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A circular economy and industrial ecology toolbox for developing an eco-industrial park: perspectives from French policy

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Abstract

The twentieth century was characterized by an increase in research studies concerning the interactions between economic system growth and environmental deterioration issues. Faced with this background, circular economy (CE) and its industrial ecology (IE) pillar seem to be an efficient way to achieve sustainable development within the industrial sector. IE consists of optimizing the networking among industries by using energy and material exchange, which are generated from by-products and waste stocks. It aims to improve the environmental potentialities of integrated clusters called eco-industrial parks (EIPs). Policy in the European Union countries and in French territories has positively influenced such EIP implementation by the establishment of a set of measures to develop the industrial symbiosis performances. The present paper reviews the key drivers to identify the methods and tools to integrate the life cycle thinking approach that defines the following five phases: design, layout, commercialization, operating and renewal phases. A toolbox for developing an EIP from scratch according to French policy is developed and discussed. This study defines a framework involving a factual eco-industrial park and network. The industrial application is a new EIP, namely "Les Portes du Tarn". It is located in the south of France and acts as an experimental field. The paper provides current results for commercialization and operating, including a model of an organizational process, a decision-making process, information technology tools and systems to manage sustainable development. It highlights the CE and IE challenges surrounding enhancing the social acceptability of an industrial park project through adaptation of a relevant governance model and establishment of a continuing collaborative context and trust relationship between diverse actors. The first candidate companies' achievements are discussed and demonstrate the

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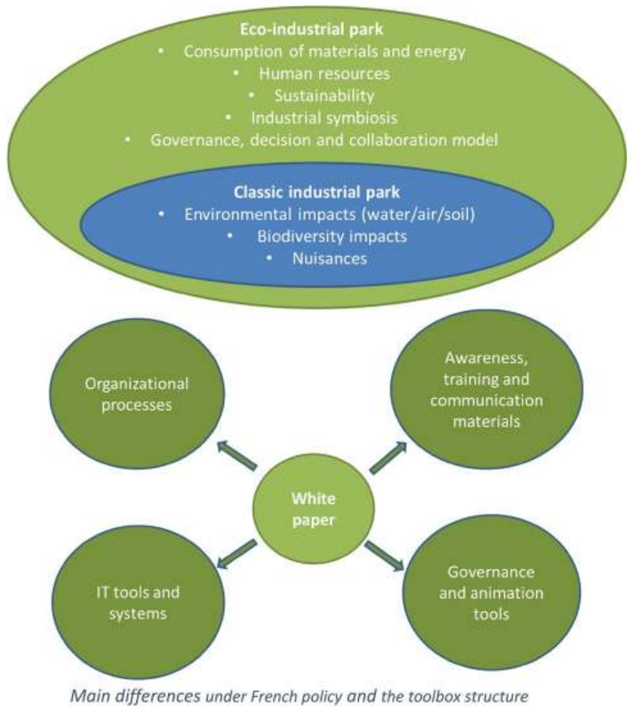
first benefits of toolbox. The paper delivers a toolbox, feedback and some good practices to support the development of EIP project from greenfield.

Graphical abstract



Keywords Circular economy · Industrial ecology · Sustainable development · Industrial symbiosis · Urban planning · Life cycle thinking

Introduction

The current production-consumption system is unsustainable. The anthropic sphere needs more than 68 billion tons of materials every year (Krausmann et al. 2009) to satisfy the needs of 7 billion citizen-consumers (United Nations 2013). This material use is related to the population size in a growing economy system. With the expectation of 10 billion inhabitants in 2050, the linear "take, make and dispose" pattern will challenge the resource stock management (for non-renewable resources), the production capacity (for renewable resources) and the biosphere resilience of our limited planet.

The industrial economy was premised at the onset of industrialization upon a linear model. It is based on the extraction and consumption of raw materials and energy to fulfil the growing customer demand. Thus, some companies and governments have noticed an increase in their negative externalities (CO_2 emissions, oil spills, pollution, etc.). This model has generated important losses and detrimental impacts along the value and material chain. It has caused economic losses, structural waste, supply risks and degradation of natural ecosystems. In the light of these various pressures, it was necessary to rethink the industrial system management. The main research efforts have to address the following two simultaneous purposes: how to preserve the positive aspects of a continued development cycle while ensuring resources and environmental protection.

Businesses and policy makers have started to seek new ways to enhance resource efficiency and to minimize the system risks. The research reveals that their common thread was the improvement of the stock management and the renewable flow control. These requirements have introduced the transition to the "circular economy (CE)" model. The circular economy concept is defined as "one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles" (Ellen-MacArthur-Foundation 2015). The application of this model would offer many opportunities for technological and social actors. Companies will be able to optimize their yield performance and have a better security of supply, whereas consumers profit from offers adapted to their needs. This approach is considered as an important pillar that contributes in the externalities reduction and the environment resilience built. It contributes to the total annual greenhouse gas emissions limitation and protects and promotes the land productivity. Since 2011, the European Commission has proposed the use of the "circular economy" model to address the current challenge (European Commission 2011).

According to the French Environment and Energy Management Agency (ADEME), the circular economy transition could be reached with a coordinated use of seven main "action fields" in a multi-scalar approach (Fig. 1). The "sustainable supply" concerns raw material extraction and exploitation modes for both renewable and non-renewable sources (materials and energies). It aims to reduce waste and limit the negative impacts on the environment. The second field is based on the "Eco-Design" process of products and services. It analyses the life cycle to develop the manufacturing ability of more eco-friendly products. Thus, the boost of a "responsible consumption", whether of economic actors and consumers, may support the progress for their use. The new applied approach moves towards the application of the "function-oriented-business models" concept. It is related to the sale of the service performance of a product instead of the product itself. Consumers could also extend the product's "usage time". The consumption systems have to focus on the restorative use of non-renewable resources, and the extraction and reuse of raw materials from waste and the "recycling" of products (Environment, Energy and Water French Ministry 2016).

In a territory system, the transition to the circular economy could mobilize another action field, namely the implementation of the "industrial ecology" (IE) concept in the territorial production system. This concept introduces an inter-company exchange of industrial flows where a purpose of zero waste needs to be reached. It aims to create waste collection and treatment, equipment, infrastructure and services mutualization. Indeed, the development of symbiotic partnerships aims to optimize the material cycles and energy flows within an industrial cluster. This cooperation leads to the creation of competitive advantages to generate "win–win situations" for businesses and to minimize environmental impacts caused by the industrial activities. Therefore, several actions have been taken to promote eco-industrial development, such as the implementation of eco-industrial parks (EIPs) and networks.

This article addresses the application of the industrial ecology approach to develop a toolbox that supports a future industrial eco-park implementation, namely "Les Portes du Tarn". We present in "Building a new industrial park using an EIP model" section a global insight on the EIP concept, its implication forms within the European and French contexts, and our applied research frame located in south of France. "Materials and methods" section addresses the materials and methods such as the integration of research actions in an EIP emergence and the integration of life cycle thinking (LCT) to develop a systemic approach. "Results" section gives first results for commercialization and operating phases, i.e. toolbox, organizational processes, IT tools and systems and first companies' achievements.

Fig. 1 Main action fields of circular economy (translated from ADEME 2017)

Building a new industrial park using an EIP model

The EIP concept

The eco-industrial park (EIP) is an important fulfilment of the industrial ecology field that was suggested by Frosch and Gallopoulos (1989). It is defined as a "community of businesses that co-operate with each other and with the local community to efficiently share resources (information, materials, water, energy, infrastructure and natural habitat), leading to economic gains, gains in environmental quality and equitable enhancement of human resources for the business and local community" (Cohen-Rosenthal and Musnikow 2003). This cooperative concept proposes the adoption of an analogy model with natural ecosystems to achieve more resources use efficiency at the park scale, namely a more sustainable industrial system (Liu et al. 2015; Valenzuela-Venegas et al. 2016). These goals rely on a system-oriented approach of the park in its natural context, the territory (Deutz and Gibbs 2008). We consider the territory as a delimited area, appropriated by a community, over which the authority of a collectivity can be exercised.

EIP involves mostly eco-industrial synergies. The substitution synergies designate the exchange of material and energy flows between two or more industries. Waste, by-products or unrecovered energy substitute flows. Mutualization synergies occur when companies have common needs. Research on existing EIPs in France and Europe show that mutualization synergies are related to mass and energy flows, as well as other components, such as infrastructure, equipment, services, employee technical skills, and specific waste collection and treatment. A pooling of these resources leads to reduced economic and environmental costs (Park and Behera 2013).

The achievement of potential synergies depends on many objective criteria. First, the exchange of some types of flows relies on the distance between factories. For example, the production or sharing of a steam or compressed air collective network needs proximity to create technical, economic and environmental benefits (Taddeo 2016). If there is a big distance, the cost of transport becomes the new issue to implement the synergy. The second selection rule is that common flows must be homogeneous to be exchangeable between companies. Third, the quantity and availability of flows must be uniform, and the synergy has to generate an economical interest in the short- and long term for the involved partners (Adoue 2010).

The industrial ecology term gained prominence in the 1990s (Erkman 1997). In a resource-constrained world, eco-industrial parks are increasingly seen as an effective way to limit the resource consumption in our economy. In 2010, the Organization for Cooperation and Development (OECD) identified industrial symbiosis (IS) as "a vital systemic innovation for green growth" (Lombardi and Laybourn 2012). China became the first country to launch an eco-industrial park standard in 2006, and 1568 national and provincial industrial parks are involved (Geng et al. 2008, Shi et al. 2012).

