Spatial organization of the Chukotka’s economy

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Abstract. Prospects for the Chukotka’s economic development are associated with several aspects: trends of the Northern Sea Route and its infrastructure revival; renewal of the peninsula energy system; the presence of profitable resource projects for the extraction of, copper, coal, oil and gas, and the need to develop the defence infrastructure on the northeast border of Russia. At the same time, extremely uncomfortable conditions for living and doing business, poor development of transport and social infrastructure, state of the energy system, shortage of skilled labor, environmental restrictions make economic indicators of projects unsatisfactory. Under these conditions, traditional project analysis should be transformed into the analysis of value chains, i.e. bundles of investment projects should be considered simultaneously. The purpose of this work was to understand the possible spatial organization of the Chukotka’s economy and economic -mathematical modelling of interrelated perspective projects within the projected centres of economic development. Systematization of data on promising projects of the Chukotka Autonomous District allowed defining the contours of three promising ATPCs - Peveksky, Anadyrsky and Lorinsky. Further, using the author's simulation model, forecasted effects of four technologically related projects were assessed: the copper deposit Peschanka, the gold deposit Kekura, the floating nuclear power plant and the Pevek sea port. The toolkit created by the authors can be used to justify the development priorities of the Chukotka Autonomous District, as well as to assess the various institutional conditions for the implementation of investment projects in the region.

1. Introduction

Chukotka Autonomous District is one of the northern regions of the Russian Federation and this leaves its mark on the course of its socio-economic development.

On land, the district borders with Yakutia, the Magadan Region and the Kamchatka Territory, while its eastern border is the sea state border of Russia with the United States.

According to the FSGS, the share of the Chukotka’s gross regional product in the total GRP of the country in 1998-2016 was in the range of 0.07-0.12%. For 2016, the GRP of the region in current prices amounted to 67 billion rubles. Per capita GRP is 1.323 million rubles and is one of the highest rates in Russia. In the Chukotka Autonomous District the highest average wage is almost 92 thousand rubles. While the population is only 49 222 people (1 January 2019), and there is a steady trend to decline, 66.5% of population lives in three cities (Anadyr, Bilibino and Pevek) and 15 urban settlements. The climate is harsh, the duration of winter is 10 months. Permafrost rocks are
widespread. There are no Railways in the district. The basis of transport complex is sea, air transport, winter roads.

As in many Northern regions, decentralized energy supply is used on the territory of the Chukotka Autonomous District. Power system the Chukotka is comprised of the Anadyr HPP (50 MW), Egvekinot GRES (34 MW) and objects of Chaun-Bilibino energy node (Bilibino plant capacity of 48 MW and the Chaun HPP - 30 MW) [1]. Annual electricity production exceeds 540 million kWh, and thermal energy is produced more than 1 million Gcal. This fully covers the demand for energy resources of the District, as well as allows exporting more than 16 million KWh to the Republic of Sakha (Yakutia). In 2019, it is planned to start the decommissioning of Bilibino ATPP (built in 1974-1976) and update the energy system configuration of the node. This determines the task of finding the optimal energy supply options for promising industrial facilities.

Today, the main activity in the Chukotka is gold mining industry. Gold mining started here in 1957. At first it was carried out only from placer deposits, and only in 1996 the first indigenous deposits (Karalveem, Dvojnoe, Rudnaya Sopka, Sypuchee, North-East, Valunistoe) were included in operation. In 2008, there was a sharp turn in Chukotka gold mining - first tons of gold from the ores of the richest gold and silver deposit of the world-class Kupol were extracted. Since then, the bulk of production falls on ore deposits [2]. In 2016, the volume of the Chukotka’s gold production amounted to 28.82 tons.

Currently, the Chukotka administration is undertaking a number of efforts to increase the investment attractiveness of the District, there are various measures to support small businesses, special tax regimes for large businesses.

Since 2016, the territory of advanced development (ADT) "Beringovsky" has been functioning in Chukotka region, the boundaries of which were expanded in 2019: after the accession of the territory of the Baimskaya ore zone, the ADT was called "Chukotka". For residents of the ADT there are financial benefits: total amount of insurance premiums for 10 years is 7.6% (instead of 30%), zero interest rates on land taxes for the first 3 years, on profits and property for the first 5 years. Also, free customs zone regime is open for residents of the ADT.

