International Journal of Economic Research

ISSN : 0972-9380

available at http: www.serialsjournals.com

Volume 14 • Number 15 (Part 4) • 2017

On the Opportunities of the Shift of Helium Industry World Center to Eastern Siberia, Russia

Larionov Aleksandr V.[1], Nogovitsyn Roman R.[2], Pavlov Nikita V.[3] and Popova Kunnai S.[4]

[1]*Aspirant, Federal state Autonomous educational institution of higher professional education "North-Eastern Federal University", Belinskogo str. 58, Yakutsk, Russian Federation. Email: sasha.larionov@gmail.com*

[2]*Head of the department of management in mining and geology, Professor, Federal state Autonomous educational institution of higher professional education "North-Eastern Federal University", Belinskogo str. 58, Yakutsk, Russian Federation. Email: rr.nogovicin@s-vfu.ru*

[3]*Researcher, Federal state budgetary institution of science Larionov Institute of physical-technical problems of the North, Siberian Branch, Russian Academy of Sciences, Oktyabrskya str. 1,Yakutsk, Russian Federation. Email: pavlov_nv@iptpn.ysn.ru*

[4]*Graduate student, Federal state Autonomous educational institution of higher education "national research technological University" MISIS, Leninskiy prospect 4, Moscow, Russian Federation. Email: pk7-77@mail.ru*

ABSTRACT

The development of helium-rich gas fields in the East of Russia, the construction of export-oriented gas pipeline "Siberia Power" and formation of large gas processing production create conditions for the displacement of the world center of the helium industry on the territory of Russia. In this regard, a number of problems arise due to the need to provide cost-effective and reliable ways to store helium unclaimed by market.

In this work the calculation of technical-economic indicators of these projects of conservation helium concentrate and suggestions for the further development of helium industry on the territory of Eastern Russia have been conducted.

JEL: O21, O25, Q35.

Keywords: Helium, underground storage, membrane technology, "Siberia Power".

1. INTRODUCTION

Today the helium industry on a global scale is characterized by intensive dynamics of development, growing demand, increasing of production capacity, development of market relations. The reason of such processes, first and foremost, is the value of helium as a rare non-renewable natural resource that is widely used in

various sectors of the world economy due to its unique physical and chemical properties. The latter include – the lowest boiling point of all known elements, low density, chemical inertness even at high temperatures, high thermal conductivity.

With the development of modern technologies it is possible to extract (to produce) helium in a variety of ways, to separate helium contained in the ambient air. However, the minimum energy and hence financial costs in the production of helium is achieved by allocating helium from natural gas deposits.

At present, the Russian public joint-stock company "Gazprom" simultaneously is working on the development of a number of fields in Eastern Siberia of Russia, the construction of the export gas pipeline "Siberia Power" and the gas processing plant in the Amur region. Synchronized commissioning of these industrial facilities should provide rational use of all valuable components of natural gas, including helium, supplied to the main gas pipeline "Siberia Power" (Ananenkov, 2008).

Meanwhile the market for commercial helium is limited. In order to maintain balance in the global helium market (maintain the world price of the resource at the appropriate level), Russia needs to supply the market with a limited amount of this gas, keeping the excess in a special storage. Given the fact that helium is contained in significant concentrations in a large number of fields in Eastern Siberia and the fact that the plans of the gas companies on their development began to be implemented, the problem of rational conservation unclaimed helium market becomes relevant.

Considering the creation of new technologies which allow effectively highlight a helium concentrate from a stream of natural gas based membrane gas separator, the opportunity to address the problem of separation, transportation and storage of helium concentrate in Eastern Siberia from a new point of view. Using membrane technology it is possible to build production schemes, allowing you to save unclaimed market helium in geological formations. The sufficiency of the country and the world in general with strategically important resource in the long termdepends on thecorrect choice of the scheme of conservation of the helium resource.

2. WORLD STOCKS

Helium gas refers to natural gas with a helium concentration of more than 0.02 percent. In its turn it is divided into separate groups: poor with a concentration of helium in natural gas 0,02 - 0,05 %, rich – 0,05 – 0,30 %, very rich – 0,30 – 1,00 %, and unique – more than 1.0%.

In the all period of exploration to find oil and gas in the world four regions which geological conditions are consistent with the possibility of accumulation of helium in natural gases in the amount of more than 0.15 %have been revealed. These regions are confined to the Eastern European, Siberian, North American and African platforms.

World reserves of helium in natural gas composition are about 44.2 billion cubic meters by the beginning of 2013 according to the report of The Bureau of Land Management. Table 1 presents the distribution of helium reserves of category A + B + C_1 to the countries (Peterson, 2004).

As can be seen from Table 1, the main part of the helium reserves is concentrated on the territory of 4 countries: Russia (12.2 billion cubic meters), USA (9.6 billion cubic meters), Algeria (8.2 billion cubic meters), Qatar (10.0 billion cubic meters) - which is more than 90 % of the world stocks.

Table 1
Distribution of helium reserve to countries (Peterson, 2004)

Country with helium reserve	*Helium reserve, billion cubic meters*	*The share of global reserves, %*	*The ranges of concentration of helium in natural gas, %*
Russia	12,20	27,60	from 0,035 to 0,60
Qatar	10,00	22,60	from 0,09 to 0,20
USA	9,60	21,70	from0,10 to 1,90
Algeria	8,20	18,60	from 0,17 to 0,19
Canada	2,00	4,50	from 0,05 to 0,19
China	1,10	2,50	from 0,15 to 0,20
The Netherlands	0,60	1,40	from 0,02 to 0,12
Poland	0,30	0,70	to 0,06
Australia	0,20	0,50	from 0,05 to 0,20
Total	44,20	100,00	

The United States of America

In recent years, the share of the U.S. presence in the global helium market has been steadily decreasing. The main reason is the depletion of raw material base of helium deposits and the energy strategy of the country, directed on reduction of volumes of extraction of hydrocarbon resources in the U.S. as energy raw materials and create a fuel base at the expense of increase of imports from other developing countries (Nuttall et. al., 2012). Of course, the heliumextraction in the United States will not be fully suspended and will be supported by the exploitation of promising resources of deposits in the Riley ridge in Wyoming (25 million cubic meters per year) and Hugoton in Texas (60 million cubic meters per year). Also significant reserves of helium contained in Cliffside depository (about 220 million cubic meters as of December 31, 2016) will lead to a significant influence of the US on the helium market. But currently the US already produces helium less than its consumption. Extraction at Riley ridge in the next 15 years is stabilized at the present level. Thus, the total production of helium in the U.S. could reach 71 million cubic metersin 2020, and 61 million cubic meters in 2030 (Nogovitsyn, 2014).