The literature on eco-industrial parks has shown that these initiatives are advantageous for companies (Veleva et al. 2015). The realization of potential synergies comes from the capacity of businesses to link and create suitable collaboration and exchange patterns (Geng et al. 2015). Each involved company must share information on their needs (mass and energy flows, employee skills, services, infrastructure, logistic, equipment, etc.) (PCSD 1997). This information could be considered as strategic for some participants because of its relation to the company performance. Therefore, it is necessary to strengthen the stakeholders' understanding, trust and respect, which could be a solid foundation for further collaboration.

This partnership leads to identifying opportunities to create a potential industrial symbiosis network (Yong et al. 2015). Chertow (2000) has defined the concept of industrial symbiosis (IS) as "engaging traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products". The main key to building a successful IS network is the "collaboration and the synergistic possibilities offered by geographic proximity" (Chertow 2000; Satoshi et al. 2016; Agarwal and Strachan 2006). The information on flows and needs could be gathered from questionnaire surveys, interviews with managers or direct meetings between the participating companies. It could also need the use or development of a software package to collect data and to create information on potential synergies (Grant et al. 2010).

The collected data on mass and energy flows and company needs' exchange often illustrate the first level of trust, whereas the implementation of industrial synergies requires a higher level due to a significant investment (equipment and process) and middle- or long-term collaboration.

In European Union countries, policy has a positive influence on EIP development through indirect incentives (Fei et al. 2014). The policy makers have established a set of measures to support the development of industrial symbiosis performances, which may reassure the stakeholders to participate in it more. However, in each country, policy influences and drivers vary with the different development situations. In some cases, governments have removed local regulatory locks and put in place incentives to EIP projects. In fact, the planning guidance is based on strict environmental standards, resource comprehensive utilization schemes, tax preference and financial support through subsidies and financial assistance (Fei et al. 2014). It offers a competitive production environment that can create integrated clusters (Zhe et al. 2015).

Eco-industrial park and network development in France

In France, the topic of industrial ecology emerged in academic and business fields at the end of the 1990s (Bourg and Erkman 2003) with the International Conference on Industrial Ecology and Sustainability (Vivien et al. 2000). Currently, 60 industrial ecology initiatives are identified (Orée 2016). These projects concern very different types of territories. They may concern areas, from industrial parks to departments, with industrial activities or small–medium enterprises and agricultural activities. Most of them began with a local institutional actor (local government, chamber of commerce and industry, etc.) and a group of local willing companies. ADEME, the French Environment and Energy Management Agency, support some of these initiatives. Among these initiatives, there are less than 10 EIP projects in France. Since 1999, some methodological (COMETHE, PNSI) and computer tools (EDITERR, INEX, Actif') have been created to develop these approaches. They are dedicated to the development of parks or eco-industrial networks within existing business systems in a given territory. And they are only restricted to synergies identification.

Therefore, the development of EIP concept in France is applied to existing industrial areas, such as in the Havre or Dunkerque harbours. Progress is boosted by the knowledge of data (company's, infrastructures, flows, materials, etc.) and social acceptance already established of industrial activities. However, such EIP project based on existing industrial system is restricted by the current organization of company's structure (processes adaptation, the ability to invest in a process change, the distance between factories, etc.), which can reduce the opportunity to implement CE and EIP concepts.

Another type of projects recently emerged in France: to promote economic activities by developing new industrial area (i.e. from scratch) in the frame of CE and EIP concepts. There are at present two initiatives. "Salaise-Sablons" (Lyon) and "Les Portes du Tarn" (Toulouse) initiatives are EIP projects integrating a new industrial area development.

This paper is the result of research work in association with "Les Portes du Tarn" initiative (presented in "An EIP in the south of France" section). The main issues compared to a project using an existing industrial system are: the big lack of data, a higher social acceptance challenge, an advanced need for communication tools, an infrastructure to develop, a civil engineering sub-project, a full park life cycle to manage, a wide-ranging design phase, a more complex layout and commercialization phases and, a governance and decision-making model to carry out. The current methods and tools available for eco-industrial park and network development in France consider an existing industrial system. From our initial analysis shared with ADEME and "Les Portes du Tarn" urban agency, they are not suitable for an EIP emergence on bare land.

The scope of our study is to develop an appropriate toolbox for developing a new eco-industrial park from scratch under French policy. As such toolbox does not exist, the French Environment and Energy Management Agency supports its creation. The toolbox is defined by several components. It consists of a central document, a free white paper providing definitions, guiding ideas and recommendations. The white paper references the other toolbox components such as processes, materials, IT applications and animation tools. An industrial project, "Les Portes du Tarn", acts as our experimental field.

French regulatory context for the development of an EIP from scratch

In 2015, French authorities have developed "the Energy Transition Law for Green Growth". It prepares for the post-oil era and the establishment of a sustainable energy model in the face of energy supply challenges, price rises, resource depletion and the necessity of environmental protection (Law No. 2015-992, 17 August 2015). It has focused on waste management as an essential pillar to ensure the transition to a circular economy model. Waste production amounts were fixed to be reduced in 2020. It aims to enhance its recovery process by increasing the valorization rate from 55% in 2020 to 65% in 2025. Policy assessment is essential to identify the opportunities and to create enabling conditions for the development of the EIP process.

For every French infrastructure project such as an industrial park, the law requires that an environmental impact assessment is attached to the planning of the project in accordance with the European Directive 2014/52/EU. It must report on the potential or actual effects on the project and make it possible to study and justify the choices made with regard to the issues identified in the territory concerned. The environmental assessment must be carried out as far upstream as possible, in particular, in case of multiple authorizations or decisions, from the first authorization or decision, and cover the entire project and its impacts. Environmental assessment is consequently part of the implementation of the principles of prevention, integration, precaution and public participation.

Stakeholders have a key role in French regulatory process. Significant opposition to the project may result in opponents occupying the area, sometimes for years. They could decide to create an "area to defend". This means that they settle on the area for a long duration to prevent the start of layouts works. In addition to this occupation, multiple legal remedies can be launched against the project. Flaws in the environmental assessment file could stop the project. Protection of biodiversity and soil occupation are two main issues. In France, opponents have blocked major industrial projects such as the "Zone A Défendre de Notre-Dame-des-Landes" from 2012 to 2018 (opposed to the new international Loire-Atlantique airport) and the Sivens hydraulic dam in 2015. Unlike these radical actions for the defence of biodiversity and non-industrial field, a nationwide protest known as "gilets jaunes" (yellow vests) started in November 2018. The opponents protest against new government measures to tax "polluting cars" for going further in the French energy transition law. In this case, oppositions arise for an (economic) "gain to defend". To develop initiatives and projects such as industrial areas are more and more complex, and social acceptance is a very tricky issue to deal with.

The French Urban Planning Code governs the creation of industrial areas under the Concerted Zones of Development (CZD) legal status. It specifies or completes the requirements of the European Directives. This national legislation includes especially an accuracy of the recovered and renewable energies development potentials in the affected area (L128-4 article from the Urban Planning Code). This policy has been boosted by other recommended measures. In 2010, the acts of "Grenelle Environment" have dealt with the design of urban planning more broadly. It aims to limit the urban spread and to ensure an efficient management of resources with preservative and restorative environmental strategies [Law No. 2010-788, 12 July 2010 supporting the national engagement for the environment (NEE law)]. Therefore, regulatory texts focus on local environmental impacts and nuisances. They prescribe technical measures to periodically monitor, limit or compensate the impacts. They also require consultation with all stakeholders (notably local residents) through a public inquiry (Fig. 2). However, it does not provide any measure to limit the consumption of material resources during the layout and the operating phases of the industrial park. An EIP approach enlarges this scope and asks the questions of future material and energy consumption, human resources, industrial symbiosis, sustainability of future economic activities and organizational models.

Fig. 2 Main differences between park policies in a French context

An EIP in the south of France

Due to the aeronautic industry development, the city of Toulouse (south of France) is experiencing rapid urban population development and dynamic economic growth. It receives approximately 9000 new habitants every year (Toulouse town hall 2017). Thus, local authorities are facing an intensive demand to accommodate a new population and new industrial activities. To reach this goal, two local authorities, the Tarn Department and the Tarn-Agout Federation of Municipalities, decided to create a local planning agency, namely SPLA81, to manage a new industrial park in south of France (Les Portes du Tarn 2018). The project has started in 2011. It is located at a distance of 20 km from Toulouse city and covers a surface of 250 ha (Fig. 3). The territory is sensitive to new industrial and development projects: the park area is 30 km far from the Sivens hydraulic dam site, project stopped in 2015, and 50 km far from the AZF industrial accident.

The social acceptability within the territory is consequently a critical issue. Recently, the corresponding area has experienced several tensions because of two main industrial accidents. In September 2001, the explosion of the chemical company "AZote Fertilizers" (AZF) caused the deaths of 31 persons and heavy material damage in the south of Toulouse. Moreover, the project of a hydraulic dam in the Sivens village, located 30 km away from the future EIP, has created violent confrontations between opponents and police in 2014. In January 2018, the French government finally abandoned "Notre-Dame-des-Landes" airport project near the city of Nantes. That highlights the difficulty of getting civil society to accept infrastructure projects in France.

