

Opportunities for Sustainable Industrial Development in Turkey: Eco-Industrial Parks

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ABSTRACT

Industrialization has an important role within the attempts for development. Against the fact that it is indispensable, industrialization causes significant environmental problems. This progress, which is in disfavor of the natural areas and resources, can not be controlled with the existing industrial and environmental policies, and thus new approaches are needed. The concept of Eco-Industrial Parks is developed in line with this approach. It is accepted widely and there exist many examples in several countries. Unfortunately they are not known sufficiently in Turkey yet, and such applications don't exist. The purpose of this study is to identify the application potential of Eco-Industrial Parks in Turkey. In this study, Organized Industrial Zones located in Kocaeli shall be investigated in respect to their similarities to Eco-Industrial Parks, the potential for establishment of Eco-Industrial Parks in Turkey shall be assessed, and some proposals for more sustainable cities shall be developed.

Key Words: *industrial ecology, eco-industrial park, Kocaeli, Organized Industrial Zones.*

1. INTRODUCTION

In the industrialized world, the importance of conservation of natural resources have been understood together with the increasing environmental problems and sustainability concept has been introduced by international organizations such as 1972 Stockholm and 1992 Rio Conferences [1]. Suggested as a solution to the conflict between urbanization and natural systems,

sustainable development is defined by the United Nations as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” [2]. Despite increasing awareness towards conservation of environment, developed approaches, concepts such as “Zero Growth”, or suggestions of “modernization in agriculture rather than industry and development in tourism” given to

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developing countries are taken skeptically by developing countries [3].

Industry has an indispensable place in the development objectives of developing countries as much as it has for developed countries. However, it is common knowledge that development of the industry brings along a lot of negativities in terms of environment. Natural sources are consumed in the production process and energy sources based on fossil fuels which have polluting effects are used for the production to a great extent. Wastes are generated in various stages of production process; during the distribution of the products and presentation of the products to the consumers. Those products which get old and useless after their useful life are generally left to the nature.

An urban development balanced in terms of economy, social structure, and ecology is emphasized with sustainable planning approaches. In the planning stage of industrial areas, the benefits to be provided for the society and ecological priorities should be pursued as well as contribution to the economy. With the introduction of “industrial ecology” approaches that are developed to fulfill this requirement, planning industrial areas by using life cycle approach has become a current practice. Within this context, “eco-industrial parks” provide an opportunity to achieve a sustainable industry with their structure compatible with natural systems, providing water and energy cycle, using renewable construction materials, and including facilities that integrate the industry.

The main purpose of this study is to establish a comparison framework that will help transferring the lessons learned from eco-industrial park applications in the world to the conventional industrial zones. Therefore, in this study, it is aimed at initially defining the eco-industrial parks and then developing strategies for transforming industrial zones in Turkey into eco-industrial parks. In the second part of the paper, industrial ecology concept and new perspectives brought to the planning area by industrial ecology are highlighted. Eco-industrial parks, which are examples of applying this approach in industrial areas, are explained in the third section and important models are mentioned. In the fourth section, the feasibility of eco-industrial parks in Turkey is presented based on the example of industrial zones in Kocaeli. Conclusions and further suggestions are provided in the fifth section.

2. INDUSTRIAL ECOLOGY

The point of origin of industrial ecology is imitation of material cycles in ecology in industrial areas. This approach resolves the conflict between industry and ecology, in a sense, considering the industry a subcomponent of the ecologic system [4]. Industrial ecology concept suggests a societal system where the responsibility of maintaining the continuity of production together with conservation of the environment is undertaken by a wide basis including manufacturers, public administrations, civil society organizations, researchers, and consumers. In this system that is regarded as industrial ecosystem, energy – raw material usage and wastes are optimized and hence industrial

ecosystem becomes analogous to the biological ecosystem. In the industrial ecology approach, it is asserted that “in order for the industrialized world to maintain its life standard and the developing countries to reach the same level of developed countries, consumers and manufacturers should change their practices in a way that they resemble industrial ecosystem as much as possible” [5].

