IOP Conf. Series: Earth and Environmental Science **459** (2020) 062024 doi:10.1088/1755-1315/459/6/062024

Assessment of the Prospects of Developing the Western Arctic Shelf Fields on the Basis of Evaluation of the Technical-Economic Potential of Fields

A M Fadeev[1] and V A Tsukerman[1]

[1]Luzin Institute for Economic Studies Federal Research Centre «Kola Science Centre of the Russian Academy of Sciences, Apatity, Russia

E-mail: AlexFadeev@gmail.com, tsukerman@iep.kolasc.net.ru

Abstract. The paper discusses the methodological issues of assessing the technical and economic potential of the Arctic hydrocarbon fields which can be used to make strategic decisions on the management of the oil and gas sector and the exploitation of natural resources. The sequence of calculation steps of the technical and economic potential of marine oil and gas fields of the Arctic which, unlike the existing ones, is based on an integral indicator that combines the financial, technical, climatic, and service-infrastructure characteristics of the fields what allows rating the fields to determine priority of the start of their development is proposed. The need to take into account a wide range of factors in a comparative analysis of oil and gas fields of the Arctic in order to make strategic management decisions on the priority of field exploitation is proved.

1. The aim of the study and its relevance

Existing methods for assessing the effectiveness of oil and gas fields (OGF) are mainly based on the analysis of material and financial flows. Such approaches related to financial analysis without affecting such important characteristics as the technical and economic potential of the assessed deposits as well as the assessment of their impact on the level of socio-economic development of nearby territories.

The insufficient elaboration of these directions as well as the orientation of existing methods for evaluating the effectiveness of design solutions in the field of OGF exploitation mainly towards financial analysis have led to the need to develop an complex mechanism of strategic project management based on the level of potential development of the analyzed objects. Arctic OGFs by their technical and economic indicators are at a different level of development.

In a broad sense the concept of the OGF development is interpreted as a system of views on any object, phenomenon or process [2]. Meanwhile, the concept of assessing the level of the Arctic OGS development gas should be determined as a system of theoretical and methodological approaches and tools for the development of an complex methodology that allows to aggregate existing plans for the exploitation of fields, make a quantitative mathematical calculation of the technical and economic potential of fields, develop indicators of project effectiveness and provide information about the impact of the exploitation level of the fields on the socio-economic development of territories.

2. Methods of complex assessment of the potential of hydrocarbon fields

Assessing the level of OGF development by a set of indicators one can encounter a situation where the same object can take both leading and lagging positions by different characteristics. Fields in the Pechora Sea can be considered as the most favorable in terms of exploitation in comparison with the fields of the Barents and Kara Seas but the severe ice conditions says otherwise. A similar situation is observed in the comparative analysis of fields by other parameters and allows to conclude that when determining the sequence of field exploitation it is necessary to take into account the maximum number of parameters both quantitative and qualitative diversifying their features. A complex indicator that aggregates a set of different parameters is proposed to be interpreted as "development level of oil and gas fields" (DLOGF). It can characterize the influence of technological and economic factors on the state of fields in a certain period of time.

For the effective strategic management of the oil and gas sector when developing marine hydrocarbon fields of the Arctic it is need to assess the aggregate technical and economic potential of each field at the initial stage.

The most common approach to the characterization of economic objects and systems in terms of their economic and technical potential is the analysis of indicators of income and expenditure, production indicators, organizational and financial characteristics, etc. [4–6]. However the use of such economic-financial approach to assessing the potential of OGF will not give a full picture since a number of different specific indicators reflecting the development of the oil and gas sector including such as resource potential, climatic conditions, and the development of service infrastructure are not taken into account.

In this regard Russian scientists [7–9] in the field of research of the energy sector development to assess the technical and economic potential of OGF use the following system of indicators: distance from the coast and the depth of resources; the necessary costs for the exploitation of deposits and obtaining the estimated profit; the amount of available energy resources, their price and estimated annual extraction. The use of the resource component when assessing the aggregate potential of OGF is substantiated by the need to determine the future economic result which is particularly important information for the investor.

