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Decision Making Approach for Industrial Ecology: Layout and Commercialization of an Industrial Park

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One of the industrial ecology fulfillments is the concept of eco-industrial park (EIP). This cooperative approach leads to a more resources-efficient production system at the park scale, namely a more sustainable industrial system. Eco-industrial parks are generally growing on existing industrial area. Existing methodological and technical tools could support such development in this context but this work aims to support initiative for the preliminary design and layout of industrial ecosystem in a new area. If the management of area allows to fulfill the technical and economic factors for many eco-industrial synergies, this is unsatisfactory concerning the relationships issues. The study of the life cycle of the park underlines importance of the layout and commercialization phases. It makes it possible to select the best technical and economical compromise for synergies and to plan and ease future information exchange, collaborative context and trust.
The experimental field is a 200ha park in Occitanie region namely “Les Portes du Tarn”, 20 km far from Toulouse (south of France). SPLA81 urban planning agency started the ecosystem development process in 2012 and needs for a formal methodology and a toolbox for layout and commercialization process and its related decisions. The scientific proposal targets the development of a simple and operational group-based decision-making methodology for industrial ecology, especially to prospect and approve a company to join the park and its territory, to identify the “optimal” synergies and to select the appropriate slot within the park area. The first applicant, a wine production industrial unit, applies this approach to join the industrial park.

1. Industrial ecology and eco-industrial park

One of the industrial ecology fulfilments is the eco-industrial park (EIP). An EIP is defined (Côté et Cohen, 1998) as an industrial park in which businesses cooperate with each other, but besides, with the local community in an attempt to reduce waste and pollution sharing efficiently resources (information, materials, water, energy, infrastructure, and natural resources) that help achieve sustainable development with the intention of increasing economic gains and improving environmental quality. This cooperative approach proposes to mimic the natural biological and natural medium to achieve a more resources-efficient sustainable industrial production system to scale. These goals rely on a system-oriented approach of the park in its natural context: the territory.
In an EIP, eco-industrial synergies could have different types. The substitution synergies designate the material and energy flow exchanges between two or more industries for which their waste flows, by-products or unrecovered energy substitute regularly used flows. The mutualization synergies occur when companies have common needs like equipment, infrastructure, services, identical mass or energy flows, employee technical skills, specific waste collect and treatment. A collective approach of theses common needs could lead to reduce economic and environmental costs.
Achievement of potential synergies depends on many criteria (Adoue 2010). First, distances between factories with common flows could be prohibitive for some types of flows like utilities. For example, necessary network for steam or compressed air collective production or exchange need proximity to have technical, economic

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and environmental sense. Second, when companies have common flow needs or can exchange another flow, quality has to be homogeneous. Third, quantity and availability of flows have to be in accordance and the synergy has to generate an economical interest for the involved companies in short or long term.
In France, industrial ecology concept emerges in the end of the 90's with the International Conference on Industrial Ecology and Sustainability (Troyes, 1999). Today, Orée NGO identifies more than 60 industrial ecology projects or initiatives. They have different forms, scales and goals. Many develop such concept on existing industrial areas, like in the Havre or Dunkerque harbors.
To develop an eco-industrial park is not a common way. A necessary condition to a synergy emergence is that companies share information on their needs (mass and energy I/O, human resources, services, infrastructure, equipment…). Some companies could consider this information as strategic because linked to the company performance. EIP development is so determined by two main context factors: industrial actors success in collaborating together and existence of a trust between them (Grant 2010). Then, information on potential synergies could appear and circulate.
This information can come from interviews and can emerge from direct meeting between companies in the EIP. Mass and energy flows information and company needs share illustrate the first level of trust. But synergy implementation needs higher level of trust because it often means investments (in equipment, in process) and middle or long term collaboration. Learnings from EIP projects reveals that temporality is central. The challenge is actually to develop and to keep trust and collaborative dynamic for many years. The EIP will evolve, companies will disappear, and others will replace them. EIP collaborative dynamic has to evolve to fit in these events and the companies behavior evolution. Adapted organization and governance are efficient tools in order to rise this challenge.