In the summer of 2016, was adopted a law that classifies the territory of the Pevek city (including territory and water area of the seaport) to the Free Port of Vladivostok. Residents of the Free port have same tax and customs benefits as residents of the ADT.

The implementation of investment projects in the territory of Chukotka will correspond to the direction of the state policy "movement to the North" and has strategic importance. At the same time, extremely uncomfortable conditions for living and doing business, poor development of transport and social infrastructure, the state of the energy system, the shortage of skilled labor, environmental restrictions complicate and increase the cost of any project initiatives. In these conditions, understanding how the economic complex of Chukotka will be organized in the medium and long term seems to be a non – trivial task of forecasting.

In this context traditional project analysis [3] should be transformed into value chain analysis. This is especially important in connection with attempts to assess complex effects of the Arctic zone of the Russian Federation development. Thus, according to V. A. Kryukov [4,5] within analysis of any Arctic project, it is necessary to assess the possible relationships between Northern projects and existing enterprises in the southern industrial zone of Russia, both consumers of production and suppliers of equipment. At the same time, due to the need for state support and/or participation of state-owned enterprises in projects, it is necessary to evaluate technologically related projects located in the same region in the same paradigm. There may be occasions when the vision of the market situation of the interested parties of the projects is not the same. As a result, the projected effects of several projects, for example, in terms of budget revenues, cannot be simply summed up, since the feasibility study contains uncoordinated parameters. In this regard, it is recommended to conduct a joint evaluation of such projects. The roots of this approach lie in the ideology of territorial-production complexes [6], when scheme and scenario of territorial development are worked out on the basis of
modeling the relationships of all projects of the territory, including production, infrastructure and social blocks.

The purpose of this work was to understand the possible spatial organization of the Chukotka’s economy and economic -mathematical modelling of interrelated perspective projects within the projected centers of economic development. To achieve the goal, the following tasks were solved:

- systematization of data on Chukotka investment projects;
- updating TPC-approach for projects Chukotka;
- construction and debugging of economic-mathematical tools to assess effects of interrelated projects;
- carrying out scenario calculations on options for implementation of the Chukotka’s priority investment projects and obtaining effects assessment for business, the region and the country.

2. Prospects for socio-economic development of the Chukotka Autonomous District

According to the authors, in the future until 2050, the concept of focal development proposed in the works of the Kola scientific center [7] and Aleshina O. V. [8] can be applied to the Chukotka Autonomous District, taking into account the "island" nature of economic life, about which Pilyasov A. N. writes [9].

The authors predict three aqua-territorial production complexes (ATPC) on the territory of Chukotka (see figure 1). The concept of aqua-territorial structures of economy was first proposed and elaborated for the regions of Pacific Russia by P. Y. Baklanov [10, 11]. The essence of ATPC is that large deposits and other projects should be developed with the support of maritime transport and the corresponding port of the Northern sea route. The specificity of Arctic ATPCs is in the defense importance of all infrastructure facilities.

Floating nuclear power plant (FNPP), discussed below, will become the backbone object of the Eastern sector of the Arctic zone of the Russian Federation. Coupled with new mining projects, such as Peschanka, Kekura, Klen as well as continuing work fields Kupol, Majskoe, etc., it will form Peveksky ATPC. At the same time, the port of Pevek as part of the developing Northern sea route will serve to reduce transport costs for the above deposits. Thus, Peveksky ATPC will specialize in the extraction of non-ferrous and noble metals and transport.

The boundaries of the Anadyrsky ATPC could coincide with the borders of the former Bering ADT. ATPC will specialize in the production of fuel and energy resources based on the development of the Bering coal basin, as well as the Zapadno-Ozernoe gas field and the Verkhne-Telekajskoe oil and gas condensate field. All necessary infrastructure for field development is being prepared.

The easternmost ATPC of Russia in the perspective up to 2050 can be formed relying on tourism and recreational services. To increase passenger traffic (mainly foreign cruise tourists) a network of balneological centers can be created. It will also require the development of transport infrastructure: seaports and airport complexes.
We can conclude that prospects for the Chukotka’s economic development are associated with several aspects: trends of the Northern Sea Route and its infrastructure revival; renewal of the peninsula energy system; the presence of profitable resource projects for the extraction of, copper, coal, oil and gas, and the need to develop the defence infrastructure on the northeast border of Russia.

