

ECO-INDUSTRIAL PARKS AS A NEW APPROACH TO ENVIRONMENTAL PROTECTION

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1. Introduction

In recent years, the development of individual societies on a large scale is based on the assumption of realizing sustainable growth. Economic growth since dawn of history was the main objective of the communities stimulating their development. So narrow understanding of these issues, the only limited to economic issues led as a result to a number of negative phenomena. An example of this can be environmental degradation in many parts of the world, climate anomalies and so on. In recent decades almost worldwide, there are taken efforts to eliminate the consequences of past mistakes and to introduce new global rules of functioning of societies. The implementation of these ideas requires a parallel look at the issues of the development of societies, not only through the prism of economics. This is done by incorporating environmental issues into functioning of the industrial sector in the framework of industrial ecology. In this way, it realizes the modern approach to sustainable growth which allows to achieve the effects of the economic, social nature taking into account the requirements of the environment on a sustainable basis

One of the ways to implement these ideas is to create clusters called eco-industrial parks. This article aims at a brief introduction to the concept of the creation of these entities by considerations of a theoretical nature as well as by showing the four cases of the functioning such solutions.

The paper consists of five chapters. The first is an introduction defining the significance of the issues presented in the article for the contemporary world.

In the second one there are given various definitions of eco-industrial parks. Simultaneously the author described the place of eco-industrial park in sustainable development.

The chapter 3 focuses on issues related to the process of installation of a newly arising eco-industrial park. In general, two situations may occur. The first assumes the existence of a functioning (or excluded from functioning)

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post-industrial complex. Construction of the eco-industrial park will consist in making significant changes in working of the infrastructure, as required by industrial ecology. Great importance for development of the park will be the ownership of assets accumulated in a given area. In the second case we are dealing with a situation in which eco-industrial park is installed from the very beginning without having any infrastructure. In that case, the ownership of land intended for the construction of the park will be essential.

In the chapter 4, the author presents a brief description of the four selected eco-industrial parks differentiated in terms of size, range and scope of activity. One of them -Kalundborg- is very often presented in the literature, as a mature example of a successful experiment that inspired a lot of people and organizations to think in terms of combining the interests of environmental protection with economic success of the entire project. The others are rarely invoked, although there are also interesting from the point of view of the solutions on the cooperation of all stakeholders. Description is a result of a study trip of the author in the framework of the research team in the implementation of a research grant.

The last chapter gives a summary of the whole article with particular attention to the benefits that may arise after installing eco-industrial park.

2. The concept of an eco-industrial park

At the present time there is no uniform definition of industrial ecology. You can find many definitions that individual authors formulate appropriate to the needs of its publications. However, there are several basic features that the organization must meet to be able to define it as an entity following the requirements of industrial ecology. These include (Chertow, 2006; Chertow, 2012; Indigo, 2017; Worrell and others, 2009):

- the system is geared towards interactions between industrial and ecological subsystems,
- construction of eco-industrial park is accompanied by deep analyses of raw material flows between companies to create symbiotic chains,
- there appears a change from linear (open) processes to cyclical (closed) processes, so that the waste from one industry is used as an input for another,
- it is expected an effort to reduce industrial systems' environmental impact on ecological systems,
- the idea of making industrial systems should emulate more efficient and sustainable natural systems,

- it appears the engagement of traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water and by-products.

The ideas related to environmental protection existed in the consciousness of society for a long time. Their specific intensification was in the mid 90's. At that time it was decided to incorporate elements of ecology into issues related to modern management and organization of manufacturing processes. There has appeared even a definition of eco-industrial development in terms of protection against pollution, management that takes into account the influence of managerial decisions on the environment, promoting cleaner production and reducing resource use (Koenig, 2009, p. 6). In many countries the industry at a rapid pace undertook the work of rebuilding and restructuring of old industrial areas into new, differently structured zones. New approaches include inter alia adapting existing factory buildings to new tasks and installation of activities not poisoning the environment. The concept proved to be very attractive for the old industrial zones, as well as for organizers of new industrial areas. On this background began to appear more and more abundant eco-industrial parks (Koenig, 2009, p. 9).