This state of affairs in the country, which is the world leader in the helium market since the advent of helium industry in the beginning of last century, could exacerbate the general shortage of helium on the world market.

Countries of Europe

In Europe, helium is extracted in the Netherlands and Poland. Helium reserves in the Netherlands decreased from 0.7 to 0.6 billion cubic meters, in Poland – from 0.8 to 0.3 billion cubic meters In Poland helium plant in Odolovyan almost stopped after 2009in connection with a significant depletion of the resource base of helium.

Algeria

In recent years, a considerable increase of helium reserves (2,1 – 8,2 billion cubic meters) took place in Algeria. However, the largest gas field Hassi-R-Mel with initial gas reserves of 1.5 trillion cubic meters and a helium content of 0.17 % greatly developed (Nuttal et. al., 2012).

Qatar

With the simultaneous depletion of raw material base in the US and Europe a major supplier of helium becomes to be in the Persian Gulf side. Qatar is among the largest reserves of helium. Since 2005, Qatar's helium began to come into the market of Asia Pacific plant in Ras-Laffan with a capacity of 17 million cubic meters per year. In 2014 after reaching the 100% load level setup "Ras-Laffan II" Qatar has supplied 25 % of the world helium (Ruban et. al., 2010). The reserves of helium in Qatar are enormous, but exhaustible in the foreseeable future.

Russia

In the European part of Russia only one Orenburg helium plant currently operates, producing annually about 5 million cubic meters of helium. But the depletion of raw materials base of the plant (Orenburg field is generated by 62.7 %) causes the end of helium production in the medium term.

A large part of the helium reserves of Russia by categories A+B+ C_1 (90 %) is concentrated in regions of Eastern Siberia and the Far East where depletion of reserves of commercial categories A+ B+ C_1 does not exceed 10 %. The helium content in these deposits is from 0.19 to 0.26 % at the Srednebotuobinskoye (gas cap) and Kovykta fields; 0,58 – 0,67% in the Chayandinskoye, Sobinskoye and Srednebotuobinskoye fields (free gas).

These fields with helium in Eastern Siberia of Russia are actively explored at present. The market has been defined and potential consumers of hydrocarbon resources are concretized, an intensive creation of production and transport infrastructure of oil and gas industry has been started.

Thus, due to the depletion of helium resource base in the United States and reduce of the selection of helium from underground depositories in Cliffside, the process of short-term changes in the helium market has been started (Cai et. al., 2010). Taking into account a large number of helium-rich fields in the East of Russia, the beginning of realization of large investment projects on their development in conjunction with the results of studies on the forecast of the world market of helium, we can conclude that in the medium term the global centre for the development of helium industry will move to East Siberia, Russia.

3. ON THE DEVELOPMENT PROSPECTS OF HELIUM INDUSTRY IN EASTERN SIBERIA, RUSSIA

The Ministry of industry and energy of the Russian Federation in 2007 has approved the Eastern gas program which involves the development of rich helium fields. A new stage of development of the helium industry in Russia has started (Ananenkov, 2008).

In 2014 Gazprom (Russia) and CNPC (China) companies have signed an agreement for the sale of gas on the Eastern route (pipeline "Siberia Power "). The parties have agreed to supply China with gas from the Yakut (the Chayandinskoye field) and Irkutsk (the Kovyktinskoye field) gas production centers in the amount of 38 billion cubic meters per year for 30 years.

"Gazprom" PJSC is planning to complete the construction of the first line of the gas pipeline "Siberia Power" in 2020 with a capacity of 32 billion cubic meters a year (with prospect of expansion to capacity of 60 billion cubic meters per year), which will connect the fields of Eastern Siberia with China, and to

begin natural gas production in the Chayandinskoye OGCF. In parallel with the construction of the export pipeline system on the border of Russia and China in the Amur region Gazprom generates power on the allocation from transported gas of valuable components of gas – wide fraction of light hydrocarbons, ethane, and helium. It is planned that WFLH and ethane after allocation will be subjected to further processing in the gas and chemical plant, and helium after fine cleaning will be sent by road or rail to Vladivostok for further transshipment on special sea tankers (access to the world market).

Figure 1: The scheme of placing of gas industry objects in Eastern Russia (Ananenkov, 2008)

In the first phase gas from the Chayanda OGCF will be extracted and transported annually in the amount of 25 billion cubic meters. In the extraction of this volume with an average helium content of 0.4 % - 0.6 % in natural gas, the associated helium production will exceed 100 million cubic meters per year. In the development of new deposits and increasing of the volume of gas flow the passing helium production will increase. In this regard, the question arises about the relevance of such volume of helium on the world market.

4. THE WORLD MARKET

The level of annual consumption of helium is one of the main indicators of development of technology-intensive sectors of the economy of any country (Molchanov, 2010). The structure of helium consumption as of 2014, according to the CryoGasInternational company data presented the following distribution: tomographs – 2 %, entertainment and advertising, aeronautics – 4 %, fiber 5 %, electronics - 7 %, welding – 9 %, leak detectors – 11 %, cryogenic system – 13 %, analytical instruments – 15 %, respiratory blend – 16 %, other – 18 % (Analises.

The expansion of helium applications is closely connected with the development of new and progressive technologies.

