THESIS SUMMARY BOOKLET

Zsófia Nemes

The circular economic model in industrial parks

International (good) practices and the domestic potential

PhD thesis

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I. Research background and justification of the topic

The circular economic model is an important paradigm of sustainable development and at the same time of development policy, which aims to realize the closed chain and cyclicity of material and resource flows, and to extend the useful life of products. The main elements of the model are resource efficiency, a low-carbon economy, sustainable waste management, production and consumption systems.

In many parts of the world, CE (circular economy) is no longer just a theoretical concept, but is integrated into the processes of policy-making and practice. Circular economy can also represent an alternative to traditional – linear – economic systems on a global level. The European Union (EU) shows a strong intention to move in this direction, as do many other countries, including the United States and China.

The present doctoral dissertation focuses on industrial production as one of the most important possible aspects of the circular economy. Within this, industrial ecosystems and so-called eco-industrial parks are given special emphasis, through which the relationship between the circular economic model and new development policy approaches can be clearly illustrated. Indeed, industrial parks or ecosystems can be considered as a terrain where a spatial dimension can be given to the concept of circular economy, it can be brought to the local or regional level, and in this way, the concept, which is otherwise not necessarily geographically defined, can be examined and interpreted in a transparent system consisting of a limited number of elements.

The related literature and international practice together show that currently, the movement towards a circular economy is progressing more slowly than desired, despite the fact that the complex environmental, social and economic benefits provided by the model can hardly be questioned. That is why it is important to examine which are the main factors that promote and which hinder the application of CE in the case of industrial production and especially, industrial parks which are in the focus of the investigations.

The aim of the dissertation is to reveal the considerations, motivations and factors behind the implementation options of circular economy in industrial parks. The dissertation aims to identify internationally relevant trends, logics and possible rules, factors that influence this process. Another important objective of the work is to determine – based on existing (good) practices and global case studies – the potential and possible scenarios for the implementation of CE in Hungarian industrial parks, the domestic policy and institutional environment, as well

as the relevant corporate, industrial park and civil actors (professional, consultancy or government institutions) by identifying and analyzing their aspects, positions and motivations.

The literature review aims at a comprehensive analysis and evaluation of the literature on CE and industrial ecosystems, eco-industrial parks. The empirical research also aimed at identifying the good practices of CE on a global level, and tries to reveal what kind of Hungarian practice and/or potential can be found in parallel with these international examples.

The literature review and empirical research together prove that the shift towards a circular operation is an indisputable and inevitable necessity, whether it is in the world's richest countries, regions or even developing states. A key aspect is how individual actors (countries, governmental and non-governmental organizations, companies, business actors, civil society and the population) see the emerging problems, challenges and opportunities inherent in the transformation, as well as whether they are capable of joint, coordinated actions and networking, in order to create synergies.

The expected results can be relevant at local, regional, national and global levels, considering that CE may play a significant role in creating new forms of employment and jobs, would contribute to the catch-up of less developed local communities, regions and countries, and to a more sustainable and resource-efficient economic and production structure globally.

II. Research questions

The research seeks the answer to the question what role the model of circular economy can play in the transformation of industrial activity and industrial parks, making them more sustainable. In accordance with the research focus, the main research question needs to be narrowed down and specified, as follows:

1. How can the CE model be applied in concentrated locations of industrial production, in particular in industrial parks?

2.a. Did the circular economic model have an impact on the operation of industrial and technology parks?

2.b. How is the operational structure of industrial and technological parks around the world being transformed by putting the principle of circularity to the focus?

3. What factors help or hinder the transformation and development of industrial parks according to the circular economic model?

4.a. Which actors play a prominent role in the emergence of CE? (e.g. business actors, public sector, civil sector)

4.b. Is the appearance of these factors promoted, and if so, how, by the cooperation of actors from different spheres?

The present phd thesis is also closely related to the research project examining the smart specialization possibilities of the Central Transdanubian region, which created an opportunity to study the formulated questions at local level, in Székesfehérvár. During the empirical research of the local dimension, the main question was the following:

5. How can the circular economic model contribute to the economic and social development of a local society, a city and its agglomeration area beyond industrial concentration?