Thus, a complex analysis of the technical and economic potential of the Arctic OGF should be carried out on the basis of a set of indicators what makes it possible to substantiate the concept "technical and economic potential" providing the aggregate ability of individual OGF to provide creation of the maximum amount of regional effects and form the highest efficiency of investment projects.

In this regard the entire aggregate of indicators characterizing the level of OGF development is proposed to be divided into the technical potential of the field (aggregate of technical indicators) and the economic potential of the field (aggregate of economic indicators).

According to the authors this classification is logical in its relationship since a certain level of technical potential of an individual field is in close relationship with the level of its economic development.

From the aggregate of the presented indicators some are quantitatively comparable others show only qualitative characteristics. In this regard it is necessary to give quantitative values to qualitative indicators with the help of ball scores. To ensure a methodically substantiated transfer of qualitative characteristics into quantitative indicators it is advisable to use a methodology based on the Harrington scale [10]. In accordance with this methodology three estimated gradations of the expression of parameters change were adopted what made it possible to present the reduced Harrington scale as follows (table 1).

Fields of the Western Arctic shelf (Pechora, Barents and Kara seas) were selected as objects of study as the most promising, since they concentrate more than 70% of energy resources [11].

Different size characteristics must be aggregated into one indicator. To do this the most suitable is the method of integral analysis [12; 13] which allows formally combining into one quantity (integral index) the entire set of features with quantitative heterogeneity. The advantage of this method is the

possibility of comparing heterogeneous indicators by aggregating them into appropriate values of the technical and economic potential of the fields.

Table 1. Reduced scale Harrington to determine quantitative values.

Indicator	Qualitative assessment	Quantitative value
Ice conditions	light	0.7–1.0
	medium	0.46–0.70
	difficult	0 – 0.45
Availability of developed coastal service infrastructure	exist	0.71–1.0
	poorly developed	0.46 – 0.70
	absent	0 – 0.45
Availability of technologies for the field exploitation	exist	0.71 – 1.0
	poorly developed	0.46 – 0.70
	absent	0 – 0.45
Logistic accessibility	light	0.71 - 1
	difficult	0.46 – 0.70
	extreme	0 – 0.45
Availability of market	obvious	0.51 – 1.0
	implicit	0 – 0.50

The calculation of the integral index in accordance with the method of V. Pluta [13] is proposed to be carried out in 4 stages:

The first stage involves the standardization of indicators. The matrix is being built and its elements are defined as a system of indicators of the technical and economic potential of the OGF. Such indicators are heterogeneous since they are expressed both in absolute and relative values what makes it impossible for the simple arithmetic operations necessary to calculate the integral indicator.

At the second stage the differentiation of indicators is performed. All used indicators describing the technical and economic potential of OGF are divided into incentives and disincentives. The basis for such a classification of indicators is the nature of their influence on the development level of the field. Parameters that have a positive stimulating effect on the development level of deposits are called incentives. Parameters that inhibit or negatively affect the development level of deposits are called disincentives.

At the third stage the calculation of the distance matrix is performed. According to the results of standardization of indicators the matrix of distances is calculated.

At the fourth stage, the integral indicator is calculated. Previously obtained distances are used to calculate the final technical and economic potential of the OGF which quantitatively expresses all the aggregated indicators.

The integral indicator of the development level of oil and gas fields presented in the paper as their technical and economic potential is positive value and ranges from 0 to 1. The economic interpretation of the values of the integral indicator is presented as follows: a separate oil and gas field in the Arctic has as higher level of development (technical and economic potential) as closer the value of its integral indicator to 1. The general DLOGF indicator is calculated by the method of weighted average value (the average value between the integral indicators of technical and economic potential).

Based on the data obtained a rating of the development level of oil and gas fields of the Arctic is compiled (table 2).

Table 2. Rating of the development level of oil and gas fields of the Arctic.