The local authorities were therefore aware that the acceptance of the industrial park project by the stakeholders would be complex and crucial. They based their strategy on the consultation of these stakeholders and the environmental excellence of the park. The park, however, had to remain attractive to industries. After the feedback from the public inquiry, the industrial park project became a mixed-use project. It involves agricultural, tertiary, leisure, tourism activities, services and shops, with the domination of the industrial field (61%). Eco-industrial synergies allow to limit energy and material consumptions. These performances could be assessed and shared with the stakeholders. To respond to the dual challenge of acceptability (social and environmental) and competitiveness (economic), the authorities decided to base the project on CE with an EIP approach as a main target.

To foster this social acceptability, holders aim for the exemplarity, innovation and transparency. At first, they decided to involve service activities in the project. They devoted 19.7% of the total area to stores and leisure and approximately 15% to agricultural activities. As an

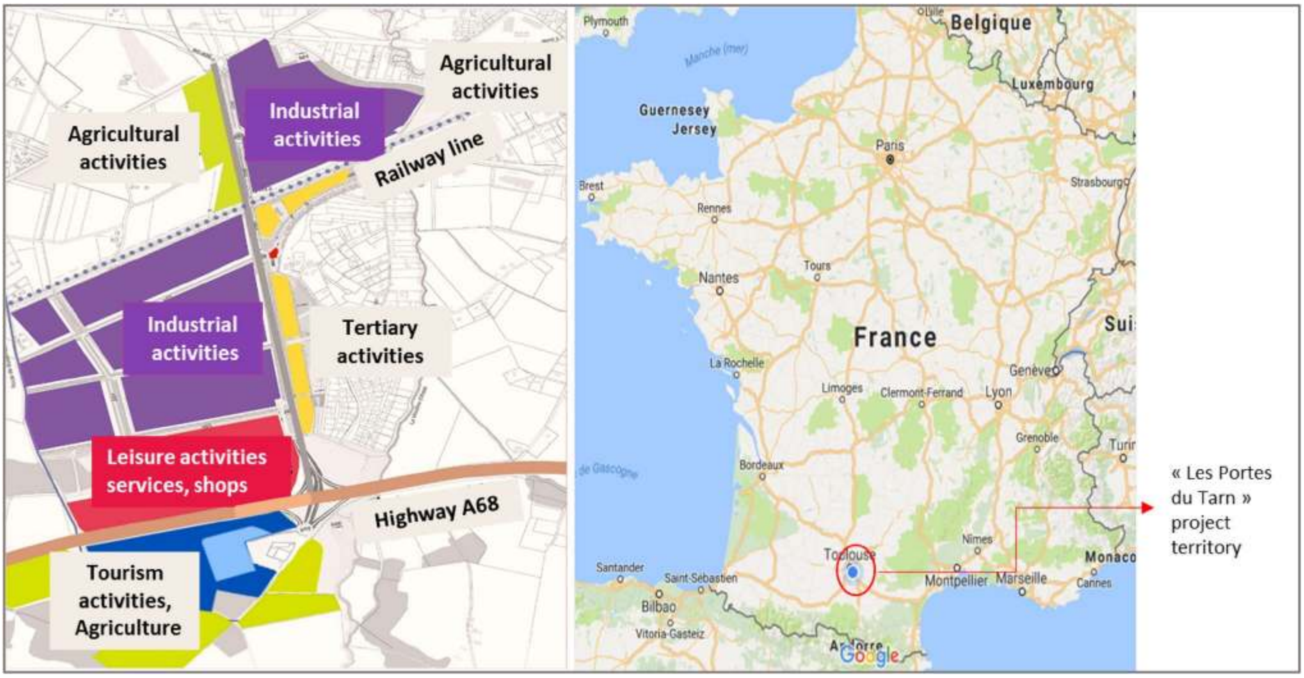


Fig. 3 Geographic location and the main activities' fields

example, slots are dedicated to the creation of shared and family gardens, and a micro-educational farm. Other plots are dedicated to tourism and office activities. Second, they initiated the design step by a regulatory public consultation (L. 121-8 article, the Environmental Code). Once accepted, holders decided to improve the social approach. Some techniques were installed to build a relationship with residents. These strategies were based on animation and transparency. Thus, a park office is settled down to receive visits and meetings. The communication staff implemented permanent digital tools to present a continuous updating of the project, such as a blog, a permanent newsletter and a YouTube channel. A physical letter was sent to residents of the neighbouring towns once per semester. This interaction is strengthened by the organization of scientific conferences for industrialists and civil society. The elected members of the Tarn Department and the Tarn-Agout Federation are directly included to the decision-making process defined in "A model of organizational process for the commercialization phase" section. They approve or disapprove all candidate applications and industrial implantations.

In France, as discussed in "Eco-industrial park and network development in France" section, the EIP process is integrated into existing parks to discover potential synergies in case of a site extension or reconversion, the installation of a common network, etc. It is also used to redeploy the industrial wastelands in order to fit within the sustainable land-use planning (Dumesnil and Ouellet 2002). Our project is pioneering, especially in France, by the application of the EIP concept on bare land, from the design step to the operating phase.

Such a situation introduces new questions: how should synergies be identified between future and unknown activities, and how should they be set up for allowing future synergies implementation? How should information exchange and trust be built and maintained between the future unknown actors? Which governance model is adapted to the next joiners? These questions have led to the identification of similar projects outside France and an adapted conceptual framework and tools (Boons et al. 2011). Some projects, such as the Synergy Park in Australia (Roberts 2004) or Red Hills Ecoplex in the USA (Gibbs and Deutz 2007), were benchmarked. They do not have the same industrial targets and do not comply with a French and European regulatory context (Eco-innovera 2012; Costa et al. 2010).

"Les Portes du Tarn" initiative aims to ensure a long-term collaboration, from now to the next 30 years. It relies on a research work (4 years, from 2014 to 2018) to develop the adapted methods and tools resulting to a toolbox creation. This project may prove, or not, the hypothesis that the integration of industrial ecology thinking (IET) to the investment remains a more effective approach to progress on the new production systems in accordance with the ecological transition French path. "Les Portes du Tarn" park can become an "actual socio-technological demonstrator" for French IET-based industrial area development. It will enable a clear view of IET integration efficiency. That is our long-term objective.

Experience feedback on EIP projects reveals that temporality is a decisive factor to implement it (Veleva et al. 2015). The challenge is to get and maintain trust and collaborative dynamic for a long period. The EIP progress may be affected by a disappearance or an addition of a company into the system. The EIP collaborative dynamic has to progress simultaneously to integrate these kinds of events and the companies' behaviour evolution. Adapted organization and governance are essential instruments to address this challenge (Heeres et al. 2004; Côté and Cohen-Rosenthal 1998; Behera et al. 2012; Oh et al. 2005). The tools available to support EIP approaches were not at all adapted to our initiative. It was therefore essential to build a toolbox for the creation of an industrial park integrating the objective of developing a long-term EIP according to French policy.

Materials and methods

The beginning of EIP supported by a research project

The local planning agency, SPLA81, and the public research institute, Toulouse INP (Laboratoire de Génie Chimique), funded a research project namely COPREI from 2014 to 2018, with the financial support of French environmental agency, ADEME. The main target is to answer the above questions, to develop the necessary methods and tools and to become an IET French demonstration field, a kind of "living lab". It is focused on the life cycle management of new industrial park, and it allows to create methodologies and tools to design, layout, commercialize and operate this park in accordance with circular economy and industrial ecology pattern. The research project has a core objective: CE and IE methods and tools in commercialization and operating phases. To progress, eight steps were used: bibliographic research; key issues formulations in urban planning, industrial engineering, political sciences, territorial economy and industrial ecology fields; confrontations with local experts and amendment; methods and information tools development; test in the "Les Portes du Tarn" industrial park; revision and correction.

The results are organized within a toolbox. The research proposals through this toolbox are directly in interaction with the professional actors involving in EIP French initiative by intensive and regular feedback loops. The professionals come from "Les Portes du Tarn" urban planning agency, company candidate to join the park or the network, IT supplier and township. The main interaction techniques are tool deployment on site, physical meeting, interview and conference call. The frequency of interaction is 4 times a month for 4 years. Therefore, the components of toolbox are tested and updated continuously in accordance with the actual EIP initiative and progress. Components of toolbox are described in "Results" section.

A systemic research approach based on life cycle thinking

To secure our applied research approach, the results are in accordance with the life cycle thinking. The approach is based on the following five phases, as shown in Fig. 4: design, layout, commercialization, operating and renewal phases (Adoue et al. 2015). The park development is based on the integration of EC and EIP paradigm into the progress of all its steps.