3. **Key investment projects of the Peveksky ATPC**

Next, we will consider in more details several investment projects that can play a strategic role in the development of the Chukotka Autonomous District.

One of the largest projects of the Chukotka Autonomous District is the copper-porphyry deposit Peschanka, discovered in 1972 and located within the gold-ore Baimskoe field. Despite such a long-standing discovery, the study of this field began only in 2008. A foreign company Millhouse Capital UK Ltd received a license to develop this field. The deposit is located 180 km from Bilibino and is connected with it by seasonal winter road.

Exploration of the Peschanka deposit will continue until the end of 2019 during which the exact total resources will be calculated. According to preliminary data, more than 7 million tons of copper reserves, 300 tons of gold, 2 million tons of silver are concentrated on the ore field within an area of 22 km². Total investment in deposit development and the construction of all necessary infrastructure is estimated at $4 billion.

Currently, the company "Highland Gold Mining Ltd" is preparing for development one of the most promising gold deposits of Chukotka. The Kekura deposit is the main development project of Highland Gold, the launch of which is expected by 2019. In the license area of 1,497 square miles located several promising gold deposits in the vicinity of the Kekura field, subject to further exploration and will provide additional capacity for gold extraction. The field itself is located 150 km...
from Bilibino and is connected with it by seasonal winter road. The resource potential of the Kekura deposit is 2.8 million ounces of gold with a content of 8.69 g per ton (probable reserves — 1.67 million ounces). The deposit is effective for underground mining with a capacity of 50 to 200 thousand tons of ore per year. Expected average annual production is 1-2 tons of gold, 3-6 tons of silver. The energy load of the plant is estimated at 16 MW (energy costs reach up to 30% of the gold cost). Total estimated capital cost of the project is $229 million.

Development of the NSR is one of the main priorities for Russia. While the resource potential of the Northern regions growing, the need for high-quality transport infrastructure is increasing. However, many of the NSR ports are not designed to absorb large quantities of freight and are in need of modernization. One of these ports is Pevek. The sea port of Pevek was founded in 1951 and is located in the eponymous city of Chukotka Autonomous District. The port is used for unloading coal, handling large cargoes, mineral raw materials, construction materials and also for oil overflow from tankers [6]. In 2013 the port infrastructure had a fairly strong physical deterioration, after which it was decided to modernize the port in order to develop foreign trade relations of the region and the country. Total amount of funding is 770 million rubles, which is fully provided by the Federal budget. During the modernization, the volume of cargo turnover of the port will grow to 500 thousand tons by 2025, which will be due to the commissioning of new resource fields [12].

In Northern areas there is an extensive niche for nuclear power stations of low power (NPPLC). The rational location of such stations are hard-to-reach settlements with a complex scheme of fuel delivery and a significant promising increase in electrical loads in connection with the development of mineral deposits. NPPLC is intended for power and heat supply of rather large settlements with concentrated load or compact territorial location of consumers.

In United States, floating nuclear power plants were used both for military and civilian purposes at the end of the XX century, but after the detection of high radioactivity of waste, were decommissioned. In Russia, this kind of projects has only been discussed. Within the framework of the state program "Effective economy" for the period of 2002-2005 and for the future of 2010, it was proposed to create a floating NPPLC. As a result of a closed tender, in 2006 the largest Russian company in the nuclear industry Rosatom commissioned the creation of this project to Sevmash in the Arkhangelsk region, and in 2008 transferred the order to the Baltic plant located in the Leningrad region [13]. Rosatom state corporation is implementing a large-scale nuclear power plant construction program both in Russian Federation and abroad. Currently, 8 power units are under construction in Russia. 34 power units are being constructed abroad [13]. According to the project, the world's first floating nuclear thermal power plant (FNPP) will be equipped with two ship reactors of the KLT-40S type, which are successfully used on nuclear icebreakers [14]. The cost of one reactor is 16.2 billion rubles, including construction, equipment, reactor and shore facilities. Floating power unit is constructed at shipyard and delivered to any location by sea in the finished form. On the site of the placement, only auxiliary facilities are built to ensure the installation of a floating power unit and the transfer of heat and electricity to the shore. According to the project, the fuel will be reloaded every three years at the manufacturer. FNPP is designed with a large margin of safety, which exceeds all possible threats and makes nuclear reactors resistant to various kinds of natural disasters. In addition, nuclear processes on ships meet all the requirements of the International atomic energy agency. In 2011, the project received a positive conclusion of the state ecological expertise, which confirms absence of environmental threats [1].

