Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5, 1186-1195
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i5.7096

Energy and infrastructural development of the arctic regions of the Russian federation

Alexander Alexandrovich Nikiforov[1*], Vera Dmitrievna Nikiforova[2], Zhanna Aleksandrovna Aksenova[3], Dmitriy Rodionov[4], Oksana Kompaniitseva[5], Evgenii Makarenko[6]
[1]Department of Industrial Economics, Empress Catherine II Saint Petersburg Mining University, 199106, St. Petersburg, Russia, Nikiforov_AA@pers.spmi.ru (E.A.N.).
[2]Department of Economics and Production Organization of the Higher School of Technology and Energy, Federal State Budgetary Educational Institution of Higher Education "Saint Petersburg State University of Industrial Technologies and Design", 191186, St. Petersburg, Russia, ver.niko2011@yandex.ru (V.D.N.)
[3]Department of Industrial Economics, Empress Catherine II Saint Petersburg Mining University, 199106, St. Petersburg, Russia, Aksenova_ZhA@pers.spmi.ru (Z.A.A.)
[4]Institute of Industrial Management, Economics and Trade, Peter the Great St. Petersburg Polytechnic University, St. Petersburg 195251, Russia, rodion_dm@mail.ru (D.R.)
[5]Graduate School of Service and Trade, Peter the Great St. Petersburg Polytechnic University, 195251 St. Petersburg, Russia; sergeilog@rambler.ru (O.K.)
[6]Department of Business-Informatics and Management, St. Petersburg State University of Aerospace Instrumentation, 190000, St. Petersburg, Russia; ss300@yandex.ru (E.M.).

Abstract: The Russian Arctic has vast resource potential, and developing this is a strategic task for the country. Energy and infrastructure development is of great importance for this territory, as is any other. The plans for large-scale "redevelopment" of the hydrocarbon resource potential of the Arctic regions of the Russian Federation largely determine the relevance of the problem under consideration, taking into account the impact of climate change factors and globalization, followed by technological, organizational, economic, political, and institutional changes, the complete and systemic understanding of which is still in the formation stage. The article reviews the results of scientific research and discussions on such aspects of sustainable development of the Arctic regions of the Russian Federation as energy supply, renewal of transport infrastructure, creation of conditions for intensifying the implementation of investment and innovation projects, and preservation of ecosystems. This study aims to analyze, summarize, and review the established approaches presented in the domestic and foreign economic literature to solve specific scientific and practical problems in the selected areas. The authors used an institutional approach to the subject of the study, relying on historical, statistical-economic, monographic, and abstract-logical methods, as well as the process of expert evaluations. The scientific novelty of the study is the determination of the degree of study of the problems under consideration, as well as the formulation of the authors' position regarding the strengthening of the influence of institutional factors on the implementation of strategic programs for the development of the fuel industry in the Arctic zone of the Russian Federation in turbulent conditions, overcoming the "trap of technological backwardness" through innovative projects of environmental orientation in the oil and gas sector, related energy and transport infrastructure. The main conclusions are based on scientific literature, statistical and analytical data from Rosstat, Rosnedra, and current regulatory and legal documents of the Russian Federation and foreign countries.

Keywords: *Arctic zone of the Russian Federation, Fuel industry, Infrastructural changes, Investments, Environmental challenges.*

History: Received: 7 March 2025; Revised: 25 April 2025; Accepted: 29 April 2025; Published: 12 May 2025
* Correspondence: Nikiforov_AA@pers.spmi.ru

1. Introduction

Over the past decade, scholarly discourse on the Arctic has intensified, reflecting the region's growing strategic significance in the long term [1-4]. In the context of socio-economic and political transformations, key discussions have focused on the international regulation of relations among Arctic states, including the coordination of sectoral boundaries for territorial delimitation, issues of military presence and national security, restrictions on economic development of natural resources, the establishment of mechanisms for social partnership, and the need to safeguard environmental security against anthropogenic pressures [5-7].

European and U.S. researchers—predominantly sociologists and environmentalists—emphasize the collective governance of the Arctic through entities such as the Arctic Council. Their recommendations often include limiting economic activities and, in some cases, banning hydrocarbon production unless European environmental standards are met. These researchers prioritize scientific exploration, geological research, and cultural and spiritual value of Arctic ecosystems. A growing concern among Western scholars is the active interest of non-Arctic Asian countries such as China, India, and Turkey in reshaping the Arctic landscape through investment in Russian mining, infrastructure, and innovation projects [8-10].

Russian scholarship presents a broad range of research perspectives on the Arctic zone of the Russian Federation, viewing it as a large-scale national megaproject central to the development of industry and infrastructure. Institutional analysis in this body of work often emphasizes legal frameworks for state regulation of economic activities, social relations, and environmental protection, advocating for a policy of protectionism and the creation of socio-economic conditions necessary to unlock the region's internal potential for self-sustained development [11-13]. Sector-specific studies, particularly those examining the fuel and energy industry's role in sustainable development in the Russian Arctic, offer valuable theoretical and methodological insights into the region's long-term strategic trajectory [14].