Natural systems have evolved in a few million years from open systems towards closed systems which constitute a dynamic balance between organisms, plants, and various biological physical and chemical productions in nature [6]. Like ecosystems, cities are also systems with material and energy inputs. In order to establish technologies and management systems that will allow integration with natural systems, cities should be considered as a whole; energy and raw materials should be analyzed; conservation of energy should be assured; wastes should be recycled and used as raw material, and hence productivity in resource usage should be provided [7].

Material flow defined in industrial ecology is a three stage process determined by raw material producers, manufacturers, and consumers. Extracted raw materials go through several operations to get prepared for production, later it is processed in the production stage, and then delivered to the user. In order to control raw material flow, wastes and error points should be determined at each stage and the materials should be brought back into the production process. A material cycle can be obtained by offering old and used products to the market for other purposes, decomposing the materials and reusing, and finally recycling them as raw materials [8].

Industrial relations determined by the industrial ecology approach necessitate an “industrial symbiosis” among the firms. Five different types of industrial symbiosis are defined [9]:

Type I: One-way waste exchange

Type II: Exchanges within a facility, firm or organization

Type III: Firms co-located in a physical park

Type IV: Firms not co-located, but within a locality

Type V: Firms not co-located, but within a broader region (virtual).

Ecosystem principles of the industrial ecology complement the relationships of this symbiosis. “Recovery” which is denoted by using renewable sources and material cycles, is the first of the four ecosystem principles of the industrial ecology. The second principle, which is “diversity”, means the diversity of cooperation when it is considered in terms of industrial environment policies and management. The presence of diversity makes it possible to build systems that involve actors using waste materials and energy in cooperation with each other. These actors are not only large industrial enterprises but also public institutions, municipalities, waste management companies, and consumers. The third principle which is “locality” requires the use of renewable sources available in the local area and hence

taking local constraints into consideration in regional developments. The fourth principle is “gradual change”. It means developing by considering transfer capacities of natural systems so that the ecosystem is able to survive [10].

3. ECO-INDUSTRIAL PARKS: MAIN PRINCIPLES AND EXAMPLES

The most important application area of industrial ecology is “eco-industrial parks”. An eco-industrial park is briefly defined as “companies’ and institutes’ working together and building a production network to develop their environmental and economic performances” [11]. According to this, an eco-industrial park is an “ecosystem where waste minimization is sought in the use of energy and raw materials, material and energy exchange is planned, and economic, ecologic, and social relations are established [12]. A classification developed by Research Triangle Institute for eco-industrial parks is presented below [13]:

- a single byproduct exchange pattern or network of exchanges.
- a recycling business cluster (e.g., resource recovery, recycling companies)
- A collection of environmental technology companies
- A collection of companies making “green” products
- an industrial park designed around a single environmental theme (i.e., a solar energy-driven park)
- a park with environmentally friendly infrastructure and construction technology
- a mixed use development (i.e., industrial, commercial, and residential)

Application of this approach on urban scale is related to the planning of industrial areas to a large extent. Especially, the connections determined by the goods and services flows between the firms define the usage of the place as well. Not only industry, but also other urban activities complementing the industry are considered within the scope of eco-industrial parks (EIP).

Local administrations also play a part in the development of EIPs as much as the central administrations do. Providing a location at the establishment stage of EIPs, necessary permits, legal and managerial regulations supporting development, developing appropriate technologies, technology transfer, providing technical training, and encouraging knowledge transfer among

EIPs are important for the applications to be successful [14].

Preparation of startup projects that will lead the design thought, conducting feasibility studies involving environment, architecture, and engineering, acquiring the land, development of residences, and finding a financial source to cover construction costs and operating costs of the project are required in each eco-industrial park project.

The following could be mentioned among the primary financial sources [14];

- Municipal bonds,
- Taxes collected for redevelopment of polluted areas,
- Allocation of lands under public ownership for investment,
- Economic development funds,
- Commercial bank supports,
- Insurance companies or environmental risk investment funds,
- Contributions of other supportive persons or institutions.