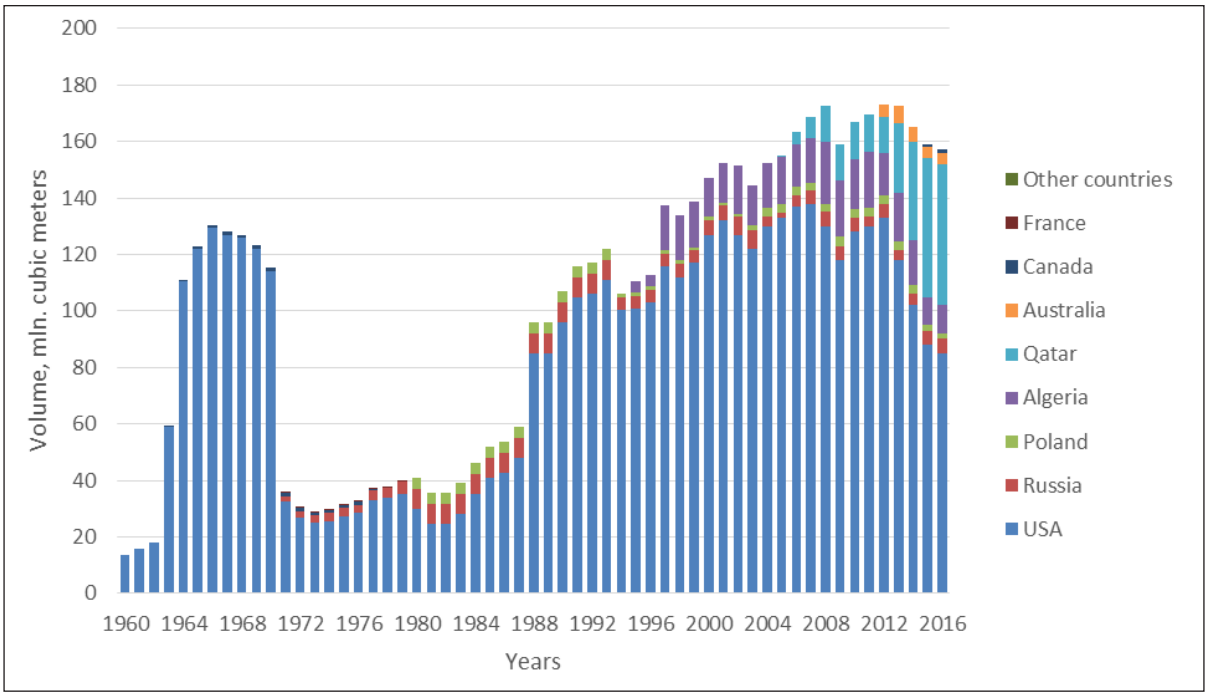


Figure 2: Dynamics of helium production in the world (including the production of helium concentrate for the storage in the world's only helium storage in Cliffside)

From the figure 2 it is shown that the helium industry, since 1980, has only a positive growth trend (Peterson, 2004). In the 21st century the world helium market has ceased to be a monopoly, new major producing countries have appeared, the geography and structure of consumption have been expanded.

Table 2
Forecast of development of production capacities in the helium production (Kryukov et. al., 2012)
In mln cub. m

Indicators	*Indicators value*				
	2019 г.	*2020 г.*	*2023 г.*	*2025 г.*	*2030 г.*
The planned volume of helium world production	173,8	173,6	170,8	168,9	165,1
Global demand for helium (at 3% annual growth)	203,0	209,1	228,5	242,4	281,0
The volume of exports from other countries	131,0	132,0	125,0	123,0	122,0
Capacity shortages	–45,0	–52,8	–76,5	–92,3	–134,7
The volume of exports from Russia	30,0	40,0	60,0	80,0	120,0

Estimating the activity of suppliers at the global helium market, it is necessary to consider the decline in helium production in the United States and the realization of several projects of construction of plants for the helium liquefaction in Qatar and Algeria by 2020. But overall, the forecast development of the world helium market (Table 2) shows that in the absence of the appearance of new, not yet announced for today projects, a deficit of helium in the world market can reach by 2020 to 209 million cubic meters, by 2030 to 280 million cubic meters per year.

As to the Russian helium market, the forecasting dynamics of the distribution of helium extracted from natural gas of Chayanda gas field is shown in Figure 3.

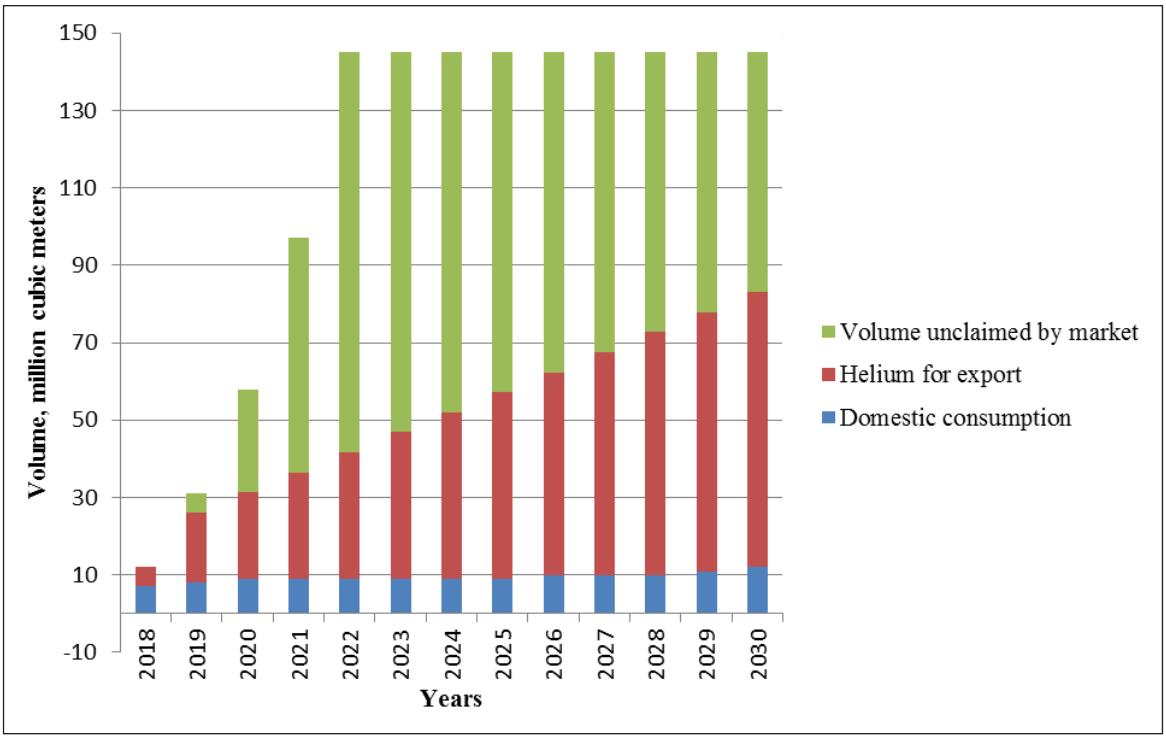


Figure 3: Forecasted dynamics of the distribution of helium extracted from natural gas of the Chayanda OGCF

