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► **To cite this version:**

Mathilde Le Tellier, Lamia Berrah, Benoit Stutz, Jean-François Audy, Simon Barnabé. A Review of Actions Towards Circular Economy for Business Park's Governance.. Going Green - CARE INNOVATION 2018, Nov 2018, Vienne, Austria. hal-01829188

HAL Id: hal-01829188

<https://hal.science/hal-01829188>

Submitted on 7 Feb 2019

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A REVIEW OF ACTIONS TOWARDS CIRCULAR ECONOMY FOR BUSINESS PARK'S GOVERNANCE.

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ABSTRACT: A perfect example of business park aligned with circular economy is called 'eco-industrial park'. However, all types of business parks, where co-locating companies can partake in synergetic relationships to reduce/recycle their resources, have a high potential to deploy circular economy. Like in any other organisation, business park management could be considered as the definition of goals with the purpose of achieving them. This paper is a part of the creation of a decision-supporting tool for the business park's governing body to accomplish its goals related to circular economy. A systemic model of the components of a business park is presented using the Unified Modelling Language (UML). From academic and grey literature, a review of business park's governing body's actions supporting the transition towards circular economy is given. The impacts of the reviewed actions are then analysed using the proposed systemic model.

1. INTRODUCTION

Business park is one of the oldest and most traditional forms of planned economic development in Europe and North America. As defined by Peddle, an industrial park or estate, now called business park, is a "large tract of land, subdivided and developed for the use of several firms simultaneously, distinguished by its shareable infrastructure and close proximity of firms" [1]. Arising from an intent to separate industrial activities from residential urban areas, industrial parks provide an attractive means for businesses to locate in suburban areas and for communities to relieve pressures on the quality of life of a city [2]. Nowadays, the term business park is preferred to industrial park and can take many shapes: office parks, science and research parks, high-tech parks, biotechnology parks, warehouse parks, etc.

Circular Economy (CE) promotes the shift from the traditional, linear, open-ended economic system to a circular economic system, with 'closing-the-loop' production patterns [3]–[5]. As highlighted by Kirchherr et al., the concept of CE is trending among both scholars and practitioners but suffers severely from a lack of clear and consensual definition [6]. They proposed an exhaustive definition of the concept: "A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial

parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations". This definition states that the two core principles of CE are the 4Rs (Reduce, Reuse, Recycle, Recover) and the systems perspective, and it links CE with sustainable development and its three dimensions. More than the 4Rs, other practices and concepts, like pollution prevention, ecological economics design for environment, product stewardship, or environmental labelling, work towards the transition to a CE (for a detailed discussion of those practices, see [7]).

Industrial Ecology is a field of study that works towards the CE and is concerned with the material and energy flows in an industrial ecosystem. It supports the idea that an industrial ecosystem should develop an optimal web for the recycling and cascading of materials and energy, just like food webs in the natural ecosystem [8]–[10]. Concepts developed within the scope of Industrial Ecology are dematerialisation, material substitution, pollution prevention, design for environment and, most famously, industrial symbiosis (IS). IS is an Industrial Ecology concept focusing on the flow of resources through clusters of geographically proximate businesses in order to add value, reduce costs and improve environmental impacts [11]. An Eco-Industrial Park (EIP) is the direct implementation of IS in a business park. An EIP is a business park which aims at the collective improvement of its companies' environmental impact and economic benefits through IS [12]. As a reminder,

EIP is cited in Kirchherr et al.'s definition, at the meso-level of the circular economic system. Indeed, Industrial Ecology, and its related concepts such as IS and EIPs support a transition from a linear towards a more circular economy, creating different alternatives of the materials and their wastes through reuse, repair, recycling and remanufacturing [7], [13].