Besides the international trends and correlations, global good practices and examples, as well as the Székesfehérvár case study, the thesis also formulates a question aimed at the Hungarian dimension, namely:

6. How does the circular economic model appear in Hungary, especially in the case of industrial parks?

In answering the above-listed research questions, the author applied various methodological tools and their combinations, striving to ensure that the used tool fits the question in the best possible way. The results of the research carried out with a combined methodology in the framework of the international case study section mainly provide answers to research questions number 1, 2a, 2b, 3, 4a and 4b, while the analysis through the local dimension (see: Székesfehérvár's case study) is reflecting on research question 5. The chapter titled *Circular economic model, industrial parks and symbioses in Hungary* focuses on research question no. 6.

III. Research methodology

III.1. Case study analyses based on literature review

One of the – secondary – methodologies applied during the research was the exploration of cases that can be identified in the literature, in order to put the research questions formulated in the previous chapter into a practical context. During this process, the focus was placed on the industrial dimension and implementation of the circular economic model, based on the practical example of eco-industrial parks and industrial symbioses. The search included the following keywords and their combinations, both in Hungarian and English:

- case study
- example
- practice
- implementation
- circular economy (-ic model)
- industrial sustainability
- industrial symbiosis
- industrial ecology
- industrial ecosystems
- industrial parks and zones
- eco-industrial parks

The first step in mapping the occurrence of the above-listed key terms in the literature was the use of Google and Google Scholar browsers. Other platforms for narrower and more specific searches were the largest international databases that collect scientific works, such as Researchgate, Elsevier, Taylor and Francis, Science Direct and Wiley Online Library.

The search in the above-mentioned internet libraries was not narrowed down or filtered by publication date, location or any other criteria, however, a well-definable time interval was still clearly visible: the vast majority of the relevant scientific works containing the key terms listed above are from the second half of the 1990s to the present day, and in terms of language, English is clearly dominant. During the selection and processing following the search, scientific works that present the latest situation of the researched topics and were published in the last 7-8 years (after 2015) were given a particularly important role.

The search and literature collection based on key terms also revealed which internationally recognized scientific journals are the primary sources of articles published on the related topics. The search gave the result that mostly the following journals deal with the circular economic model and the development of industrial ecosystems and eco-industrial parks (based on the number of search results): *Journal of Cleaner Production; Journal of Industrial Ecology; Sustainability.*

The global examples and case studies found in the databases of scientific journals showed a significant geographical diversity, but it is also important to note that the studies from the Asian continent – especially with regard to the Chinese practice – are more decisive both in terms of their number and importance, compared to other continents or regions. The locations were selected with the aim of covering as wide geographical spectrum as possible and presenting examples from very diverse environmental, social, economic and political structures.

In the selection of the processed literature sources, it was very important to list as many relevant and available international examples as possible, where the concept of CE and industrial symbioses have already reached a certain maturity level, and thus can be suitable to present the so-called 'good or best practices'. The examined case studies can be divided into two categories: national-level policies and initiatives that are also considered progressive in a global sense (e.g. United Kingdom, China); and specific eco-industrial parks (e.g. Denmark, United States, Netherlands, South Korea).

Circular economy and industrial ecosystems are typically topics on which, due to their highly practice-oriented nature, significant policy documentation is also available, especially at the European Union level, in addition to the very abundant and wide collection of literature sources. The dissertation operated with these sources as well in terms of secondary methodology.

III.2. Structured interviews

When choosing the methodology, the author of this dissertation made the decision that the systematic analysis of the cases and practical examples should be presented within the section of the empirical results, as the exploration and analysis of international (good) practices is largely based on their literature, but it is supplemented with primary, independently conducted empirical research as well, e.g. structured interviews with experts. For the visual representation of the methodological framework of the doctoral dissertation, see Fig.1.