One of the first definitions of eco-industrial park formulated by M.R. Chertow stated, inter alia, „(...) *The emerging field of industrial ecology demands resolute attention to the flow of materials and energy through local, regional, and global economies. The part of industrial ecology known as industrial symbiosis engages traditionally separate entities in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity. Eco-industrial parks are examined as concrete realizations of the industrial symbiosis concept (...)*” (Chertow, 2000, p. 314).

In relation to this definition, today's approach broadens the concept eco-industrial park by attaching to the issues of flow of goods problems of sustainable development including the resource-saving and environmental protection (Rehn, 2013, p. 8).

It seems that a fuller, more similar to today's realities of the functioning of eco-industrial parks definition brings another source. According to it eco-industrial park is a community of manufacturing and service companies focused on the common territory. The participants of such a system achieve enhanced environmental, economic and social benefits through cooperation in the field of environmental protection and resource management (Koenig, 2009, p. 4).

An additional aspect raises another definition. It is said in it that the necessary conditions for the proper functioning of the system, which is the eco-industrial park are primarily (Cavallo, 2013, pp. 266-267):

- feasibility in financial terms: the implementation of the eco-industrial park must be cost-effective, significant reduction of costs and expected revenue growth should be the result treated as a magnet for the others;
- local community and government should be interested in installing eco-industrial park in their area;
- there must be a common desire for cooperation between companies (tenants of assets gathered in a park).

In the above definition economic efficiency is thus elevated to a basic condition for the existence of the project, assuming (in default) that there exists consistent cooperation with the local community. It can be said that the concept of the eco-industrial park presupposes to mirror (in an industrial context) the inter-linkages and material flows observed between organisms in natural ecosystems.

Designers of such ventures must establish such a construction of an eco-industrial park, which to the utmost reflects in the economic and social life the perfection of solutions occurring in nature. So we can further assume that „(...) *Eco-Industrial park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize if it optimized its individual performance only*” (Lowe, 2000, p. 3). In a similar way eco-industrial parks are also defined in other contemporary literature sources (Heeres and others, 2004, p. 985; Lowitt, Côté, 2013, p. 343; Liwarska-Bizukojc and others, 2009, p. 733).

In summary, it can be stated that the primary purpose of eco-industrial parks is to improve the economic performance of companies participating in it while minimizing their impact on the environment. The main pillars of this approach are primarily an appropriate infrastructure (including flora), from the assumption cleaner production, protection against pollution, improving energy efficiency and cooperation between enterprises. In a broader sense, the participants and beneficiaries of such solutions are the communities adjacent to the park (Lowe, 2001, p. 1). It should therefore be further accepted that (Fleig, 2000, p. 3):

- there is extensive cooperation between companies, managing authority of the park and the local community (the participants of eco-industrial park);
- eco-industrial park participants are keen to realize the vision of this sustainable growth system, both in the economic, environmental and social dimensions.

It is often emphasized the requirement of geographical proximity of individual park participants. In many considerations, however, the existence of the so-called virtual park is also allowed (Agarwal, 2011, p. 16). In practice it means that the

participants may be geographically distant companies, but on a daily basis they actively cooperate with each other according to the rules in the aforementioned definitions (Cohen-Rosenthal and others, 1996).

3. Property ownership conditions vs. implementation of eco-industrial parks

Very often it happens that eco-industrial parks are formed in place of former brownfield sites. These areas have their history in the form of legacy resulting from the actions of previous owners, as well as entities operating in the vicinity of such facilities. Reuse of assets installed by previous generations often requires expansion or remodelling to adapt them to the needs of today. Particular attention should be paid to the risk of the existence of long-term contamination of the area. Their presence is highly likely, as in previous periods attention to these issues left much to be desired. On the other hand, infrastructure that is the legacy of past epochs has advantages in the form of more or less stylish architectural buildings, functioning traffic routes, energy sources, convenient transportation, other facilities and finally the local sentiment of society to object whose existence has often assured existence previous generations of region.