Aside from EIPs, all business parks have the capacity to engage in the creation of a circular economic system. Indeed, business parks gather various economic activities and can be managed to encourage sustainability and collaboration between companies. The United Nations Environment Program says that *“An industrial estate combines large-scale and diversity in its industrial activities. It is unlikely that a single factory will cover as many different industry sectors, resulting in a wider range of environmental aspects and the possibility of synergies between effects.”* [14]. Moreover, at the other end of the spectrum, business parks planned, built and managed with little concern for their impact on the environment can be a source of environmental damages. Sustainability and circularity should therefore be one of the biggest parts of the business parks' agenda. In a nutshell, a sustainable business park comprises two different aspects [15]:

- sustainable construction of the park with, for example, efficient use of space, high-quality and energy efficient buildings, infrastructure and systems, or integration of the site in its natural and cultural environment, etc.
- circular production processes thanks to, for instance, exchanges of material, energy and water, joint logistics, collective waste management, or production and use of renewable energy, etc.

As a result, business parks need to be properly managed even after their construction and this management needs to go further than renting/selling buildings/lots to companies. Business parks' managers can be called by various names: 'management body', 'governing body', 'coordinating body', etc. In this paper, the term 'governing body' is used as a way to combine decision making with managerial function.

The paper's overall objective is to define the business park's governing body's range of actions to transition towards CE. The first contribution is a systemic modelling of a business park through its entities and their interactions. This model offers a layered description of the business park from its governing body's point of view. A business park is composed of three main entities: its infrastructures, diverse and maintained by the governing body, its

buildings, owned by public or private proprietor, and its companies, implanted on the business park, in the buildings. This model is represented with a class diagram of the Unified Modelling Language (UML). The second contribution is a definition of the governing body's role, through its goals and CE-relevant actions. First, a state of the art of academic and grey literature on potential CE-relevant actions undertaken by business parks' governing body is presented. The identified actions are then classified using the UML systemic modelling. For each action, the class on which they have an impact is determined. This impact analysis of the reviewed actions will give decision makers a more coherent perspective on the concrete actions they can undertake for a transition towards CE in their business park.

The paper is structured as follows. In Section 2, the business park is represented through systemic modelling, defining its entities and their interactions with particular focus on its governing body. Section 3 offers a state of the art from academic and grey literature of the CE-relevant actions that can be undertaken in business parks to transition to a more circular economy. Then, in Section 4, using the systemic model and the survey from previous sections, an impact analysis of each action will offer a repertory of good practices to business parks' governing bodies. The relationship of this repertory with the performance of circular business parks is discussed in the concluding Section 5.

2. SYSTEMIC MODELLING OF BUSINESS PARKS TRANSITIONING TOWARDS CE

As a resilient, self-organizing, integrated whole of nested systems (companies) with non-linear behaviour, a business park transitioning towards CE can be considered as an artificial system [16]–[18]. Hence, using its systemic nature, the business park can be modelled through its goals, its entities and their interactions. This model offers a representation basis that is suitable to every kind of business park with optional elements characterizing the transition towards CE¹.

The Unified Modelling Language (UML) provides a standard way to visualize the design of a system [19]. UML is usually associated with software engineering but it has been used for organisations modelling. For example, Hein et al. provided a framework for EIPs using UML to model the park and more specifically the IS [20]. As this paper's focus is broader than IS, an original model of the business park is presented. In UML, a class can be seen as a template for instances and a class diagram is used for defining classes and

¹ The following model is an adaptation of a model for sustainable business park described in unpublished work.

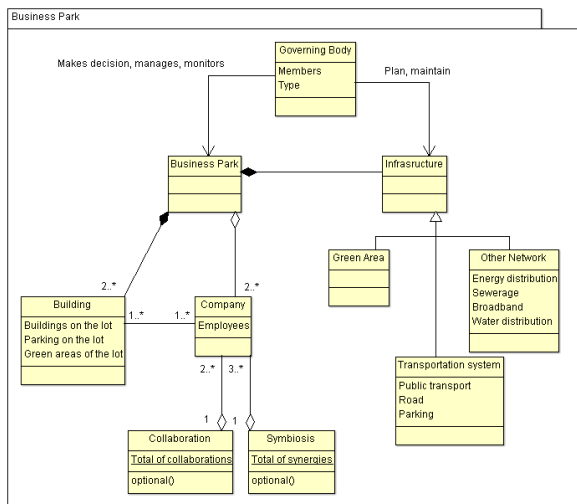


Figure 1 Class diagram of the business park

their relationships [20]. Here, it is used for defining the organisation of a business park: its different entities, their attributes, and their relationships.