2. Material and method

2.1 EIP framework as a success factor

The city of Toulouse (France) is currently living an intense economic growth and urban development thanks to the aeronautic industry development. It leads to an intense demand for sustainable industrial activity in the city and in the neighboring municipalities. With this purpose, two local authorities (The Tarn department and the Tarn-Agout federation of municipalities) decided to create a local planning agency: the SPLA81, in order to manage a new industrial park "Les Portes du Tarn", a 200ha park located to 20 km from Toulouse (Les Portes du Tarn 2017). To meet the dual challenge of acceptability (social and environmental) and competitiveness (economic), the authorities decided to ground their approach based on EIP concept.
So design, layout and commercialization of an industrial park are key steps in order to ensure this park becomes an EIP. If many approaches exist to find potential synergies between existing plants of an industrial park, a such way of thinking introduce new questions: how to identify synergies between future and unknown activities, how to layout to allow future synergies implementation, how to build and maintain information exchange and trust between the future actors? These questions have led to benchmark similar projects and adapted conceptual framework (Boons et al. 2011) and tools. Some close cases like Synergy Park in Australia (Roberts and Brian 2004) or Red Hills Ecoplex in USA are identified, but none could be found with the same industrial targets and in conformance with French and European regulatory corpus.

2.2 A life cycle thinking based approach

Toulouse urban area receives 6 000 new inhabitants every year (INSEE 2016) thanks to a dynamic economic development. Main industrial activities in the territory are aeronautic and space, pharmaceutical, chemical and food industry. Free plots in existing industrial parks for new factories are rare and expensive. Tarn department and the Tarn-Agout federation of municipalities decided to create a business park 25 km far from Toulouse city. The 200 ha project combined different kind of activities. Industrial activities will take up the main area (61%). In December 2016, layout phase finished and the first factory building began. Commercialization is planned on the next 20 years.
One of the principal issue for an industrial installation project is an acceptability issue within the territory from the populations especially. Indeed, two major issues have in the past created several conflicts about industrial installation in the Territory: (i) In 2001, the AZF industrial accident killed 34 peoples in south of Toulouse. (ii) 30 km away from the future Industrial park, a hydraulic dam project in the Sivens Village, generated clash with violent confrontations between opponents and police.
As a first decision for local acceptability, project holders decided to dedicate some plots to service activities for peoples: stores and leisure activities (19,7%), agriculture (urban agriculture, viticulture…: 15%). Other plots will receive tourism or office activities. Second decision is to have an "exemplary policy" for environmental side of the project. Third, they decided to continue consultation of residents started with the regulatory public consultation.

To secure environmental performances of “Les Portes du Tarn” park, life cycle thinking is necessary. This life cycle thinking approach defines 5 main life cycle phases (figure 1): “Design”, “Layout”, “Commercialization”, “Operating”, “Renewal” (Adoue et al. 2015). In addition, during the commercialization phase, life cycle assessment (LCA) method should be used to evaluate the environmental impacts of expected industrial synergies (Mattila et al. 2010).

Figure 1: Industrial park life cycle

Eco-industrial park concept becomes an interesting tool to combine environmental impact control during the operating phase and a competitive advantage during the commercialization phase. Commercialization is indeed a critical phase to select and place potential synergy activities and to allow short-term eco-industrial park development.
We analyze and model the commercialization process to show EIP framework within the different decision activities. This analysis allows to understand the three main actors and their potential role in multi-criteria decision-making process. Many decision-making methods are available like Promethee, Electre, Delphi, analytic hierarchy process (Leong et al. 2015). The approach needs to be simple and operational for all stakeholders (with different types and levels of skills). That relies on Delphi and the Simon’s decision-making model (Simon 1960) according to three steps: intelligence, design and choice.

3. A decision making approach for commercialization: first results

Commercialization process was studied through interviews of skilled people in particular the chief executive and the seller: managers from the SPLA81 company. Common commercialisation process involves two main actor’s types: the candidate (the “applicant” from industry, agriculture or service domain) and the appointed seller (the “SPLA”). In summary, the seller meets industrials with defined factory project. The eller makes an offer adapted to the potential customer needs and the regulatory framework. Application files are analysed and negotiations could or not lead to a bill of sale, before the factory building.
“Les Portes du Tarn” project has two distinctive features: the EIP framework and the acceptability issue. To contribute to the acceptability of every future factory building, a third actor type was included to the commercialization process: elected members of the Tarn department and the Tarn-Agout federation of municipalities. They are elected to direct universal suffrage and represent local residents. They have to approve or disapprove every industrial installation and application. The commercialization phase is characterized through a BPMN (OMG 2014) model with many activities and sub processes, for instance Market research, Application and (final) Decision making (figure 2).
In the Market research activity, potential synergies with already existing factories in park are targeted feeding the environmental and acceptability area. From the industrial view, the potential synergies (steam and industrial water availability, any substitutions and mutualisations) are associated to cost savings and competitiveness improvement. In the Application sub-process, applicant company provides information on its needs like type of products and planned buildings, mass, water and energy needs. Estimated rough for these mass and energy needs identify potential synergies between the applicant and the implanted industry. In this approach, the applicant can generate inner synergies (from park to park) and/or outer synergies (from park to territory).
This Commercialization phase is divided into three (collaborative) decision making steps according to the Simon’s model and is adapted from (Heintz, 2014). Figure 3 gives a simplified picture.

