Implementation of Project Management in Eco-Industrial Parks Development in Russian Cities

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Abstract. Recently solid waste management problems show growing trend in the most of Russian cities. This trend proves the relevance of the research on project approach to development of eco-industrial parks focused on diminishing waste flows going to landfills and increasing recycling and reusing of secondary materials. The purpose of the paper is to systematize the ideas on the possibilities of using project management methods for amplification of eco-industrial parks in the cities of Russia. The research clarifies the term "eco-industrial park" and concepts of its application to Russian practice. Different parameters, including composition of the waste flows and types of final products, were used for developed classification of eco-industrial parks. Based on the study of the experience of eco-industrial parks functioning in the cities of Russia, the authors analyzed the prospective and limitations for implementation of project approach to the creation of effective waste management schemes in these parks. The results of the research are of practical importance for public authorities, existing and potential participants of eco-industrial parks, specialists in the field of waste management, researchers in the field of environmental science and economics.

Keywords: project management, eco-industrial park, project, city, waste management

1. Introduction

Russian cities face many waste management problems, such as exhaustion of landfills’ capacities, growing territories of unauthorized dumps, undeveloped system of separate collection of municipal solid waste, shortage of solid waste processing facilities, disunity of secondary resources market. 85 % of municipal solid waste is currently going to the facilities that do not provide any economic or ecologic security, only 10 % is going to the landfills fulfilling the requirements on environmental safety and as little as 5 % is going to waste processing plants [1].

In the last decade, most of the countries began to consider municipal and industrial solid waste as a valuable resource to be involved in the production process within eco-industrial parks. Therefore,
from 100 % of municipal solid waste it is possible to get 5 % of secondary material resources, 25 % of certified fuel for cement plants or complexes for the production of electric and thermal energy, 40 % of compost, man-made soil and only 20 % is a residue that can be sent in compressed form to a landfill site [2].

In Russia, usage of industrial waste as secondary materials is not a common practice. So, cities with developed industries face even more environmental problems than others. The most burdensome city of the planet, according to UNESCO, is the Russian city of Karabash, a recipient of waste from copper production. A toxic chromium lake of seven million tons was artificially created in Pervouralsk. 70 thousand tons of chemicals require processing or disposal in Dzerzhinsk.

All these problems need to be solved as soon as possible to stop the growth of their negative impact on the environment and people’s health. In the world practice, eco-industrial parks are well-recognized as structures aimed to diminish environmental degradation, involve municipal and industrial waste in technological processes and increase energy efficiency and resource saving.

Many of these eco-industrial parks functioning based on the principles of project management, which allows optimizing the usage of financial resources for municipal and industrial waste utilization under time constraints. Russian cities have some, but very limited experience of eco-industrial parks operation. There are almost no scientific papers, books or manuals considering the possibilities of applying project management for the development of eco-industrial parks.

2. Clarification of the Term "Eco-industrial park" and Concepts of Its Application to Russian Practice

In the world practice, the term "eco-industrial park", or "eco-technical park", is often refer to a group of enterprises cooperating with each other and with the local community in order to efficiently exchange resources, information, materials, water, energy, infrastructure and natural habitat. It leads to economic benefits and improving the quality of the environment [3].

The goal of eco-industrial parks development is to achieve economic, environmental and social benefits while reducing the use of raw materials and energy resources, involving secondary resources in the technological cycle, reducing the level of environmental impact of existing industrial facilities and eliminating the accumulated environmental damage [4].

In the Russian practice, the normative definition of the concept of "eco-industrial park" is included in the Strategy for the Development of Industry for the Processing, Utilization and Disposal of Waste of Production and Consumption by 2030.

According to this Strategy, "eco-industrial park" is a complex of objects united by energy links, including buildings and facilities, technological and laboratory equipment used for the processing, utilization and neutralization of waste, ensuring continuous converting waste into industrial products, as well as the implementation of scientific and (or) educational activities in the field of waste management.

