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Problems of unconventional gas resources production in arctic zone -Russia-

Problemas de producción de recursos gasíferos no convencionales en la zona ártica rusa

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Content

ABSTRACT:
This paper is aimed to underline strategic importance of the Arctic as a wealth of petroleum and mineral resources. One of the most potential nonconventional sources of natural gas is gas hydrates, which impressive resources are concentrated in the Arctic Zone. The paper in general presents main characteristics of the Russian Arctic and gas recourses. Then we present some economic issues of gas hydrates production and it is paid special attention to environmental regulation of natural recourses production.
Keywords: Arctic, gas production, environmental regulation.

RESUMEN:
Este documento tiene como objetivo subrayar la importancia estratégica del Ártico como una riqueza de petróleo y recursos minerales. Una de las fuentes no convencionales más importantes de gas natural son los hidratos de gas, cuyos impresionantes recursos se concentran en la zona ártica. El documento en general presenta las principales características del Ártico ruso y los recursos de gas. A continuación, presentamos algunos aspectos económicos de la producción de hidratos de gas y se presta especial atención a la regulación ambiental de la producción de recursos naturales.
Palabras clave: Ártico, producción de gas, regulación ambiental.

1. Introduction

Russia is one of the most important players in the Arctic Zone with wide range of economic, security and political interests in the region. Arctic is a wealth of petroleum, gas and other mineral resources. From being regarded almost like a restricted area, the Arctic has become a global economic, ecological and social concern (Moe,2016).

In 2008, the United States Geological Survey (USGS) estimated that the Arctic might contain 13% of the world's undiscovered oil and 30 % of its undiscovered gas (Gautier, 2009). Of these hydrocarbon resources, 84% were believed to be offshore and most of them are not distributed: the highest concentrations are expected to be in north of Alaska and in the western part of Russia (Moe,2016).

Oil and gas resources are vital to Russian national security and economy; oil and gas alone account for roughly 20-25% of Russian GDP (Simola, 2013).

Arctic has been proclaimed as the resource base of the twenty-first century (Moe,2016). The Russian Arctic shelf in the future can become the main source of hydrocarbons for both Russia and the world market in the whole. Its industrial development in some circumstances (oil and gas prices, new knowledge and technologies, legal framework, etc.) may compensate decrease in oil and gas production in the old deposits in Russia (Western Siberia). The special role is assigned to up-to-date extraction technologies and oil and gas recovery technologies, providing energy effectiveness and ecology safety [Cherepovitsyn,2016; Zyrin, 2016: Nikolaev, 2016] and also to extraction of nonconventional oil and gas resources. One of the most important nonconventional sources of natural gas is gas hydrates (GH).

Gas hydrates are crystalline gas and water compounds with a variable composition. According to various estimates, natural gas hydrates contain about 2,000-5,000 trillion cubic meters of natural gas. Most part of these gas resources is concentrated in the Arctic Zone. According to Russian estimates, up to 1,000 trillion cubic meters of gas hydrates may be present in the Russian Arctic (Youkashev, 2015).

In this paper we would like to pay special attention to the technologies providing gas hydrates production in the Arctic Zone and to the ecological aspect of this activity

2. Methodology

The base for the research is analytical review of up-to date, law requirements and economical and ecological aspects for Arctic zone gas recovery, methods of case study has been used.

3. Results

Despite the wide range of existing papers devoted to different aspects of Arctic zone development ward [8,9,10] perspectives of oil and gas production in the Arctic (Henderson, 2014; Zysk, 2011; Keil, 2012;Conley, 2013; Conley, 2010), there are no publications devoted to prospects of gas hydrates production in the Arctic that take into account peculiarities of the Arctic territories and necessity of environmental safety and compliance on this territories. Previous studies have addressed policy interests of different countries in the Arctic (Conley, 2010; Heininen, 2012; Kapyla, 2013), Arctic energy policy and energy security (Peimani, 2013; Tamnes, 2014), Russian thinking, policies, and challenges in the Arctic (Laruelle, 2014) and others.