Separate issues in turn occur in a situation in which eco-industrial park will be built in the place where in the past was not conducted intensive industrial activity. According to the author shape of the evolution of brownfields towards eco-industrial park or new sites designated under its existence is largely dependent on the current ownership relations. From this point of view we can distinguish the following cases:

- installation of the park in an area where economic activity takes place in the present time on a regular basis;
- construction of the park in an area in which previously there was not significant industrial activity;
- transformation and revitalization of the existing complex of brownfields;
- limited revitalization of the industrial zone.

The criterion for distinguishing these cases is the ownership of the asset, based on which will be built and developed eco-industrial park. Contrary to appearances, the shape and success of this project will strongly depend on the ownership relations in the field of property intended for use as part of the park.

From this point of view, the first case is the most trivial. The owners of currently functioning industrial sites decide to reorganize the complex in the spirit of the implementation of the symbiotic chain having full domination over the functioning assets.

From this point of view, such a decision is no different than many other undertakings carrying short and long-term effects. Much more interesting are the three remaining cases, and they will be given attention in this chapter.

3.1. Construction eco-industrial park in a new location

The decision to build the park usually is an initiative of the local authorities. In principle there is no infrastructure, or it should be assumed that a site is poorly developed. The basis is the land paid as a contribution by the organizer eco-industrial park.

Newly-built park requires the identification of „core” of the system. In the next two models organizer of eco-industrial park meet the situation strongly defined by history. Some solutions are imposed in advance, while the others are excluded from the definition. In the discussed case, construction of such a system „in the middle of nowhere” means that we are dealing with a very creative project. The entity or institution around which you can start the construction of the park forms the core of the emerging system. For example, the kernel may be the existence or installation the entity that will be supplier of cheap, green energy. Such an object consequently becomes a „magnet” attracting or encouraging other potential participants of the park. The role of the organizer of the project would be their selection from the point of view of the analysis of the technological processes in order to create a symbiotic chains. Based on a network of technological links, the entire structure of eco-industrial park is being developed step by step, together with a network of organizational and financial links in the project.

The advantage of this approach is the ability to design eco-industrial park from the very beginning to the end. The choice of the „kernel of the system” determines, in some sense, the selection of the next participants selected in accordance with the pre-determined logic subordinated to the benefits of the whole project.

The advantage of this approach (the ability to work out the shape of the park according to one's own needs) is at the same time a source of problems. They arise from the fact that the organizer of the project will be forced to bear the organizational, investment and financial efforts alone. Starting from the proverbial „empty field” means that it is likely to belong to him:

- system design;
- finding or building a „kernel of the system”;
- seeking first potential participants and negotiations with them;
- carrying out the necessary investment works consisting in bringing to the area dedicated to the ecological industrial park the basic infrastructure in the

form of roads, power lines, water supply, not to mention the basic for starting the activity of buildings or other installations.

Such processes may last for a significant time contributing to organizational and financial tensions. Only after reaching a certain critical mass eco-industrial park has the chance to start automatically attracting new volunteers to participate in the venture, from which you can make a selection in terms of their suitability.

This approach is a long-term project that gives the organizer the effects over many years. The emergence of more participants and investors will allow him to fully realize the original intentions and it will be possible for him possible withdrawal from the investment.

3.2. Transformation and revitalization of the existing post-industrial complex

The leitmotif of this model is the fundamental transformation and revitalization of brownfield complex. It exists as a heritage after previous eras. It's a luggage that makes to the local authorities, or to the current owners problems with development or maintenance.