2. Literature Review

Global events, such as the COVID-19 pandemic, Russia's military operation in Ukraine, and Western sanctions, have substantially impacted the trajectory of the Russian Arctic's development and significantly disrupted access to foreign technology and financing. Over 40 Arctic Council projects have been suspended, and operations in exploration and production have been limited [15]. Russia's exclusion from international debt markets has further compounded these challenges [16].

2.1. Economic Impacts and GRP Decline in Arctic Regions

According to Rosstat [17] data, the contribution of Arctic regions to Russia's GDP has steadily declined. Notably, the Gross Regional Product (GRP) of the Arctic Zone dropped from 7.67% in 2017 to 5.71% in 2021. Regions like the Komi Republic, Nenets Autonomous Area, and Krasnoyarsk Territory have reported notable GRP reductions in absolute terms. Nonetheless, the Arctic still plays a vital role in national energy production, particularly through the Yamalo-Nenets Autonomous District, which contributes over 80% of natural gas and 17% of oil output [17]. Efforts to modernize Arctic infrastructure, such as developing the Northern Sea Route and implementing satellite communication systems, are central to boosting economic competitiveness. These initiatives are expected to enhance year-round navigation and connectivity by 2025–2030, facilitating industrial growth and social services, especially healthcare (Ponomarenko et al., 2022). Despite global decarbonization efforts, the Arctic coal industry remains relevant due to regional demand, particularly for northern deliveries. However, many open-pit mines have closed due to economic and environmental risks. Researchers advocate for transforming the coal sector through:

- Development of deep processing complexes (e.g., in the Komi Republic),
- Expansion of mining hubs (e.g., Republic of Sakha, Chukot Autonomous Area) and

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 1186-1195, 2025
DOI: 10.55214/25768484.v9i5.7096

- Establishment of coal industry clusters (e.g., Krasnoyarsk Territory) [15].

Although a long-term global shift from coal is underway, developing economies are expected to maintain demand for traditional coal beyond 2035 and even 2050. Adopting cleaner and cutting-edge technologies in coal processing and pollution mitigation is essential to its ongoing relevance [18].

A critical challenge in Arctic development is transitioning from raw resource extraction to local processing and diversification. While diversification reduces economic vulnerability, specialization is necessary for boosting GRP per capita. According to Fadeev and Larichkin [19] only the Murmansk and Arkhangelsk regions demonstrated substantial economic diversity. In contrast, regions like the Chukot Autonomous Area, Komi Republic, and Sakha Republic remain highly dependent on mineral extraction.

2.2. Import Substitution and Technological Sovereignty

In the face of import restrictions, import substitution has become central to Russia's Arctic strategy. Over 40–45% of equipment used in major Arctic energy projects is foreign-made. Scholars urge Russian firms to modernize their business models and prioritize domestic suppliers [16, 20]. The case of Norway is frequently cited: through long-term R&D and localization efforts, it evolved from import dependence in the 1970s to a global leader in offshore equipment manufacturing [18]. Experts emphasize the importance of establishing a closed innovation cycle in the Arctic oil and gas sector to prevent technological stagnation and retain qualified personnel [18]. Integration of Arctic industry with the military-industrial complex and the development of collaborative innovation systems are critical for long-term self-sufficiency. Protective trade measures are insufficient in the context of Western sanctions. Instead, incentive-based tools—such as preferential taxation and production subsidies—are recommended to encourage local technological innovation. In 2023, Russia increased compensation rates for domestically developed equipment from 20% to 50%, with subsidies extending up to 20 million rubles per project [15]. Despite significant oil, gas and transport infrastructure investments, the Arctic lags in high-tech output. Many regions remain trapped in a technological backwardness trap, where weak innovation demand and inadequate investment limit the development of advanced technologies and services [20]. Such stagnation may weaken the broader goal of achieving technological sovereignty and sustainable regional development.

The literature reveals a multifaceted picture of Arctic development under pressure from global crises, economic sanctions, and structural limitations. The Arctic remains crucial to Russia's energy strategy because its long-term growth depends on successfully navigating import substitution, diversifying regional economies, developing innovation ecosystems, and investing in high-tech infrastructure. The transition from extractive dependency to a diversified, innovation-driven Arctic economy remains a critical frontier for national security and economic resilience.

3. Methodology

A shared feature of foreign and domestic economic research is the commitment to models of sustainable development. Many of these studies are interdisciplinary, integrating aspects of policy, socio-economic progress, and environmental sustainability, and are primarily focused on addressing current practical challenges. However, some experts argue that implementing international experiences in the context of Russia is complicated due to significant differences in institutional frameworks, economic approaches to resource utilization in the Arctic, and other structural conditions. Foreign research can offer valuable perspectives and provide innovative ideas and frameworks for advancing domestic research and practice.