Field name	Calculated values of integral indicators			Position in the aggregate rating
	Technical potential	Economic potential	DLOGF	
Dolginskoe	0.25	0.27	0.67	1
Murmanskoe	0.83	0.21	0.64	2
Varandey-more	0.90	0.03	0.61	3
Severo-Kildinskoe	0.59	0.25	0.61	4
Pomorskoe	0.34	0.27	0.59	5
Prirazlomnoe	0.33	0.17	0.59	6
Severo-Gulyaevskoe	0.45	0.10	0.59	7
Medynskoe-more	0.35	0.24	0.59	8
Rusanovskoe	0.16	0.45	0.57	9
Leningradskoe	0.10	0.49	0.57	10
Shtokmanovskoe	0.41	0.34	0.52	11
Severo-Kamennomysskoe	0.33	0.30	0.50	12
Kamennomysskoe	0.42	0.22	0.48	13
Ledovoe	0.24	0.08	0.43	14
Ludlovskoe	0.22	0.11	0.42	15

The method of integrated analysis allowed aggregating into one indicator the entire set of heterogeneous factors for each of the analyzed fields to compile their ratings by the size of the total technical and economic potential. For this purpose the final rank (ranking positions) is calculated which should be interpreted in such a way that the first rank in the ranking is considered the best.

The results of the analysis showed that such fields as the Varandey-more and the Murmanskoe gas fields have the highest development level of the technical potential and their integral indicators are respectively 0.90 and 0.83. Thus the leading positions for the exploitation of the Varandey-more field are based on low values of indicators-disincentives namely remoteness from the coastline and the depth of the sea in the area of the field what makes the exploitation of this field relatively favorable. For the Murmansk field the first positions in the rating were achieved due to light ice conditions, the availability of developed coastal service infrastructure, technologies for field exploitation which are defined as indicator-incentives that is those that positively affect the final level of technical potential.

The Rusanovskoye and Leningradskoye fields have the lowest technical potential in the comparative rating and their integral indicators are respectively 0.16 and 0.10. Closing positions in the rating of these fields are due to the relatively high values of the depth indicator of the sea in the waters of the Kara Sea as well as the lack of a developed coastal service infrastructure.

The average value of the aggregate of the analyzed objects is 0.39, of which 6 fields (Varandey-more, Murmanskoe, Severo-Kildinskoe, Severo-Gulyaevskoe, Kamennomysskoe, Shtokmanovskoe) have a level of technical potential above the average what is a good trend for the industry and positively characterizes the decision to start the development of such objects. The difference between the maximum and minimum value of the integral indicators of technical potential is 88% what characterizes the high degree of difference between the analyzed fields in terms of their technical characteristics. This is one of the bases for making management decisions regarding the start of field exploitation activities in order of determining their priority. The second basis should be considered as the level of economic potential of fields.

The results of calculations showed that such fields as Leningradskoe, Rusanovskoye and Shtokmanovskoe have the highest development level of the economic potential and their integral indicators are 0.49, 0.45 and 0.34 respectively.

Thus the leading positions for the Leningradskoe, Rusanovskoye and Shtokmanovskoe fields were achieved due to the highest values of the indicator of the predicted volume of energy production what

fairly characterizes these fields as unique in terms of reserves. At the same time Shtokmanovskoe field has the maximum forecasted amount of energy resources but it ranks third among the leaders. This is due to the influence of such indicators-disincentives as the need for large capital investments and high operating costs associated with the field exploitation and dictated to a greater degree by the technical characteristics of the field namely the distance from the coast, depth and the increased complexity of ice conditions.

The lowest level of economic potential in the compiled rating have Varandey-more and Ledovoe fields with integral indicators 0.03 and 0.08 respectively. The closing positions in the rating of the fields ensured by relatively low values of the forecast volumes of energy resources production (for Ledovoe field) and by the minimum indicator of the investor's expected income (for Varandey-more field).

The average value by the aggregate of the analyzed objects is 0.23, of which 8 fields (Leningradskoe, Rusanovskoye, Shtokmanovskoe, Severo-Kamennomysskoe, Dolginskoe, Pomorskoe, Severo-Kildinskoe and Medynskoe-more) have a level of economic potential above the average what is a good trend in the industry average and positively characterizes the decision to start the exploitation of such objects. The difference between the maximum and minimum values of the integral indicators of the economic potential is more than 90% which also indicates a high degree of difference between the analyzed fields in terms of their economic characteristics.