The selected interviewees are decision-makers, representatives of governmental and non-governmental organizations (i.e. NGOs), and economic actors who are potentially interested and involved in the implementation possibilities of the circular economic model. The structured interviews complement the processing of secondary sources and information gathered from scientific publications.

These interviews can be divided into 5 main categories:

1. International organizations whose profile is specifically related to the promotion of the circular economic model and industrial sustainability. The doctoral student interviewed the following actors (in accordance with data protection rules, the names will not be disclosed, the interviewed persons can only be identified by position):

- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH: 3 interviewees - consultants/experts, sustainable industrial sites project
- World Bank Group: 1 interviewee - Senior Private Sector Development Specialist, head of the Climate Efficient Industries working group
- United Nations Industrial Development Organization (UNIDO): 1 interviewee, chief consultant - Global Eco-Industrial Parks Program (GEIPP)
- SOFIES Group/University of Lausanne: 1 interviewee – Chairman of the Board, head of the industrial ecology group at the University of Lausanne (IPTEH)
- Alpen-Adria Universität Klagenfurt, Austria: 1 interviewee – expert, research innovation management/enterprises and industrial parks
- Location: MS Teams/online
- Date: February-April 2022 and April 2023

2. The management and experts of certain eco-industrial parks: The author of the dissertation wanted to get to know the international practices and specific examples identified through the literature case study in more detail by means of structured interviews. In order to do this, the doctoral student contacted many– more than 25 – eco-industrial parks, but at the same time the reach turned out to be extremely low. In only 5 cases did the persons invited to the interview respond, and in 2 cases they refused it, due to busyness and lack of time.

- Kalundborg Symbiosis (Denmark): 2 interviewees – senior symbiosis advisor (Kalundborg); and expert, researcher – innovation management/enterprises and industrial parks (Alpen-Adria Universität Klagenfurt, Austria)
- Ökopark Hartberg (Austria): 1 interviewee – head of department – Ökopark real estate management
- Location: MS Teams/online
- Date: April 2022 and April 2023

3. Policy-makers of Hungarian governmental institutions: The structured interviews also covered the viewpoints of domestic government actors who are responsible for the Hungarian policy and regulatory environment for the development of the circular economy and/or industrial ecosystems and eco-industrial parks.

- Ministry of Innovation and Technology, Secretary of State for Economic Strategy and Regulation: 1 interviewee – policy-maker
- Location: offline interview, Ministry of Innovation and Technology, Secretariat of the Deputy State Secretary Responsible for Industrial Strategies and Regulation, Budapest
- Date: May 2022

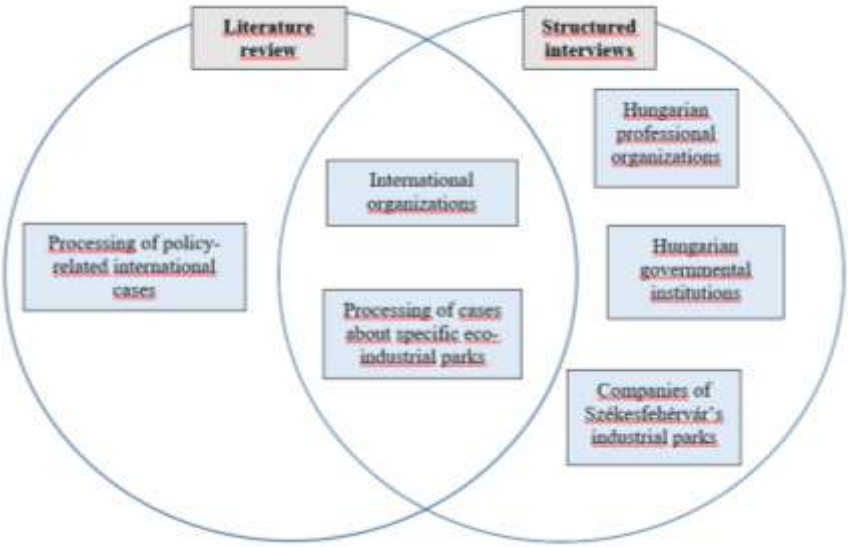
4. Hungarian professional organizations: The essence of the sampling strategy in this case was to address interviewees who are able to cover a wide spectrum of Hungarian and international practice regarding the circular economic model, industrial parks and symbioses, as well as related innovations. The doctoral student wanted to involve actors in the research who had previously participated or are currently participating, e.g. in the development of CE pilot projects.