Contemporary scientific literature presents diverse approaches to forming the "sustainable development" concept across various levels of governance and regulation: global, national, regional, sectoral, and organizational. In regional studies, the plurality of interpretations often reflects the specific objectives set by researchers. Some scholars define regional sustainable development as a continuous process of maintaining systemic integrity, ecological balance and the efficient use of resources to foster

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 1186-1195, 2025
DOI: 10.55214/25768484.v9i5.7096

regional innovation infrastructure [21]. Others frame it as a process of balanced socio-economic and ecological development, primarily focusing on economic growth as a driver for improving the quality of life for regional populations [7, 22].

In this context, economic development is the key to industries, including the fuel and energy sectors and establishing infrastructure in the Arctic microregion is integral to utilizing regional potential. These elements are inextricably linked to the preservation of natural habitats and the enhancement of living standards. The goal is to stimulate structural changes that are both quantitative and qualitative while ensuring the system's capacity to maintain equilibrium. Accordingly, the study adopts a systemic approach to formulating policies for developing the fuel and energy sector and related infrastructure in the Arctic zone of the Russian Federation, especially in light of the rapid pace of regional transformation.

A substantial body of literature has explored the theoretical foundations of the contemporary role and corporate social responsibility of fuel and energy companies in advancing socio-economic development in the Russian North and Arctic zone [18, 19, 23, 24]. Additional research has enriched the theoretical and practical understanding of support zones, industrial clustering, infrastructure (including transport systems), and interregional cooperation in the context of mineral resource exploitation in the Arctic [25-28]. Moreover, recent studies have made significant contributions to understanding investment and innovation in the fuel and energy sector, with a particular focus on environmental sustainability and regulatory compliance [29-32].

The authors identify future research directions in exploring pathways to minimize inconsistencies among regulatory and governance systems, foster sustainable growth in the Arctic fuel and energy sector, and mitigate adverse environmental impacts. The study approaches the Arctic region of the Russian Federation as an open system integrated into the formation of global value chains at the national level. The research methodology is grounded in institutional and systemic analysis and the foundational principles of sustainable development. The study's conceptual framework is supported by a combination of general scientific and practice-oriented approaches widely recognized within the academic community. Supplementary methodological perspectives, including resource-based, informational and normative approaches, were also employed to deepen the analysis.

4. Results and Discussion

4.1. Economic and Technological Challenges in the Development of the Russian Arctic

The coronavirus pandemic is a quarantine measure; Russia's military operation in Ukraine and escalating sanctions from Western countries have significantly heightened the risks to the growth of the Russian Arctic's fuel industry and regional economies. Several factors are severely limited in accessing the crucial exploration and production equipment from the United States and the European Union, leading to the suspension of over 40 out of 130 projects from the Arctic Council. Furthermore, Russia's access to international debt capital markets has effectively been blocked.

As a result, the share of the Arctic regions in the country's GDP has declined, and structural changes in their Gross Regional Product (GRP) are evident. According to the Russian Federal State Statistics Service (Rosstat), regions such as the Nenets Autonomous Area, the Komi Republic, and the Krasnoyarsk Territory have reported decreases in GRP in absolute terms. The GRP of the Arctic Zone of the Russian Federation fell from 7.67% in 2017 to 5.71% in 2021. Despite this, more than 80% of the country's natural gas and 17% of its oil (including gas condensate) are still produced in the Arctic, with the Yamalo-Nenets Autonomous District playing a pivotal role in the growth of the Arctic oil and gas industry.

The development of year-round navigation and communication infrastructure along the Northern Sea Route, including the use of highly elliptical satellite systems, is expected to significantly boost the competitiveness of the Arctic economy by 2025-2030. These infrastructure advancements will help address national challenges by providing affordable and high-quality communications to all economic

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 1186-1195, 2025
DOI: 10.55214/25768484.v9i5.7096

sectors in the Arctic, including fuel industry companies, primarily in the oil and gas sector and social infrastructure, especially in healthcare.

Meanwhile, the coal industry is gradually declining due to decarbonization goals, although localized demand for coal remains, especially for northern deliveries. Despite profitable operations, many open-pit coal mines have ceased activity due to high-risk factors, creating social issues, particularly in areas where coal mining is a city-forming industry. Many Russian researchers, such as Petrov, et al. [15] suggest that the coal sector's future may lie in developing deep processing complexes (in the Komi Republic), expanding coal mining and centres in regions like the Republic of Sakha and Chukot Autonomous Area, and establishing coal industry clusters, particularly in the Krasnoyarsk Territory. The coal industry in the Russian Arctic is expected to remain significant not only through 2035 but also by 2050. Developing countries, driven by economic interests, will likely prioritize traditional coal supplies over a green agenda. This shift will accompany the gradual adoption of breakthrough technologies in coal mining, metallurgy and pollution mitigation.