It is observed that three types of areas are considered in terms of location selection. These are “industrial areas” where industrial relationships of an existing industrial area are utilized, “brown fields” that are environmentally damaged because of the industry and are in recession economically, and “green fields” which are not in any industrial development yet and open for new applications [14]. As a result of the assessments in the literature [15], [16], [17] regarding current eco-industrial parks, it is observed that these three types of settlement areas have positive and negative features. These features are compared in Table 1.

It is possible to analyze economical benefits that will be provided by EIPs separately for private companies and society. Primary economical benefits for private companies are potential cost savings, advertisement and marketing facilities, and opportunities for new investments. Primary benefits that will be provided for the society by the development of EIPs are increasing local job opportunities and incomes from tax, repairing the image of polluted areas, increasing and disseminating technological renovations, and decreasing infrastructure development costs [18].

Table 1. Comparison of positive and negative features of investment areas.

Positive Features	Negative Features
Industrial areas	
<ul style="list-style-type: none"> - Provides investment guarantee - The idea that previous business connections can be maintained motivates the investors in a better way - The advantages provided by current transportation and communication facilities already developed 	<ul style="list-style-type: none"> - Difficulty of overcoming stereotyped ideational structure - Not being able to perform rearrangements in extremely intervened areas in the physical environment
Brown fields	
<ul style="list-style-type: none"> - Urgent intervention to polluted areas - Reduction of investment costs since land values are decreased 	<ul style="list-style-type: none"> - Areas polluted with industrial wastes are not attractive for investors
Green fields	
<ul style="list-style-type: none"> - It is possible to try new approaches - It is possible to carry out each stage of the design process in a controlled way 	<ul style="list-style-type: none"> - Areas with high environmental sensitivity have risk

There are also some barriers for eco-industrial parks. These are as follows [19]:

- Technical barriers; the difficulty of achieving harmony among the firms,
- Knowledge barriers; new users' lack of knowledge regarding the use of waste products and the market,
- Economic barriers; the market generated is not always economically reliable,
- Regulatory barriers; legal barriers for waste exchange between firms,
- Motivation barriers; lack of desire to work together among firms and local actors.

Both in the USA and in Europe there are many applications of EIP. Each one, being a resulting product of its local conditions, is either developed naturally, or is built with inspirations from the natural life or existing examples. Therefore the existing samples should be considered as inimitable genuine concepts. In this context, the important thing is to try to understand the principles and the philosophy of the existing examples of EIPs. The most important two examples of eco-industrial parks in Europe are Kalundborg and Stryian.

3.1. Kalundborg

The first example defined as an eco-industrial park is the industrial symbiosis in Kalundborg [20]. Located approximately 75 miles east of Copenhagen, Kalundborg is a small industrial area on the seashore of Denmark.

Industrial symbiosis has begun by waste management among the members and search for new ways to use

water resources more effectively and development of cost reduction efforts [21].

The process, which started in 1960 by the establishment of Asnaes Electricity Station, has obtained a structure that could be regarded as "industrial symbiosis" in 1990s [22]. There are six basic members of the industrial symbiosis established in Kalundborg [23]. These members are given below;

- Energy E2 Asnæs Power Station,
- the plasterboard factory BPB Gyproc A/S,
- the pharmaceutical plant Novo Nordisk A/S and the enzyme producer Novozymes A/S,
- the oil refinery Statoil A/S,
- Bioteknisk Jordrens Soilrem A/S
- the waste company Noveren I/S and Kalundborg Municipality.