At the discussion stage, there is a draft on amending the Federal Law 488-FZ "On Industrial Policy in the Russian Federation". This Law define the "eco-industrial park" as a set of objects of industrial infrastructure and equipment located in the territory of one constituent entity of the Russian Federation or territories of several constituent entities of the Russian Federation, which are used by industrial enterprises for processing, utilization and decontamination of wastes and ensuring on their basis the production of industrial products.

By waste in both documents authors mean the waste of production and consumption, the term also used in the Federal Law 89-FZ "On waste of production and consumption".

By authors’ opinion, for classifying an "industrial technopark" as "eco-industrial park" the following criterial could be used:
1) availability of exchange options for material and energy resources both inside the park and with remote partners;
2) organization of the cascade system of water supply and integrated wastewater treatment of residents (tenants) of the park (and in some cases also integrated with municipal sewage of nearby settlements);

3) organization of a common system for managing the material and energy resources (through the identification of a focal point and (or) "anchor resident");

4) use of the general infrastructure of the park, including administrative, transport, waste management, energy and water supply systems.

The coordination center of the "eco-industrial park" is the administrative body, responsible for organizing network for exchange of material and energy resources within the enterprises inside the park and beyond. The anchor resident of the "eco-industrial park" is a key organization, which provides most of the material and energy flows for industrial symbiosis. It could be company from energy sector, large communal or industrial enterprise.

From authors' point of view, the key difference between the "industrial technopark" and "eco-industrial park" is the functioning of the "eco-industrial park" on the basis of the principles of industrial symbiosis, which implies:

1) reuse of by-products and (or) waste, that means exchange of product-specific materials between two or more companies to replace the use of commercial products or raw materials;

2) sharing of utilities (infrastructure facilities), that means joint use and management of such resources as energy, water, electricity and heat, as well as joint operation of water treatment facilities and gas cleaning equipment [5];

3) joint using of services, that means provision the general needs of companies for the implementation of auxiliary activities such as fire safety, transportation and others.

In addition, there is an approach that allows the authors to identify the concept of "eco-industrial park" with the notion of "industrial ecosystem", that presents the "model of the ecologically equipped industrial area" [6]. According to this, the creation of an eco-industrial park is the development and transformation of an existing industrial system into an "industrial-ecosystem" that means the integration of the industrial system and ecosystem based on the ecofriendly waste management mechanism.

Industrial system (enterprise, industrial city) is a spatially defined set of industrial entities and living organisms, united by a single environment of existence.

Ecosystem is a spatially defined set of living organisms and their habitat, united by material and energy exchange and information interaction.

Ecofriendly waste management mechanism can be defined as management of material and energy flows through information interaction between ecosystem components and the environment, ensuring self-organization and sustainable development of the ecosystem [7].

The authors’ approach, which is also used by domestic practitioners, unites all the above definitions and allows us to propose the following interpretation of the concept of "eco-industrial park" as a complex of innovative solutions, equipment, facilities unified with ultimate goal to replace in technological processes up to 100% of raw materials and energy with secondary ones.

3. Classification of Existing and Planned Eco-industrial Parks in the Cities of Russia

For systematization of eco-industrial parks, which already exist or just planned to be created in Russian cities, it’s rational to propose the following parameters within the current legal framework:

1) orientation on the type of waste;

2) sources of generation of the flows of material and energy resources;

3) availability of a key organization that generates most of the exchange flows of material and energy resources;

4) level of localization.

Depending on the orientation on the type of waste, eco-industrial parks could be:

1) oriented on utilization of the components of industrial solid waste;

2) oriented on utilization of the components of municipal solid waste;
3) oriented on joint utilization and neutralization of municipal and industrial solid waste (with possibility to involve the components of medical and biological waste).

Depending on the sources of flows of material and energy resources, eco-industrial parks could be:
1) with industrial enterprise (enterprises) as a source of material and energy resources;
2) with households as sources of material and energy resources;
3) with mixed sources of material and energy resources.