A key point in economic development is shifting from resource extraction to processing, creating economic diversification opportunities across the Arctic regions. While diversification mitigates risk, specialization becomes crucial for achieving high GRP per capita [19]. According to an analysis of 2021 data, only the Murmansk and Arkhangelsk regions had diversified economies. Other regions, such as the Chukot Autonomous Area, Republic of Karelia, Komi Republic, Sakha Republic, and Krasnoyarsk Territory, either remain moderately concentrated or highly dependent on mineral extraction (Nenets Autonomous Area, Yamalo-Nenets Autonomous District).

Import substitution has emerged as a significant factor in energy development, particularly for sizeable Russian mining and processing corporations, where imported equipment and parts account for over 40-45% of their needs. Experts argue that Russian corporations must update their business processes to rely more on domestic suppliers, ensuring comprehensive service and maintenance based on domestic production and technological innovations [16, 20].

Norway is a noteworthy example, transitioning from complete dependence on imported oil and gas equipment in the 1970s to becoming a global leader in producing and exporting high-tech equipment for offshore hydrocarbon operations, thanks to substantial investments in R&D and technology localization. Russia can replicate this success, but a closed innovation cycle in the Arctic oil and gas sector is essential to avoid technological lag and the loss of competitive personnel, as highlighted by experts [18].

The import substitution strategy should include developing a domestic oil and gas service sector based on local technology and personnel, alongside best practices for collaboration between the Arctic industry and the military-industrial complex. Some scholars propose using protective and incentive mechanisms to encourage domestic producers to invest in import substitution, which could accelerate the development of local production capacities. However, in the current context of Western sanctions, using incentive mechanisms such as preferential tax regimes and production subsidies may prove more effective than protective measures, as Western companies have already imposed restrictions on their supplies to Russia. From 2023, Russia has increased compensation for domestically developed equipment from 20% to 50%, with an expanded subsidy range (up to 20 million rubles) for qualifying applicants.

Investments in the Russian Arctic are predominantly directed towards oil and gas production and mineral extraction projects (particularly in the Yamalo-Nenets Autonomous District). Substantial funds are also invested in transport infrastructure development. Despite this, the share of high-tech, innovative goods and services produced in the Arctic regions remains low and, in some cases, is decreasing. This results in a "technological backwardness trap," where a lack of demand for innovations and insufficient investment in technological development hinder progress Table 1.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 1186-1195, 2025
DOI: 10.55214/25768484.v9i5.7096

Table 1.
Dynamics of growth of the share of high-tech and science-intensive products in the GRP of the constituent entities of the Russian Federation in the Arctic zone for 2017-2020, %.

Constituent entity of the Russian Federation	Chain indicators				Average for the period
	2017	2018	2019	2020	
Regions the territories of which have fully become parts of the Arctic zone of the Russian Federation					
Murmansk Region	0	5.66	-2.98	-10.43	-8.18
Nenets Autonomous Area	2.86	-22.22	-7.14	61.53	20.0
Chukot Autonomous Area	-2.4	7.38	-16.03	-10.91	-20.8
Yamalo-Nenets Autonomous District	-10.81	33.33	-13.64	13.16	16.2
Regions the territories of which have partially become parts of the Arctic zone of the Russian Federation					
Republic of Karelia	-10.06	13.29	6.79	4.62	13.84
Komi Republic	3.54	-8.55	2.8	24.55	21.24
Republic of Sakha	0.88	-1.75	0	11.61	10.62
Krasnoyarsk Territory	-3.76	-5.47	-1.65	4.2	-6.77
Arkhangelsk Region without the Nenets Autonomous Area	9.72	4.8	-1.16	6.27	9.72
for the whole of the Russian Federation	0	0	2.7	8.95	11.89

Source: Author's Estimated based on the data of the Russian Federal State Statistics Service (Rosstat); 2016 was taken as the base period.

4.2. Innovative Development and Environmental Sustainability in the Russian Arctic

The innovative development of the Arctic is not only a global trend but also a strategic political priority for the Russian state. Since 2020, the Russian Government has implemented state-supported measures to promote innovative entrepreneurial activity in the Arctic zone. Over 500 companies across nine Arctic regions have received preferential treatment under this initiative, amounting to more than 800 billion investment rubles. Researchers anticipate transformative developments in small-scale energy generation through state-business collaboration.

Despite these positive strides, the proportion of domestic R&D expenditures in the gross regional product of Arctic regions remains significantly lower—two to three times—than the national average (excluding the Krasnoyarsk Territory). Moreover, when compared to other Arctic and sub-Arctic nations, Russia's R&D intensity (1.1%) falls behind Finland (2.91%), Denmark (2.96%), Sweden (3.53%), the USA (3.45%), Canada (1.70%), Ireland (1.23%), and Norway (2.28%).