- IFKA Industrial Development Public Nonprofit Kft.:
  - 1 interviewee - Industry 4.0 project – manager and industrial development consultant

    - 1 interviewee - Green Economy Group – manager
- Association of Industrial, Scientific, Innovation and Technology Parks (IPE): 1 interviewee (head of professional organization)
- Location: personal interviews at the headquarters of the organizations
- Date: April 2019

5. Companies of Székesfehérvár's industrial parks and local authorities:

The most detailed, case study-type, domestic empirical research is linked to Székesfehérvár, one of Hungary's most important and prosperous industrial centers, where a sufficient amount of capital and innovation potential are available (Székesfehérvár MJV Integrated Settlement Development Strategy, 2018), and there are already existing or potentially feasible synergies, symbiotic collaborations under the principle of circularity. The empirical research in Székesfehérvár was carried out within the Széchenyi 2020 program framework (EFOP-3.6.1-16-2016-00013) under the European Union project titled: "Institutional developments for intelligent specialisation at the Székesfehérvár Campus of Corvinus University of Budapest".



1. figure: Graphic representation of the methodological framework of the doctoral dissertation; Source: the author's own editing

Linking the methodological tools with the research questions

	Applied methodology	
Research question	Structured literature review	Structured interviews
1.	X	X
2.a.	X	X
2.b.	X	X
3.	X	X
4.a.	X	X
4.b.	X	X
5.		X
6.		X

***1**. table: Linking the methodological tools with the research questions; Source: the author's own editing*

IV. Research results

IV.1. Summary of international practices and trends

The formation and operation of eco-industrial parks and industrial symbioses can be greatly hindered by the fact that such investments and developments within Europe cannot benefit from public funding, or only very rarely and to a small extent - i.e. the investments are almost 100% financed by the private sector. Compared to this, the direction that has developed e.g. in China over the past few years is significantly different, where these types of developments receive massive resources from the state budget, and in fact, are very often implemented entirely from public funds.

The main reason behind this difference lies in the fact that decision-makers, central and local government actors in European states often do not yet see the serious economic and social benefits inherent in industrial symbiosis, as well as the specific rates of return for each project (although there are many case studies available that quantify and underpin these financial benefits). A problem closely related to this issue is that the EU's strict competition policy rules apply to the support of market players, and the room for maneuver is in many cases severely limited. Structural problems and deficiencies characteristic of the field of research, development and innovation can be further inhibiting factors in European practice: inefficient allocation and/or lack of resources in many cases (mainly in less developed European regions and member states).

In addition to all this, many further difficulties can be identified at the European Union level, mainly the harmonization problems of the regulatory (legal) framework - e.g. in the field of waste or water management, recycling and reuse, as well as pollution and emissions. One of the most important competitiveness challenges for the future of the EU may be whether it will be able to act as a single entity for the effective implementation of sustainability and the circular economic model, and whether it will be able to create the framework for such cross-border cooperation networks that will help each individually operating, isolated IS/EIP projects to be linked.

We can see that two types of management systems can be found in the case of eco-industrial parks at the international level. Some parks are publicly owned and managed by a board, council or committee in which both the partner companies and the various local authorities are represented. In contrast, private facilities are typically managed by the company that is also the founder and owner of the EIP. In the latter case, the dominant role belongs to a

specific company that creates a partnership with the other companies present, but the hierarchical control is maintained throughout.

Based on the sample of the empirical research (n=15), it can be established that the vast majority of the examined eco-industrial park initiatives and developments had been realized as a result of conscious planning. About 2/3 of the investigated cases are located in developed countries.