Fig. 1 is a class diagram of the business park transitioning towards CE; it shows the constitutive entities of a business park and their relationship. Those entities, or classes, and their potential attributes are presented in the following subsections. The logical connections between the classes are represented with different UML relationships.

- A simple line and an arrow are respectively called bi-directional and uni-directional relationship. They allow one instance of a class to cause another to perform an action on its behalf. For example, the Governing Body plans and maintains the instances from the class Infrastructure.
- A hollow triangle shape represents an inheritance. It indicates that one of the two related classes is considered to be a specialized form of the other. For example, Green Space, Transportation System or Other Network are all specialized forms of the class Infrastructure.
- A filled diamond shape represents a composition. It implies that a class (the one on the diamond shape end of the line) contains another class. When the containing class disappears, the contained class disappears as well. For example, if a business park is destroyed, the buildings and infrastructures are destroyed.
- A hollow diamond shape represents an aggregation. Contrary to the composition, in an aggregation the contained class doesn't disappear with the containing class. For example, the companies will not be destroyed when destroying the business park.

- The numbers on the ends of the lines are optional notation that give information on the multiplicity. The multiplicity is the range of number of instances that participate in the relationship from the perspective of the other end. For example, a business park is the composition of two or more buildings.

The business park is constituted of several classes. The central class of the business park is the 'governing body'. This particular class and its role are detailed in Section 3.

The class 'building' relates to every building constructed in the park, which shelters the companies. An instance of this class includes a building and all the infrastructures of its private lot, like parking or green areas. The class 'company' relates to every tenant company of the park, including its employees. To be a member of a business park, a potential company should adhere to a set of principles and rules in terms of behaviour, structure and processes. This set of principles, or charter, can be assembled and enforced by the governing body. The buildings and companies are considered in two separate classes since a company does not necessarily own its premises and can both represent different stakeholders with different goals.

The class 'infrastructure' relates to all the elements of infrastructure managed by the governing body of the business park. The instances of this class are very diverse since it characterises roads, parking, green areas, or various distribution networks like sewerage, energy or broadband. The key aspects for high-performing infrastructures are their design, or sometimes redesign, and their maintenance.

An optional class for the business park system, that becomes mandatory for an EIP, is the class 'symbiosis'. In an attempt to promote complex exchange network, Chertow introduced the 3-2 heuristic, which requires that "at least three different entities must be involved in exchanging at least two different resources to be counted as a basic type of industrial symbiosis" [24]. According to this heuristic, the class 'symbiosis' must involve at least three company instances and can involve up to all the companies of the business park. The creation of a mature and strong symbiosis between the companies is one of the most important goals of a business park wanting to transition towards CE.

Another optional class is the class 'collaboration'. This class designates the collection of all immaterial relationships and flows of services or information between the tenants. For example, a company outsourcing a part of its operations to another company of the park, a car-sharing platform, offices renting, or a shared restaurant or day nursery, can all be collaboration opportunities. The development of a maximum of inter-firm exchanges and shared services

will be beneficial to the business park by directly contributing to its development, the attraction of new tenants, the animation of the local economic and social fabric, the satisfaction of the tenants and the promotion of local know-how. Indirectly, the development of collaboration will also strengthen the transition towards CE by initiating the dialogue and building trust between the stakeholders.

3. GOVERNING BODY OF THE BUSINESS PARK: DEFINITION AND ITS ROLE

As its name indicates, the governing body is the decision maker for the business park, working towards its development. This body can be composed of several actors with different individual goals, shifting during the different stages of development of the business park. It can be composed of public or private investors, planners, local governments, designated decision makers of the business park, etc. For example, in the particular case of EIP governance, Tessitore et al. collected the type of governing body for several international EIPs [21]. The majority of cases were located in China, the rest were based in the UK, Brazil and the USA. In some rare cases, the identified governing body was the biggest company of the EIP, called ‘anchor company’ or ‘key enterprise’. In the majority of cases, governing bodies were public institutions or institutions mandated by local authorities.

