

Features, Opportunities and Problems of Decarbonization of the Russian Arctic

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Abstract. The relevance of the study is determined by the fact that climate mitigation and increased interest in the development of the Arctic, accompanied by state support, gives impetus to the development of new industrial projects, social and industrial infrastructure. As a result of the increased anthropogenic impact, there has been a trend towards an increase in greenhouse gas emissions and disruption of the fragile ecological balance of the Arctic territories. It was revealed that carbon pollution in the Arctic has its own characteristics associated with natural and anthropogenic causes. The low ability of Arctic ecosystems to absorb greenhouse gases, on the one hand, and the need to reduce the cost of production of Arctic enterprises in the current conditions, on the other hand, predetermined the need for CO₂ sequestration in the Arctic zone of the Russian Federation. It is substantiated that the current deterrents for the decarbonization of the Arctic are geopolitical risks and sanctions pressure from unfriendly countries.

1 Introduction

The Arctic is a territory to which the attention of many countries of the world is riveted. Being historically little developed, the territory of the Russian Arctic experienced an insignificant anthropogenic load and developed steadily, ensuring a balance between the Arctic ecosystems, the livelihoods of the local population, and insignificant social and industrial infrastructure. These remote territories began to develop at an accelerated pace due to the special state attention to the Russian Arctic. The Arctic zone of the Russian Federation was created as a special object of management, a set of territorial development programs has been developed and is being successfully implemented. A positive development factor was also the mitigation of the Arctic climate, which was caused, on the one hand, by the accumulation of greenhouse gases in the atmosphere, largely produced by anthropogenic activities, and, on the other hand, by natural cyclical processes of temperature fluctuations. Together, these factors have marked a trend towards the development of industry in the Arctic and an increase in greenhouse gas emissions into the atmosphere. The current situation actualizes the research topic.

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The purpose of the work is to evaluate new opportunities and identify new risks for the sustainable development of the Russian Arctic.

To achieve this goal, it is necessary to solve a number of interrelated tasks:

- identify the features of carbon pollution in the Arctic;
- determine the dynamics of carbon dioxide and methane emissions in the Russian Arctic;
- assess the opportunities and challenges of the Arctic zone of the Russian Federation as a carbon neutral territory.

2 Research Methodology

The methodology of the presented study is based on a critical analysis and generalization of studies, including the author's, in the field of studying decarbonization processes in the Arctic. In the process of research, the following main methods of economic research were used: formalization, systemic and comparative analysis, expert research method, induction, deduction. It is based on a dialectical approach and system analysis, which made it possible to comprehensively solve the set scientific problems.

The information base of the study was the data presented in the state report "On the state and protection of the environment of the Russian Federation in 2021", materials of the Arctic Research Center and Observatory in Barrow, USA, statistical information of the State Statistics Committee of Russia on the socio-economic development of the Arctic zone of the Russian Federation. The use of verified data from official sources determines the credibility of the study results.

The dynamics of carbon dioxide and methane emissions was determined on the basis of data from meteorological stations located in the settlements of Teriberka and Tiksi. At these stations, located on the territory of the Russian Arctic in conditions close to natural, regular monitoring of the content of greenhouse gases in the atmospheric air is organized.

Materials for the period from 2012 to 2021 were involved in the study. This time period was chosen due to the fact that it includes several most important periods for the Russian economy: the crisis in 2014 and a gradual recovery from it in 2015-2016; the period of economic stagnation due to the coronavirus pandemic, which peaked in 2020, as well as the years before and after this stagnation. This approach to the study period makes it possible to assess the impact of external challenges, socio-economic and geopolitical factors on the trends in greenhouse gas emissions.

3 Results and Discussions

An analysis of numerous scientific papers, as well as the authors' own research, revealed the following factors that determine the characteristics of carbon pollution in the Arctic:

- special natural and climatic conditions due to lack of oxygen and solar heat due to high latitudes; long snowy and low-temperature winter; permafrost; ice sheet on land and in the Arctic seas [1, 2];
- slow biological and chemical-biological processes, which reduces the ability of ecosystems to self-purify and makes them particularly vulnerable to anthropogenic impact [3, 4];
- short vegetation period of plants and insufficient ability of vegetation to absorb carbon dioxide [5];
- the economy of the territories, aimed primarily at the extraction of natural resources using technologies that allow the emission of greenhouse gases [6-9];

- poorly developed system of cities and rural settlements, which does not have a significant impact on carbon pollution [10-12];
- special attention of the state administration to ensuring the decarbonization of industrial projects [13-15];
- close international cooperation to ensure environmental safety and reduce greenhouse gas emissions [16, 17].

Since these characteristics have almost all territories of the Arctic, both belonging to Russia and under the jurisdiction of other Arctic countries, they can be considered basic. Basic characteristics determine the features of carbon pollution in the Arctic.