As can be seen from Figure 3 during the operation of the Chayanda field there will have a substantial amount of helium concentrate. Taking into account t the projected production volume of helium can be from 100 to 150 million 0cubic meters per year. The specified volume will not be in demand on the market in the medium term in full. Small current need of helium for both Russian and global industry leads to the development of new technologies and methods for long-term storage (over 100 years) helium concentrate with minimizing its losses.

Thus, the first step towards the conservation of the helium resource on a global scale is the establishment of the state reserve of helium in Russia. Such volumes can be stored only in special underground reservoirs.

Currently, there is a large amount of generalizing works on the development of helium industry, however, the following works do not practically consider the actual problem of accumulation and long-term storage of large amounts of helium which is part of the gases developed helium fields.

In the present work an attempt is made to economically assess the possibility to fulfill alternative options for saving helium on the basis of the existing raw material base of helium, condition of helium market, geological surveys and taking into account the emergence of new technologies of membrane separation of the helium concentrate from a stream of natural gas.

5. METHODS OF HELIUM CONCENTRATE CONSERVATION

According to the results of the analysis of the mineral resource base in Eastern Siberia and the Far East, geological surveys carried out previously on the search for promising areas to establish long-term

reservoirs of helium concentrate (Khan et. al., 2015) and technical and economic indicators of large-scale investment projects in the oil and gas industry in the particular region the following options of projects for the extraction, storage, processing and sales of helium extracted from natural gas in Eastern Siberia and Yakutia are offered:

1. Project no 1 The conservation of the helium resource by technology of re-injection of the main mass of helium into the layers of a producing field;
2. Project no 2 The conservation of the helium resource by establishing a centralized reservoir for helium concentrate in isolated deposits of depleted oil and gas fields;
3. Project no 3 The conservation of the helium resource by establishing a centralized reservoir for helium concentrate in underground reservoirs in salt caverns.

Project no 1 considers the application of membrane technologies for re-injection into the field layer of a part of helium extracted together with gas to control the content of helium in the main pipeline. The proposed scheme is presented in figure 4.

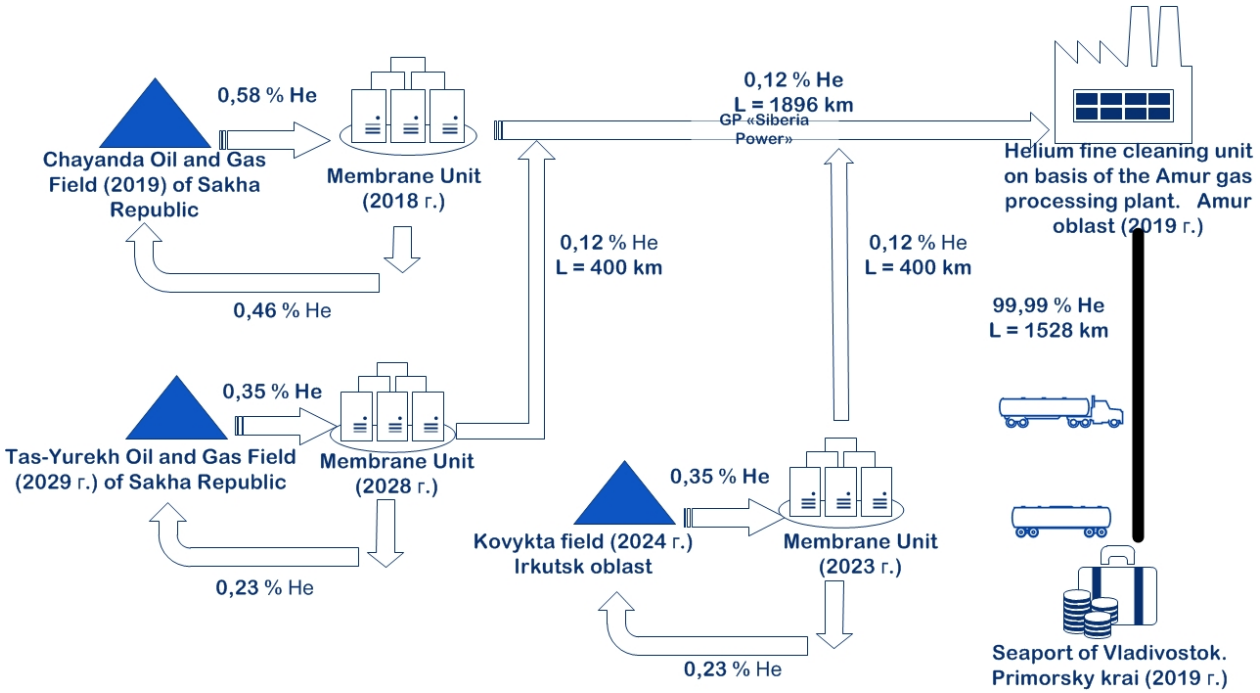


Figure 4: Diagram of re-injection of helium into the developed layers of helium gas fields according to Project no 1

At present in the Kovykta gas and condensate field the scientific and production company "Grasis" carries out the experimental and industrial tests of the first two-stage membrane setup for helium concentrate. In the case of successful completion of all scheduled tests it will be possible to ascertain the fact that there are technologies which allow allocating 20 % helium concentrate (Archegov, 2015) from the stream of natural gas under climatic conditions of the North of the Irkutsk region and the South-West of Yakutia.