Design phase

With a lack of advanced information on future industrial participants and their needs and flows, the integration of the EIP concept into the design phase was complex. The studies of targeted industrial activities reveal the following three major requirements: the need for water, energy and support service. Therefore, the EIP project plan has integrated the decision of the installation of energy and industrial water networks. Several possibilities were studied for the energy supply, such as the use of deep geothermal resources, the incorporation of a residual energy system resulting from a domestic waste incinerator (located at a distance of 10 km

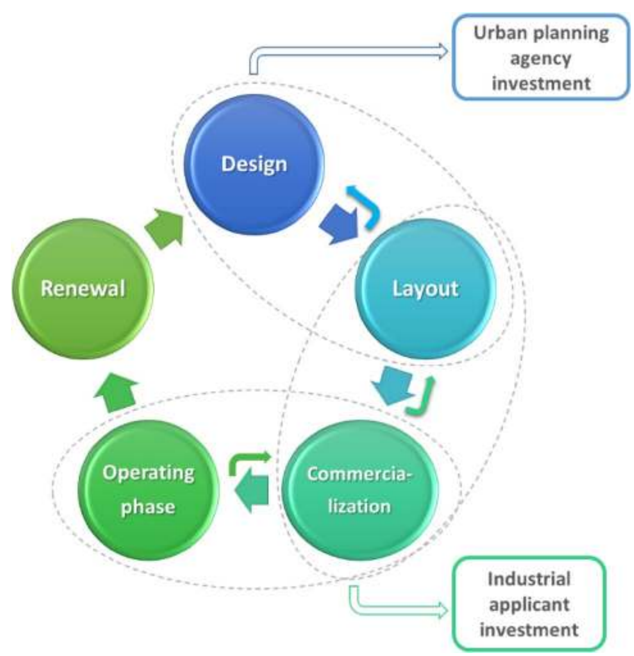


Fig. 4 Industrial park life cycle

away from the park), and the use of the territory's wood biomass. The most appropriate choice for a period of 30 years was the use of a solid recovered fuel originating from the territory waste (the park and the neighbouring areas). Preliminary discussions were held with the waste management Tarn syndicate, which developed a project of fuel production from territory waste and guaranteed a low price for the kWh over several decades.

Layout phase

The main issue of the layout phase was the cut-and-fill problem. In France, the excavated soil is the largest waste stream. Their evacuation and treatment in landfills generate an important economic and environmental cost. It is mainly caused by the carbon dioxide emissions due to the transport. It was decided to minimize the production of this type of waste. The layout phase generates 100,000 m^3 of excavated soil. The programming of public works contracts has integrated land movements so that the generated soil flows can be stored within the park area before their total reuse. This storage strategy has been used within the different public works contracts required for the development of the park.

Commercialization phase

During the commercialization phase, process analysis was performed to determine the necessary project improvements. In a common EIP project, the development of this approach needs industrial flow data management to identify and create potential synergies. The shared information between the concerned companies could be collected by two main methods. The first approach is based on the engagement of a third party, whose mission is to manage a systematic data collection work of participant company inputs/outputs flows. Then, the information is processed to select potential mutualizations or substitutions. Second, the involved companies could arrange direct meetings in which they discuss their common flow issues. They could also seek feasibility of new synergies or other needs of specific flows. This monitoring procedure takes less time on a lifetime project, but it is less detailed. In our EIP project, participating industries are not yet identified. Therefore, the direct meetings method could not be applied. Otherwise, even if future companies will be located in the park, they should consider some flow information as confidential to their development strategies and should not share it with the "prospect" company.

Generally, a data collection system is based on a specific software use. This software tool contributes to the synergy implementation process, specifically to its identification and its publishing and review steps after their creation (Grant et al. 2010). The software operation may be limited by the variety of flow types, synergic situations and information needs for opportunities assessment. Future potential synergies could be estimated throughout this information system. As an industrial objective, it aims to improve the cost saving and competitiveness advancement. It aims to enhance the social acceptability and minimize the environmental impacts.

The EIP project is extending over an area of 250 ha. Some synergies could need critical characteristics to be economically advantageous. Synergy opportunity research, only at the park scale, could then be considered as a failure factor. Thus, the applicant can generate inner synergies (between companies from the park) and/or outer synergies

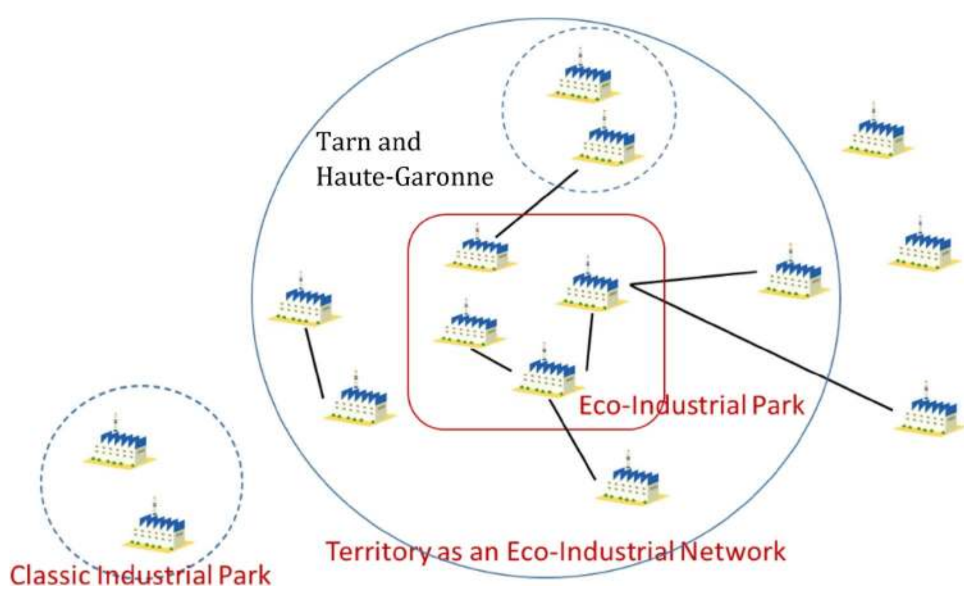


Fig. 5 Synergy potentiality for "Les Portes du Tarn" park and network (Adapted from Lowe 2001)

(from park companies to territory companies: the Tarn and Haute-Garonne departments), as illustrated in Fig. 5.

Operating phase

The EIP concept intends to interconnect companies in a local economic structure. Involved partners could gain benefits from the new efficient services created throughout industrial synergies and waste management. Thus, flow assessment and the evaluation of synergies' impacts are the necessary concerns to continue the EIP development. Two core challenges are identified for the future operating phase. From an industrial point of view, companies' collaboration and their information exchange should be continuously maintained. As said in "An EIP in the south of France" section, the second challenge is the acceptance of the project dynamic by the stakeholders, especially residents and non-governmental organizations, in the next 30 years. Figure 6 provides the five types of actors who interact.

The collaboration in the EIP initiative makes the exchange of information between involved companies possible. It enables the participating businesses to discuss the synergies' performance and inherent risks. This approach ensures a trust context between stakeholders and mobilizes the involvement of new actors. The settled strategy is to monitor the environmental performances during the operating phase and to largely circulate the information. The project includes surveys of the following four main metrics: water, air, traffic and noise. In the local area, the environmental risk assessment is detected through a metrological approach, whereas global impacts need a processed data system to control mass and energy flows.

Renewal phase

The renewal phase aims to anticipate the main modifications within the system functioning. Therefore, it enables updating of the project scheduling according to each case specificities and planning of the associated refurbishment works. To achieve this objective, the proposed methodology will be strongly linked to the potential investment reversibility, which involves the opportunities of the infrastructures deconstruction, their recycling, the artificialization of soils, etc. The associated method for this phase is ongoing development.

Results

Six main research lines for developing toolbox

The progress of EIP is based on the application of life cycle thinking process in a systemic approach. Six main lines of research are identified to develop the required methodological and technical tools box allocated to the commercialization and operating phases (Fig. 7).

The first line aims to understand how to include the EIP criteria in the decision-making procedure of industrial applications. Studies involve a classic commercialization process analysis and allow the improvement of many sub-processes to adapt it to the project framework. This approach leads to the creation of a data collection tool designed for the future applicant companies. The adopted solution is to provide a software product to capitalize and operate flows information. This management tool is designed to identify the opportunities to create potential industrial synergies in the scope of commercialization (Line 2). A marketing strategy is developed to explain the EIP framework and the objectives that are supposed to be achieved. This strategy has to include a set of rules to advance a long-term collaboration between the future partners. The EIP operation system, including material, energy and logistic flows, generates different environmental impacts. Some of them could be collected with the companies' data flows systems, but others need to

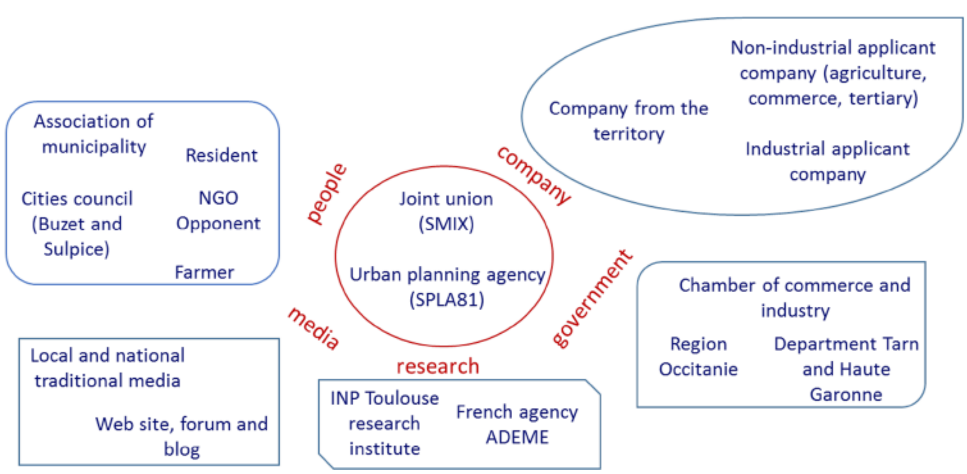
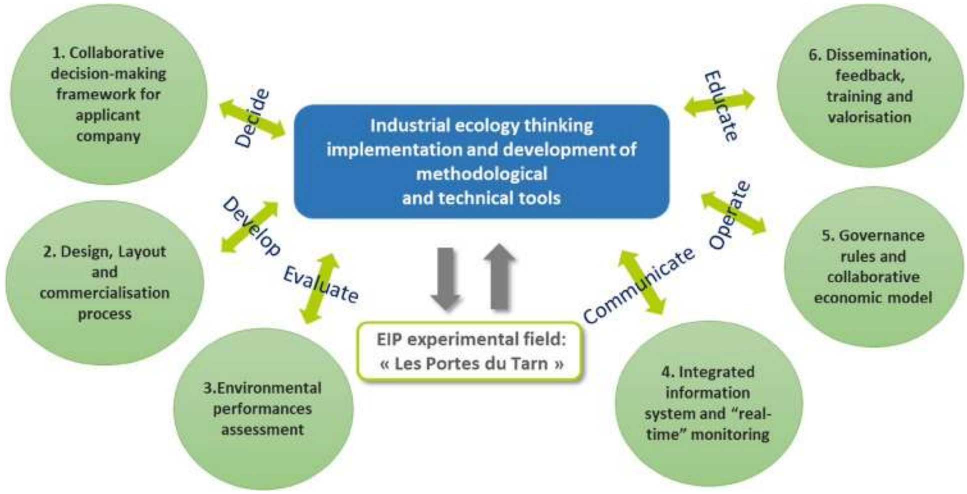