As our studies have shown, the largest Russian corporations with production assets in the Arctic are actively modernizing equipment and developing technologies that reduce the flow of pollutants into natural areas, including the emission of greenhouse gases into the atmosphere [9, 13, 18]. As a result, for the period 2017-2019, there is a reduction in emissions of atmospheric pollutants - from 3356.5 thousand tons to 3284.6 thousand tons, wastewater discharge - from 638 million m³ to 619 million m³, waste recycling is expanding - from 18.7 million tons to 35.5 million tons [19].

Despite the crisis that has gripped industrial production around the world in the past few years, enterprises are not solving the problem of reducing their carbon footprint. The decarbonization of production, the main criterion of which is the reduction of greenhouse gas emissions, is no longer an accompanying task, but one of the main development goals. A special place is occupied by the social effects and social significance of decarbonization projects. Greenhouse gas sequestration is part of the project to ensure sustainable development for the benefit of future generations, which has become the humanitarian basis of the modern globalized society [8, 17, 20].

In the Russian Arctic, at three stations located in the settlements of Teriberka, Tiksi and Novy Port, regular monitoring of the content of greenhouse gases in the atmospheric air is organized [21]. Of particular interest are the results of observations at Teriberka and Tiksi stations, since they are in conditions close to natural (Table 1).

Table 1. Concentrations of carbon dioxide and methane in the Russian Arctic

Year	Teriberka				Tiksi			
	CH ₄ , billion ⁻¹	ΔCH ₄ , billion ⁻¹	CO ₂ , billion ⁻¹	ΔCO ₂ , billion ⁻¹	CH ₄ , billion ⁻¹	ΔCH ₄ , billion ⁻¹	CO ₂ , billion ⁻¹	ΔCO ₂ , billion ⁻¹
2012	1910,2	4,0	396,6	2,3	1910,2	-3,0	396,1	1,9
2013	1907,8	-2,4	398,8	2,2	1915,1	4,9	399,1	3,0
2014	1913,5	5,7	400,7	1,9	1930,8	15,7	400,7	1,6
2015	1924,4	10,9	402,2	1,5	1940,1	9,3	403,2	2,5
2016	1946,7	22,3	405,7	3,4	1946,4	6,3	406,1	2,9
2017	1947,1	0,4	409,1	3,5	1956,7	10,3	408,7	2,6
2018	1950,4	3,3	411,4	2,2	1960,4	3,7	411,3	2,6
2019	1961,8	11,4	414,1	2,7	1983,7	23,3	414,3	3,0
2020	1980,4	18,6	415,8	1,8	1993,6	9,9	416,5	2,2
2021	1999,1	18,7	418,5	2,6	2014,1	20,5	419,1	2,6

A study over a ten-year period from 2012 to 2021 showed an almost constant increase in carbon dioxide and methane concentrations. Over ten years, CO₂ concentration increased by 6%, reaching a maximum (418.5 ppm in Teriberka and 419.1 ppm in Tiksi) in 2021; CH₄ concentration increased by 5%, also peaking (1999.1 ppb in Teriberka and 2014.1 ppb in Tiksi) in 2021. Such values are close to the data of the Barrow Arctic Research Center in Alaska [22].

The strengthening of economic activity after the 2014 crisis and the growth of industrial production, which began in 2015 and strengthened in 2016, led to an increase in carbon dioxide and methane emissions.

In 2020, the growth rate of CO₂ concentration decreased to 1.8-2.2 ppm per year. The likely reason for this was the reduction in production caused by the COVID-19 pandemic. In 2021, greenhouse gas emissions increased again, with an increase of 2.6 million-1 per year. In the same year, there was a significant increase in the concentration of CH₄ in the atmosphere (18.7 ppm in Teriberka and 20.5 ppm in Tiksi).

Thus, it is obvious that the emission of carbon dioxide and methane depends on the intensity of economic activity, which, in turn, is largely determined by foreign policy and socio-economic conditions.

The energy crisis in the circumpolar or subarctic countries, caused by a reduction in the consumption of energy resources from Russia due to political and economic reasons, leads to an increase in the share of coal, fuel oil, and wood among energy sources. The use of such energy resources leads to an increase in greenhouse gases and a weakening of the policy of decarbonization of production [23-25].

Extremely negative consequences for the decarbonization of the Arctic on a global scale is the suspension of the activities of the Arctic Council, as well as other cooperation between the circumpolar countries and the Russian Federation on the development of joint programs for limiting greenhouse gas emissions, environmental protection, and rational use of natural resources.

Obviously, the possibilities of achieving carbon neutrality in the regions of Russia differ significantly. The smallest opportunities are in the old industrial regions, the main production assets of which were formed at a time when greenhouse gas sequestration was not even thought of [9, 16, 17]. Moreover, this situation is typical not only for Russia, but also for most industrialized countries [6, 23, 24]. The best opportunities are in territories where there are no large industrial clusters. Such characteristics are met, for example, by Sakhalin, on whose territory a comprehensive project is being implemented to achieve carbon neutrality by the end of 2025.