Depending on the availability of a key organization generating the most of the exchange flows of material and energy resources, eco-industrial parks could be:
1) park without an anchor resident (main participant);
2) park with anchor resident (main participant).

Depending on the level of localization, eco-industrial parks could be:
1) Federal eco-industrial parks, supervised by Union of waste processing companies; final products are made in the park from secondary materials supplied from regional eco-industrial parks (total capacity 1.5 million tons);
2) Regional eco-industrial parks, supervised by Regional Waste Management Operator; activities are aimed at minimization of waste landfillsing by selection and utilization of valuable components, neutralization of organic, medical and biological waste, and disposal only certain types of waste (the proportion of decontamination and disposal is 60-80%);
3) Corporate or municipal eco-industrial parks, primarily aimed at addressing the relevant problems of the urban community.

4. The Concept of Project Management Implementation for Eco-industrial Parks Development in the Cities of Russia

The implementation of project management for the development of eco-industrial parks in the cities of Russia assumes the formation of projects as a way to solve the problems facing the management of the eco-industrial parks. In this context, the project is a set of interrelated activities aimed at recycling or processing of certain type of waste under time and resource constraints to achieve a measurable result obtained by the project team (temporary organizational structure).

Each project is considered as an object of management, which requires planning, organization and control of the labor, financial and material resources, to achieve the project objectives in the most effective way.

Application of project management for the development of eco-industrial parks shows the most effective results as a method of organizing the operation of the park since each project is an innovative business unit. The project team achieves the results through the application of modern methods, tools and technologies. Thus, the implementation of each project is a transition to a new qualitative level.

The project team could be formed from the number of residents of eco-industrial park with possibility for inviting the external experts. The resident (tenant) of the eco-industrial parks is an enterprise that participates in industrial symbiosis and (or) uses the integrated services of the eco-industrial parks (administrative, infrastructural), an industrial enterprise that accepts water, energy and material resources as input, and produces products, water, energy and waste [8].

Therefore, residents (tenants), as well as representatives of local (regional) authorities, expert communities, industry associations, unions, research institutes and other interested parties are the possible team members. If there is an anchor resident in the eco-technical park, he can also be a part of the project team. The head of the project team could be the manager of any of the above structures. That is determined individually for each project.

The implementation of the project management for the development of eco-industrial parks assumes the presence of a project office in its structure, which is responsible for methodological and organizational support, planning and monitoring the project portfolio, implementation and development of the information system for project planning and monitoring, and the formation of consolidated project reporting. Building a well-structured framework for information exchange is an "urgent task in order to achieve further process simulation and optimization in the eco-industrial
parks” [9]. Some experts talk about big prospective for implementation of a "cyber-infrastructure system based on a virtual, hierarchical representation of an eco-industrial park, by employing ideas and technologies from Industry 4.0” [9].

A conceptual scheme for the implementation of project management for the development of eco-industrial parks is presented in Figure 1.

![Figure 1](image_url)

**Figure 1. The Concept of Project Management Implementation for Eco-industrial Parks Development in the Cities of Russia**  
*Source: compiled by authors*

Projects aimed at the solution of similar or interrelated tasks can be combined into a program, a set of projects and programs to form a portfolio of eco-industrial parks.

The introduction of project management for the development of eco-industrial parks in the cities of Russia requires the participants to have relevant competencies.

Project competencies are a type of professional competencies that form the knowledge and skills of employees of the structures included in the eco-industrial parks to implement project management in accordance with their role in the project.

The study of foreign experience in the operation of eco-industrial parks (in the cities of Denmark, Finland, Great Britain) showed that the introduction of the project approach allows achieving the following effects:
1. Increase in productivity of secondary raw materials, received within the framework of specific projects and used for energy supply of cities, on average by 17 %;
2. An increase in the number of educational projects in the field of energy efficiency and energy conservation, waste management in city schools, is average of 62 %;
3. Reduction of the cost of secondary raw materials due to optimization of labor resources, on average by 5 %;
4. Attracting bank funds in the framework of project lending, which is the most attractive for investors (the best example is the eco-industrial park Kalundborg, Denmark);
5. Increase in the number of budget subsidies, as they are allocated for specific projects.