Frequently such brownfields belongs to the local authority. A thorough transformation and revitalization of the complex requires from organizer the total, or almost total ownership of land, buildings, constructions and installations. With this legal status organizer of eco-industrial park will be able to freely dispose of all elements of the property and make it available to entities interested in participating in the park on the basis of long-term lease within the symbiotic chain. In relation to the previous case, (i.e. the construction and organization of the park from the very beginning) situation is different. The time allowed for the installation of the park should be significantly shorter, and the process itself simpler. The owner of a post-industrial complex can use the existing (often quite considerable fortune) assets, and any possible work will consist in adaptations of old technologies to new needs. Furthermore, companies interested in participating in the park alone exhibit ingenuity in the use of the shared infrastructure. Therefore, the installation of tenants and bringing the complex to a state of the full operation should be significantly shorter than the previous model.

An additional advantage of this solution is related to the other arguments. One can imagine a situation in which the present owner (most often local authority) does not want to take the effort to maintain a post-industrial complex. Owner decides to close it, because there is no good idea to develop the object so far.

Apart from the cost of the demolition of construction, site remediation one should still have in mind the social impact of the liquidation of such facilities. Quite often they are associated with the history and traditions of the local community. Ignoring these facts in times of the promotion and creation of „small

homelands” it would be difficult to accept and implement such an idea. It should be assumed that especially in the case of one of the major stakeholders (local authority), which has inherited an unwanted complex, such thinking is dominant. What's more sensible re-launch of complex may reduce social problems (such as unemployment), economically activate the region, attract investors and tourists, and in the end help to increase local revenues in the long term.

Just as in the previously discussed case, the primary task is to plan system based on the „nucleus” of the system. In other words, it is necessary to have or create the leading value for the entire project such as a cheap source of energy, water mains, buildings, storage area networks, rail ramps etc. In accordance with a plan of creating a symbiotic chain to the already defined „kernel” you can gradually add new tenants with the obvious requirement to reorient their own processes focused on co-operation with already existing companies in the complex.

Such actions will only be possible if you have a full governance over infrastructure. Such a situation creates a very comfortable position to manage the plant, and this fact is a value in itself. An important advantage of this solution is the fact that this form of organization of the park does not require to have large liquid funds. In this model relatively early may arise income from rents for the use of infrastructure. The companies themselves quickly reach full production capacity, having at their disposal relatively easily achievable infrastructure.

You can imagine the situation of a lack of entities willing to participate in the symbiotic chain, or companies matching the profile of eco-industrial park. Even in such a case owner can provide for himself permanent access to cash. You can enable to the park tenants not related to the symbiotic chain, but obligatory satisfying a condition of doing business neutral for environment. Such a situation requires signing lease agreements for relatively short terms, optionally to conclude contracts which are easy to be cancelled.

3.3. Limited revitalization of the post-industrial zone

As in the previous case, the starting point is the already existing degraded, inactive industrial complex. The difference lies in the nature of ownership relations. The previous model assumed almost complete ownership of the properties belonging to the complex. In this case, the existing infrastructure, which is the basis for the park being created, is only to a small extent the property of the organizer of the idea.

Unfortunately, in Poland, this situation is very likely. Large industrial complexes have become a significant problem in the last decade of the twentieth century. Changing the model of functioning of the state from a centrally planned

economy to the market-oriented resulted in a gradual falls of large scale economic organisms (often employing thousands of people each) across the country. You could have met justification of this fact in mass media. Often it was used argument that in a developed capitalist economy there is no place for such large companies. As a result, in many places in Poland appeared inactive complexes of brownfields. Their owners, bankruptcy trustees or a local authorities were suddenly burdened by unwanted ballast and as a result they encountered big problems. In the absence of a developed vision of the further functioning of the immobilized complex they undertook numerous efforts to get rid of it as soon as possible. It is obvious that this was conducive to uncontrollable solutions. Possible buyers did not apply for large pieces of organized property. They, however, were only satisfied with small fragments of a dead infrastructure at the moment, meeting their small-scale needs.

Owners not seeing real opportunities for profitable sale of such a complex as a whole, resigned most frequently from long-term development plans concerning property for ad hoc solutions, however, resulting in the current inflow of cash. The result of this approach was a gradual and disorganized sale of assets to all appearing interested purchasers.