According to the United Nations Environment Program, a business park, or industrial estate, functions through an administration that assumes three roles [14].

- A *managerial role* for enforcing restrictive covenants in leasing agreements, deciding on the entry of new companies into the estate, collecting rents and ensuring that taxes and charges are paid, and being responsible for maintenance and order on the estate.
- A *technical role* that covers responsibility for common facilities as well as training or other technical services.
- A *financial role* including overseeing loans to tenant companies on the estate or arranging bulk purchasing agreements for materials.

For Brand & De Bruijn, the role of a governing body could be twofold with an initiating and stimulating role (driving force) and a coordinating role between the different actions [15].

It should also be noted that the power delegated to the governing body is influenced by the country in which the business park or EIP is implanted. For example, as pointed out by Qu et al., in a command economy such as China, the EIP managers play a pivotal role in planning, designing, organising, and

implementing the systems and processes for creating IS [22]. In France, discussion with business park managers revealed that they had restricted capacity in controlling the behaviour of company or driving the creation of inter-firm synergies.

In this model, the term governing body is used as a way to combine decision making (‘What *should we do?*’) with managerial function (‘How *should we do it?*’) [23]. In a simple manner, like in any other organisation, business park operation could be considered as the definition of goals with the purpose of achieving them. The accomplishment of these objectives requires decision making to identify appropriate strategies and actions, and monitoring of the undertaken actions. The selection of actions depends on the broadness of the range of actions available to the governing body.

As guardian of the business park’s sustainable development, the governing body can act on the different classes of the system to shape a CE through IS. The following section provides a review of the potential actions that can be undertaken by a governing body to transition a business park towards CE.

4. REVIEW OF ACTIONS TOWARDS CIRCULAR ECONOMY IN BUSINESS PARKS

4.1. Method and materials

In recent years, operational and academic literature on business parks, has considered the management topic and investigated the strategies implemented for the sustainable development of the parks, the tenants and their relationships. Whether called ‘management body’, ‘governing body’ or ‘coordinating body’, the importance of a team catalysing the development and functioning of a business park, and more particularly an EIP, has been cited in many papers [21], [22], [25], [26].

The following three phases of existence of a sustainable business park were proposed by the UNEP [14].

1. The planning and construction phase, where the environmental concept can be moulded as a function of the type of business park that is envisaged (for example heavy industry, technology- or science-based industry, or service industry), the choice of site and how industries will be located within it.
2. At the stage where companies are negotiating to come into the business park, the environmental criteria used by the business park’s management will be crucial in setting the scene for the type of company that will eventually locate there and what kind of environmental footprint the park will have.

3. The operating phase, or day-to-day running of the business park, which will require the creation of a coherent environmental program, such as through the use of an Environmental Management System (EMS).

It is also important to differentiate the revitalisation of existing business parks and the sustainable creation of new ones. One should note that the review of actions for the creation of CE in business parks only relates to the management of the park, not its planning. According to the three phases described above, the following review is mostly relevant to the second and third phases.

The information presented in the next sections is logged in Table 1 in Appendix 1. It was retrieved from academic literature in the industrial ecology field, principally on eco-industrial parks ([15], [22], [27], [28]) and from operational literature on industrial park environmental management ([14], [29], [30]). After reviewing an article, the identified actions were logged with their respective authors and redundant actions were eliminated. Lastly, actions relating to the creation of a governing body, like “*Establish a liaison mechanism with relevant local authorities*” or “*Establish a monitoring and coordination unit for the liaison mechanism with relevant local authorities*” in the PALME (Parc d’Activités Labellisé Maîtrise de l’Environnement) guidelines, were eliminated since the presence of a governing body is considered as a mandatory feature of a business park.