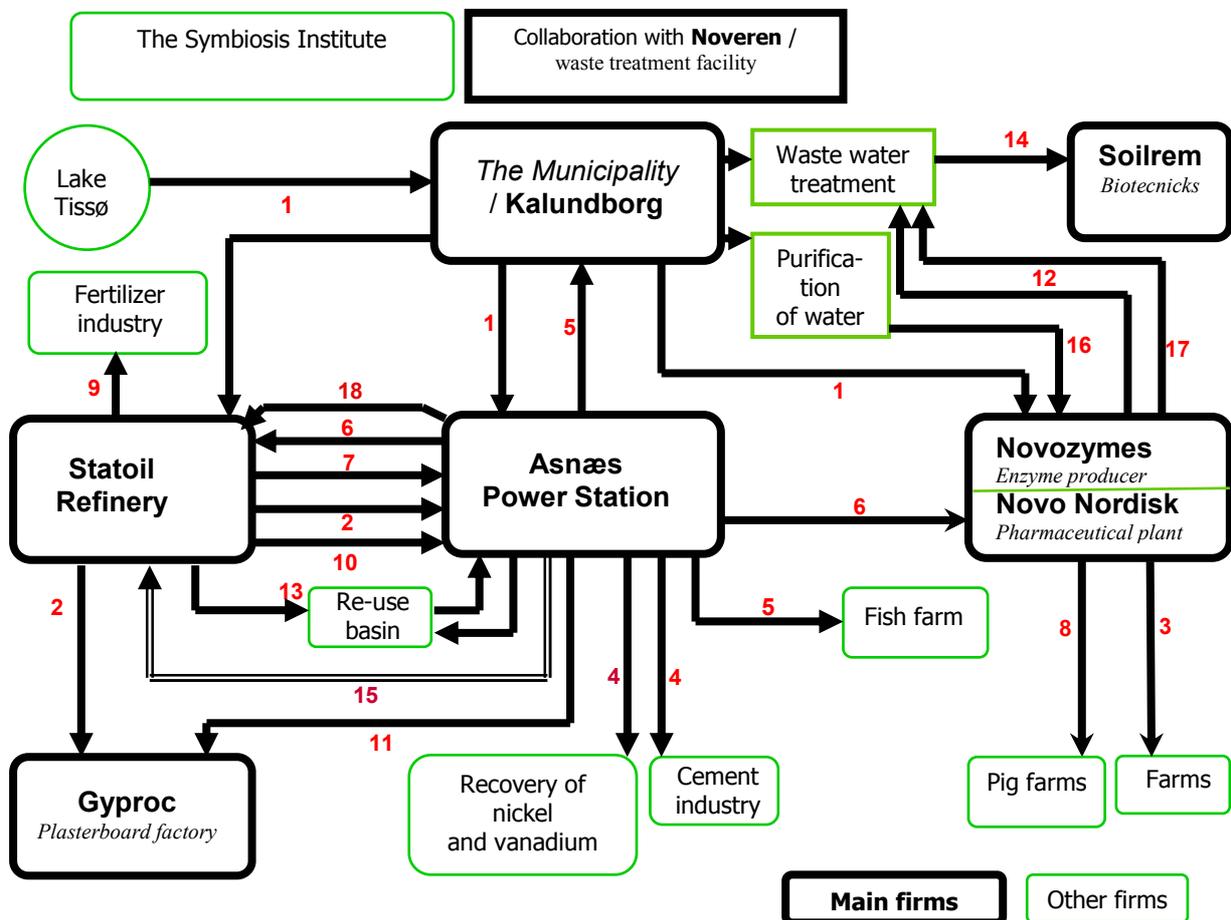
In the time period from its establishment until today, an industrial symbiosis is developed in Kalundborg on its own, without any support from the government or any other organization [24]. With the industrial symbiosis in Kalundborg, reduction in energy consumption and SO₂

and CO₂ emissions was achieved; moreover, wastes such as ash, sulfur, biological mud, and gypsum were transformed into raw materials to be used for production. Today, the systematic environmental way of thinking that can be applied in other industries and that will be beneficial for planning industrial complexes of the future has been developed and deservedly, the image that Kalundborg is a clean industrial city has been established [25].

One of the characteristics of Kalundborg that is the most difficult to be taken as an example by other eco-industrial parks is the structure of the society that helped the developments start on their own. Along with technology and harmony among firms, the trust relationship between the members of the system and openness are also important [26] because ideational proximity as well as physical proximity should be established for a successful EIP.