There are a several technologies of gas hydrates production, which are proposed in numerous publications and researches (Boswell, 2011), which are based on dissociation process and include: depressurization (decompression), thermal treatment (injection), chemical treatment, CO2 (carbon dioxide) or other gas injection.

Despite the enough quantity of technologies there is no any which has a stable wide commercial implementation, only several days' field tests.

Because of the growing interest for gas hydrates as a future potential energy source the ecological aspects is taken the leading role. The researches (Zhen-guo Zhang, 2012; Hatzikiriakos, 1993) show that methane hydrate recovery is a process with several important ecological problems. Firstly, hydrate is 25 times more active greenhouse gas as a carbon dioxide and massive methane releasing can be shortly the source of intensive global climate change. This issue is especially significant for Arctic region, which sensitive for any climate changes. But some papers (Hatzikiriakos, 1993) shows that global temperature rising to 0.08◦C per year may cause heating the Arctic gas hydrate permafrost formations at a depth 198 m less than 100 years without technological impact, for any final conclusions the more researches should be done.

The second important problem is concerned with seabed stability for marine formations. The methane gas hydrate plays a leading role in stability of seafloor. Massive methane release could impact on fragile marine ecolife and cause sediment slide under gravity force down the continental slope.

So, many papers present case descriptions related to the Arctic and discuss such issues as geopolitics, politics interests, energy security, and others. A lot of papers devoted to oil and gas projects also are narrative and many papers are op-ed articles. However, there are not enough research papers focusing specifically on perspectives of gas hydrates production in the Arctic and ecological aspects of this activity. In fact, activities such as gas hydrates production in the Arctic have different underlying issues that could be taken into account. This paper sets out to research this issue.

3.1. Economic issues of gas hydrates production in the Arctic

Today, there is only one pilot project of gas hydrate production, storage and transportation in Japan. That's why now it is impossible to estimate the costs of such projects due to the lack of field trials of this technology in Russia (The Arctic 2015).

In general the commercial attractiveness of many Arctic projects is questioned (Laruelle,2014); for instance, economic efficiency of offshore oil and gas projects in the current conditions is low. Research conducted by the authors of this paper in 2011-2012 proved that these projects can be marginally profitable. The detailed calculations obtained on the basis of data of the Gazprom Company present that in case of oil price about 80-90 dollars for barrel Internal Rate of Return (IRR) of main oil and gas shelf projects is around 6-10%. Considering the oil price nowadays (55-60 dollars for barrel) it is logical that IRR considerably decreased. Taking into account the fact that technologies of gas hydrate's production, storage and transportation are not developed and are not adopted to the Arctic conditions in Russia, it is possible to assume that gas hydrate projects are less profitable than shelf oil and gas projects.

One more crucial problem of gas hydrate's projects in the Arctic is environmental safety and compliance. The additional concerns raised by increased industrial activity in the Arctic, in particular connected with oil and gas production, are currently leading to calls for greater attention to environment and ecology. The importance of ecological aspect in the Arctic cannot be overestimated: it is the area of global ecological concern (Ilinova,2017).

3.2. Environmental regulation of natural recourses production in the Arctic

From the point of view of government regulation, many state documents have considered strategies of different countries in the Arctic (Finland, Kingdom of Denmark, Norway, Sweden, US)

The development of the Arctic region in Russia is governed at the state level by set of different legal documents. The main document is The Strategy of developing the Arctic zone of the Russian Federation and national security system for the period till 2020.Analyzing the main acts and documenting it are possible to conclude that most likely; it has a theoretical character than practical. Russia does not have a comprehensive strategy in the form of an integrated and coordinated policy in the Arctic [19], including environmental regulation in the region. Even though a document entitled Strategy for development of Russia's Arctic zone was adopted in 2013, this observation still stands.