Enhancing support for university-based research, experimental platforms, technology clusters, business incubators, technology transfer centres and venture capital funds is vital to addressing this gap. Creating a robust ecosystem that integrates science, education, and innovation—especially in partnership with vocational training institutions and businesses aligned with Arctic megaprojects—is critical. Many large domestic firms prioritize gaining preferential treatment over fostering cooperative efforts with universities or other domestic firms, undermining potential synergies in joint financing, enterprise development, and innovation partnerships.

The expansion of the fuel industry in the Arctic—frequently examined in domestic and international literature—is closely tied to environmental challenges and climate change [5, 30, 33]. Russia's active exploitation of Arctic natural resources and relatively larger Arctic population necessitate urgent environmental measures. As a signatory to the 2019 Paris Agreement under the UN Framework Convention, Russia has committed to reducing greenhouse gas emissions and fostering low-carbon economic development. National and regional programs have since been adopted to improve environmental safety and advance scientific research on Arctic ecosystems.

Experts say Russia's legal framework lacks environmental restrictions related to Arctic industrial activity. Unlike detailed Arctic-specific legislation in nations like the United States and Canada, existing laws only provide broad guidance. The fragility of Arctic ecosystems—characterized by low self-purification capacity, extreme climatic conditions, and slow natural regeneration—demands special legal and regulatory considerations [34].

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 1186-1195, 2025
DOI: 10.55214/25768484.v9i5.7096

Research conducted by international experts and Tomsk Polytechnic University highlights several categories of environmental risks specific to the Russian Arctic:

1. Natural and environmental risks – including methane emissions and persistent organic pollutants;
2. Technical and environmental risks – stemming from accumulated pollution at industrial sites;
3. Artificial impact risks – such as oil spills from resource extraction activities;
4. Pollutant emissions – affecting atmospheric and marine environments and
5. Socio-environmental risks threaten the traditional lifestyles of Indigenous communities [35-38].

While much of the Soviet-era environmental damage has been remediated, up to 15% of the Arctic region remains critically polluted. Primary pollution sources include mining operations, abandoned industrial sites, drilling waste, and long-range airborne and waterborne pollutants [39, 40]. A contentious debate persists regarding the comparative impact of mining versus metallurgical activities on environmental degradation. Oil-related accidents during production, storage, or transportation pose arguably the most significant risk, especially as real-world oil spill response rates in Arctic conditions are estimated at only 10–15%—far below the theoretical 90%. Moreover, increased military activity under the North Strategic Command has intensified anthropogenic pressure [41].

According to Article 39 of the Russian Environmental Protection Law, environmental restoration must accompany the decommissioning of capital construction projects. However, enforcement remains weak and legal compliance is often inconsistent. As of 2018, the official registry listed 102 sites with accumulated environmental damage in the Arctic zone—59 in the Krasnoyarsk Territory and 39 in the Yamalo-Nenets Autonomous District.

A chemical analysis of surface waters near the Kharasaveysky gas condensate field revealed moderate pollution in 53% of samples. Bottom sediments showed nickel concentrations 1.9 times above acceptable levels, zinc 2.6 times higher, and oil products exceeding limits by 26.4 times—clear indicators of severe environmental degradation. Experts emphasize the growing impact of consumer waste alongside industrial pollution [42].

Current trends in the Russian Arctic indicate (1) increased waste generation and consumption, (2) rising waste disposal and recycling, and (3) a generally negative rate of waste treatment and neutralization. It suggests the ongoing accumulation of ecological damage.

Table 2.
Rates of changes in generation, disposal and neutralization of production and consumption waste in the Arctic zone of the Russian Federation, %.

Indicators	2019/2018	2020/2019	2021/2020	2021/2018
1. Waste generation	+16.7	+6.6	+5.7	+31.4
2. Waste treated	+173.8	-89.8	+31.3	-63.3
3. Waste disposal	-0.1	+3.3	+7.5	+10.9
including recycling	-24.9	-12.1	+40.5	-7.3
4. Waste neutralization	-32.4	-49.1	+170.3	-6.9

Source: Author's Estimation based on the data of the Russian Federal State Statistics Service (Rosstat).

Domestic experts advocate combining traditional and renewable energy sources to mitigate greenhouse gas emissions—nuclear, hydro, wind, thermal (≥100 MW), and solar. Renewable energy is also increasingly utilized in infrastructure along the Northern Sea Route, such as the 37 weather stations along the Arctic Ocean coastline. Global renewable energy capacity is growing at 30–35% annually [39, 40].