It should be noted that an extensive body of literature was reviewed but, to the best of our knowledge, very few publications addressed the topic of the governing body’s actions. Indeed, most articles presented general policies or concepts that could be planned or implemented into business parks and EIPs, but few articles discussed the subject from the governing body’s perspective and at the operating phase.

4.2. State of the art on the actions supporting the transition to a CE in a business park

4.2.1 Operational literature

The Veurne Industrieterrein I business park, located in Flanders, presented their actions to achieve sustainable development. Those actions mainly seem to be orientated towards environmental performance of the park and are not concerned with the operation of the business park [29]. They identified four strategies with actions.

- Moving towards a more efficient use of resources, with actions relating to heat exchange, energy-efficient light system and clustering of services related to energy.
- Promoting sustainable mobility, with actions relating to bike mobility, sustainable use of

cars and connection to public transport network.

- Increase energy production from renewable sources, with actions relating to collective solar and wind energy production.
- Sustainable living and working environment, with actions relating to green areas, common security system and shared facilities.

Tessitore et al. investigated Italian EIPs’ management and concluded that i) the management body of an EIP represents the link between the companies and the public authorities and ii) it promotes the development of the EIP and the environment protection [21]. They observed that the local community participated in the development of the EIP thanks to the management body, which identified the needs and requests of the companies.

In a report addressed to business park managers, the Chamber of Commerce and Industry of Marseille identified the key elements for a sustainable performance of their parks [30]. Those key elements are ‘*management and maintenance of the park*’, ‘*animation of the park*’, ‘*shared services*’, ‘*animation of the local economic fabric*’, ‘*strategic services to the tenants*’, ‘*functionality of park planning*’, ‘*quality of park planning*’ and ‘*promotion and communication*’. The particularity of those principles is that they are not solely orientated towards IS but also towards sustainable management and urban planning.

In a similar manner, the French eco-label for industrial parks PALME, provides a different interpretation of the sustainable industrial park. PALME does not emphasise process coupling and by-product exchange, instead the requirements of the label give priority to environmental planning and management of the park [14], [31].

4.2.2 Academic literature

Qu et al. identified three types of environmental practices in an EIP [22].

- Instituting environmental norms such as setting up environment management systems, setting up regulations about pollution or securing the ISO 14001 certification.
- Building IS, for instance by establishing a by-product exchange platform, encouraging enterprises to exchange by-products, establishing water cascade between the tenants or sharing information between the enterprises.
- Providing guidance to key enterprise, for example by implementing energy audit and material flow analysis in the key enterprises or encouraging them to implement cleaner production or to secure the ISO 14001 certification.

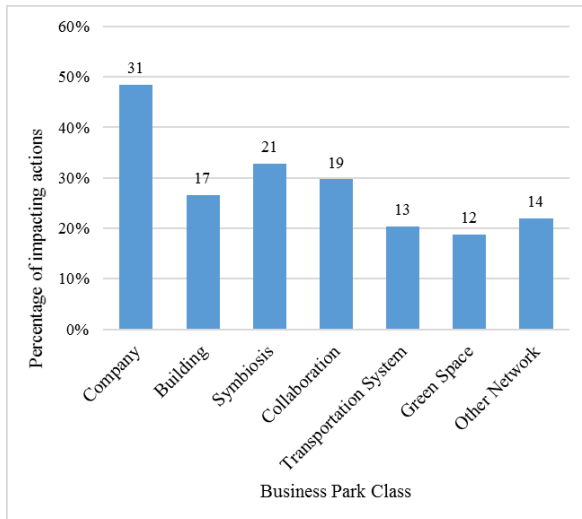


Figure 2 Percentages of actions impacting business park class

Tikhanov et al. proposed similar practices [28]: *"Raising the standards of ecological and energy efficiency of the park's resident enterprises; Enhancing and expanding inter-firm cooperation in production, research and marketing; Assistance to residents provided by the management company in order to attract financial and non-financial state support for the development of production on the territory of the park."*