An important role in environmental policy in the Arctic plays such international environmental organizations and structures as International Independent University of Environmental and Political Sciences, International Arctic Scientific Committee, Arctic Monitoring and Assessment Program, World Meteorological Organization, Greenpeace, World Wildlife Fund and others. The most influential are such international organizations as the Arctic Council, Convention for the Protection of the Marine Environment of the North-East

Atlantic (OSPAR) and Helsinki Commission (HELCOM). Russia is a permanent member of the Arctic Council.

From the point of view of government regulation, set of state documents in different countries regulates environmental policy in the Arctic. Legal framework of the Arctic countries is presented in **TABLE 1**.

TABLE 1
Environmental regulation in the Arctic countries

Country	Regulatory documents and laws
USA	Federal Environmental Law. 999 edition. West Group 1999, 42 U.S.C.A. § 4321 to 4370b (1999) Comprehensive Environmental Response, Compensation and Liability Act – CERCLA (1980) Outer Continental Shelf Lands (OCSLA) (1972) Marine Protection, Research and Sanctuaries Act (MPRSA)(1972) Energy Policy Act (2005)
Canada	Northwest Game Act (1906) Arctic Waters Pollution Prevention Act (1970 R.S.C. 1985) Gas Flaring and Venting in Alberta: Report and Recommendations for the Upstream Petroleum Industry by the Flaring/Venting Project Team. – Clean Air Strategic Alliance (2002) Canadian Environmental Protection Act (CEPA) (1999) Canadian Environmental Assessment Act (CEAA) (2012) Reclaimed Industrial Sites Act (2006)
Denmark	Consolidated Environmental Protection Act № 698 (1998) Act No. 292 of April 27, On Access to Information Relating to the Environment «Environmental Information Act» (1994) Act no. 420 of June 13, on Waste Deposits (1990) Greenland Bureau of Minerals and Petroleum Drilling Guidelines (2011)
Norway	Act relating to petroleum activities in 1997 (“1997 Petroleum Regulation”) Guidelines for offshore environmental monitoring (2011)
Russia	Federal Law on Environmental Protection (2002) Federal Law on the Continental Shelf of the Russian Federation (1995) Federal Law dated July 31, N 155 On Internal Sea Waters, Territorial Sea and Adjacent Zone of the Russian (1998) The Federal Law «On Specially Protected Natural Territories» dated March 14, № 33 (1995)

In spite of the fact that nowadays in Russia there is a number of documents fully or partly devoted to environmental regulation in the Arctic Zone, the environmental opposition to Arctic oil and gas projects is minimal in Russia. In the past, Russia has not given environmental problems as much attention as many Western countries have, but an energy policy has now been presented for the public discussion as a Project of Energy Strategy of Russian Federation for the period till 2035 (edition of February 1, 2017). The Strategy objectives include improved energy efficiency as well as limitation of the impact of the fuel and energy complex on the environment and climate.

3.3. Technological and environmental issues of gas hydrates production in the Arctic

The gas hydrate recovery technologies are based on dissociation process, i.e. hydrate separation on gas and water and can be joined in the groups as following: depressurization, heat treatment, chemical treatment.

These methods include decreasing pressure inside the formation around the drilling well or water or free gas pressure on the hydrate after it removing.

3.3.1 Depressurization. Numerous theoretical and field researches reveal that the depressurization is the most effective method for GH recovery. The main idea of this method is decreasing pressure inside the formation around the well or water or free gas pressure on hydrate seam. Depressurization is effective for the deposits with depth more 700 m, especially for located near the free gas layer.

The technology firstly has been field tested within the framework of Japanese-Canadian joint research program at the Mallik site, Canada, and has provided sustained production during 6 days with use of submersible pumps (Hancock, 2005; Dallimore, 2002). Mallik site is located at Canada permafrost region, where hydrate formation locates on depth more than 900 m.

The second field test of the depressurization technology was provided by Japan MH-21 program at Atsumi deposit but for the deep water conditions (depth around 1300 m). After 6 days test the production rate was 13 000 m3 of methane.