Fig. 6 Stakeholders in "Les Portes du Tarn" initiative

Fig. 7 Lines of research in association with the toolbox development



be measured (Line 3). Studies move towards the third line and seek an adapted environmental assessment of the EIP. The calculation methods and the technical tools for environmental impact monitoring are identified. The objective of the fourth research line is to create an integrated monitoring system to assess the environmental performances (Line 4). Information collected is periodically transmitted to the stakeholders via communication tools (website, information letters, local panels, etc.). To support the EIP approach, the planners must define an adapted form of governance for the long term (Ceglia et al. 2017) (Line 5). The identification of the potential methods and tools of social mobilization is necessary to strengthen the project framework. The governance system has to enhance the acceptability of the project and maintain an active collaboration between the participants. Finally, the results from the project have to be disseminated and popularized through communication and education tools (Line 6).

The EIP conception is based on a systemic approach that enables multi-level modelling (Pan et al. 2016). It needs the development of efficient methodologies and tools to optimize the flow management in the different EIP phases. To meet the lines from Fig. 7 along the industrial park life cycle, especially commercialization and operating, a toolbox gathers our applied research results.

A toolbox for commercialization and operating phases

The toolbox contains five materials (Fig. 8): White paper; Organizational processes; Awareness, training and communication materials; IT tools and systems especially for synergies management and environmental performances assessment, survey and monitoring; Governance and animation tools. A national workshop (http://www.portesdutarn.fr/economie-circulaire/colloque-coprei) was organized

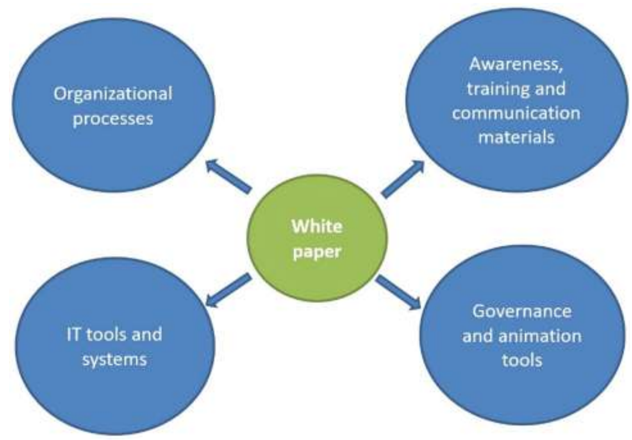


Fig. 8 Toolbox structure

in June 2018 by authors as a final event of research project. It joined scientists, industrialists, journalists, national and local elected officials, urban planning agencies, public officials, NGO members and interested persons. The toolbox was released for this event, each part having its proper copyright conditions. The white paper (Adoue et al. 2018) is the key public output and acts as the main door for going forward with the other components of the toolbox. In the next sections, "A model of organizational process for the commercialization phase" section focuses on specific organizational processes for commercialization. "IT tools and systems for commercialization and operating phases" identifies IT tools and systems for commercialization and operating phases. Finally, "First companies' achievements" section gives inputs on the governance model and on in-progress achievements of candidate companies.

A model of organizational process for the commercialization phase

The commercialization of plots in the Toulouse neighbourhood occurs in the context of competition between the zones of the urban areas. The commercialization process is based on a systematic data collection system. The model of organizational process for commercialization (Fig. 9) involves the following three types of actors: the applicant (the candidate from an industry, agriculture or service domain), the seller (managers from SPLA81 urban agency) and the elected member. The seller conducts interviews with the candidate who introduces its regulatory framework and potential needs. Negotiations deal with the seller's factory project and the estimated material and energy needs of industry (type of products and planned buildings, etc.). They could lead to a sale action or not. Then, the elected members decided on the installation acceptability. A Business Process Model and Notation (BPMN) model has been used to characterize the commercialization phase. This model reorganizes many activities and gathers them in three main activities, namely market research, application analysis and finally decision-making.

In the market research stage, the commercialization process aims to include the factories in the park into the EIP framework. Therefore, its industrial synergies are identified and contribute to answer to environmental and social acceptability concerns. In the second step, the applicant company provides information presenting its material and energy requirements. Studies aim to identify potential synergies between the implanted industries and the candidate. The profit and loss account are based on a rough estimation of given flow needs. The commercialization phase is based on a decision-making process. This sub-process is divided into the following three collaborative steps according to Simon's model (Simon 1960): the intelligence, design and choice steps (Heintz et al. 2014) (Fig. 10).

The intelligence step's objective is to facilitate sale actions in the EIP project framework. In fact, the SPLA81 members collect necessary information during the intelligence and design steps. They introduce the EIP concept to the stakeholders. The elected members then propose a set of rules to the project manager to promote the industrial installations in the territory. Hence, it allows the support of the seller for the market study. The applicant assessment is based on specific evaluation criteria, such as energy efficiency, environmental impacts, waste and water management, and mobility and