It is not difficult to guess that in relation to the previously presented cases described circumstances create the most problems. Taking as a starting point the possibility of a rational and efficient construction of eco-industrial park full ownership of its assets is crucial to the success of the whole project. While in the previous two cases, the organizer was an independent decision-maker as to the disposal of infrastructure, whereas in the present situation, the success of the project depends primarily on the quality and strength of persuasion in relation to the actual owners of fragmented parts of the assets of the former industrial complex. The current owners of individual parts of the complex some when undertook the decision to purchase them. And it was much earlier than they heard about the symbiotic chains. They certainly had their own vision of establishing and running their businesses. It is believed that they put a lot of energy and financial means in their projects. For these reasons, they are far less susceptible to environmental arguments. Additionally point of view of the organizer of the park is associated with the vision of a comprehensive restoration the entire complex for his own tasks.

As a result, the chances of successful construction of the park depend largely on the case, and happy coincidences. It is possible to imagine the situation when a symbiotic chain is created in a way that is not controlled by anyone. Companies operating within the industrial complex may spontaneously create a symbiotic chain i.e. production waste from subsequent companies can create the raw material for the following ones.

You can also expect that the change in the production profile suggested by the organizer of the park would meet the entrepreneur's needs. As a result, he would be interested in changing the current production profile, as under the changed circumstances he would find more favourable operating conditions for the future.

To consider is also the option of gradual repurchase the subsequent a part of assets from the current owners to return to the original ownership relations. Another solution would be to find attractive kernel by designers of eco-industrial park. The benefits for the individual entrepreneurs from accepting the organizer's proposal should, however, be significant for them. To achieve them, entrepreneurs might be willing to incur substantial inconveniences or they would be willing to revise their original objectives of their own functioning on a selected area.

Thinking realistically, however, in this model, the position of the organizer of the project is the weakest. Many decisions relating to organization and functioning of the park will depend upon the attitude of the current owners of individual parts of assets of the former manufacturing complex. Organizers of the whole undertaking will be often limited to perform advisory functions to promote only some of the ideas and solutions, but without the possibility of their effective enforcement.

4. Examples of functioning of eco-industrial parks

4.1. Kalundborg

Kalundborg city has 16,343 inhabitants (as of January 1, 2015). It is an industrial center located on the Danish Island of Zealand approx. 110 km west of Copenhagen. It works here seaport and numerous industrial companies. Symbiotic relationships were formed spontaneously (as opposed to most other parks today-functioning) for several decades solely on commercial terms. The first element of the system was a coal plant, which was established in 1959 (the core of eco-industrial park), and the second was refinery which was built two years later. It is estimated that the first works linked to the coordination of activities started in 1974 and ended in 1993. Our case is one of the most branded solutions, perhaps the most quoted and oldest implementations in the field of industrial symbiosis. Each of the companies located in the park is a tycoon in its sector in Denmark. Quite often, these entities have numerous international connections.

The focal point of the park is the coal plant Asnaes (1500 MW), which has a material and energy ties with the city. Surplus of thermal energy is transferred to heat 3,500 homes, in addition to the nearby fish farm, which, in turn, the biological sludge is processed into fertilizer. The water from the nearby lake is

used for cooling power. The water vapour produced in power plant is sold to the company Novo Nordisk, which is the manufacturer of medicines and enzymes and also to Statoil refinery. Reuse of heat energy reduces thermal pollution discharged into the nearby fjord. In addition, a by-product of the power plant is gypsum (FGD effect), which is sold to a nearby factory of plasterboard, which represents almost all of its needs. Definitely this reduces the demand for this raw material obtained by surface mining. What's more fly ashes and clinker from the power plant are used for road construction and cement production. A special role is played by the company Novoren, which not only collects waste from all the companies participating in symbiosis (these companies in return receive raw materials), but processes them or directed for further processing (paper, metals, glass). It also produces compost, biogas, fuel for power plant, electricity and aggregate. The role of the park in Kalundborg in industrial ecology was huge. Shortly after the announcement of the results of the implementation of the Kalundborg began searching symbiotic chains in 27 European and non-European countries (Rahman and others, 2016, p. 012). At the moment, we can distinguish 302 initiatives known as eco-innovations (Massard and others, 2014, p. 7). This number includes both eco-industrial parks, industrial parks with environmentally friendly initiatives in selected areas (but not meeting all requirements imposed on the symbiotic chain) and of the urban organisms called eco-cities (Massard and others, 2014, p. 7).