We defend the position that the Arctic zone of the Russian Federation has all the opportunities to achieve carbon neutrality. Compared to Sakhalin, the Arctic is incomparably more important for the Russian economy. Arctic minerals and bioresources are in great demand [1, 5, 13]. At the same time, northern ecosystems are extremely vulnerable. As noted, the absorptive capacity of the sparse northern vegetation is insignificant, and biochemical processes are slowed down due to low temperatures.

Commitments to sequester CO₂ emissions up to full carbon neutrality, which the Russian Federation has assumed, will to some extent reduce the impact of negative factors of anthropogenic pollution on the Arctic ecosystems, but at the same time, the production potential for the development of the Arctic will be constrained. However, projects to ensure carbon neutrality can provide a significant economic effect associated with a reduction in the cost of production due to the conservation of energy resources, which are extremely expensive in harsh Arctic conditions. In addition, the sequestration of greenhouse gases will lead to a reduction in the cross-border carbon tax, which will increase the profits of Russian corporations in the Arctic territories. Thus, the Arctic zone of the Russian Federation, like no other territory, needs carbon neutrality.

Opportunities for the Arctic to become a carbon neutral territory are associated with the small population of the Arctic, the local location of stationary sources of pollutants - industrial enterprises and large settlements, experience in implementing decarbonization projects, sustained interest and financial support from the state and large businesses.

For the Russian Arctic, the idea of carbon neutrality has been embodied in a mechanism that comprehensively combines the following factors:

- Technological: Use of the most accessible technologies for decarbonization of production;

- Economic: Ensuring the growth of the main financial and production indicators of decarbonization projects;
- Environmental: Rational use of natural resources and minimization of greenhouse gas emissions.

These factors for ensuring carbon neutrality complement each other in a complex way. As a result, a synergistic effect is formed that enhances the influence of each individual factor on the achievement of the overall result. The synergistic effect of decarbonization opens up new opportunities for enterprises in the Russian Arctic to develop and simultaneously achieve multidirectional goals.

The following main stages of ensuring the carbon neutrality of the Russian Arctic can be distinguished:

- firstly, the formation by the authorities of the concept of ensuring carbon neutrality, which consists in the adoption of a unified strategy; defining goals and objectives; motivation of industrial, transport and other enterprises engaged in economic and economic, including export, activities;
- secondly, the development of specific projects and programs to ensure carbon neutrality for nine support zones for the development of the Russian Arctic, including specific stages, deadlines, amounts of funding, etc.;
- thirdly, providing projects with the necessary financial, labor, material, technical, and information resources;
- Fourthly, the transformation of production and business processes by using the most available technologies in order to decarbonize production and reduce greenhouse gas emissions.

The deterrent factors for the decarbonization of the Arctic are currently geopolitical risks. Under the sanctions imposed against Russia by unfriendly countries, large-scale carbon-neutral development projects in the Arctic are becoming more difficult and expensive: many foreign technologies, equipment, and transport routes are becoming less accessible or not available at all. Decision-making processes for greenhouse gas sequestration take place in an environment of uncertainty, which increases with the emergence of new challenges.

4 Conclusions

The study allows us to draw the following conclusions:

1. Climate mitigation and increased interest in the development of the Arctic, accompanied by state support, gives impetus to the development of new industrial projects, social and industrial infrastructure. The increased anthropogenic impact has marked a trend towards disruption of the fragile ecological balance of the Arctic territories and an increase in greenhouse gas emissions. The low ability of Arctic ecosystems to absorb greenhouse gases, on the one hand, and the need to reduce the cost of production of Arctic enterprises in the current conditions, on the other hand, predetermined the need for CO₂ sequestration in the Arctic zone of the Russian Federation. For the Russian Arctic, the idea of carbon neutrality has become a mechanism that comprehensively combines technological, economic and environmental factors.

2. The study showed that the emission of carbon dioxide and methane from the territories of the Russian Arctic depends on the intensity of economic activity, which, in turn, is largely determined by foreign policy and socio-economic conditions. Despite the crisis that has gripped industrial production around the world in the past few years, enterprises are not solving the problem of reducing their carbon footprint. The decarbonization of production, the main criterion of which is the reduction of greenhouse gas emissions, is no longer an accompanying task, but one of the main development goals.

3. Sanctions against the Russian Federation may lead to an increase in CO₂ emissions into the atmosphere. Geopolitical risks and sanctions pressure from unfriendly countries are currently limiting factors for the decarbonization of the Arctic. The situation is complicated by the breakdown of partnerships in the field of rational nature management and environmental protection between Russia and other circumpolar countries. greenhouse gas changes all this leads to a weakening of the policy of decarbonization of production on a global scale.

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