The main feature of the depressurization technology is that it highly depends on the deposit location, so for marine reservoir (such as Atsumi, Japan), where the complicated formation structure was the reason of experiment stop, because the rock parties which was held by hydrate became mobile after hydrate dissociation and have blocked the well. But this test results shows the real recovery problems, the main of which can be solved with using sand-control methods or similar technologies.

3.3.2 Heat treatment. Heat treatment technology includes steam injection, hot water or brine injection, cyclic stimulation technologies, electrical heating (Liang, 2005).

Scientific experiments conducted at the Mallik site in arctic Canada (2002) was based on the injection on heated up to 80◦C water. But technology has shown low results – 470 m3 for 5 days when, as it was mentioned above, with the depressurization the 13 000 m3 of methane has been produced.

The efficiency of this technology depends on the formation depth. The main drawbacks of the heat treatment technologies are high energy consumption, problems with heating agent transporting to the hydrate zone without heat loss and prevention of upper layers heating, long time dissociation process.

3.3.3 Chemical treatment. Chemical treatment technologies require injection of chemical inhibitors (methanol, brain, glycol etc.) for faster and efficient hydrate dissociation. But the main limiting point for these technologies is high ecological risks of using inhibitors and proven low speed of process. Another way of chemical methods is CO2 injection, but it efficient only for water-bearing gas hydrates reservoirs, physical and chemical reactions are very difficult and require a numerous researches.

Analyzing above mentioned technologies, depressurization shows the highest potential, but combination of methods could provide more effective gas production.

The potential technologies for methane producing from GH are energy effective complexes, which could combine several recovery methods and guarantee the ecological safety. For instance, the electrothermal complex, created in Saint-Petersburg Mining University, which can be used for depressurization and combination of heat and chemical treatment (Kozyaruk, 2015).

Despite of complex gas hydrate formation recovery the much more important problem need to be taken into account – the ecological risks, especially for Arctic region.

3.3.4 Ecological impact. Today's research about gas hydrate impact on climate change is numerous, but only several make some predictions for Arctic region. But most of them are about the risks of massive methane release after uncontrolled hydrate dissociation, which has no connection to technological treatment.

Gas from hydrate is powerful greenhouse gas and this fact is very important and need to be considered for the Arctic regions. The East Siberian Arctic Shelf at Svalbard formation (Shakhova, 2010; Westbrook, 2009) reveals the release of methane from the Arctic zone to the ocean, but the source of gas is not clear. That is why releasing the methane due to technological treatment need to be researched carefully. After that the potential risks and limitation of used methods for Arctic can be evaluated. Proved fact is that for GH formation with low depth drilling process is the reason for gas releasing and occurrence of accidents.

Another ecological issue is impact of possible hydrate production from marine deposits to stability of seabed. Strict bonds of hydrate with the near formation provide the seafloor stability and it methane extraction could rise seafloor slumps. Nevertheless, the research of the large slide in the Cape Fear shows low impact of hydrate on this process detailed study of the largest slide feature (the Cape Fear slide), has shown little evidence of a significant role for gas hydrates in that. To prevent seabed deformation can be used technologies proposed the replacement of hydrate-forming gases by pumping seawater with the dissolved natural hydrogen sulphide (Oveckiy, 2016).

4. Conclusions

In the whole, at this stage the Russian Federation largely keeps up from the European countries and USA in the sphere of environmental issues, that is why close cooperation with international ecological organizations can have a positive effect both on the development of the national science and in this area, and on the improvement of new ecologically friendly technologies. Active ecological policy in respect of distinguishing technologies for oil and gas production in the Arctic will help to save ecosystems of the most important strategic region of the Russian Federation and the whole world for the further effective and sustainable development of the territories.