4.2. Hartberg¹

Hartberg is a small city (6.5 thousand, inhabitants) lying in the east of Styria (Austria). The organizer and manager of the entire project is one of the subsidiaries of the municipal company Stadtwerke Hartberg Verwaltungs GmbH, whose main task is the collection and disposal of municipal waste. Eco-industrial park called Oekopark Hartberg GmbH was founded in 1997 on the grounds of the abandoned brickworks previously owned by the city.

Park project is based on the local use of energy produced. The initiative also assumes the activity in several business areas such as cooperation between enterprises in the use of waste, entertainment activities for residents of the city (large format movies), popularizing and educational activities in the field of ecology, energy production mainly for the needs of the park by waste disposal and the use of renewable energy (wind and solar energy).

¹ The chapter is based on the author's own information coming from a study trip in the 2009 research theme and Liwarska-Bizukojc E., Bizukojc M., Marcinkowski A., Doniec A., *The conceptual model of an eco-industrial park based upon ecological relationships*, Journal of Cleaner Production 17, 2009, pp. 738-739.

The most important members of the eco-industrial park in Hartberg are three power plants which together form the centre of energy (Energiezentrale). Energy companies generate energy from renewable sources, including solar energy, biomass energy and heat generated from the combustion of biogas. This energy is supplied to companies of the park and the city of Hartberg at favorable prices.

Symbiotic relationships in the park revolve around the company manufacturing cellulose insulation.

It arises as a result of reuse of paper waste coming from the areas surrounding the park and from the town of Hartberg. Products of this company are in turn used by the manufacturer of wooden houses also located at the park. Wood dust generated during the production process of summer houses is in turn waste production passed back to the producer of insulation materials.

Subsequent enterprises belonging to Oekopark Hartberg operate mainly in the field of waste management. These include the Municipal Purification Plant and the company which specializes in the utilization of municipal waste. The first of the companies is engaged in the collection, segregation and disposal of waste from the city and the park. The organic part of municipal waste is the raw material for methane fermentation, by which biogas is obtained. Green waste from the city, among which a significant share of which are branches and grasses are processed into compost. It is enriched by sludge that remains after the methane fermentation. The compost is distributed in two ways. It is the subject of the commercial trade in goods, and sometimes the object of settlements with the citizens of the city. In the latter case it is part of the tied transaction. In return for the collection of municipal waste Hartberg's residents receive compost in a free.

The company specialized in the management of other municipal waste partially operates the park, and in part out of it. It is connected with segregation and recycling of construction waste, which are inert to the environment. Their landfill is located within the park. The company furthermore leads segregation of hazardous waste from households.

In addition to the above-mentioned companies operating in Oekopark Hartberg there are several service companies not directly related to any symbiotic and technological chain, such as the office of legal advice office, consulting firms, the editors of local newspapers.

Eco-industrial park has features of weakly centralized organization with a vision of the slow implementation more and more interesting ecological solutions in the future.

4.3. Valuepark®²

The next eco-industrial park is located in Germany in Schkopau near Merseburg (33.4 thousand inhabitants) in Saxony-Anhalt. Schkopau is a small city (3.5 thousand inhabitants). However, even before the war next to the town existed a huge industrial centre focused on the production of chemicals (built since 1933). After the war all the legacy was taken over by the GDR. They maintained and expanded the production profile of the entire chemical complex for several decades, without undue concern for the state of the natural environment. Privatization of the complex was made in the mid-90s of the last century. A company called DOW Olefinverbund GmbH in Schkopau was the acquiring company. This entity is 100% dependent on the US, a world leader in the chemical sector with the name DOW Chemical Company. Available data show that in 2008 the value of sales of the entire group reached 49 billion USD, of which „the German part” accounted about 4 billion USD.