The first results obtained on the experimental-industrial membrane installation, the existing theoretical calculations and the successful operation of similar installations in Qatar allow assuming with a high

degree of confidence that the membrane technology will be successfully implemented in the framework of the Eastern gas program. With its help, PJSC "Gazprom" plans to organize the storage of helium concentrate on individual blocks of the Chayandinskoye and TAS-Yuryakhskoye fields. To this end, the company conducts exploration on the southern block in the khamakinsky horizon of the Chayandinskoye oil and gas condensate field and the central unit in the talakhsky horizon of Tas-Yuryakhskoye gas field.

Thus, by setting the membrane installation and establishing reservoirs for rich helium fields, it will be possible to control the helium concentrations transported to a gas processing plant. So, commodity helium will be extracted only in that volume demanded by market.

Advantages	*Disadvantages*
– unlimited period of storage of helium concentrate; – the ability to increase the integrity of object by use of special sealed wells; – low loss of helium concentrate for injection of helium concentrate in productive layers containing residual gas compared to the helium return to the main developing field; – the possibility to use underground reservoirs after the full selection of helium for storage of other products or depositing of industrial waste.	– high requirements for the tightness of wells on a depository; – requirements for the tightness of a cover on helium. To prevent compromising the integrity of a cover it is necessary to control the value of formation pressure value and control its excess over the initial; – no special research on the study of filtration and diffusion processes occurring in a layer.

Project no 2 and Project no 3 are based on the idea of the establishment of a centralized depository of helium. The scheme described above which is developed in the present time by PJSC "Gazprom" is aimed at preserving of unclaimed helium in the bowels of the Russian Federation, achieving the highest possible economic results in one specific project and minimizing capital investments. Meanwhile, the lack of a direct pipeline between the storage of helium concentrate and installation of helium fine cleaning leads to the impossibility of rapid response of helium production volumes on a possible market changes. Under market conditions that could put a manufacturer of products at a disadvantage. It remains an open question of implementation of this scheme in the long term with the depletion of reserves.

It should be also taken into account the fact that in Eastern Siberia and Yakutia there is helium not only on "Gazprom" deposits, but also on deposits OC "Dulisma", LLC "Irkutsk oil company", PJSC "Surgutneftegaz", PJSC "Rosneft", JSC "ALROSA-GAZ". Helium reserves are not so great there that subsoil users could economically cost effective to implement projects for the extraction, storage and purification of helium. In this regard, there are concerns that the strategically important product will only be held on large fields (Nuttal, 2012).

The following scheme to conserve helium in the Eastern region of Russia is offered: a membrane unit is installed directly on a gas transmission system and processes the entire volume of gas transported by guiding the helium concentrate by special pipeline to the underground reservoir.

Taking into account the declared parameter of membrane plant of SPC "Grasis" on the maximum input gas source pressure of 11.0 MPa and the stated working pressure of the main gas pipeline "Siberia Power" 9.8 MPa, it can be assumed that this scheme can be implemented from the technical point of view.

The location of the membrane unit to save the maximum amount of strategic raw materials, it is advisable to choose between the latest "inset" of helium field in the main gas pipeline "Siberia Power" and the Amur gas processing plant.

It is proposed to organize the storage of helium concentrate according to the Project № 2: in depleted gas fields the scheme is shown in Figure 5.

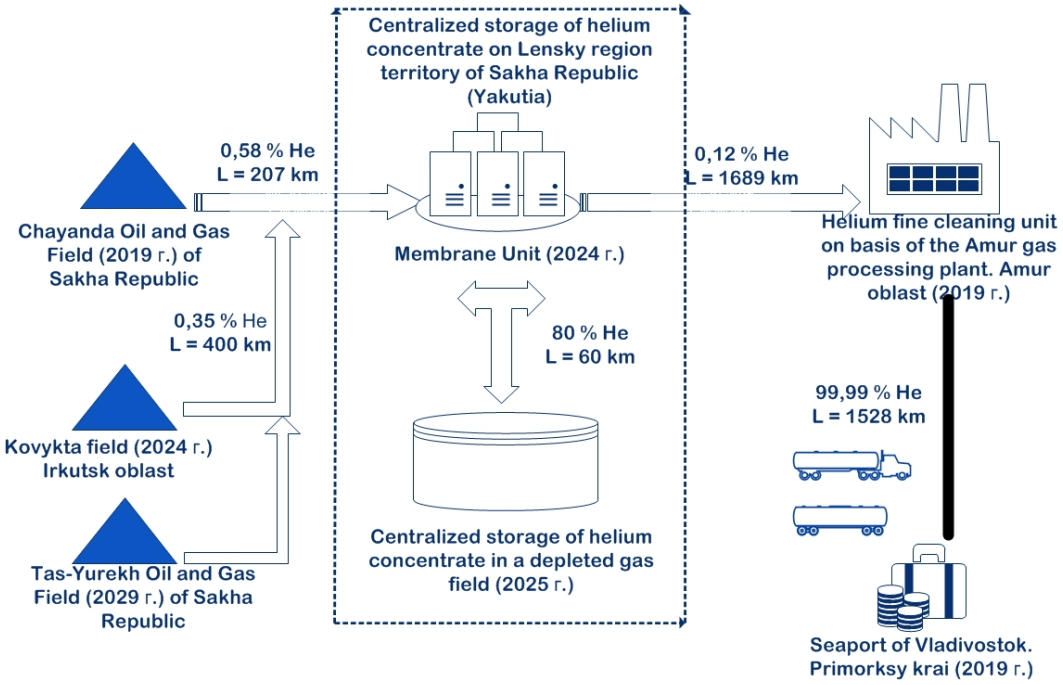


Figure 5: Scheme of placement of long-term underground reservoirs of helium concentrate in depleted gas fields

Indeed, on the highway of passing of the main gas pipeline "Siberia Power" there is a number of promising areas for the establishment of underground gas reservoirs by diluting salts (Ruban et. al., 2010), but given the high capital intensity, the duration of establishment, small thickness and heterogeneity of the saline formations (respectively, the risks of leaks of objects) it is advisable to consider the use of depleted gas fields. The presence of gas in a field and the fact of their existence testify about the potential long-term storage of helium concentrate (of course, considering the high penetrating power of helium relative to methane, it will be necessary to conduct some survey work).