In April 2018 construction of the first power unit was completed, which in early may to Murmansk went to be towed further. The planned commissioning of the head unit as part of the FNPP is scheduled on December 2019. According to experts, the station will last about 35-40 years [14]. Presumably, 2 teams of 69 people working in shifts will maintain the station.

The station is called "Academician Lomonosov" and will be located in the northernmost city of Russia —Pevek. The main purpose of FNPP creation is to provide energy to large industrial enterprises on the mainland, port cities, as well as gas and oil platforms located in the Northern seas in the future until 2050. One of the possible locations for NPP of this class is Severodvinsk, Arkhangelsk region,
which is the Northern center of shipbuilding and ship repair in Russia. Many countries in Africa, Asia and Europe are interested in such complexes.

The total electric power of the nuclear power plant will be 70 MW. This should provide in the nominal mode the supply of electricity to coastal networks and up to 50 Gcal/h of thermal energy to heating water in the Far North and the Far East [13]. It is planned that "Academician Lomonosov" will replace the Bilibino NPP, which will be decommissioned in 2019-2021. According to the rules and norms of nuclear energetics, nuclear power plant unit, stopped for decommissioning, continues to be in operation until the spent nuclear fuel is removed from the station. In the future, there will be long-term work on decontamination and dismantling of equipment, as well as processing of radioactive waste from the station. At the disposal of the Bilibino plant, construction of a floating nuclear power plant in Pevek will allow to meet the future needs of the Chaun-Bilibino node, since the total load of the Kupol, Dvoynoe and Elveneyskoye deposits is estimated at 33 MW. In the same area locates a promising Kekura deposit (16 MW), considered in this work.

The successful operation of Bilibino NPP confirms safety and efficiency of nuclear power in fuel-free Northern regions. FNPP "Academician Lomonosov", planned to be launched in 2019, will provide energy not only to nearby areas of Pevek, but also to the entire Chaun-Bilibino node, which concentrates a number of mining facilities and industrial enterprises. Due to the growing demand for electricity, with the support of Chukotka’s administration, high-voltage lines 110 kV Bilibino–Peschanka–Kekura and 220 kV Omsukchan–Kekura-Peschanka will be built along with the launch of the FNPP, capable of transferring the necessary amount of energy to remote territories of Chukotka and Magadan region. Construction of appropriate energy infrastructure will increase the investment attractiveness of the region. The operating experience of such an object can be used by other Arctic subjects of Federation.

In view of strategic importance of the above investment projects for the Russian Federation, under the "reversal" of domestic economic policy to the North and external to the East, it is necessary to work out scenarios for implementation of projects based on various mechanisms for territories development. The choice of optimal development approach should be based on the features of investment projects, their specialization and the territory of their operation.

4. Modeling and evaluation of the Chukotka’s investment projects

In order to assess the effects for business, region and country under different strategies of owners and the state in the implementation of the studied projects, was modified the simulation model of interests coordination of O. V. Tarasova [15]. The used model has a block structure: sources of project financing block, production and economic block, tax revenues block. The budget block disaggregates budget effects for the region and Federal budget (figure 2).
In the center of simulation are projects of Chukotka’s development: floating nuclear power plant "Academician Lomonosov", deposits "Kekura" and "Peschanka", as well as Pevek sea port. The main task is to form links between them: Kekura and Peschanka deposits will use the electricity generated at the FNPP. The alternative is the more expensive energy from the local low-power plant on imported fuel with all the consequences: higher prices, environmental burden, risks associated with the delivery of fuel. In turn, transportation of finished products in the form of concentrates from deposits will be provided by the sea port of Pevek, which will be reconstructed before the launch of the Kekura project. In total these projects will form the basis of Peveksky ATPC.