In 1998, on the initiative of DOW Olefinverbund GmbH (hereinafter abbreviated DOW) was created eco-industrial park with the name Valuepark®, whose name was proprietary. It aims primarily to achieve good financial results, but also the development of cooperation between enterprises in conjunction with meticulous attention to the natural environment. Production complex taken from the German owners has undergone extensive modernization, for example:

- from the 3,500 factory and administrative buildings were left only 250;
- contaminated land has been rehabilitated (150 ha, in some cases up to several meters deep), and contaminated ground water is still purified. According to information from the company, this process is expected to last for the next 50 years;
- all technological connections with the „outside world” are carried out by a pipeline network (including connections to two ports in Rostock and Hamburg in about 500 km each). Economic and environmental considerations were behind these investments;
- well-equipped control centre has been installed in the field of environmental protection;
- outdated production technologies have been converted to healthier and more efficient. For example, as a result of the improvement of exhaust gas cleaning technology, the daily recovery of gypsum from CHP is 2300 tons;

² The chapter is based on the author's own information coming from a study trip in the 2009 research theme and from the web site. <http://www.dow.com/valuepark/about/index.htm>

- in the site it has appeared the scientific and research institution with the name Fraunhofer Institute (Merseburger Innovations- und Technologiezentrum Fraunhofer Pilotanlagezentrum) conducting research and design works, including pilot trials for partners of Valuepark®.

The concept of Valuepark® assumes that it is an entity which is to create new value for the plants DOW. On its grounds it is installed 15 companies legally and financially independent from the DOW. They have the status of investors in Valuepark®. They are mostly companies of the chemical industry. They deal with the processing of plastics, which are manufactured by DOW. DOW also establishes the principles of joining companies to the park. It therefore fulfils the role of centre of management. Enterprises most of the material supply (approximately 60%) obligatorily acquire from the DOW plants. Ultimately, about 25% of the products manufactured by DOW must be processed on the site, the remainder is transported by pipelines and further through the ports to customers all over the world. In addition, one of the tasks imposed on investors (tenants) is to work for DOW connected with the penetration of world markets. With these assumptions, typical in the world zero-one competition strategies turns into a win-win strategy.

DOW offers for current and future investors with Valuepark® the following benefits (available at cost price):

- effects of operation of industrial infrastructure, including electricity, steam with various parameters, natural gas, gases, water of different qualities, cooling water, compressed air and nitrogen;
- advice and support in obtaining permits from local authorities as well as bank loans and guarantees;
- services in the form of wastewater treatment, waste incineration, emergency services, security services work, health and the environment, fire services, quality control, rail transport and storage.

An important result of this cooperation is also shortening the supply chain between Dow and companies that convert their products. With a minimum distance from the primary producer co-operators are able to obtain a competitive advantage by reducing transport and storage costs. A huge role is given to the issues of environmental protection, health and safety at work. The program called „Vision Null” was introduced. Its implementation is a realization of the postulate of the total elimination of pollution and accidents. The result is a very low number of accidents at work, as well as compliance with all applicable environmental standards.

The company does not enter into retail operations. Its role is to manufacture various components used in the chemical industry and their mass sales. It was found that entering the retail business de facto boosts the cost of functioning of the company. This resulted in a cheap and flat organizational structure.