Key elements for the success of Kalundborg are as follows:

- Presence of many large industries in the city,
- Relatively small physical distance,
- Harmony among the firms,
- Economic incentives,
- Non-existence of legal barriers,
- Effective communication,
- The size of the community,
- No competitors involved
- Administrators' knowing each other in the same social environment,
- Open management style [22].



Materials: 1:Surface Water / 2:Gas / 3:Biomass / 4:Fly Ash / 5:Heat / 6:Steam / 7:Cooling Water / 8:Yeast Slurry / 9:Sulphure Fertilizer / 10:Tech.Water / 11:Gypsum / 12:Waste Water / 13:Drain Water / 14:Sludge / 15:Deionized Water / 16:Water / 17:Alcoholic Residue / 18: Sea Water

Figure 1. Material flows in the Kalundborg (Adapted from Christensen, 2006).

3.2. Styrian

Another industrial structure similar to Kalundborg is formed in Styrian located in Austria [27]. Styrian is an industrial zone where there are firms from different sectors with high innovation potential. Primary sectors are paper and wood products, machinery, metal and steel, and automotive [28]. Clustering of firms in a region help them reduce their costs as well as make it possible to establish a network among firms where wastes are used. It is possible to recycle materials such as paper, gypsum, iron parts, used oil, and rubber in the established system. With these non-expensive byproducts, costs of the firms are reduced and at the same time, environmental benefits are obtained. Hence, whole region benefits from the established recycling system [27].

There are strong connections among the firms and research institutes and a transformation from conventional towards a more innovative structure is expected in the region. In recent years, it is indicated that automotive industry is more effective than paper and wood products industry which is set as an example for the symbiosis relationships established in these clusters [29].

4. EEP POTENTIAL IN ORGANIZED INDUSTRIAL ZONES: EXAMPLE KOCAELI

In Turkey, industrial areas where environmental control is the strongest are organized industrial zones (OIZ). Being an important tool for development, OIZs provide opportunities for planned development of the industry. The definition of the OIZs are given in OIZ Law No 4562 as “goods and services production zones that are established for the purposes of making the industry structure in the appropriate areas, directing the

urbanization process, preventing environmental problems, benefiting from information and communication technologies, location and development of manufacturing industry types within the scope of a certain plan; boundaries of which are determined by the allocated land pieces, which are provided with the required infrastructure services and social facilities to be determined according to the needs and which are provided with techno-parks; which are allocated to the industry within the scope of certain systems”.

In this study, OIZs in Kocaeli and EIPs analyzed in the examples from the literature are compared and similarities and differences are defined. Kocaeli is an important industry city where GDP per capita is the highest in Turkey. Economy of the city depends to a great extent on the industry and the respective services developed accordingly. Sector-specific distribution in the city and in the region is given in comparison with Turkey in Table 2.

Development of industry in the city has speeded up with the establishment of Yarimca Petrochemical facility in 1960 and in time, it is observed that within the decentralization process of the industry in Istanbul, those industries that wanted to get rid of the disadvantages of Istanbul and those industries that polluted the environment had settled down in Gebze-Dilovasi-Izmit-Sakarya corridor [30]. Hence, the development of industry in Kocaeli gained speed with its transportation facilities, developed urban functions, and its proximity to Istanbul [31]. However this situation caused some environmental problems to arise in time [32]. Major problems among these are air pollution, solid wastes, sea pollution, and pollution in water resources.

Table 2. Sector-specific distribution according to the share in total employment (TUİK - 2000).

Employment	Kocaeli (%)	İstanbul (%)	Marmara Region (%)	Turkey (%)
Industry	20.32	32.15	25.67	13.35
Trade	9.21	18.73	14.28	9.67
Finance	2.71	8.16	5.39	3.11
Agriculture	39.04	8.13	25.33	48.38

Increasing pollution necessitated industrial investments in the city to be directed with a wider perspective. It is thought that a participatory understanding highlighting ecological sensitivity provided by the industrial ecology concept and local characteristics will bring a new perspective to the region in this sense. It is thought that especially OIZs in the city have a great potential ahead to prevent environmental problems.