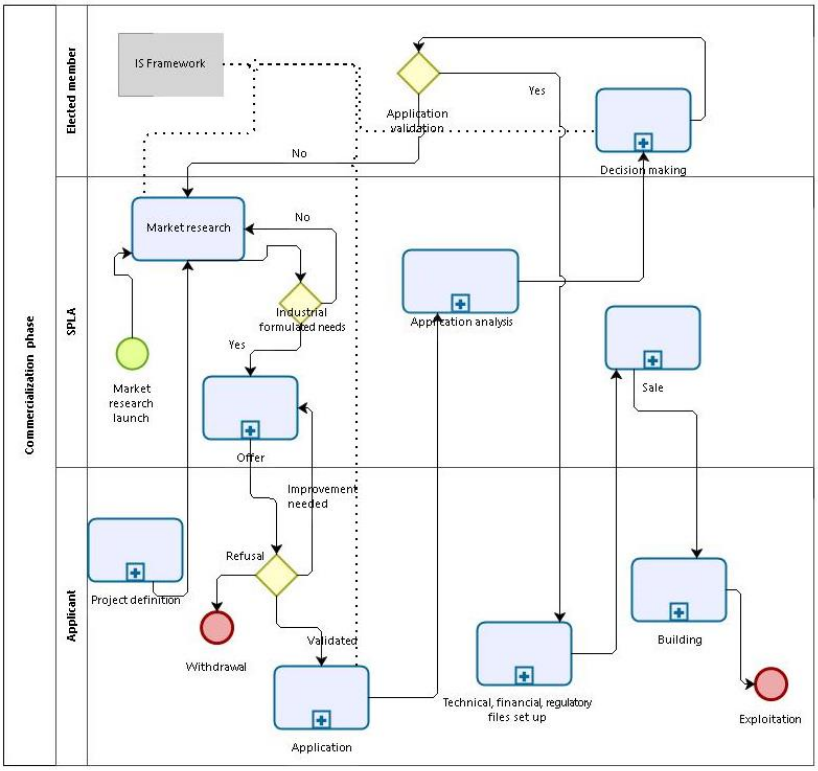

Figure 2: The park commercialization process

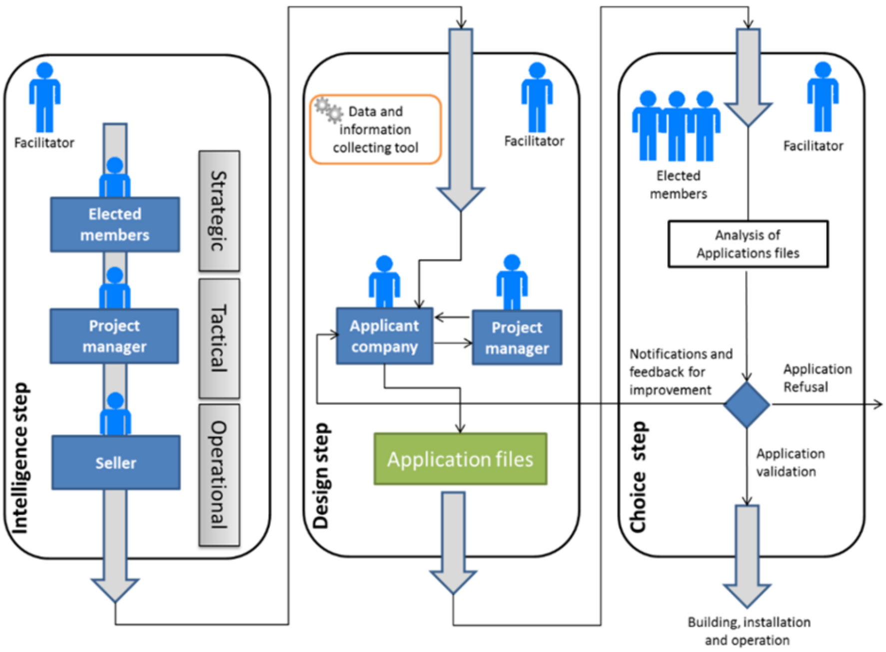

Figure 3: Decision making process in commercialization phase

3.1 Intelligence step

Within the SPLA company, we distinguish two key actors: the project manager and the effective seller. In addition, a facilitator is defined to support the whole decision making approach. In operational context, the facilitator role is important to explain the EIP concept, to catch the necessary information during the intelligence and design steps and to help the elected members with potential synergies and other criteria. He supports the seller for the market study.
In the first step, elected members propose a set of rules to the SPLA manager to facilitate every industrial implantation acceptability. Coming from the frame of sustainability, key criteria for applicant assessment are defined such as synergies (inner-park and outer-park), environmental impacts (Busset et al. 2015), energy efficiency, renewable energy sources, waste and water management, flow risk management, mobility, transportation (materials and people), air pollution and noise prevention, cultural, social, health and safety.

3.2 Design step

When the seller agrees with an applicant, application files (technical, financial, regulatory files) are built through information exchanges between the applicant company and the project manager. Thanks to an inner data and information collecting tool, facilitator gets necessary data and information to assess potential synergies and criteria values. It allows to know the main needs of the applicant: primary matters, goods, water, energy consumptions, materials, infrastructure (waste water treatment station, warehouse, services …). In addition, facilitator helps to identify the best plot and to lead the financial negotiations.

3.3 Choice step

The choice step allows the elected members to approve or disapprove every application files or to request improvements. Vote is used when consensus cannot be found. Many criteria are used by the elected members, such as those mentioned previously. Facilitator presents the potential synergies, the environmental impacts and the other criteria to feed the (group-based) multi criteria decision-making. Financial and employment interest for the territory, resident's acceptability and potential pollutions are the main topics for discussion. Synergy potentialities are today a new criterion for the elected members in the decision-making. The choice step relies on an approach adapted from Delphi methodology. The main issue is the difficulty to identify and classify all criteria used by the elected members. Each member has actually his own criteria informal hierarchy.

3.4 Experimentation

