Increasing the Waste Management Efficiency in the Arctic Zone of Russia through the Projects of Eco-Industrial Parks’ Development

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Abstract. The relevance of the study is due to the waste management and environmental safety issues at the territory of the Arctic zone of Russia. Some of these problems could be solved in the process of creating and operating of eco-industrial parks on the basis of a project approach. The purpose of the article is to systematize the ideas on the possibilities of applying project management for the development of eco-industrial parks in the Arctic zone of Russia. The article clarifies the concept of ”eco-industrial park” in the framework of relevant Russian legislation and practice. The classification of eco-industrial parks has been developed taking into account different characteristics, including content of main waste flow and type of processing technology. The main challenges for the implementation of the project approach on the territory of the Arctic zone of Russia are indicated. The results of the research are of practical importance for public authorities, the governing body and residents of eco-industrial parks, specialists in the field of waste management, scientists studying the environmental and economic aspects of the Arctic zone of Russia.

1. Introduction

At present, at the territory of the Arctic zone, one of the most important areas of sustainable development is the provision of effective waste management. Preservation of unique Arctic ecosystems and elimination of accumulated pollution in the Arctic regions are the key tasks of state policy and fulfillment of Russia's international obligations [1,2].

The Arctic coast of Russia from Murmansk to Pevek and many islands of the Arctic zone of the Russian Federation are littered with piles of metal debris, including rusted ships and machinery, cars, containers, endless deposits of two-hundred barrels and huge tanks for oil products. According to some estimates, in the coastal zone of the Arctic Ocean there are up to 4 million tons of industrial and construction debris, as well as from 4 to 12 million iron barrels.

Enlarged, in the regions of the Arctic zone, there are five main environmental problems:

- the negative consequences and threats of the ongoing global climate change;
- land degradation and violation of land using conditions;
- change of biological diversity and reduction of bio resources reserves;
deterioration of the habitat of the indigenous population of the Arctic regions of Russia and the conditions of their traditional nature using.

The most significant accumulation of pollutants and violations of Arctic natural landscapes occurred in the 1930s and 1980s, when intensive industrialization and extensive extraction of natural resources in the regions of the North of Russia was underway. By the end of that time frame, about 70% of enterprises of the industry of extraction and processing of natural resources contributed to the formation of a significant amount of solid, liquid and gaseous waste [3].

Sources of pollution in the regions of the Arctic zone of Russia are presented in Table 1.

Table 1. Main industries contributing to pollutions in the regions of the Arctic zone of Russia.

| Region | Industry/Object |
|--------|----------------|
| Kola   | Non-ferrous metallurgy, mining industry, nuclear power plant (NPP), thermal power plants (TPP), objects of radioactive waste generation |
| Severodvinsk (Archangelsk Region) Islands of the Arctic zone of Russia | Pulp-and-paper industry, military facilities, thermal power plants (TPP), objects of radioactive waste generation |
| Novozemelsky | Military facilities, scientific stations and hydro-meteorological services |
| Novozemelsky | Military facilities, flooding of nuclear installations and other radioactive waste in the Kara Sea |
| Timano-Pechora | Extraction and transportation of hydrocarbons |
| Vorkuta | Mining industry, thermal power plants (TPP) |
| Norilsk | Mining and metallurgical industry |
| Yano-Indigirsky | Mining industry |
| Chukchi | Mining industry, nuclear power plant (NPP), thermal power plants (TPP), objects of radioactive waste generation |

Source: compiled by authors based on [3]

For example, on Belyi Island there are 42 sources of pollution. The largest source of waste is building timber, including demolition residues (99%). The other sources include barrels (1%), scrap and waste of ferrous metals (0.1%), household waste (less than 0.1%), lead batteries (less than 0.1%), construction and demolition waste (less than 0.1%), etc.

Solving these problems requires the following measures:

- implementation of new technologies, including technologies for cleaning the territory of islands, coastal zones and water areas of the Arctic seas from anthropogenic pollution;
- conducting scientific research on the assessment of nomenclature and quantitative characteristics of negative impacts (risks) on the environment throughout the Arctic;
- conducting predictive assessments of the types and volumes of hazardous wastes generation, emissions of harmful substances;
- creation of technology for collection and processing of accumulated hazardous wastes taking into account climatic conditions. [3]

The institutional environment for the implementation of these measures can be created through special clusters, or Arctic eco-industrial parks. The best foreign practices of eco-industrial parks have been created in Denmark, Austria, Finland, Great Britain, China, and Sweden. Their functioning showed that 100% of the waste could be gained 25% of certified fuel for the production of electricity and heat, 5% of secondary material resources, 40% of compost and man-made soil, and only 20% is a residue that can be sent in compressed form to landfills [4].
The problem of energy supply is relevant for the Arctic zone of Russia. The Arctic regions are characterized by high energy intensity and low efficiency of natural resource extraction, costs of northern production in the absence of effective compensation mechanisms, low labor productivity, and underdevelopment of the energy system, as well as irrational structure of generating capacities, high production costs of generation and transportation of electricity. A high level of economically justified tariff for the production of electric energy is 600-2000 rubles per kW per hour.