Gas hydrates are one of promising nonconventional sources of gas in the long term period. In this regard issues of development of ecologically safe technologies which will allow to get gas hydrates is especially relevant. The ecological risks are the main point for future gas hydrate production, and technological progress should be based on the ecological safety, and could be provided in the following ways:

1. Government and public control for any implemented Arctic hydrate recovery technologies
2. Complex research of drilling process for GH formation
3. Proved by numerical researches and simulation, field test efficiency and safeness of implemented technologies for Arctic deposits
4. Careful technology control – control for formation condition, gas production rates prevention of creating so called gas-hydrate bomb
5. Control on hydrate decomposition and gas releasing through evaporation
6. Exclude aggressive inhibitors based technologies for Arctic zone
7. Careful control for heating methods, preventing heating of near layers.

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Bibliographic references

Austvik, O., Moe, A. (2016). Oil and gas extraction in the Barents Region. *Encyclopedia of the Barents Region (Volume II)*. Oslo.

Boswell, R., Collett, T., 2011. Current perspectives on gas hydrate resources. *Energy and Environmental Science*, 4, 1206-1215. DOI: https://doi.org/ 10.1039/C0EE00203H

Cherepovitsyn, A., Ilinova, A. (2016). Ecological, economic and social issues of implementing carbon dioxide sequestration technologies in the oil and gas industry in Russia. *Journal of Ecological Engineering;* 17(2): 19–23. DOI: https://doi.org/10.12911/22998993/62281

Conley, H. et. all. (2013). Arctic Economics in the 21st Century. The Benefits and Costs of Cold. Report of the CSIS Europe Program.

Conley, H., Kraut, J. (2010). Strategic Interests in the Arctic: An assessment of current Challenges and New Opportunities for Cooperation: A Report of the CSIS Europe Program.

Dallimore, S., and Collett, T., (eds), Scientific results from Mallik (2002). Gas Hydrate Production Research Well Program, Mackenzie delta, Northwest Territories, Canada, GSC Bulletin 585.

Finland's Strategy for the Arctic Region 2010 (2010). Prime Minister's Office Publications. 8/2010.

Youkashev V. Gas hydrates energy: New opportunities. *The Arctic*, November 2015. URL: http://arctic.ru/analitic/20151126/241782.html

Gautier, D. L. et al. (2009). Assessment of Undiscovered Oil and Gas in the Arctic, *Science*, 324 (5931): 1175 – 79. https://doi.org/10.1126/science.1169467

Hancock, S., Dallimore, S., Collett, T., Carle, D., Weatherhill, B., Satoh, T., Inoue, T. (2005). Overview of pressure-drawdown production-test results for the JAPEX/JNOC/GSC et al., Mallik 5L-38 gas hydrate production research well.

Hatzikiriakos, S. G., and P. Englezos. 1993. "The relationship between global warming and methane gas hydrates in the earth". Chemical Engineering Science,48, pp. 3963-69. DOI https://doi.org/10.1016/0009-2509(93)80375-Z

Heininen, L. (2012). Arctic Strategies and Policies. Inventory and Comparative Study.

Henderson, J., Loe, J. (2014). The Prospects and Challenges for Arctic Oil Development. Retrieved from https://www.oxfordenergy.org/wpcms/wp-content/uploads/2014/11/WPM-56.pdf

Ilinova, A., Dmitrieva, D. (2017). Strategic development of the Russian Arctic: socioecological approach. *17th International Multidisciplinary Scientific Geoconference SGEM 2017. Conference proceedings*. Volume 17. Issue 52. pp. 851-858. DOI: https://doi.org/10.5593/sgem2017/52/S20.109

Kapyla, J. & Mikkola, H. (2013). The global Arctic. The Growing Arctic interests of Russia, China, The US and European Union. Global security research programme. The Finnish institute of international affairs.