Greenfield or brownfield types of investments occur in a ratio of roughly half-half. In terms of the sectoral concentration, there is a slight majority of those examples where there is not a single well-defined sector or a specific company that plays a prominent role in the industrial park, but instead, we can meet diverse participants.

As for the initiator side, a significant diversity can be seen, but it is the public sector (local, regional or central government) that fulfills the coordinating role in about 2/3 of the cases.

The examination of policy initiatives at national level shows that among these examples (n=10), the proportion of developing countries is about 60%, where the projects typically started with national coverage, and are being implemented even today, continuously focusing on the circular economy programs that support the transition and also develop industrial ecosystems. If we examine in how many cases the declared goal of the given policy program was the development of eco-industrial parks, we can see that this is by no means typical, but rather a more complex set of goals (transition to a circular economic model, improving the energy efficiency of the country, business/ making it attractive from an investment point of view) can be identified.

Summarizing the individual cases, including pilot projects and policy-level initiatives, it can be concluded that the transition towards a circular economic model and a radical change in the logic of industrial production still appear only sporadically in one country, region or settlement today – even though the idea itself is obviously not new, since the desire to maximize the use of resources and avoid 'waste' is practically as old as humanity. Development ambitions are very diverse, but wherever the need to create symbiosis appears, the goal is always to maximize economic and/or social benefits. Of course, this is not a negative thing, on the contrary: added value can be the real incentive, not just green thinking or environmental awareness. The most important step is always the accurate assessment of the situation in the case of the given geographical or economic unit, even through a simple SWOT analysis. It is

important to involve all stakeholders in the process from the beginning, this is the starting point of a network cooperation. There are examples where the bottom-up logic worked, while in others the top-down logic was succesful, so there is no single recipe for a good practice. However, it is certain that if there is already someone leading by example in a given location – be it an eco-industrial park or a business cluster – then the development concept of CE and industrial symbioses can spread much faster. It is important to emphasize that in the case of developing and emerging economies, it is typical that the implementation of CE, the development of a specific park takes place within the framework of an international development cooperation, so the role of international organizations (UNIDO, UN, World Bank, development agencies) is crucial to the given country. In emerging countries, eco-industrial parks can not only result in cleaner or more efficient production, but might contribute to the development of the local economy in a complex way, attracting foreign direct investments, creating new jobs and supporting economic catch-up.

IV.2. Summary of domestic practices and trends

In case of Hungary, it is clear that despite the successful elements and positive outcomes of the 2010-12 National Industrial Symbiosis Program, many steps are still needed to achieve circularity and industrial sustainability, and in this the public sector certainly has to play a much more intensive and proactive role than it does at present. Of course, this also applies to the business sector which must learn certain good practices and patterns in order to reinterpret its own production chain and logic. The domestic professional organizations interviewed during the research see themselves as very important mediators between the government and the economic sector. An integral part of this mediating role is the building of trust for all parties involved, as well as the demonstration and dissemination of good practices as widely as possible. The situation in Hungary shows that we are not significantly behind the other EU member states in terms of innovation potential, but serious shortcomings can be detected both in terms of the circular economic model and the wider implementation of industrial symbioses. The 'transition process' that the Hungarian economy and industry are facing will undoubtedly be one of the most decisive challenges for our country in the coming years (or decades) and will determine the country's regional and global competitiveness.

The most recent publication on the topic (published on April 28, 2023), is the OECD report titled *Towards a National Circular Economy Strategy for Hungary*, showing the domestic policy trends, visions and specific measures, as well as the most important statistical data characterizing the macroeconomic environment and supporting the necessity of

transitioning to a circular economic model (OECD, 2023). The detailed analysis of this source was not possible due to submission deadline of the present thesis (May 2023), however, the author continues to monitor the policy development of the subject area in Hungary. Based on the findings of the publication, it can be stated that, in accordance with the Hungary-related literature processed in the dissertation, as well as the results of the structured interviews, a comprehensive policy framework dedicated to a circular economy is very much needed in our country, so the top-down logic still prevails and is unavoidable. Another important aspect is the circular economic potential inherent in individual sectors, but still untapped, with particular regard to the food industry, biomass production or agriculture.