Solar energy holds particular promise in the Russian Arctic due to the cost-effectiveness and high efficiency of photovoltaic (PV) converters at low temperatures. While the polar night presents a challenge, this can be offset by electrochemical batteries offering long service life, lightweight design, and environmental advantages. Experts agree that small-scale and alternative energy solutions offer viable pathways for powering remote areas, especially in the Republic of Sakha and the Krasnoyarsk

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 1186-1195, 2025
DOI: 10.55214/25768484.v9i5.7096

Territory. The average payback period for such installations is approximately 10 years, excluding the cost of additional equipment.

According to the Ministry of Energy, nine major projects are scheduled for launch in the Arctic by 2035, with planned investments of 15 trillion rubles. These projects include infrastructure and high-tech development, deep mineral processing, scientific expeditions, and commitments by energy companies to environmental responsibility. Economic research on the Russian Arctic increasingly ties development to social objectives: improving living standards, creating jobs, expanding access to quality education, and fostering sustainable communities. Crucially, Arctic development must support permanent population settlements and preserve indigenous ways of life [43].

5. Conclusion

In general, the study showed that despite the differences in the formulation of the "sustainable development" concept, the common thing for domestic and foreign scientists and practitioners is the recognition of the need to balance social development, economic growth and environmental safety in the Arctic. However, we often encounter differences in approaches to solving strategic management problems related to the balanced development of the Arctic regions on the part of Western and Eastern views.

In the era of complex relations with the countries of the Arctic Council and the macroeconomic situation, issues of interregional international cooperation continue to occupy an essential place in the joint search for solutions to the problems of energy development, climate change, and indigenous peoples in the Russian zone of the Arctic in the context of growing turbulence that causes social, economic, and climate change. Today, it is becoming evident to many Russian researchers that the return of the Arctic to the economic space of the Russian Federation is objectively necessary and dictated not only by changes in the world space but also by the internal needs to solve strategic problems of socio-economic development and ensuring the national security of the country.

It seems to us that the issues related to the search for optimal approaches to the management system of the Russian Arctic macro-region to overcome geopolitical constraints, amend the legislation of the Russian Federation, improve the forms of state support and the use of market instruments about companies in the fuel industry, transport infrastructure, social processes, and environmental protection remain relevant. It is due, first of all, to the scale and multifaceted nature of the region's development tasks, as well as the need to overcome the inertia of the existing system of coordination of the activities of actors in state programs, accompanied by underfunding, personnel shortages, lack of own technologies, and the accumulation of environmental damage.

Research related to the creation of favourable conditions for the broader use of private property in the Arctic economy's natural resource sector and the state's gradual withdrawal from this sector will be of particular importance in the future. It is because the state owns subsoil. The results of their operation are privatized based on a license (transferred to a private company). Still, a private company cannot always invest significantly in geological exploration to create the necessary social and industrial infrastructure (energy, transport, housing, communal services, and other communications). Also, a tangle of contradictions remains about the indigenous population of the North, which is mainly formed around the rights to land and resources of the territory of their residence. This circumstance strengthens the actualization of research in state protectionist policy.

The conclusions and recommendations of researchers related to the diversification of the economies of the regions of the AZ of the Russian Federation, the reorientation of corporations in the field of production and processing to domestic suppliers, the creation of a closed investment and innovation cycle in the oil and gas sector, the tightening of environmental requirements for business, the integration of specialized universities into joint activities with representatives of business and other projects may also be of practical importance for regional and sectoral authorities alternative energy through bonded loans and concessions, regional syndicated loans.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 1186-1195, 2025
DOI: 10.55214/25768484.v9i5.7096

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Acknowledgement:

The research is financed as part of the project "Development of a methodology for instrumental base formation for analysis and modelling of the spatial socio-economic development of systems based on internal reserves in the context of digitalization" (FSEG-2023-0008)

References

[1] G. Hønneland, "Marine stewardship council (MSC) certification of arctic fisheries: Processes and outcomes," *Arctic Review on Law and Politics*, vol. 11, pp. 133-156, 2020. http://doi.org/10.23865/arctic.v11.2488

[2] V. Ingimundarson, "Framing the national interest: the political uses of the Arctic in Iceland's foreign and domestic policies," *The Polar Journal*, vol. 5, no. 1, pp. 82-100, 2015. https://doi.org/10.1080/2154896X.2015.1025492

[3] A. E. Nilsson, "The United States and the making of an Arctic nation," *Polar Record*, vol. 54, no. 2, pp. 95-107, 2018. http://doi.org//10.1017/S0032247418000219

[4] D. Nong, A. M. Countryman, and T. Warziniack, "Potential impacts of expanded Arctic Alaska energy resource extraction on US energy sectors," *Energy Policy*, vol. 119, pp. 574-584, 2018. https://doi.org/10.1016/j.enpol.2018.05.003

[5] E. Klyuchnikova and A. Korppoo, "Implementation of the "green growth" concept in the Russian Arctic (on the example of the Murmansk region)," *Arctic: Ecology and Economy*, vol. 11, no. 4, pp. 493-503, 2021. https://doi.org/10.25283/2223-4594-2021-4-4-493-503