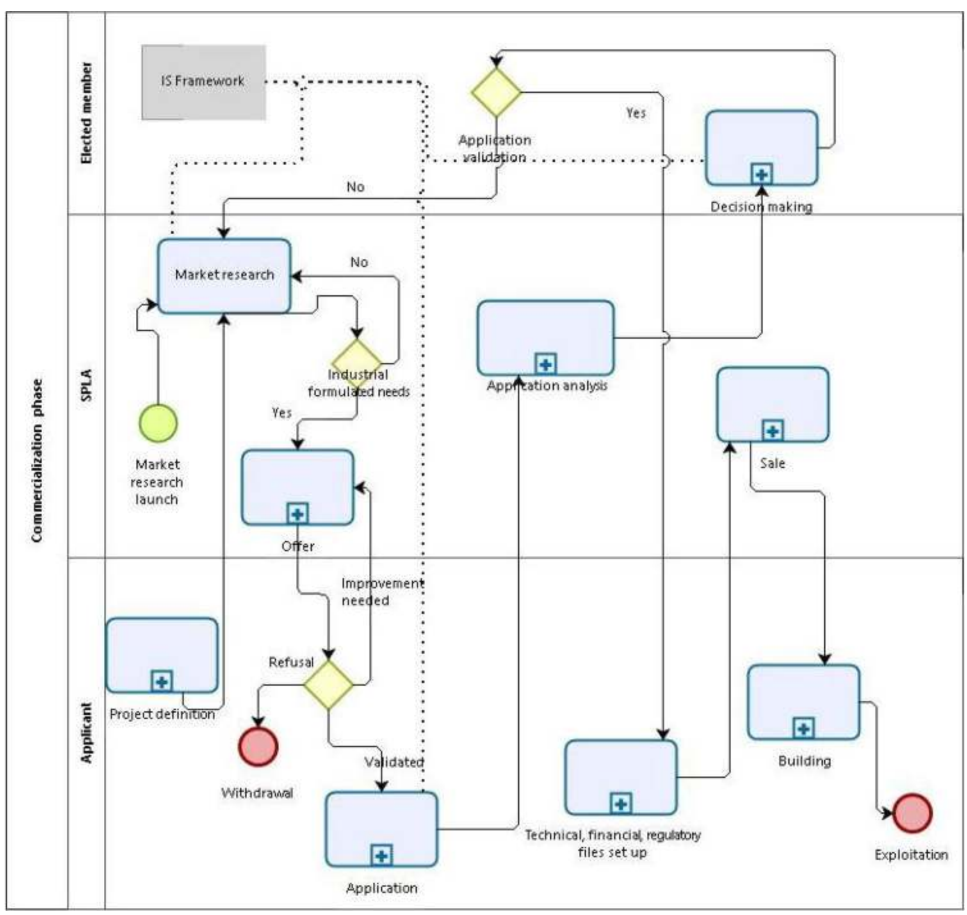


Fig. 9 Model of EIP commercialization process

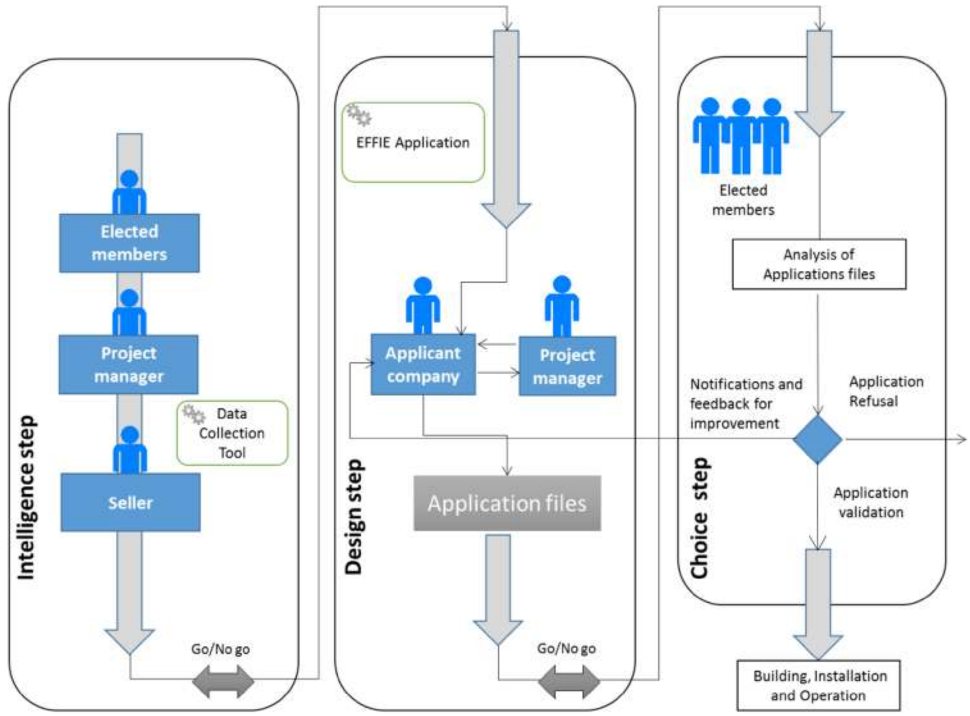


Fig. 10 Decision-making process applied in the commercialization phase

transport flows. When the applicant and the seller reach an agreement, they continue to exchange information to fill out the application files. The folder includes technical, financial and regulatory parts. The potential synergies analysis is based on an IT tool, EFFIE™ discussed in the next section. It allows the identification of the main needs of an applicant and to coordinate it with the EIP framework. The choice step relies on an adopted approach to evaluate the potential system, which is based on the Delphi methodology (Okoli and Pawlowski 2004). It is based on (group-based) multi-criteria decision-making, including economic, social, environmental benefit, eco-industrial construction and management-level criteria (Zhao et al. 2016). In our case, the application files are analysed by elected members. The negotiation involves the territorial financial and employment interest, residents' acceptability and the potential pollutions. Thus, they are able to approve or disapprove it, or to request other information or improvements. The main issue is the difficulty in identifying all criteria used by the elected members. Each member actually has in addition his own criteria linked to his voters' interests and views.

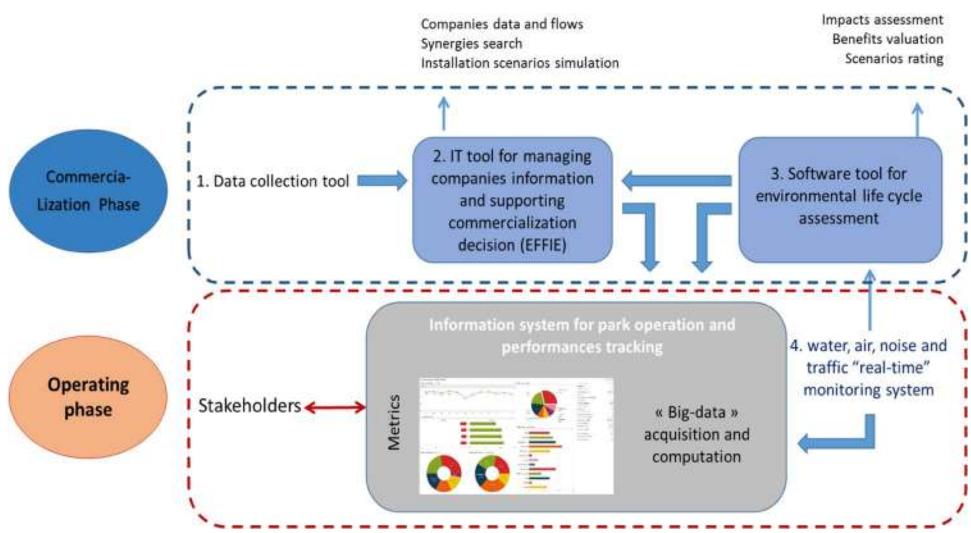


Fig. 11 IT tools and systems to manage the park life cycle

IT tools and systems for commercialization and operating phases

The toolbox includes four IT tools and systems to support the commercialization and operating phase (Fig. 11). The commercialization process includes the design of three IT tools: a data collection tool (1), an IT tool to manage companies' information called EFFIE™ (2) and an environmental assessment tool (3). In the operating phase, the follow-up of the core criteria identified in the commercialization phase is designed. Thus, this phase involves a monitoring system to control the potential impacts in "real time" (4). In addition to these four tools and systems, an integrating global information system will be developed. That will collect field data from the park, real-time data from monitoring systems and external data from the territory, as a "big-data" approach applied in natural hazards management and chemical process engineering (Belaud 2014). It will enable the broadcasting of adapted information to the stakeholders.

The identification of potential synergy opportunities needs a rough estimation of the generated physical flows. Research was initiated by the development of a data collection tool from the intelligence step. The study includes the material and energy flows generated by future industrial installations and/or those existing in the EIP and its territory. The current system allows the collection and characterization of the data stream. It is based on a questionnaire study completed during interviews of industrial applicants. The collected data includes information about the company site, the main production utilities (heat and cold generation, conditioning air, demineralized water, etc.) and logistic services. It contains the input/output flows data, in accordance with the French nomenclature 2607 (CPF 2015).

Energy and resources use efficiency in a network among industries is the key for eco-industrial development, which is a building block of cities' sustainability (Yedla and Park 2017). The interconnected industries lead to more complex engineered systems "whose design and operation require appropriate methodologies capable to capture, address and solve the different structural and behavioural challenges, which emerge" (Kuznetsova et al. 2016). Some developed methodologies for industrial process design can be used to identify the future potential synergies in EIP. This approach needs data sources and a mixed method to develop a multiple-study approach. EFFIE™ ("EFFiciency For Industrial Ecology") is a collaborative web application that is dedicated to the park managers, commercial and companies' contacts and ensures the assessment of input/output data flows. The IT tool identifies the future potential synergies by creating information on the potential of substitution and mutualization synergies for material, energy, equipment and services. It allows the simulation of potential industrial installation scenarios and integrates a Web GIS (Geographical Information System) technology to identify the "best" plot for an applicant company. That is an original function as shown in Table 1. The "best" plot is identified according to many criteria, especially the capability of synergies. This first version of EFFIE™ application does not contain any optimization function. A rigorous mathematical optimization function for water or energy synergies is not for now a need face to the other needs and parameters. A technology transfer is ongoing from research laboratory to a company providing professional services and expertise in CE and IET. The EFFIE™ technology will be under licensing in March 2019. Some industrial parks planning companies (related to brownfield redevelopment and industrial extension) have asked for an EFFIE™ technology adaptation and deployment in their industrial context.

The potential symbiotic relationships are presumed to be environmentally advantageous, "although these benefits have seldom been carefully measured" (Chertow 2007). Thus, the research studies have identified several methods to analyse the environmental performance in different situations. Each approach has its strengths and weaknesses. A comparison of nine methods used in 35 study cases has shown that there is no perfect tool to establish a complete assessment of a

Table 1 Main characteristics of tools for synergy search

Name of tool	Type of tools	Main functions
Actif	Web GIS	Data storage on flows of studied companies Synergies identification and geocoding
Inex	GIS	Data storage on flows of studied companies Theoretical data on flows of main industrial processes Synergies identification and geocoding using theoretical and real data
Editerr	GIS	Data storage on flows of studied companies Theoretical data on flows of main industrial processes Synergies identification and geocoding using theoretical and real data
EFFIE	Web GIS	Data storage on flows of studied companies Synergies identification and geocoding Identification of the "best" plot with potential synergies for an applicant industrial

territory. Nevertheless, the LCA method seems to be the most efficient and global way to quantify the environmental performances of a territory installations (Loiseau et al. 2014; Mattila et al. 2012), but this must be proven. LCA is too complex to implement in "Les Portes du Tarn" context at this stage and at the current level of maturity. We select the ELIPSE method ("EvaLuatIon des PerformanceS des démarches d'Ecologie industrielle et territoriale", http://www.referentiel-elipse-eit.org), based on the quantities of resources or energy not consumed. Elipse has 61 indicators and is promoted by the ADEME for the reporting of eco-industrial park or eco-industrial networks in France.