In the future, it will therefore be inevitable that innovation, research & development and the 'greening' of the economy will lead our country in the direction of circularity, and new industrial development strategies and projects will undoubtedly play a very significant role in this (see e.g. Industry 4.0), which were also emphasized in the interviews with domestic policy makers and representatives of professional organizations. In Hungary, the circular economic model is currently only present in an early, immature form, while it is practically completely absent in industrial parks. The Hungarian economy has a significant potential for the implementation of CE in industrial parks, but a very strong governmental involvement is needed for its implementation, both in the development of the policy and regulatory environment, and with the intensive participation of the relevant economic actors and industrial companies.

IV.3. Summary of the research results from Székesfehérvár

In the case of all surveyed companies (n=16), social responsibility appeared to be of particular importance, but at the same time there were significant differences in whether the economic, social or environmental dimension was emphasized. It was a determining factor for the companies to optimize their own energy consumption and at the same time reduce the amount of waste generated, but these measures were only implemented within the company and did not establish inter-company collaborations (which are of fundamental importance in the case of eco-industrial parks). Some companies demonstrated outstanding environmental awareness, especially Grundfos and Denso Hungary have a very progressive and conscious sustainability concept – which they implement and apply in practice. In case of the former, this is largely due to the good practices and models adopted from the Danish parent company. It can be concluded that there is a difference between 100% Hungarian-owned companies and foreign subsidiaries in terms of CSR, and the international background and embeddedness can

contribute to a more effective implementation of the circular economic model. There are collaborations between the companies, but mainly in an ad-hoc form, within the framework of a joint action or project.

Sharing knowledge and experience with each other was considered very important by all interviewees. However, this does not yet have an institutionalized platform, it rather works in an informal way, but the intention and willingness to cooperate more closely appeared everywhere. Regarding eco-industrial parks, the answers were very diverse. Some companies did not have any information about what exactly this concept meant, while others considered the future implementation of this type of model conceivable – with economic rationality at the centre of thinking.

In addition to selective waste collection and the use of recycled materials, the institutions of the public sector are constantly applying for domestic and European Union funds in order to achieve better energy efficiency and to 'green' the city, and these aspects are clearly considered important from the point of view of the perception and reputation of the settlement. The organizations themselves apply many green solutions, e.g. electric cars, solar panels, innovative heating solutions, composting, etc. At the same time, they are not leading at all in the use of other renewable energy sources (e.g. wind or geothermal energy). The interviewees showed an openness and willingness to cooperate more closely with the companies in Székesfehérvár, however, they described the current relations as mostly administrative in nature, and they could only name very few jointly implemented projects. Local government institutions are open to joint work and mostly receive good feedback about it, although they could not name many specific projects or areas of organic cooperation between the two sectors.

The municipality basically considers the 100 largest local tax-paying companies during the cooperation or joint decision-making, which can mean an imbalance in the representation of the interests of the private sector. At the same time, this confirms that the public sector is still willing to involve the private sector in the decision-making mechanisms to a certain extent. The investigated public institutions consider their own sustainability-related work to be good and innovative, and are open to further development.

At the same time, the interviewees tend to represent the view that large companies in industrial parks (especially multinationals) are isolated in their own industrial world, which suggests that public-private partnership networks and their potential are not well evaluated, perceived and used. However, during the interviews, it was possible to identify some new ideas

for improving communication between the municipality and the private sector (via online questionnaires and platforms), which were recently initiated directly by the mayor of the city. The title of the scientific article containing a detailed evaluation of the information collected during the research and the structured interviews is: *The state of green energy transition in regional industrial centers—The case study of Székesfehérvár*, the authors are András Márton, Zsófia Nemes and Márton Péti (Márton et al., 2022). The article was published in the scientific journal *Society and Economy*, rated Q3, in 2022.

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VI. Own publications related to the topic

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