The decision making approach was applied successfully with the first industrial applicant: Vinovalies company, a wine production industrial unit. EIP framework in the design step underlines two potential substitution synergies: recycling of silica in bottles rinsing water and recycling of rinsing water through the future industrial water network, providing a cheap input water to the next joiner. As a result, Vinovalies bought a plot for its new bottling factory. Potential synergies were major item for getting “Application validation” decision during the choice step.

4. Conclusion and perspectives

Life cycle thinking applied on “Les Portes du Tarn” industrial park project allows us, in a systemic approach, to identify five main research challenges to design the required methodological and technical tools to achieve the objectives: develop an EIP accepted by the stakeholder during the next 20 years allocated to the commercialization phase. The first challenge is to consider a simple and operational (group-based) decision making approach for the layout and commercialization of an industrial park and to understand how to include EIP criteria in decision making process for an applicant company.
The objectives of the second research challenge are to integrate deeply the EIP framework in the design, layout and commercialization process. Software applications to support this decision making approach and the search for eco-synergies opportunities are on-going development. Another expected result is the definition of a marketing strategy including EIP objectives and a set of rules to further long-term collaboration.
According to an “action-research” project, interactive work with the SPLA urban planning agency allows to confront every development to the truth of an eco-park layout and commercialization, taking advantage from the experimental field “Les Portes du Tarn”.
The next research challenges are several: (i) to design an adapted methodology and to implement an associated software application in order to assess the environmental performances of the EIP and to broadcast an adapted and dedicated information to the stakeholders, especially the local authorities and populations. (ii) to develop an integrated information system to monitor special local indicators of the park (water and air quality, noise, logistic and people traffic) and to provide metrics and alarms to the park

management team. (iii) to define an adapted governance in long-term view. This governance has to allow acceptability of the park activities by the stakeholders and active collaboration between park participants (industrial, service, agriculture, etc.). The hot issue is to operate this governance policy as companies plays the role of applicant at this time, within the intelligence and design steps.

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