There are a total of 10 OIZs in Kocaeli three of which are at the establishment stage yet and administrative centers of them are located in Istanbul. The OIZs in the city are given below:

- Gebze OIZ

- TOSB - TAYSAD OIZ
- Gebze VI.(İMES) OIZ
- Gebze Plastikçiler OIZ
- Dilovası OIZ
- Gebze IV. İst. Mak. İm. San. OIZ
- Gebze Güzeller OIZ
- Gebze Kömürçüler OIZ
- Arslanbey OIZ
- Alikahya OIZ

OIZs located in the city have some advantages for being considered as EIPs [15], [33]:

- Location advantages: They are located on the axis of Istanbul-Ankara
- Transportation advantages: TEM and D-100 connections, Izmit Airport, proximity to Kurtkoy Airport, Izmit's being a natural port, existence of ports such as Derince and Diliskelesi
- Industrial organizations within the close environment: Large scale industrial organizations in the region such as Honda and Isuzu, enterprises in Anatolian side of Istanbul and other enterprises in Sakarya
- Agricultural organizations in the region: greenhouses, fish farms, etc.
- Energy facilities: Petrol refineries, natural gas transformation facilities

- Organizational advantages: innovative and participatory management structure of the OIZs in the region,
- Research and innovation potential: Universities in the region (GYTE, GYTE-TEKMER, Sabanci Unv., Kocaeli University) and research institutions (TÜBİTAK-MAM, TSE)
- Civil society organizations: Kocaeli Chamber of Industry, KSO Waste Stock Exchange, Town Chambers of Commerce and other professional organizations
- Waste treatment facilities: İZAYDAŞ

However, despite these similarities, there are some basic differences between OIZs and EIPs (Table 3). It is necessary to take into account these differences in the transformation process of OIZs.

Table 3. Characteristics of OIZ and EIP [33].

Characteristics	OIZ	EIP
Sector based diversity	Single sector or current sectors not related to each other	Sector structure complementary for each other
Benefits provided by the park	Share of physical area	Cooperation including production processes and complementariness
The impact of institutions	Commerce and/or industry chamber	Business environment, research organizations, institutions, universities, and civil society organizations
Purpose	Economic success	Environmental earnings as much as economic success
Waste disposal	Waste treatment, some waste exchange applications	Recycling, reusing, industrial symbiosis
Location selection of the park	Firm objectives have priority	Complementary for regional development
Environmental objectives	Current legal framework	Innovative applications increasing environmental performance
Information flow among firms	Hidden	Effective and continuous information flow
Off-park relations	At firm level	Complementary for the park, systematic
Environmental certificates	Environmental management systems (i.e. ISO 14000)	Along with environmental management systems (ISO 14000), certificates such as design for environment (DFE) and Pollution prevention (P2)

Basic principles of EIP design [34] provide guidelines for the transformation of OIZs. The first principle is “integration into natural systems”. This principle, which means reduction of costs by using local resources and

development of local potential, necessitates strong connections with local authorities and usage of natural and economical local resources.

The second principle is “energy optimization”. Efficient use of energy is a fundamental strategy for decreasing production costs and burdens on the environment. Using outputs such as hot water, heat, and steam released as byproducts of industrial production for energy saving purposes provides great savings of energy and water in EIPs. Moreover, renewable energy sources such as wind-solar energy are also used.

“Material flows and waste management” is the third principle. The objective of decreasing raw material use and benefiting from wastes provided increased efforts for

using each material released as a byproduct of production as raw material by another enterprise or recycling these byproducts through certain processes. Firms located in the EIP complementing each other as they are parts of a whole realize the circulation of materials at the greatest extent possible and optimize the use of raw materials.

The fourth principle, which is “water flows”, includes using secondary water resources such as rain etc. as much as another firm’s reusing used waters released by organizations.

“Integration into the host community” involves by-services that contribute to the production and management of the firms. These are services such as organization of activities to bring firms together, construction of facilities, training centers, improving communication etc. systems, providing office areas, and recreation.

