europa.eu/strategy-and-policy/priorities-2019-2024_en.

Polska Agencja Inwestycji i Handlu, https://www.paih.gov.pl/dlaczego_polska/zachety_inwestycyjne/parki_przemyslowe_i_technologiczne/.

SINTEF, https://www.sintef.no/en/.

Strengthening the European Innovation Ecosystem via the enhanced involvement of STPs and AOIs, April 2020, Malaga. IASP – International Association of Science Parks and Areas of Innovation.

UN ESCAP (2019). *Establishing Science and Technology Parks: A Reference Guidebook for Policymakers in Asia and the Pacific*, https://www.unescap.org/sites/default/files/Guidebook_Final.pdf.

UNIDO (2021). *A New Generation of Science and Technology Parks, UNIDO's Strategic Approach to Fostering Innovation and Technology for Inclusive and Sustainable Industrial Development*, https://hub.unido.org/sites/default/files/publications/Publication_%20New%20Generation%20of%20STI%20parks_2021.pdf.

United Nations, https://sdgs.un.org/.

Waligóra, K. (2015). Parki naukowe, technologiczne i przemysłowe jako narzędzie wspierające potencjał innowacyjny polskiej gospodarki. W: *Współczesne wyzwania rozwoju gospodarczego: polityka i kreacja potencjału*. Cz. 1: *Kreacja, innowacyjność, handel zagraniczny*, ed. Ewa Gruszewska (pp. 171–186). Wydawnictwo Uniwersytetu w Białymstoku.

List of figures

List of pictures

List of tables