The evaluation of EIP development experienced a more sustainable state and a cumulative environmental performances improvement (Song et al. 2016). This progress is due to the eco-efficiency and environmental technical change. We are working on the development of an adapted model to assess the global environmental impacts of the industrial activities. The selected indicators and calculation methodology must produce conclusive results to the stakeholders in accordance with the transparency strategy. The measurement and monitoring network of the local environmental impacts are essential in the operating phase. A first work to identify the local impacts has been carried out initially. It has been updated through the exchanges with the stakeholders during the public survey. The monitoring system involves the following main potential impacts: air, water, noise and traffic. The objective of the quality control network is to survey the influence of industrial activities on each factor's pollution. For the air quality, the measurement sensitivity depends on the project objectives, its location, the referred pollutions, etc. In our project, the monitoring network aims to measure the quality of the air at the park outskirts, and in the case of pollution, it permits the location of its associated source. The following three measurement points are already installed: in the peripheral zone, close to the riverside communities dwelling, and in the prevailing wind direction. The pollutant sources are located by a weather station. The scanned parameters are sulphur dioxide, ozone, nitrogen dioxide and particulate matter. It also includes the temperature measurement, the relative humidity and the pressure. To survey the water quality, measurement points are implemented according to the regulatory requirements (the points' number, the concerned watercourses, etc.) and the ownership of the lands on which the material is installed. The scanned parameters are chemical oxygen demand, biochemical oxygen demand, suspended solids and hydrocarbons. Noise and traffic control systems are also developed to avoid the residents' disturbance. The noise measurement method enables the monitoring of noise effects generated by the park activities. The stored data that were gained by the installed sensors are sent automatically to a computer server to be analysed. The measurement point mapping of the traffic control was carried out according to the road networks serving the park zone to be able to count the incoming and outgoing traffic flows.

First companies' achievements

"Les Portes du Tarn" park and network were officially inaugurated on 6 July 2017 but commercialization phase started in 2015. The toolbox, especially its components such as decision-making process, data collection tool and EFFIE™, was applied successfully with the first industrial applicant, the Vinovalie company. It is a wine production industrial unit. In line with its CSR policy, Vinovalie company has already booked a plot for its new bottling factory, and the building started in October 2016. A planned 25 million bottles a year and approximately 100 jobs on site are created by this new industrial unit. The industrial operation starts in the spring of 2018. Two potential substitution synergies were identified in the design step (Fig. 10): recycling silica in bottle rinsing water and recycling rinsing water through the future industrial water network, providing a cheap input of water to the next joiners. In addition, an industrial and wine tourism tour is scheduled to strengthen social acceptability. In the sector of services, JMG PARTNERS, a national promoter of commercial real estate, is investing in the park to build a platform for industrial logistics, covering an area of around 70,000 m^2.

A second industrialist is applying (for confidentiality, it is called "BF company" in this paper). Firstly, the company had targeted another classic industrial park in France, 200 km east. BF is applying recently in "Les Portes du Tarn" thanks to the CE and EIT approach. The future plant will produce biofuel from wood waste coming from the territory promoting a local loop of energy production and consumption. The investment is over 80 million of euros. The industrial process is energy intensive, and an energy network contributes directly and significantly to the competitiveness of the investment.

The application of BF company was processed using the toolbox. For intelligence step, main inputs and output flows were collected thanks to the data collection tool. In the design step, BF planned to use heat from the park heat network (Fig. 12). EFFIE™ tool has allowed to identify a 200,000-m^2 plot connected to the heat network. The rest of the necessary heat had to be produced by a new biomass boiler. A part of the waste heat of the process had to be converted into electricity injected on the French electrical network, thanks to a cogeneration unit. A quantity of the waste heat was lost.

Many iterations between BF, the applicant company and the park manager led to identify and design new opportunities with respect to CE and IE paradigm. Indeed, a third-party applicant company in the leisure sector (namely "L company") with large heat needs can consume the heat stream. In such situation, the park heat network will require an increase in power. The company BF therefore chose to over-size (+ 60%) its initial boiler to meet its own needs and supply the heating network to answer to the L needs (Fig. 13). A fuel source was then sought on the territory, fuel derived from municipal solid waste (MSW) produced by the Tarn inhabitants. This fuel is produced by the local waste management company (Trifyl) located in the eco-industrial network. In comparison with the initial project, it decreases heat from gas stream (alpha) and removes wood biomass flow (Z and B). The execution of organizational and decision-making process ("A model of organizational process for the commercialization phase" section) and the usage of IT tools led to a new project.

Finally, the main decision criteria according to BF company point of view are provided in Table 2. Elected members for the choice step (Fig. 10) analysed the BF company application file in December 2018. BF company application got an approval.

From those case studies, the toolbox allows to identify the potential synergies, beneficial for the industrialist and the park and to find a plot that makes it possible. "Les Portes du Tarn" contributes directly and significantly to the competitiveness of the investment. The industrialist has modified

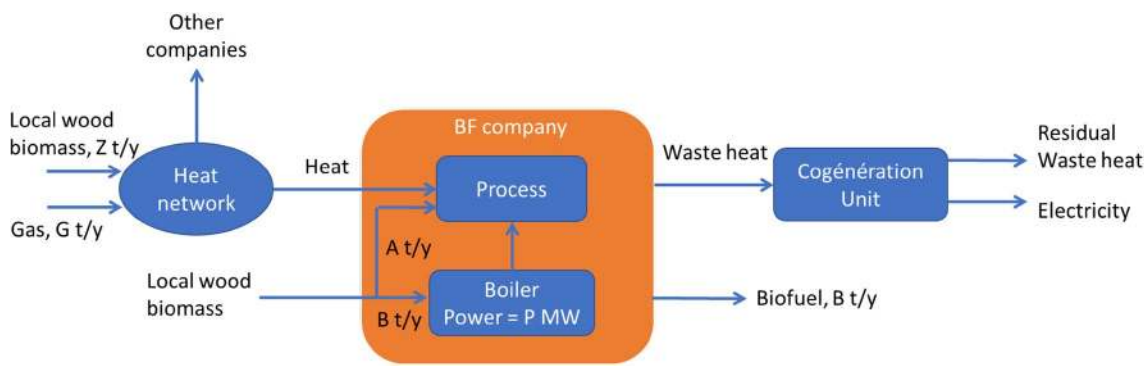


Fig. 12 The initial industrial project of BF company (t/y: tonne per year, MW: megawatt)

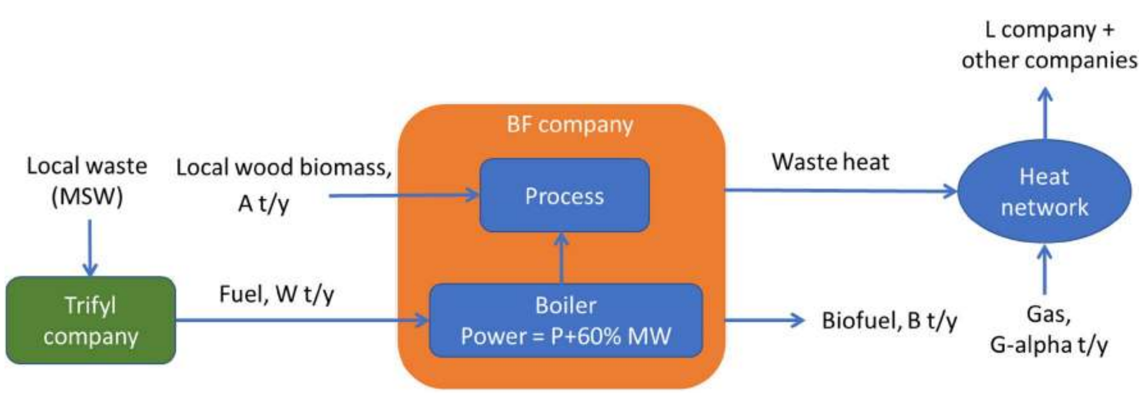


Fig. 13 The final industrial project of BF company (t/y: tonne per year, MW: megawatt)

Table 2 Main positive items for investment decision in the case of BF company

Initial project in a classic industrial park, east of France	Final project in eco-industrial park, "Les Portes du Tarn"
Consumers proximity	EC and EIP approaches in accordance with CSR policy
Price of plot	Price of utilities (water)
Less risk of implantation for social acceptance	Collaboration between BF company, L company, SPLA81 and local waste management company
	Higher annual sales by redesigning the process
	Improved return on investment

his processes and initial implantation so that this waste heat feeds a heat network.

Potential synergies establishment was a main item in terms of obtaining the "application validation" decision during the "choice step". Other companies in the domain of industry, agriculture and services are presently under study in the commercialization phase in the domain. At this stage, the commercialization phase could last less than 8 years, while it was planned initially 20 years. According to the SPLA81's chief executive, "the geographic location and the voluntarist CE and IET speed up the commercialization step and lead to the success of this French eco-industrial park development from greenfields. The toolbox is essential for supporting this development".

If adapted organization and governance are essential to build a sustainable EIP development in the next decades, we do not know all the future established companies at this stage of the project. In France, governance of the former eco-industrial parks or networks are based on "1901 law" associations that bring together companies and the concerned institutions (local governments, chambers of commerce and industry, etc.), similar to that in the Dunkerque, Valenciennes or Troyes EIPs. We have begun discussion with the different known actors to think on the creation of an appropriate consortium.

Conclusion and perspective

This paper deals with the first French eco-industrial park and network case of a concrete IE and CE integration in its full life cycle management. We have developed a toolbox to implement the EIP approach for industrial area projects in a French context. The first version of the toolbox resulting from a research project gathering a public laboratory, an urban planning company and the French government environmental agency is introduced. It includes technical and methodological tools. Particularly, a white paper was published in June 2018 promoting the industrial ecology thinking and providing the core of our materials and methods. We are in the beginning of the commercialization phase, and many more results will be available in future. With the release of the toolbox, other French eco-industrial parks with an extension or a requalification will provide us new needs and feedbacks on order to improve the different toolbox components.