All these effects can be obtained in Russia. In addition, the authors believe that the introduction of a project approach to the activities of eco-industrial parks can contribute to the systematization of waste management in cities required for a particular project.

5. **The Project Management Implementation Practice at the Eco-industrial Parks in the Cities of Russia**

Currently, eco-industrial parks are established only in several cities of Russia, among them Tambov, Novokuznetsk, Nizhny Novgorod, Kazan, Naberezhnye Chelny, Kurgan.

On the territory of the eco-industrial park in the city of Tambov, there is a technological complex for the processing of municipal solid waste and other types of waste based on the technology of thermolysis. This technological complex allows accomplishing the following tasks:
1) deep degree of utilization (up to 90 %);
2) insignificant (in comparison with the economic and ecological effect) tariff growth for the population of the city where the eco-industrial park is located;
3) extension of the service life of the existing landfills (up to 3–4 times);
4) reduction the size of the sites planned for organizing new landfills.

Technology of thermolysis allows to receive in Eco-industrial Park Tambov several types of by-products:
1) synthetic black oil fraction – mass output of 8 %, is used as a component of liquid heating fuel for municipal needs of the city;
2) artificial coal – mass output of about 30 %, demanded as a fuel in ferrous metallurgy, power generation, production of automobile tires, and as RDF for cement plants;
3) fuel synthesis gas – mass output up to 20 %, is used for own needs of eco-industrial park as a secondary fuel.

The use for the needs of the city of artificial oil and coal instead of raw ones allows to stay almost with the same tariff (slight increase from 35.42 rubles a month per person to 43.75 rubles in 2018 using the claimed technology).

Eco-industrial park with specific processing of industrial waste is created in Novokuznetsk, the structure of waste generated in the city is shown in Figure 2.

![Figure 2. Structure of waste generated in Novokuznetsk](image)

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**Figure 2. Structure of waste generated in Novokuznetsk**

*Source:* compiled by authors

The reasons for creating of eco-industrial park in the city of Novokuznetsk are the following:
1) availability of facilities with intensive waste generation, such as mining and metallurgy, thermal power engineering (the metallurgical plant of JSC "EVRAZ ZSMK", the OAF JSC "EVRAZ Ruda", the aluminum plant of OAO "RUSAL Novokuznetsk", the ferroalloy plant of OAO "Kuznetsk Ferroalloys", 4 coal preparation plants, 3 thermal power plants and over 100 coal-fired boiler houses;
2) significant resource base of accumulated industrial waste, up to 500 million tons;
3) operating waste processing plants, development of processing of accumulated industrial waste;
4) self-organization of waste-processing enterprises in the Kuzbass Association of Waste Recyclers, that is real support for the waste processing enterprises;
5) waste recycling is one of the strategic goals for the further development of the urban economy, it is included in the Strategy of Social and Economic Development of the Novokuznetsk Municipal District by 2035;
6) availability of a developed industrial and transport infrastructure, production sites with communication support in the city;
7) modern landfill for municipal solid waste with a mechanical sorting capacity of 200 thousand tons per year;
8) availability of metallurgical enterprises as potential consumers of industrial waste and by-products as materials;
9) machine-building base for the production of equipment for the waste-processing industry;
10) scientific school developing new technologies in the field of waste processing, and so on [6].

The organizational structure of the Eco-industrial Park "Novokuznetsk" and interaction with external stakeholders are presented in Figure 3.

**Figure 3.** Organizational structure of Eco-industrial Park "Novokuznetsk"

*Source:* compiled by authors

Administration of the Kemerovo Region is involved in organization of waste supply process for the eco-technical park. Universities in the region is involved in personnel training and consulting the project team. The certification center conducts tests, certification at the request of the eco-industrial park.