Undoubtedly, the Arctic regions have special climate challenges. Even under not favourable climate conditions, the first experience of creating an eco-industrial park has already been obtained in the Murmansk region. The mechanism of functioning of this park could be improved within the framework of the project approach.

At the same time, increase in the number of eco-industrial parks on the territory of the Arctic zone of Russia could be gained through implementation of related projects.

So it’s equally important to use project approach for creation and development of eco-industrial parks, but both aspects remain practically unexplored in the scientific literature and will be presented in this study.

2. The concept and classification of eco-industrial parks

In the world practice, the term "eco-industrial park" means the group of industrial enterprises increasing the efficiency of using natural resources through cooperation and interaction based on a systematic approach.

The purpose of creating eco-industrial parks is to achieve economic, environmental and social benefits while reducing the consumption of primary material and energy resources, involving secondary resources in the production turnover, reducing the level of environmental impact of existing industrial facilities and eliminating the accumulated environmental damage [5].

The presence of an industrial component in the definition of the concept of "eco-industrial park" does not allow it to be identified with the concept of "industrial techno park", which, of course, is broader.

Criteria for classifying an industrial techno park as an eco-industrial park are following:

- availability of exchange of material and energy resources both within the park and with remote partners;
- organization of a cascade system of water supply and integrated wastewater treatment in the eco-industrial park with possible involvement of municipal wastewater from closely located settlements;
- organization of a common system for managing the material and energy resources of the eco-industrial park (through the identification of a focal point and (or) "anchor tenant");
- use of the general infrastructure of the park, including administrative, transport, energy and water supply systems, waste management of the eco-industrial park.

The coordinating centre of the eco-industrial park is the governing body of the eco-industrial park with functions of searching and developing the opportunities for implementation of network exchanges of material and energy resources between the enterprises within the eco-industrial park and beyond. The approximate organizational structure of the eco-industrial park is shown in Figure 1.
Anchor resident of the eco-industrial park is the key organization in the eco-industrial park, which provides most of the material and energy flows for industrial symbiosis:

- a physical anchor tenant (for example, an energy company, a large industrial enterprise);
- an institutional anchor tenant (for example, a scientific and technical university).

By the authors’ opinion, the key difference between the techno park and the eco-industrial park (EIP) is the functioning of the EIP on the basis of the principles of industrial symbiosis, which implies:

- reuse of by-products and (or) waste;
- exchange of product-specific materials between two or more companies to replace the use of commercial products or raw materials);
- joint use of public services (infrastructure facilities) and joint management of such resources as energy, water, electricity and heat, as well as joint operation of water treatment facilities and gas cleaning equipment;
- joint provision of services, satisfying 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 us to identify the concept of "eco-industrial park" with the notion of "techno-ecosystem". According to it, the creation of an eco-industrial park is the development and transformation of an existing industrial technological system into a techno-ecosystem. That means the integration of the technosystem and ecosystem based on the ecosystem waste management mechanism.

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Fig. 1. Organizational structure of Eco-industrial Park. Source: compiled by authors.
Technosystem (enterprise, city) is a spatially defined set of production components and living organisms, united by a single environment of existence.

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

Ecosystem waste management is the management of material and energy flows through information interaction between ecosystem components and the environment, ensuring self-organization and sustainable development of the ecosystem [6].

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”. It is a complex of technological solutions, equipment, facilities that provide a unified technological process with ultimate goal is manufacturing goods from recycled materials.

In order to systematize the idea of potential eco-industrial parks that at the territory of Russia within the framework of the current legislation, the classification can be proposed with the following criteria:

- orientation to the type of waste;
- sources of formation of flows of material and energy resources;
- availability of a key organization that generates most of the flows of material and energy resources;
- level of localization.

Depending on the orientation of the type of waste EIP can be:
1. oriented on utilization and processing of solid municipal waste components;
2. oriented on mixed utilization, neutralization and processing of municipal solid waste, industrial, medical and biological waste.