“Sustainable design and construction”, which is the sixth principle, means reduction of impacts on the ecosystem in the preparation stage of ecological compatibility of buildings, park system, and settlement. Parks are designed so that they are durable, sustainable, and they allow for rearrangements to easily adapt with changes. In this design process, it is also aimed at recycling construction materials as well.

It is observed that despite the potential in industrial areas in Kocaeli, waste sharing mechanisms are not used and cooperation with other firms in terms of joint production or waste exchange is not realized. Firms have a tendency to keep their conventional production practices and current commercial relationships as they are. However, when it is detected that there are economical benefits, firms conduct studies on waste reduction or reuse [33].

5. CONCLUSION

In order for the OIZs located in Kocaeli to transform into EIPs, initially, an “industrial symbiosis scenario” should be established. This scenario shall be a guide to establish the basis of waste management and waste recovery. This scenario, which is a guide to both the companies and also to the other actors in EIP, is important in building a confidence environment among the companies as well as in providing an auditing possibility of the implementations too.

Constitution of an environmentally and economically effective “industrial coexistence scenario” brings a need

to correctly determine the companies and the other actors in the area.

A database with active participation of all firms in the region should be constructed to reach the most appropriate matching among the units. With the participation of universities and research institutions, a symbiosis scenario that is going to be updated by using this database and that is open for change and fulfilling firm requirements should be constructed.

The role of OIZs in the “industrial coexistence scenario” should be discussed considering their complementary status. Considering that especially in Turkey OIZs are not constituted by single sector companies, this subject is appears to be the most important topic in transformation of OIZs to EIPs. In addition to waste sharing, sharing of energy and by-products among the companies can definitely bring environmental and economical benefits.

Energy infrastructure and proximity of the industry and residential areas provide a potential; however, the risk of earthquakes should also be taken into account. Infrastructure arrangements should be done to support the cooperation which will be established by the participation of local administrations as well. Projects for producing energy from energy should be developed, electricity production from natural gas, use of heat (steam) released as a result of using this energy in industrial organizations in residential areas and agricultural enterprises should be assured.

In addition to current recycling facilities, other recycling facilities for materials such as metal, paper, or plastic should be established. New investments in the region should be given incentives so that they are made in sectors which will support the industrial symbiosis.

There is a need for applications to encourage the companies on this topic as well as legal regulations. In establishment of new EIPs or transformation of existing OIZs to EIPs, in addition to the chambers of trade and industry, other local actors like universities, public and private research institutions, non-governmental organizations should take part in the process.

In this process there will be certain difficulties. Although being a developed industrial zone Kocaeli is an attractive area for industrial investments, enforcing an environment protection based innovative approach to the investors will not be so easy. Therefore, an efficient training and advertising activity, correct explanation to the investors of economical and environmental benefits is necessary.

Additionally, existing over-structuring in the city will affect the infrastructure investments needed to support EIPs. Considering the fact that existing structuring does not have sustainable characteristics and that there is a need for transformations to increase the quality of life, the infrastructure arrangements to be made should take into account the topics to support EIPs, like the recovery of water resources, efficient distribution of energy among the companies and other actors.

The fact that industrial ecology approach is not sufficiently recognized despite the potentials of the OIZs constitutes a barrier for transformation of OIZs into EIPs or design of new OIZs as EIPs. EIPs being effective

applications of increasing the economic earnings of the firms without harming the environment and increasing cooperation and productivity within the whole industrial region should be analyzed as models for increasing OIZs' environmental and economical earnings.

Benefits to be obtained not only by firms but also by cities have made this issue an important matter. Use of natural sources in a sustainable way, realizing more productive industrial production by using less raw material and energy, minimization of wastes and conservation of environmental values, translation of local potentials into production, increasing urban quality with the qualified industrial production and residential areas are the most important benefits among others.

In conclusion, closer recognition of eco-industrial parks both in industrial environments and in society, discussion of their advantages and disadvantages in scientific environments, and transferring the obtained results into practice will be useful for planning and application of sustainable industrial areas.

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