In the Eco-industrial Park "Novokuznetsk" experience of project management was obtained in the framework of the projects presented in Table 1.

In the eco-industrial park of Nizhny Novgorod the importance of the project approach is evaluated, which confirms the implementation of the projects presented in Table 2.

The regional eco-industrial park in the city of Volzhsky is under the opening process. The start of operation is planned for the first half of 2018. This park also implements project management principles, and at this stage, already united:
1) the largest waste processing complex in the Southern Federal District with a capacity of up to 450 thousand tons waste per year;
2) modern landfill for municipal solid waste with a capacity of up to 2.5 million cubic meters per year;
3) facility for utilization of construction and demolishing waste with a capacity of more than 100 thousand tons per year;
4) facility for neutralization of medical, biological and other types of waste with the capacity of more than 12 thousand tons per year.

**Table 1. Projects, completed in the framework of Eco-industrial Park "Novokuznetsk"**

| Name of the Project                                  | Capacity, thousand tons per year | Investments, millions of RUR | By-Product                          |
|------------------------------------------------------|----------------------------------|-----------------------------|-------------------------------------|
| Recycling of waste refractories                      | waste sorting: more than 130     | More than 30                | –                                   |
|                                                      | waste recycling: 180             |                             |                                     |
|                                                      | production of by-products: 120   |                             |                                     |
| Recycling of waste coke                              | 25                               | 60 (2006–2015)              | Sleeper impregnated oil             |
| production located in the "resin" lake               |                                  | 97 (2016–2018)              |                                     |
| Processing of steelmaking slags of metallurgical     | More than 100                    | More than 160               | Man-made iron concentrate, crushed  |
| enterprises                                          |                                  |                             | stone                               |
| Creation of waste processing                         | 162                              | More than 600               | Fuel, fuel additives and coal       |
| complex for coke and chemical                        |                                  |                             | sorbents                            |
| and coal-enrichment industries                       |                                  |                             |                                     |
| Processing of ash and slag wastes                    | 15                               | 48                          | Facade and fireproof protective     |
| (aluminosilicate gold mine)                          |                                  |                             | paint                               |

*Source: compiled by authors*

**Table 2. Projects planned for implementation in Nizhny Novgorod eco-industrial park**

| Name of the Project                                  | Recycled waste, thousand tons per year | Investments, millions of RUR | Completion of the project, year |
|------------------------------------------------------|---------------------------------------|-----------------------------|---------------------------------|
| Utilization of waste from galvanic and               | 300                                   | 800                         | 2021                            |
| metallurgical industries                             |                                       |                             |                                 |
| Utilization of industrial rubber waste               | 1                                     | 55                          | 2019                            |
| Recycling of polymer waste                           | 2.1                                   | 77                          | 2020                            |

*Source: compiled by authors*

At the stage of primary operation or creation at present there are 10 similar eco-industrial parks: 6 in the Vologda region; 2 in the Rostov region; one of each in the Astrakhan Region and the Republic of Kalmykia.

**6. Conclusion**

Eco-industrial parks play an important role in circular economy, which is recognized as the most recourse and energy efficient type of economy [10]. Currently, the development of eco-industrial park in Russia is at the stage of formation, the following results can be attributed to the expected results of their functioning in the cities:

1) Improvement of the environmental situation;
2) Increase in the share of recycled waste and demanded by-products;
3) Containment of tariffs for waste processing and energy generation for city residents;
4) Growth of the number of jobs for qualified specialists;
5) Increase in the revenue of the city budget.

To increase the manageability and efficiency of eco-industrial parks, it is necessary to include project management principles in their operation process. The positive experience is already obtained in the eco-industrial parks of Novokuznetsk and Tambov. At the same time, the expansion of project management to eco-industrial parks may face a number of difficulties, such as the lack of project
competencies among potential project participants and primarily employees of resident organizations of eco-technical parks.

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