[6] C. B. Barrett *et al.*, "A scoping review of the development resilience literature: Theory, methods and evidence," *World Development*, vol. 146, p. 105612, 2021. https://doi.org/10.1016/j.worlddev.2021.105612

[7] T. Semenova, A. Al-Dirawi, and T. Al-Saadi, "Environmental challenges for fragile economies: Adaptation opportunities on the examples of the arctic and Iraq," *Agronomy*, vol. 12, no. 9, p. 2021, 2022. https://doi.org/10.3390/agronomy12092021

[8] J. Käpylä and H. Mikkola, *The global arctic: The growing arctic interests of Russia, China, the United States and the European Union*. Helsinki, Finland: Finnish Institute of International Affairs (FIIA), 2013.

[9] A. Council, *Arctic resilience report*. Stockholm, Sweden: Stockholm Environment Institute and Stockholm Resilience Centre, 2016.

[10] M. Ahmad, S. Beddu, Z. b. Itam, and F. B. I. Alanimi, "State of the art compendium of macro and micro energies," *Advances in Science and Technology. Research Journal*, vol. 13, no. 1, pp. 88-109, 2019. https://doi.org/10.12913/22998624/103425

[11] T. P. Skuf'ina and M. N. Mitroshina, "Transformation of the socio-economic space of the Russian Arctic in the context of geopolitics, macroeconomics, and internal development factors," *Arctic and North*, no. 41, pp. 87–112, 2020. http://doi.org/10.37482/issn2221-2698.2020.41.87

[12] V. A. Kryukov *et al.*, "Economy of the modern Arctic: effective interaction and management of integral risks are the basis of success," 2020. https://doi.org/10.37614/978.5.91137.416.7

[13] A. E. Cherepovitsyn, P. S. Tsvetkov, and O. O. Evseeva, "Critical analysis of methodological approaches to assessing sustainability of arctic oil and gas projects," *Notes of the Mining Institute*, vol. 249, pp. 463-478, 2021. https://doi.org/10.31897/PMI.2021.3.15

[14] Y. Gribanov, "Digital transformation of socio-economic systems on the basis of development institute of service integration," *Doctor of Economics*, vol. 1, no. 1, pp. 1-355, 2019.

[15] I. V. Petrov, I. I. Utkin, and V. B. Dzhayyant, "Proposals for decarbonization of the coal industry and sustainable development of remote regions based on underground coal gasification," *Ugol*, vol. 9, no. (9 [1158]), pp. 41–46, 2022.

[16] V. Väätänen, "Securing anticipatory geographies: Finland's Arctic strategy and the geopolitics of international competitiveness," *Geopolitics*, vol. 26, no. 2, pp. 615-638, 2021. https://doi.org/10.1080/14650045.2019.1580267

[17] Rosstat, "Gross regional product by constituent entities of the Russian federation 2017–2021. Federal State Statistics Service," Retrieved: http://www.gks.ru/. [Accessed 2022.

[18] T. Ponomarenko, E. Marin, and S. Galevskiy, "Economic evaluation of oil and gas projects: justification of engineering solutions in the implementation of field development projects," *Energies*, vol. 15, no. 9, p. 3103, 2022. https://doi.org/10.3390/en15093103

[19] A. Fadeev and F. Larichkin, "Social and economic approaches for the arctic shelf's hydrocarbon field development," *Journal of Mining Institute*, vol. 184, pp. 180-187, 2009.

[20] I. Kotliarov, "The outsourcing-based Model of organization of oil and Gas Industry in Russia: Problems and Ways of Solving," *Voprosy Ekonomiki*, no. 9, 2015. http://doi.org/10.32609/0042-8736-2015-9-45-64

[21] A. Dale and L. Newman, "Social capital: A necessary and sufficient condition for sustainable community development?," *Community Development Journal*, vol. 45, no. 1, pp. 5-21, 2010. https://doi.org/10.1093/cdj/bsn028

[22] A. O. Nedosekin, E. I. Rejshakhrit, and A. N. Kozlovskii, "Strategic approach to assessing economic sustainability of objects in the mineral resources sector of Russia," *Journal of Mining Institute*, vol. 237, no. 3, pp. 354–360, 2019. https://doi.org/10.31897/pmi.2019.3.354

[23] D. Rodionov, M. Gataullin, I. Smirnova, E. Konnikov, D. Kryzhko, and A. Shmatko, "Risk modeling in the oil and gas industry," *International Journal of Technology*, vol. 14, no. 8, pp. 1-12, 2023. https://doi.org/10.14716/ijtech.v14i8.6852

[24] Y. V. Ilyushin, "Development of a process control system for the production of high-paraffin oil," *Energies*, vol. 15, no. 17, p. 6462, 2022. https://doi.org/10.3390/en15176462

[25] T. Semenova and J. Y. Martínez Santoyo, "Economic strategy for developing the oil industry in mexico by incorporating environmental factors," *Sustainability*, vol. 16, no. 1, p. 36, 2024. https://doi.org/10.3390/su16010036

[26] E. Katysheva, "The role of the Russian Arctic gas industry in the Northern Sea Route development," in *IOP Conference Series: Earth and Environmental Science*, 2020, vol. 539, no. 1: IOP Publishing, p. 012075.