Launching of FNPP and "Kekura" will be available by the end of 2019, the port of Pevek by 2020, and the field "Peschanka" by 2025. 31% of investments in the construction of FNPP are to be at the expense of the Federal budget, the rest is financed by Rosatom. Development of the Kekura deposit is fully provided by the foreign company Highland Gold Mining Ltd, and the Peschanka deposit is provided by Millhouse Capital UK Ltd. Reconstruction and modernization of the Pevek port is carried out at the expense of Federal budget. On the basis of this information, as well as the main characteristics of the projects, the net present values (NPV) for each project, for regional and Federal budget on 2035 were calculated and the total effect of four projects was calculated.

According to the results of calculations in the initial scenario, by 2035 the Peschanka deposit does not pay off: Millhouse Capital UK Ltd has a negative NPV of 162 billion rubles. Negative NPV serves as a reference for cancellation the development of copper deposit. With this outcome, a baseline scenario for the development is being constructed: it takes into account only coordination of interests of three projects: FNPP−the Kekura deposit−the port of Pevek. As a result of baseline scenario...
implementation, NPV of the three project developers remains unchanged, but the NPV of the region and the country are declining (see table 1).

| Table 1. Comparison of project effects under various institutional scenarios (billion rubles) |
|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
|                                             | Initial scenario                            | Baseline scenario                           | Scenario of ATD foundation                  |
| Total effect                                | 16,593                                     | 23,115                                      | 44,751                                      | 43,277                                      |
| including:                                  |                                             |                                             |                                             |                                             |
| Federation budget                           | 76,157                                     | 12,085                                      | -24,759                                     | -23,846                                     |
| Budget of Chukotka                         | 88,193                                     | -3,232                                      | 27,026                                      | 22,685                                      |
| FNPP                                        | 3,398                                      | 3,398                                       | 9,643                                       | 9,643                                       |
| «Peschanka»                                 | -162,019                                   | 0                                           | 15,652                                      | 17,216                                      |
| «Kekura»                                    | 10,095                                     | 10,095                                      | 16,043                                      | 16,433                                      |
| Sea port Pevek                              | 0,769                                      | 0,769                                       | 1,146                                       | 1,146                                       |

There are two reasons for this. First – a strong reduction in tax revenues to the budgets of the region and Federation, and second – "Rosatom" is losing a potentially large consumer of energy produced on FNPP. According to the Order No. 1615 of the Russian Federation Government from 28.07.2017 "On prices (tariffs) for electric energy (power) for the subjects of Russian Federation that are parts of the Far Eastern Federal district", a basic level of prices for electric energy for guaranteeing suppliers in the amount of 4 rubles/KWh is established in the territory of Chukotka. Energy producers receive subsidies from the regional budget. Thus, they are partly compensated the cost of electricity: on the territory of Chukotka it is 12.76 rub/KW*h. Therefore, in the regional budget expenditure will exceed revenues and NPV in 2035 will be equal to -3,232 billion rub. The total effect of the projects will increase by 39% and amount to 23,115 billion rub.

When implementing the baseline scenario, it is necessary to introduce a mechanism that would increase the total benefit of all participants. A development scenario involving the creation of the Baim ADT (recently implemented in the form of the Chukotka ADT) was considered. This mechanism involves the work of resource projects Peschanka and Kekura inside ADT with the corresponding benefits. As for the technological bundles in the complex, the following assumptions were made. In connection with the launch of a large copper mining project, the turnover of the Pevek port will increase by 20% and will amount to 600 thousand tons per year. Also, the launch of the project will affect the development of FNPP: with a positive effect of scale, the productivity of FNPP will grow by 40%, which will lead to a decrease in electricity prices (a decrease in the price growth rate by 1%). We see that the creation of ADT entails an increase in tax revenues to the budget of the region and the Federation, at the same time, the total costs of subsidizing electricity purchases increase. As a result of this scenario, the profit from Kekura project will increase by 58.9% and will amount to 16,043 billion rubles. The total effect will increase to 44,751 billion rub. due to large flows from the project Peschanka. Development of this field is of particular interest for various large companies, one of which is Norilsk Nickel. This means that launching such a large project is necessary not only for the development of the region. To implement the project, it will be necessary to attract more than 4,000 people (slightly less than 10% of the Chukotka population) to Bilibino area. Our next scenario is based on the assumption that at least 1/5 of employees will become local residents. With a family coefficient of 2.5 it will be necessary to build about 55 thousand square meters of housing as well as 2 schools. We have allocated these costs to the district budget (see the Integrated development scenario in table 1). At the same time, the costs of companies operating resource facilities will decrease as soon as a number of shift workers who need to be delivered to the work place will decrease. The total gain will
be 43.277 billion rub. (lower estimate, since the operating costs of educational institutions and utilities for new housing are not included in the model).