Keil, K. (2012). Opening Oil and Gas Development in the Arctic: A Conflict and Risk Assessment. Tvergastein Interdisciplinary Journal of the Environment, 2nd issue, November 2012, pp. 36-43. DOI https://doi.org/10.1177/0010836713482555

Kingdom of Denmark Strategy for the Arctic 2011 - 2020

Kozyaruk, A., Zagrivniy, E., Malarev, V., Zyrin, V. (2015). Device for gas hydrate deposit heat treatment. *RU Patent*, 2516303, May 2015.

Laruelle, M. (2014). Russia's Arctic strategies and future of the far north. Armonk, New York: M.E. Sharpe Inc. 251 p

Liang G. Tang , Rui Xiao , Chong Huang , Z. P. Feng and Shuan S. Fan (2005). Experimental Investigation of Production Behavior of Gas Hydrate under Thermal Stimulation in Unconsolidated Sediment Energy Fuels, 2005, 19 (6), pp 2402–2407.
DOI: 10.1021/ef050223g

Moe, A. (2016). The Dynamics of Arctic Development // In Vijay Sakhuja and Kapil Narula (eds), Asia in the Arctic. Singapore, Springer, pp. 3-13. DOI: https://doi.org/10.1007/978-981-10-2059-9_1

National Strategy for the Arctic Region. Washington D.C., May 2013. — 13 p.

Nikolaev, N., Lu Tianli (2016). The modern technology of drilling and casing of well during the exploration of gas hydrates. *Journal of Mining Institute*, t. 218, 2016, pp. 206-214.

Norwegian Government's High North strategy 2006.

Oveckiy, S., Savchuk, V. (2016). A method to increase technological and ecological efficiency of gas production from hydrate deposit. Eastern-European Journal of Enterprise Technologies, 3/10(81), 41-47. DOI: 10.3390/en5072112

Quadrennial technology review (2015), chapter 7. Advancing systems and technologies to produce cleaner fuels, gas hydrate research and development.

Shakhova, N., Semiletov, I., Salyuk, A., Yusupov, V., Kosmach, D., Gustafsson, O. (2010). Extensive methane venting to the atmosphere from sediments of the East Siberian Arctic Shelf: *Science,* 327, 1246-1250. DOI: 10.1126/science.1182221

Simola, H. et al. (2013). Perspectives on Russia's Energy Sector. *BOFIT Online* 3/2013, p. 4.

Sweden's Strategy for the Arctic region (2011). Government Offices of Sweden. Ministry for Foreign Affairs. Department for Eastern Europe and Central Asia. Arctic Secretariat. Stockholm, Sweden, 52 p.

Tamnes R. Geopolitics and Security in the Arctic: Regional dynamics in a global world (Routledge Global Security Studies) (2014).

The Strategy of developing the Arctic zone of the Russian Federation and national security system for the period till 2020.

Westbrook, G., Thatcher, K., Rohling, E., Piotrowski, A., Palike, H., Osborne, A., Nisbet, E., Minshull, T., Lanoiselle, M., James, R., Huhnerbach, V., Green, D., Fisher, R., Crocker, A., Chabert, A., Bolton, C., Beszczynski-Moller, A., Berndt, C., Aguilina, A. (2009). Escape of methane gas from the seabed along the West Spitsbergen continental margin. *Geophys.* Res. Lett. 36 (15).

Zhen-guo Zhang, Yu Wang, Lian-feng Gao, Ying Zhang, Chang-shui Liu, 2012. Marine gas hydrates: future energy or environmental killer? Energy Procedia 16(2012), 933-938. DOIhttps://doi.org/10.1016/j.egypro.2012.01.149

Zyrin, V., Ilinova, A. (2016). Ecology safety technologies of unconventional oil reserves recovery for sustainable oil and gas industry development. *Journal of Ecological Engineering*; 17(4): 35–40. DOI: https://doi.org/10.12911/22998993/64637

Zysk, K. (2011). The Evolving Arctic Security Environment: An Assessment", in Blank, Stephen J. (ed.). *Russia in the Arctic*, Carlisle: Strategic Studies Institute, pp. 96-97.

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