5. IMPACT ANALYSIS OF THE ACTIONS ON THE ENTITIES OF THE BUSINESS PARK

Using the systemic modelling presented in Section 2, the actions presented in Section 3 are classified according to the classes of business park on which they have a significant impact. This impact analysis offers a repertory of 'good practices' according to the business park's management perspective. This allows decision makers to select the most adequate action(s) according to their situation while taking into account their sometimes limited, range of options. For each action, the entities on which they have an impact are identified. For example, the action 'Set up requirement of energy exhaust for enterprises in the EIP' [22] has an impact on the instances of the class 'company' exclusively, while the action 'Set up collective solar energy production' [29] will have a benefit on the development of a symbiosis and in turn will have an impact on the buildings and the green areas where the solar energy production systems will likely be installed. Table 1 in Appendix 1 represents the impact matrix resulting from this analysis.

Figure 2 gives a summary of the impact analysis. The results are that the inventoried actions supporting the transition toward CE in business park focus mostly on the companies. The rest of the entities have a

relatively similar number of actions impacting them. This observation can seem surprising since the companies are the entities the governing body usually has the least power over, but it emphasizes the importance that the companies play in the circularity and therefore, sustainability, of the park. Indeed, the symbiosis is an important feature of CE but not the only one.

This analysis underlines the relevance of the review of the governing body's actions. It also highlights the relevance of a systemic model with diverse entities and the presence of a governing body coordinating those entities. The fact that the inventoried actions do not contradict one another is also noteworthy.

Lastly, it should be noted that this analysis doesn't account for the significance of an impact on the transition towards CE.

6. CONCLUSION

Due to relentlessly growing environmental concerns and distrust in the concept of sustainability, the concept of CE has gained a lot of attention in academic and operational literature. Defining CE, a concrete application of the concept at the meso-scale was found to be the EIP. An EIP is a business park which openly aims at the collective improvement of its companies' environmental and economic performance through collaboration and resources exchanges. More than EIPs, every business park, from simple industrial or office parks to more specific science and research parks or high-tech parks, can support the transition towards CE and benefit from it. Indeed, all business parks have the potential to be 'EIPs', or at least, more circular and sustainable. The potential of a business park needs to be harvested by a governing body, acting as a decision maker ('*What should we do (to create a CE)?*') and a manager ('*How should we do it?*').

After presenting a UML systemic model of a business park, a review of the potential actions that can be undertaken by the governing body of such business park was provided. This review, from the academic and operational literature was then analysed through the prism of such systemic model. This analysis underlines, to some extent, the relevance of the review and the systemic model. This work set up the basis toward the development of a Performance Measurement System, with goals and metrics associated to each goal. Moreover, for practitioners, this work provides the first state-of-the-art repertory of good practices in the area of circular business park's governance.