4.4. Port Rotterdam³

The port of Rotterdam is a huge organism which constitutes one of the largest ports in the world. It covers 10 thousand hectares, half of which is land managed by the company Rotterdam Municipal Port Management (RMPM). This is a port for ocean-going vessels stretching 50 km inland along the Rhine. The total tonnage of transhipped goods amounts about 370 million tones. Crude oil for five refineries processing 100 million tons of oil annually, chemicals (for over 30 plants) are the main handled goods. Together these companies occupy about 60% of the land and the port gives directly 14 thousand and indirectly 66 thousand jobs. The Port of Rotterdam creates good conditions for businesses to recycle waste, by-products and energy in their mutual relations. It has been implemented several projects including project called INES (Industrial Eco-System), which was implemented in the western part of the port. Its initiator was a business association called Europort/Botlek Interests Industry Association. It arranged implementation of Environmental Management Systems (Environmental Management System – EMS) with the participation of 69 member companies. The works involved the members of the board of the association mentioned above, the President of the institution which is the communication platform in environmental matters in Rotterdam and academic staff of the Erasmus University. INES was introduced in order to stimulate the development of the concept of „cleaner production”, the analysis of network links activities of enterprises and their flow of raw materials and energy. An important aim was also to create infrastructure for the information base in order to facilitate the functioning of eco-industrial park in the region. The works were multi-stage. The first project INES Project covered the years 1994-1997, and then INES Mainport Rotterdam implemented in 1999-2002. The last project was the Rotterdam Harbour and Industry Complex (HIC) implemented in 2003-2007. The following sequence of involvement of stakeholders took place within INES:

**Enterprises ⇔ Port ⇔ City ⇔ Other neighbouring towns
(communities)**

The process was not structured and depended largely on the human consciousness. The work was conducted by leaps and bounds, which resulted from revealing the difficulties of political and jurisdictional nature. Stakeholder participation when installing eco-industrial park is presented in Table 1.

³ The chapter is based on the author's own information coming from a study trip within the research theme in 2009.

Table 1. Roles of stakeholders in the formation of eco-industrial park INES in Rotterdam

INES	Initiator	Managers	Consultants	Activity executors (non-financial))	Financial Participant s in the Project
Local Government					+
Regional Authorities					+
Central Authorities			+		+
Chamber of Commerce			+		
Enterprises				+	+
Business Associations	+	+		+	
Educational Institutions			+		
Consulting Agencies			+		

Source: own study based on: (Agarwal, Strachan, 2006).

More than \$100 million has been spent on the project INES, the annual financial effect is estimated at more than EUR 16 million (2008). On an annual basis the environmental benefits are the following savings:

- 157.6 MW of energy,
- 151.2 M Nm³ of gas per year,
- 272.5 kilotons CO₂,
- 225.6 tons of NO_x,
- 158 MW of hot water,
- other additional savings in the use of resources.

5. Conclusions

Eco-industrial park is an organization that assumes compliance with Industrial Ecology guidelines. It should be a dynamic system in which human activities are carried out in a sustainable way. By installing eco-industrial park in parallel you can achieve many advantages, such as (Huber, 2012, p. 3):

- the ability to achieve savings and generate new revenue through access to cheap services (eg. energy sources), regulatory facilities (within the decision policy of local authorities interested in the existence and operation of such organizations in its area), increased competitiveness in relation to the

outside world (access to cheap sources of supply based on the use of by-products);

- in the area local authority obtains cleaner production and as a result a healthier environment, installation in the park new businesses, reduction of an unemployment and social problems, and finally liquidation of the eternal conflict between industrial development and environmental protection;
- local authorities have the possibility of obtaining increased tax revenues, the development of eco-industrial park favours the elimination of pressure on the development of infrastructure that otherwise would have to be generated by own local government activities, in many cases disappearing costs of environmental protection and health of citizens;
- the environmental benefit consists in reduced demand for non-renewable resources, reduction of local and global pollution, increased use of renewable energies and materials, and overall reduction in the devastation of natural systems.

Thus, the eco-industrial park assumes the co-operation of three stakeholder groups (companies, local authorities and environmental institutions) in the area of refining the raw material-process-product chain. The former, developed over the centuries model of human activities was very wasteful, because it was assuming unlimited access to factors of production. Hence the multiplicity and great scale of the accumulated and still produced by-products.

The eco-industrial concept that implements institutional and legal requirements, based on credible environmental performance measurements, together with the positive financial results of the project, will certainly meet the requirements of a new environmental approach in the future.

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