Small gas fields located in the Lensk region of the Sakha Republic (Yakutia): for example, Otradnenskoe gas condensate field (JSC "Sakhatransneftegaz", gas reserves in categories A+ B+C_1 6.2 billion cubic meters, C_2 20 billion cubic meters) or Khotogo-Murbayskaya licensed site (the Fund "Energy") might suit under outlined criteria.

Taking into account that Otradnenskoe field is currently being developed and connected to the gas mains with the town of Lensk, it is possible to develop completely a field and to connect to the main gas pipeline "Siberia Power" among the first connectors. In this case, within 5 to 10 years one can produce and implement main gas reserves and to use Otradnenskoe gas condensate field as a depository for helium in the future.

Advantages:

- high tightness of underground reservoirs;
- preservation of helium product categories during the entire storage period with no re-cleaning prior to delivery;
- alternate commissioning of underground reservoirs at the increase of produced helium volume;
- years of research have confirmed the safety of product quality during its contact with the rock salt and the brine remained after its initial filling;
- possibility to use underground reservoirs after full selection of helium for storage of other products or depositing industrial waste.

Disadvantages:

- high capital intensity;
- duration of creation;
- small thickness of the salt layer and its heterogeneity. This can lead to a significant loss of helium during long storage;
- depositories in salt caverns, if necessary, are capable of high daily output with a small volume of stored gas. On the contrary, for the storage of helium concentrate premises with low daily productivity of the wells are suitable.

According to the Project no 3 it is proposed to organize storage of helium concentrate in salt caverns by building of special reservoirs, situational scheme of which is shown in Figure 6.

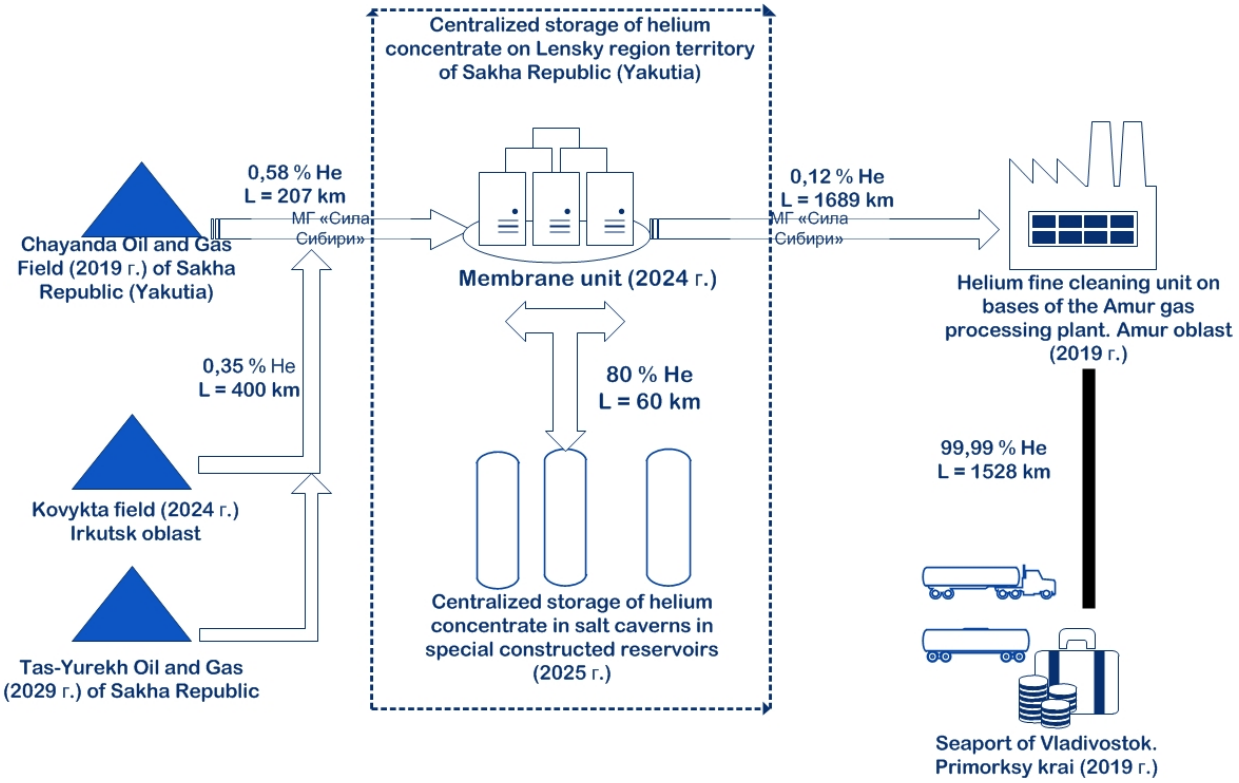


Figure 6: Scheme of placement of a long-term underground reservoir of helium concentrate according to Project No.3: in salt caverns by establishing special reservoirs