The French EIP project, namely "Les Portes du Tarn", is an original experimental field that creates the opportunity to implement industrial ecology thinking from scratch, from the initial design to the operating phase. It aims to establish a more well-balanced economic development next to the Toulouse metropolis. This approach allows the management of urban area to develop EIPs for future decades. It aims to enhance the performance and competitiveness of the industrial system by the installation of symbiotic and complementary activities according to the European and French regulatory frameworks. This ambition raises many challenges at different levels. A systemic approach includes different stakeholders (neighbouring companies, applicant companies, local authorities, NGOs, neighbours, etc.) along the different lifecycle steps.

A key path to improve EIP project performances is to foster industrial synergies and to increase cleaner production, processes and technologies. The approach manages the environmental assessment of involved companies and upgrades the industrial structure. In our experimental context, the implementation of such IE framework needs to be acceptable by the stakeholders in the short- and long term, especially after the industrial accidents that occurred in this territory. To meet the dual challenge of competitiveness (economic) and acceptability (social and environmental), we work on the design of our inner toolbox that requires methodological and technical tools to apply the circular economy and industrial ecology framework.

The first challenge is to develop a simple and operational (group-based) decision-making process for the commercialization phase of an industrial park and to understand how to include EIP criteria in the decision-making process for an applicant company. IT tools and systems to support the decision-making approach, the executive management and search for eco-synergies opportunities include: (1) a data collection tool, (2) the EFFIE™ application, (3) an environmental life cycle assessment tool and (4) monitoring systems to survey special local indicators of the park (water and air quality, noise, car and truck traffic) and to provide metrics and alarms to the park administration.

The French and European framework influences the EIP project results. At a local scale, the EIP implementation depends on the urban policy and leadership of the project (urban agency, local authorities and residents). This framework is conditioned by the economic context of the city of Toulouse and its influence on the market research strategy. Currently, the toolbox has been successfully applied for the implementation of first industrial companies (Vinovalie, BF and L) within the park and for the identification of first flow synergies within the network (water, wood biomass, MSW, fuel, waste heat). Moreover, several negotiations are in progress with other candidates to integrate the park. Our research project leads to the testing of industrial ecology thinking, in which the investment decision-making remains the most effective tool to ensure the transition to sustainable production systems. The implementation of an EIP on a specific area requires tight social interconnections, which are based on individuals, organizations, culture, values and institutions. The social acceptability is then one of the main issues of the current project to mediate between industrial ecology's system approach and the complex structures of the society (Schiller et al. 2014). To enhance social relationship building, some techniques have been installed, such as devoted areas to services, agriculture and leisure activities, the elected members' implication in the management decisions and permanent communication digital tools. Other yet-to-be-developed tools might also contribute in later phases to enhancing social acceptability. For example, a global information system has to be designed to integrate territory and park data. It will generate information and dashboard dedicated to the park steering committee, local citizens and other stakeholders.

We target the building of a methodological and technical toolbox for developers of industrial zones, especially in the context of French policy. Our next main purpose is the definition of a set of rules to advance on a long-term collaboration. The future partnership needs the following necessary factors to be maintained: information exchange, collaborative context and trust. Thus, we aim to state an adapted governance model with unknown actors, i.e. future involved industrialists. It aims to address the evolution of the participant companies' situations to maintain their active collaboration. To support such a good practice model, French and European policy makers should more adequately include IE in urban planning code.

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Aerial view of EIP area (east)

Aerial view of EIP area (west)

RETOUR AU SOMMAIRE

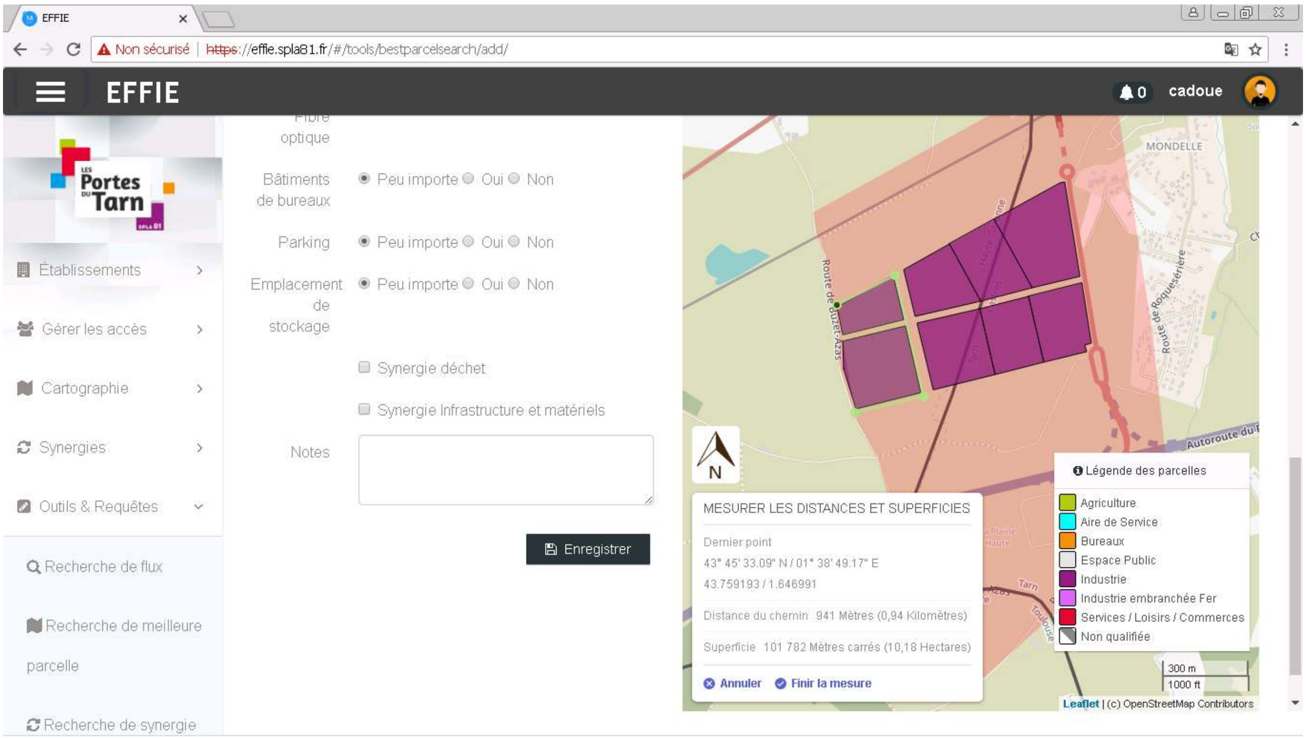
FLUX ENTRANTS

>> Ne pas oublier les flux liées au services administratifs, bureautique, conditionnement, nettoyage, maintenance...

		Nomenclature des produits	Nom de Flux	Précision si "Autres flux"	Qualité	Procédé utilisateur	Quantité	Unité
6	ME 3	Zinc brut	Zinc				9000	T/an
7	ME 4	Chlorure d'hydrogène ; oléum ; pentaoxyde de diphosphore ; autres acides inc	Acide chlorhydrique				7000	T/an
8	ME 5	Chlorure d'hydrogène ; oléum ; pentaoxyde de diphosphore ; autres acides inc	Acide phosphorique				500	T/an
9	ME 6	Plaques, feuilles, films, bandes et lames, en matières plastiques, non munie	Film plastique					
10	ME 7	Chaux vive, chaux éteinte et chaux hydraulique	Chaux				200	T/an
11	ME 8	Chlorure d'ammonium ; nitrites	Autres flux de matières	hlorure d'ammonium et de zinc				
12	ME 9	Hydrogène, argon, gaz rares, azote et oxygène		O2				
13	ME 10	Pantalons, salopettes, culottes et shorts de travail pour hommes	Autres flux de matières	Vêtement de travail				
14	ME 11	Chaussures étanches à semelles extérieures et dessus en caoutchouc ou en n	Autres flux de matières	Chaussures de sécurité				
15	ME 12	Eau potable	Eau potable			Traitements de surface	5000	m3/an
16	ME 13	Éthylène, propylène, butylène, butadiène et autres gaz de pétrole ou hydrocar	Autres flux de matières	Acétylène		Chalumeau		
17	ME 14	Hydrogène, argon, gaz rares, azote et oxygène	Autres flux de matières	Azote		Chalumeau		
18	ME 15	Gazoles	GAZOIL			Chariots élévateurs		
19	ME 16	Fil machine enroulé en couronnes irrégulières, laminé à chaud, en acier non allié		Fil de fer		Galva	120	T/an
20	ME 17							
21	ME 18							
22	ME 19							
23	ME 20							
24	ME 21							
25	ME 22							

A lire avant de commencer | INFORMATIONS SITE | UTILITÉS | FLUX ENTRANTS | FLUX SORTANTS | SERVICES | LOGISTIQUE | AUTRES RENSEIGNEMENTS | CON ...

Example of data collection with the data collection tool - case of a galvanization applicant company



EFFIE application screenshot (French web interface)

Aerial view of Vinovalie company (artist's view)

The Vinovalie industrial production starts in the spring of 2018.