Thus, various scenarios for the development Pevek ATPC were analyzed, among which the most profitable for participants was selected - the foundation of advanced development territory. In this case, there is an increase in business gains, as well as an increase in the total effect of four projects.

5. Conclusions
Systematization of data on promising projects of the Chukotka Autonomous District allowed defining the contours of three promising ATPCs - Peveksky, Anadyrsky and Lorinsky. Further, using the author's simulation model, forecasted effects of four technologically related projects were assessed: the copper deposit Peschanka, the gold deposit Kekura, the floating nuclear power station and the Pevek sea port. The toolkit created by the authors can be used to justify the development priorities of the Chukotka Autonomous District, as well as to assess the various institutional conditions for the implementation of investment projects in the region.

Acknowledgements
The article was prepared as a part of the research project of IEIE SB RAS AAAA-A17-117022250123-0.

References
[1] Ivanova I Yu et al 2002 Small-scaled energy of the North: problems and ways of development (Novosibirsk: Nauka Publ.) p 188
[2] Volkov A V et al 2017 Prospects of gold mining development in the Chukotka autonomous district Arctic: Ecol. and Econ. 4(28) 83-97
[3] Vilenskiy P L et al 2008 Assessment of Efficiency of Investment Projects: Theory and Practice (Moscow: Delo Publ) p 1104
[4] Kryukov V A et al 2016 Formation of Interregional Process Chains to Improve the Economic Efficiency of Developing Popigai DiamondLonsdalite Deposit ECO 8 51-66.
[5] Kryukov V A and Kryukov Ya V 2017 The interaction of the North and the South of Siberia: management of multiplicative effects Vestnik NSUEM 4 22-27
[6] Bandman K M and Chistobaev A I (eds) 1990 Territorial production complexes: experience and problems of formation (St. Petersburg: Nauka Publ.) p 216
[7] Selin V S and Bashmakova E P (eds) 2012 Economic security and reducing the uneven spatial development of the Russian North and the Arctic (Apatity, Publ. of Kola Sc. Center RAS) p 232
[8] Malov V Yu, Tarasova O V 2014 Transport in the Arctic zone of Russia as a sphere of common interests of the state and corporations Reg.: econ. and soc. 4 129-135
[9] Pilyasov A N 2017 Economy of the Arctic «Islands»: The Case of Nenets and Chukotka Autonomous Okrugs) Econ. of Reg. 1 114-125
[10] Baklanov P Ya 1988 Features of complex formation in coastal districts (Geography of ocean theory, practice, problems. Leningrad: Nauka Publ.) 131-148
[11] Baklanov P Ya Territorial structures of the economy in the regional administration 2007 (Moscow, Nauka Publ.) p 23
[12] Levachev S N and Kantarzhi I G 2015 Research and design of port facilities at the port of Pevek Scien. and Safety 15 17-33
[13] Rosenergoatom 2012 Annual Report of Rosenergoatom Concern OJSC Available from: http://www.rosatom.ru/upload/iblock/852/8525d76a39d2f133140e1e4e53e0da43.pdf [Accessed 3rd September 2017]
[14] Ipatov P L 2016 FNPP - prospects for the power supply of the northern territories Presentation of the report on IX Regional Public Forum-Discourse “Nuclear Energy in the Arctic: Ecology and Safety” Available from: https://www.osatom.ru/mediafiles/u/files/IX_reg_forum_2016/3_Ipatov_20160510_Obshestvennyj_
forum_po_razvitiyu_Arktiki.pdf [Accessed 20th February 2018]
[15] Tarasova O V 2013 Coordination of interests of the northern territories development participants (Novosibir: Publ. of IEIE SB RAS) p 189