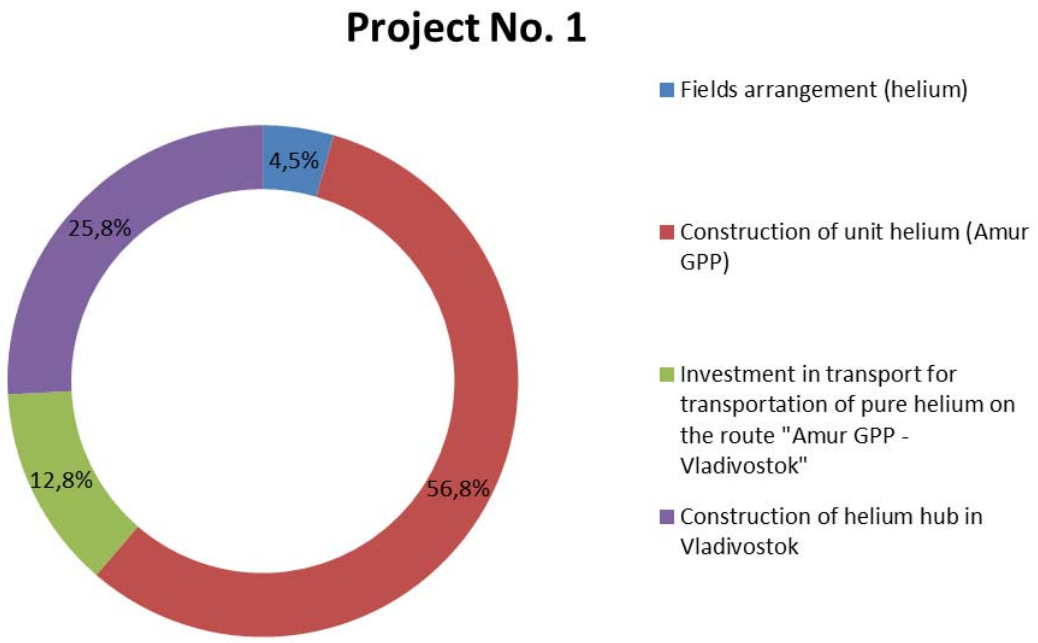
6. RESULTS AND DISCUSSION

In the work (Larionov et. al., 2017) there was conducted the analysis of economic efficiency of the presented projects demonstrating the technology for the production of helium concentrate, its further transportation to the Amur gas processing plant with the aim of obtaining marketable helium and its export from the field to Vladivostok, for example, by motor transport, and its selling on the open market.

Advantages:	*Disadvantages:*
– high tightness of underground reservoirs; – preservation of helium product conditions during the entire storage period with no re-cleaning prior to delivery; – alternate commissioning of underground reservoirs at the increase of produced helium volume; – years of research have confirmed the safety of product quality during its contact with the rock salt and the brine remained after its initial filling; – possibility to use underground reservoirs after full selection of helium for storage of other products or depositing industrial waste.	– high capital intensity; – the duration of creation; – small thickness of the salt layer and its heterogeneity. This can lead to a significant loss of helium during long storage; – reservoirs in salt caverns, if necessary, are capable of high daily output with a small volume of stored gas. On the contrary, low daily productivity of the wells are suitable for the storage of helium concentrate.

As a result of calculations it is established that according to the first project (with reverse pumping of natural gas enriched with helium back into the layers of the mined deposits) net present value is 21050, 09 million rubles, the payback period is 11.18 years (discounted payback period is 19.93 years), internal rate of return is 14 %, the index return is 1.11. When establishing the store on the basis of the depleted oil and gas fields, according to the second project net present value is 17853,78 million rubles, the payback period is 11.45 years (discounted payback period 20, 49 years), internal rate of return is 13.8 %, the index return of 1.09. When you create custom tanks in salt caverns on the third project NPV is 14912,97 million rubles, the payback period is 11.47 years (discounted payback period is 20.94 years), internal rate of return is 13.6 %, the index return on the investment is 1.07.

The main difference of the considered three projects is the difference in the volume of capital expenditures. Analysis of the structure of capital investments is presented in figure 7.