7. REFERENCES

- [1] M. T. Peddle, "Planned Industrial and

- Commercial Developments in the United States: A Review of the History, Literature, and Empirical Evidence Regarding Industrial Parks and Research Parks,” *Econ. Dev. Quaterly*, vol. 7, no. 1, pp. 107–124, 1993.
- [2] A. J. D. Lambert and F. A. Boons, “Eco-industrial parks: Stimulating sustainable development in mixed industrial parks,” *Technovation*, vol. 22, no. 8, pp. 471–484, 2002.
- [3] F. Preston, “A Global Redesign? Shaping the Circular Economy,” *Energy, Environ. Resour. Gov.*, no. March, pp. 1–20, 2012.
- [4] P. Ghisellini, C. Cialani, and S. Ulgiati, “A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems,” *J. Clean. Prod.*, vol. 114, pp. 11–32, 2016.
- [5] Ellen MacArthur Foundation, “Towards the Circular Economy,” 2013.
- [6] J. Kirchherr, D. Reike, and M. Hekkert, “Conceptualizing the circular economy: An analysis of 114 definitions,” *Resources, Conservation and Recycling*. 2017.
- [7] N. Nakajima, “A vision of industrial ecology: State-of-the-art practices for a circular and service-based economy,” *Bull. Sci. Technol. Soc.*, 2000.
- [8] S. Erkman, “Industrial ecology: An historical view,” *J. Clean. Prod.*, vol. 5, no. 1–2, pp. 1–10, 1997.
- [9] R. A. Frosch and N. E. Gallopoulos, “Strategies for Manufacturing Waste from one industrial process can serve as the raw materials for another, thereby reducing the impact of industry on the environment,” *Sci. Am. Ou Sci. Am.*, vol. 189, no. 2613, pp. 144–152, 1989.
- [10] J. Korhonen, “Four ecosystem principles for an industrial ecosystem,” *J. Clean. Prod.*, vol. 9, no. 3, pp. 253–259, 2001.
- [11] M. R. Chertow, “Industrial symbiosis: Literature and taxonomy,” *Annu. Rev. Energy Environ.*, vol. 25, pp. 313–337, 2000.
- [12] U.S President Council on Sustainable Development, “Eco-industrial park workshop proceedings,” Washington, DC, 1997.
- [13] Y. M. B. Saavedra, D. R. Iritani, A. L. R. Pavan, and A. R. Ometto, “Theoretical contribution of industrial ecology to circular economy,” *J. Clean. Prod.*, vol. 170, pp. 1514–1522, 2017.
- [14] United Nations Environment Programm, *Environmental Management for Industrial Estates: Information and Training Resources*. 2001.
- [15] E. Brand and T. De Bruijn, “Shared responsibility at the regional level: The building of sustainable industrial estates,” *Eur. Environ.*, 1999.
- [16] R. Chapman, P. Howden-Chapman, and A. Capon, “Understanding the systemic nature of cities to improve health and climate change mitigation,” *Environ. Int.*, vol. 94, pp. 380–387, 2016.
- [17] M. Felicio and D. C. Amaral, “Environmental indicators applied to reality of Eco-Industrial Park (EIP),” *11th Glob. Conf. Sustain. Manuf.*, 2013.
- [18] E. Romero and M. C. Ruiz, “Framework for applying a complex adaptive system approach to model the operation of eco-industrial parks,” *J. Ind. Ecol.*, vol. 17, no. 5, pp. 731–741, 2013.
- [19] Object Management Group, “UML 2.0 Specification,” 2017.
- [20] A. M. Hein, M. Jankovic, R. Farel, and B. Yannou, “A Conceptual Framework for Eco-Industrial Parks,” in *Volume 4: 20th Design for Manufacturing and the Life Cycle Conference; 9th International Conference on Micro- and Nanosystems*, 2015.
- [21] S. Tessitore, T. Daddi, and F. Iraldo, “Eco-industrial parks development and integrated management challenges: Findings from Italy,” *Sustain.*, 2015.
- [22] Y. Qu, Y. Liu, R. R. Nayak, and M. Li, “Sustainable development of eco-industrial parks in China: Effects of managers’ environmental awareness on the relationships between practice and performance,” *J. Clean. Prod.*, 2015.
- [23] B. Tricker, *Corporate Governance: Principles, Policies and Practices*. 2012.
- [24] M. R. Chertow, “‘Uncovering’ Industrial Symbiosis,” *J. Ind. Ecol.*, vol. 11, no. 1, pp. 11–30, 2007.
- [25] M. Mirata, “Experiences from early stages of a national industrial symbiosis programme in the UK: Determinants and coordination challenges,” *Journal of Cleaner Production*. 2004.
- [26] I. P. McCarthy, B. S. Silvestre, A. von Nordenflycht, and S. M. Breznitz, “A typology of university research park strategies: What parks do and why it matters,” *J. Eng. Technol. Manag. - JET-M*, 2018.
- [27] C. Erdmenger, “From business to municipality—and back,” *Local Environ.*, vol. 3, no. 3, pp. 371–379, 1998.
- [28] E. Tikhonov, V. Krivorotov, A. Kalina, and S. Erypalov, “Model of eco-industrial park development as a tool for fostering energy efficient economy,” in *E3S Web of*