A comparative assessment of oil and gas fields by set of parameters characterizing their technical and economic potential indicates that some of the fields that are leaders in technical potential have last positions in terms of economic potential. This statement is also true in the opposite direction. These circumstances have led to the need to calculate the complex final integral indicator which in this study is defined as DLOGF for all technical and economic parameters at once.

At the end of the ranking are Ludlovskoe and Ledovoe fields and their integral indicators are to 0.42 and 0.43 respectively. These positions are primarily due to the difficult conditions of energy resources extraction (remoteness from the coast, sea depth and moderate ice conditions), extreme logistic accessibility and an implicit market. In this case despite the significant reserves of energy resources which make it possible to characterize such fields as large the indicator-disincentives had a negative impact on the aggregate rating.

3. Conclusions

The proposed sequence of actions for a complex assessment of the potential of hydrocarbon fields of the Russian Arctic has revealed and proved a number of contradictions. In this case we are discussing the fact that the most promising regions of the Western Arctic shelf in terms of estimated volumes of energy reserves as well as geographic proximity to foreign consumers being leaders in the economic potential rating are far from the first positions in the comparative analysis of DLOGF by the entire set of features. The reason for the change of positions in the aggregate rating is the influence of the climatic characteristics of the Arctic shelf which make the fields difficult to access and exploit in technical and technological terms [14]. It leads to the need for ultra high costs for the development of projects as well as the need to attract for Russian companies not only additional investment capital but also new technologies and experience of foreign companies.

The proposed arrangement of objects in the aggregate rating proves the need to take into account a wide range of factors in a comparative analysis of oil and gas fields of the Arctic.

The methodology for analyzing projects for the OGF exploitation should include not only the calculation of the economic efficiency of the project but also an assessment of the technical, infrastructure, climate and other characteristics of the study object. It proves the fact that against to the popular opinion that the largest fields by the volume of energy resources are subject to priority development it is necessary to involve into the analysis such parameters that allow taking into account the diverse properties of the study object [14, 15].

References

[1] Belogoryev A M, Bushuev V V, Gromov A I, Kurichev N K, Mastepanov A M, Troitsky A A 2011 Trends and scenarios for the development of world energy in the first half of the XXI century *Energy* (Moscow)
[2] Butler B 2007 Finance Oxford Dictionary (English-Russian) *Ves Mir Publishers* (Moscow)
[3] Ozhegov S I 1999 Explanatory dictionary of the Russian language: 8000 words and phraseological expressions *Azbukovnik* (Moscow)
[4] Vlasov M P, Shimko P D 2011 Modeling of economic processes *Phoenix* (Rostov on Don)
[5] Kvint V L 2012 Strategic management and economics on a global forming market *Business Atlas* (Moscow)
[6] 2010 Modeling of economic processes *Unity* (Moscow)
[7] Bushuev V V 2007 World energy: state, problems, prospects *Publishing and analytical center Energy* (Moscow)
[8] Voronin A Yu 2004 Energy strategy of Russia *Financial control* (Moscow)
[9] Gitelman L D, Ratnikov B E 2008 Energy business *Business* (Moscow)
[10] Litavak V G 1998 Management decisions *EKMOS* (Moscow)
[11] 2010 The North and the Arctic in the spatial development of Russia: scientific and analytical report *KSC RAS* (Apatity)
[12] Soshnikova L M, Tamashevich V N 1999 Multidimensional statistical analysis in economics *UNITY* (Moscow)
[13] Pluta V 1989 Comparative multidimensional analysis in econometric modeling *Finance and Statistics* (Moscow)
[14] Fadeev A M 2011 Management of the oil and gas sector of the new mining region when exploiting marine hydrocarbon fields of the Arctic *KSC RAS* (Apatity)
[15] Fadeev A M, Cherepovitsyn A E, Larichkin F D, Egorov O I 2010 Economic features of the implementation of projects for the exploitation of shelf hydrocarbon fields *Economic and Social Changes: Facts, Trends Forecast* **3(11)** 61-74

Acknowledgments

The work was supported by the RFBR project 17-02-00248 "Innovative factors in the development of the Arctic shelf and the problems of import substitution". Authors thank Ivanov Stanislav Victorovich for translation and help with preparation of materials.