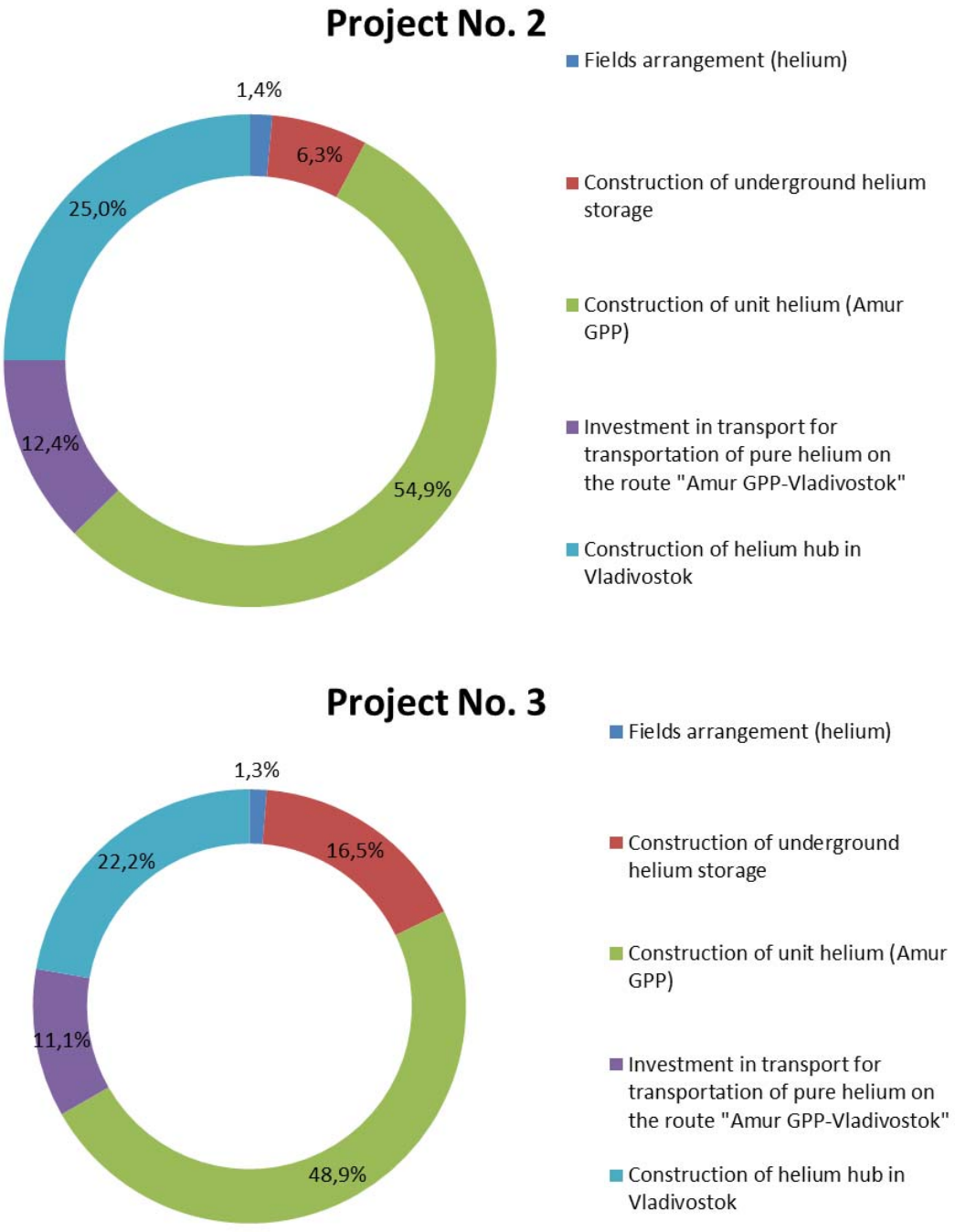


Figure 7: Structure of capital investments for the implementation of solutions

The development of oil and gas fields in Eastern Siberia and Republic of Sakha (Yakutia) is a very important project of key importance for economic development of the region. Major investment projects will provide not only the increase in tax payments to all budget levels, but will also result in a multiplier effect for the whole economy of macroregion. Since this project will involve almost all sectors of the economy. The total area of potentially major oil and gas territories of East Siberia and Republic of Sakha (Yakutia) is over 10 million sq. km. They are characterized by weak and uneven geological knowledge. The achieved

degree of development of inferred resources is at an average 20%. Oil and gas development requires the construction of appropriate energy, transport and logistics infrastructure to create a favorable investment climate (Popov et. al., 2015).

The implementation of this major oil and gas project has socio-economic, geopolitical and macroeconomic objectives of sustainable development of Russia. An important condition of efficiency of the project is to consolidate the efforts and resources of participants to achieve as a government strategic and corporate objectives. The oil and gas industry should become the core of modern clusters, the center of economic development of the Far East region.

7. CONCLUSION

Possible schemes for helium resource conservation have been analyzed and areas suitable for placement of helium storage have been identified. Each of the considered schemes has its advantages and disadvantages. The main advantage of the scheme of re-injection of helium into a layer using a membrane plant according to the technological scheme no 1 is the possibility of reducing the cost of construction and the minimum period of operation. However, the technological scheme remains a number of issues related to the reliability of helium concentrate safety and overall development prospects of helium industry in the long term.

Extraction and storage of helium condensate of the Chayandinskoye field in natural storage (geologic conditions for which exist on the territory of Lensky district) according to the technological scheme no 2 and no 3 may be strategically more advantageous and allows if to not avoid but significantly reduce negative consequences. With a long period of selection of the helium gas from underground storage facilities, created on the basis of depleted gas field, or specially created in the salt caverns, the recovery factor can be quite high.

Taking into account the above proves the importance and validity of the creation of a balanced system "extraction of helium concentrate-storage-cleaning-transport-distribution".

References

Analises on Natural Gas Market, Resource, and Pipeline in Northeast Asia Strategy of Natural Gas Trunkline Development. Tokyo: NAGPF, Asian Pipeline Research Society of Japan, 2004.

Ananenkov A.G, 2008, The Eastern gas program is the implementation beginning. *Gas industry,* **12,** pp. 8-10.

Archegov V.B, 2015. The strategy of sustainable development of high quality helium resources of the Siberian platform. *Proceedings of the Mining Institute.* **211**, pp. 5-15

Galli A., Armstrong M., 1999. Comparing three methods for evaluating oil projects: option pricing, decision trees, and Monte Carlo simulations. *Journal of Petroleum Technology*, pp. 44-50.

Khan S.A., Igoshin A.I., Kazaryan V.A., Skryabina A.S., Sokhranskiy V.B. *Underground Storage of Helium.* Moscow – Izhevsk, Institute of Computer Research, 2015, 272 p.

Kryukov V.A., Silkin V.Yu., Tokarev A.N., Shmat V.V, 2012. Comprehensive reengineering of the economic development processes of helium resources in Eastern Russia. Novosibirsk: Institute of Economy and Industrial Production Organization of SB RAS, 184 p.

Larionov A.V., Pavlov N.V., Popova K.S., 2017. Efficiency evaluation of investment projects in the extraction, realization and conservation of helium resource in the Chayandinskoye oil and gas condensate field of the Sakha Republic (Yakutia). *Bulletin of Far Eastern Federal University*. **3.**

Molchanov S.A, 2010. Improvement of domestic technology and technical means in the process of separation of helium from natural gas at the Orenburg helium plant. *Environmental protection in oil and gas complex*. **2**, pp. 51-57.

Nogovitsyn R., Sokolov. A., 2014. Preliminary Calculation of the EROI for the Production of Gas in Russia. *Sustainability journal*. **6(10)**, pp. 6751-6765.

Charles Weinstein, Tuba Firincioglu, Alejandro Albertoni, 2003. Optimizing Helium Gas Recovery: A Compositional Dual Porosity Reservoir Simulation Study of the Bush Dome Helium Storage Reservoir, Amarillo, Texas, NITEC LLC, SPE ATCE, Denver.

Peterson Joseph B., 2004. Helium. Ch. In Minerals Yearbook, Annual. Vol. 7.

Popov A.A., Myreev A.N., Fedorova S.V., 2015. The quality of life of the population under conditions of economy transformation: theory, problems, practice (on the example of regions of the far North and Arctic zone). Yakutsk. NEFU. *584* p.

Ruban G.N., Bondarev V.L., Koroleva V.P., Korolev D.S, 2010. Criteria for selection of helium concentrate storage facilities in Eastern Siberia. *Georesources*. **4 (36)**, pp. 29-32.

William J. Nuttall, Richard H. Clarke and Bartek A. Glowacki, 2012. The Future of Helium as a Natural Resource. NewYork, 330 p.

Zhiming Cai, Richard H. Clarke, Bartek A. Glowacki, William J. Nuttall, Nick Ward, 2010. Ongoing ascent to the helium production plateau—Insights from system dynamics. *Resources Policy*. **35**, issue 2, pp. 77-89.