[27] S. A. Agarkov *et al.*, "Global trends in the development of energy resources in the Russian Arctic," 2019. http://doi.org/10.25702/KSC.978.5.91137.397.9-1

[28] E. V. Korchagina, S. E. Barykin, L. G. Desfonteines, S. Ray, I. M. Shapovalova, and V. Repnikova, "Digitalisation of ecosystem-based management and the logistics potential of the arctic region," *Journal of Environmental Assessment Policy and Management*, vol. 24, no. 03, p. 2250034, 2022. https://doi.org/10.1142/S146433322250034X

[29] E. Klyuchnikova, A. Orlov, and A. Korppoo, "The municipal solid waste processing industry on the path toward "green" growth," 2022. http://dx.doi.org/10.30680/ECO0131-7652-2022-8-67-88

[30] E. A. Konnikov, O. A. Konnikova, and D. G. Rodionov, "Impact of 3D-Printing technologies on the transformation of industrial production in the arctic zone," *Resources*, vol. 8, no. 1, p. 20, 2019. https://doi.org/10.3390/resources8010020

[31] I. Masoni, B. Pagliccia, and G. Thalmann, "The use of drones for innovative seismic acquisition: A change of paradigm for HSE," in *International Petroleum Technology Conference*, 2019: IPTC, p. D031S058R003.

[32] S. G. Borgerson, *The great game moves north* (Foreign affairs). New York: Council on Foreign Relations, 2009.

[33] N. S. Shulaev, V. V. Pryanichnikova, and R. R. Kadyrov, "Regularities of electrochemical cleaning of oil-contaminated soils," *Notes of the Mining Institute*, vol. 252, pp. 937-946, 2021.

[34] A. V. Beloshitsky and A. E. Cherepovitsyn, "Prospects for the development of Russian oilfield services in the context of the transition to "green energy," *Perm University Herald. Series: Economics*, vol. 17, no. 1, pp. 65-76, 2022. http://doi.org/10.17072/1994-9960-2022-1-65-76

[35] S. Kodaneva, "Circular economy: Actual approaches to content and measurement," *Social and humanitarian sciences: Domestic and foreign literature. Ser*, vol. 2, pp. 51-58, 2020.

[36] J. S. Loe and I. Kelman, "Arctic petroleum's community impacts: Local perceptions from Hammerfest, Norway," *Energy Research & Social Science*, vol. 16, pp. 25-34, 2016. https://doi.org/10.1016/j.erss.2016.03.008

[37] B. Dale, S. Veland, and A. M. Hansen, "Petroleum as a challenge to arctic societies: Ontological security and the oil-driven 'push to the north'," *The Extractive Industries and Society*, vol. 6, no. 2, pp. 367-377, 2019. https://doi.org/10.1016/j.exis.2018.10.002

[38] S. Grimstad, "Subsea well integrity-permanent monitoring solution to verify critical well barriers, simplify and reduce cost of periodic testing," in *SPE Annual Technical Conference and Exhibition?*, 2018: SPE, p. D011S002R006.

[39] V. Yurak, A. Dushin, and L. Mochalova, "Against sustainable development: Scenarios for the future," *Notes of the Mining Institute*, vol. 242, pp. 242-247, 2020. http://doi.org/10.31897/PMI.2020.2.242

[40] V. A. Akatyev, M. P. Tyurin, and E. S. Borodina, "Improving energy efficiency in the production, transmission, and consumption of electricity," *Energy Security and Energy Saving*, no. 6, p. 18, 2020. http://doi.org/10.18635/2071-2219-2020-6-8-17

[41] E. Golovina and O. Shchelkonogova, "Possibilities of using the unitization model in the development of transboundary groundwater deposits," *Water*, vol. 15, no. 2, p. 298, 2023. https://doi.org/10.3390/w15020298

[42] D. L. Gautier and T. E. Moore, "Introduction to the 2008 circum-arctic resource appraisal (CARA) professional paper," US Geological Survey. https://doi.org/10.3133/pp1824A, 2330-7102, 2017.

[43] C. C. Smits, J. C. S. Justinussen, and R. G. Bertelsen, "Human capital development and a social license to operate: Examples from Arctic energy development in the Faroe Islands, Iceland and Greenland," *Energy Research & Social Science*, vol. 16, pp. 122-131, 2016. https://doi.org/10.1016/j.erss.2016.03.016