Table 1 (continued)

| | Actions | Business Park Class | | | | | | | Ref. |
|---------------------------------------|---|---------------------|---|----|----|----|----|---|--|
| | | C | B | Sy | Co | Tr | Gr | O | |
| Impacting Company class | Organisation of open-houses, collaborating with academia | 1 | | | | | | | (CCIMP, 2010) |
| | Deployment of communication tools (newsletter, website ...) | 1 | | | | | | | (CCIMP, 2010) |
| | Set up meetings and thematic work session between the tenants | 1 | | | | | | | (CCIMP, 2010) |
| | Organisation of events related to the activities of the companies and the theme of park | 1 | | | | | | | (CCIMP, 2010) |
| | Raise the standards of ecological and energy efficiency of the park's resident enterprises | 1 | | | | | | | (Tikhonov et al., 2016) |
| | Establish an advisory service for clean technologies | 1 | | | | | | | (UNEP, 2001) |
| Impacting Building class | Monitor available constructible land and available buildings | | 1 | | | | | | (CCIMP, 2010) |
| | Integrate regulatory requirements regarding the use of natural light in buildings in permits for refurbishment and new buildings construction | | 1 | | | | | | Veurne Industrieterrein I |
| | Establish a landscaping plan and architectural requirements for buildings | | 1 | | | | | | (UNEP, 2001) |
| | Develop and implement a 'clean construction site' programme | | 1 | | | | | | (UNEP, 2001) |
| Impacting Symbiosis class | Establish the by-product and wastes exchange platform | | | 1 | | | | | (Qu et al., 2015) |
| | Build eco-industrial chains in the EIP | | | 1 | | | | | (Qu et al., 2015) |
| | Establish water cascade among the enterprises | | | 1 | | | | | (Qu et al., 2015) |
| | Build energy cascade among the enterprises | | | 1 | | | | | (Qu et al., 2015) |
| | Encourage the enterprises in the EIP to exchange by-products | | | 1 | | | | | (Qu et al., 2015) |
| | Establish heat exchange | | | 1 | | | | | Veurne Industrieterrein I |
| | Promote clustering of services related to energy | | | 1 | | | | | Veurne Industrieterrein I |
| Impacting Collaboration class | Support the setup of services for the companies and users | | | | 1 | | | | (CCIMP, 2010) |
| | Provision of services to the companies: wastes collect, green areas and buildings maintenance, security system, commuter plan, meeting rooms and office renting ... | | | | 1 | | | | (CCIMP, 2010) |
| | Provision of services to the employees: Restauration, day nursery, sports facilities, convenience stores, hotels etc. | | | | 1 | | | | (CCIMP, 2010), Veurne Industrieterrein I |
| | Guidance of targeted companies (business incubator and accelerator, ...) | | | | 1 | | | | (CCIMP, 2010) |
| | Provision of equipment (laboratories, research units, innovative materials ...) | | | | 1 | | | | (CCIMP, 2010) |
| | Mutualise equipment (laboratories, test platform, IT platform, ...) | | | | 1 | | | | (CCIMP, 2010) |
| Impacting Transportation system class | Organise the logistics of the park (transport of goods and peoples, parking management, security, ...) | | | | | 1 | | | (CCIMP, 2010) |
| | (Re)Think the location and accessibility of the services | | | | | 1 | | | (CCIMP, 2010) |
| | Promote bicycle mobility | | | | | 1 | | | Veurne Industrieterrein I |
| | Promote sustainable use of cars (with car-sharing or car-pooling services) | | | | | 1 | | | Veurne Industrieterrein I |
| | Improve the connection to public transport network | | | | | 1 | | | Veurne Industrieterrein I |
| Impacting Green Space class | Design of the public spaces (sustainable gardening, materials, street furniture, urban, architectural and environmental quality, ...) | | | | | | 1 | | (CCIMP, 2010), Veurne Industrieterrein I |
| | Implement a public awareness and information programme concerning natural environmental and conservation | | | | | | 1 | | (UNEP, 2001) |
| Impacting Other Network class | Maintenance/Renovation of the networks | | | | | | | 1 | (CCIMP, 2010) |
| | (Re)Size and manage the different networks (lighting, sewerage, water, energy, broadband, ...) | | | | | | | 1 | (CCIMP, 2010) |