Depending on the sources of material and energy resources, eco-industrial parks can be divided into:
1. EIP with the flows of material and energy resources focused on solid municipal waste;
2. EIP with the flows of material and energy resources focused on industrial waste and by-products;
3. EIP of combined type.

Depending on the availability of a key organization that generates most of the flows of material and energy resources, eco-industrial parks can be divided into:
1. EIP without anchor resident;
2. EIP with an anchor resident.

Depending on the level of localization, eco-industrial parks can be divided into:
1. Federal EIP focused on the production of final products from secondary raw materials, supplied from regional eco-industrial parks with a total capacity of at least 1.5 million tons.
2. Regional EIP focused on minimization of waste disposal by maximizing the selection of useful fractions, disposing of certain types of waste and neutralizing organic, medical, biological and other waste depending on the specifics of the subject (the proportion of decontamination and disposal is 60-80%). It is a union of operators for processing, disposal, neutralization, disposal of waste., and also an area of activity of the regional operator.
3. Corporate or urban EIP, primarily focused on addressing the relevant problems of the urban community.

3. Increasing waste management efficiency through the implementation of the project approach for the development of eco-industrial parks in the Arctic zone of Russia

As it was noted in the introduction, use of the project approach for the development of eco-industrial parks in the Arctic zone of Russia has prospective both at the stages of EIP creation and EIP functioning improvement (Figure 2).
Figure 2. Directions for the implementation of the project approach for increasing environmental safety through the development of eco-industrial parks in the Arctic zone of Russia. Source: compiled by authors.

The creation of eco-industrial parks on the territory of the Arctic zone of Russia can be implemented within the framework of projects of public-private partnership, concession projects, special investment contracts.

Thus, the total volume of investments in the sphere of functioning of eco-industrial parks is 12%, taking into account the need to provide a logistical relationship between the objects of the park at the level of 20%.

At the same time, only a few concession agreements with regional authorities have been concluded in the Arctic zone of Russia, and the territory of implementation of these agreements is limited by Murmansk and Arkhangelsk regions.

Murmansk region has the most favorable investment climate, and the best practice of applying the project approach for the development of the region's infrastructure. Only in 2017, the region's authorities concluded 4 concession agreements and 1 special investment contract. By now, there are 16 agreements and contracts in the region with 107 billion rubles of total investments and 18,000 of new jobs created.

The project for development of eco-industrial park in the Murmansk region involves the territory of Murmansk city, municipalities of Severomorsk, Aleksandrovsk, Vidyayevo, Zaozersk, and Kola and Pechenga districts. The Government of the Murmansk region, as the concessionaire, provides the facilities created for the project to JSC "Waste Management" for 40 years.

The project includes formation by the end of 2018 a landfill with capacity of 250 thousand tons per year, waste sorting complex with capacity of 180 thousand tons per year, and waste processing stations with total capacity of 70 thousand tons per year. By now, in the framework of the project, 1.86 billion rubles were invested in solving environmental problems in the region.

As a result of the project, it is planned to close 5 landfills, launch a mandatory waste treatment system, including stages from collection to processing and disposal, and monitoring of illegal disposal of solid waste.

The facilities in the framework of the project are fully comply with the requirements of the Russian legislation in the field of environmental protection and ensure minimal impact on the ecosystem of the Murmansk region. The project uses Russian technologies and equipment that take into account the severe climatic characteristics of the Murmansk region.

To calculate the environmental and economic efficiency of project’s implementation, the following formula can be used within the framework of the mentioned mechanisms:

$$BE = \sum_{i=1}^{t} \left( \frac{D'_k + D'_p - RB}{(1 + Sr)^{t-i}} \right)$$

where $D_k$ – expected revenues of the regional budget of the Arctic zone of Russia from the functioning of the eco-industrial park for each year of the calculation period, thousand rubles;
$Dp$ – savings of the budget of the region of the Arctic zone of Russia from the functioning of the eco-industrial park for each year of the calculation period, thousand rubles;

$RB$ – expenditures of the budget of the region of the Arctic zone of Russia from the functioning of the eco-industrial park for each year of the calculation period, thousand rubles;

$Sr$ – relevant rate of refinancing established by the Central Bank of the Russian Federation;

$t$ – the estimated period for the budgetary effect, from $t_{min} = 1$ year till $t_{max} = \text{planned period of operation and maintenance of the eco-industrial park within the framework of a specific project implemented in the Arctic region of Russia.}$

Project of creation or development of eco-industrial park at the territory of the Arctic zone of Russia could be considered effective if the result of calculation of the budgetary efficiency is equal or more than 1.

In this context, the project is a set of interrelated activities aimed at recycling or processing a certain type of waste under time and resource constraints to obtain a measurable result 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 logistical resources, used to effectively achieve the project objectives [8].

The use of project management for the development of eco-industrial parks is seen as the most effective way of organizing the EIP activities since each project is an innovative business unit [9, 10]. The project team achieves the results through the application of modern methods, instruments and technologies. Thus, the implementation of each project is a transition to a new qualitative level of EIP development.

The project team is formed from the number of participants of the eco-industrial park. EIP participants are residents (tenants), as well as representatives of local (regional) authorities, expert communities, industry associations, unions, research institutes and other interested parties.

A resident (tenant) of an eco-industrial park is an enterprise involved in industrial symbiosis and (or) using the integrated services of an eco-industrial park (administrative, logistic, etc. infrastructure). If there is an anchor resident in the eco-industrial park, it’s of a great use to include the manager of this enterprise into the project team. The head of the project team could be the manager of an anchor resident or any other resident (enterprise). For each project it’s determined individually.

The implementation of the project approach for the development of eco-industrial parks presupposes the presence of a project office in EIP structure, as a unit responsible for methodological and organizational support of project management in the eco-industrial park, planning and monitoring the project portfolio, implementation and development of the information system for collection, accumulation of the data and reporting on projects.

The implementation of the project management for EIP development is presented in Figure 3.

![Figure 3. The Concept of Project Management Implementation for Eco-industrial Parks Development. Source: compiled by authors.](image-url)
Projects focused on solving of similar or interrelated tasks can be combined into a program, a set of projects and form the portfolio of the eco-industrial park.

4. Challenges of the implementation of the project approach to increasing environmental safety in the Arctic zone of Russia based on eco-industrial parks

The main challenges for the implementation of the project approach for the development of eco-industrial parks on the territory of the Arctic zone of Russia are the following (Table 2):

1. Severe climate conditions;
2. Demographic features;
3. Overpriced resources, lack of supply of resources;
4. Remoteness from the main production and distribution markets;
5. Lack of institutional environment in the regions for the implementation of projects for the EIP creation.

Table 2. The main challenges of the implementation of the project approach to increasing environmental safety in the Arctic zone of Russia.

| Challenge                                                                 | Description                                                                 | Methods of overcoming                                                                 |
|---------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Severe climate conditions affecting the requirements for projects and increasing the amount of investments | Low temperatures<br>Large amount of precipitation, especially snow<br>Short construction season<br>Difficulties in selecting a land plot for a landfill that complies with legislation | State co-financing of capital-intensive projects and using of special funds<br>Legislative support for the using waste as secondary material and energy resources|
| Geography affecting the accessibility of project sites                    | High percentage of island territories<br>Large distances between settlements<br>Vast uninhabited territories | Tax privileges and preferences for state procurement for enterprises using secondary material and energy resources (VAT, property tax)<br>Implementation of green tariffs for transporting waste to disposal sites |
| Conditions of scarcity and overpricing on resources affecting the accessibility of materials and labour | Decreasing population<br>Lack of qualified personnel<br>High investment and operating costs<br>Higher prices for fuels, payroll, additional social benefits | |
| Remoteness from the main production and distribution markets              | Limited access to markets for by-products<br>High transport leverage and unprofitable high rates for waste processing | |
| Lack of institutional environment in the regions for the implementation of projects for the creation of eco-industrial parks | The authorized body in the sphere of PPP, concessions and special investment contracts is not defined<br>The specialized information resource in the sphere of PPP, concessions and special investment contracts has not been created | Expanding the institutional environment established in the Murmansk region to all Arctic zone of Russia<br>Recruiting external specialists<br>Training under supplementary education programs |
| Qualification requirements for participants in the implementation of the project approach | Lack of specialists with project competencies (the type of professional competencies that allow to implement project management in accordance with the role in the project) | |

Source: compiled by authors based on [11]
5. Conclusions
Currently, the development of eco-industrial parks in the Arctic regions of Russia is at the stage of formation. The expected results of their functioning include the following:

- improving environmental situation;
- increasing share of recycled waste and using by-products;
- growing number of jobs for qualified specialists;
- increasing revenue side of the budgets of the Arctic regions.

To improve the manageability and efficiency of the eco-industrial parks, their functioning can be advanced within the framework of the project approach. The positive experience of implementation of this concept was obtained in the eco-industrial park of the Murmansk region.

At the same time, the distribution of this type of management under study to eco-industrial parks may face a number of difficulties, including climate and location challenges, absence of project competencies among potential project participants (regional authorities and EIP residents’ employees).

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