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Key Factors of Public Perception of Carbon Dioxide Capture and Storage Projects

Sergey V. FEDOSEEV[1], **Pavel S. TCVETKOV**[2] ✉
[1] *Institute of Economic Problems G.P.Luzin, Kola Scientific Center of the Russian Academy of Sciences, Apatity, Russia*
[2] *Saint-Petersburg Mining University, Saint-Petersburg, Russia*

One of the major challenges of the modern world is the problem of global warming, the solution of which requires the implementation of a set of strategic projects in the field of transition of the energy sector to the path of environmentally balanced development. One of the ways to implement this transition is the development of technologies for capturing and storage of technogenic carbon dioxide, which is recognized as the main one of greenhouse gases. At the same time, in the Russian context, the most expedient is the implementation of technological chains for capturing and storing CO_2 which are aimed at enhanced oil recovery, the effectiveness of which has been proven by world practice.

Implementation of these projects requires consolidation of efforts of many parties, including government agencies, enterprises-issuers (power generating facilities and energy-intensive industry), oil-producing enterprises, non-state environmental organizations, media and public. World practice has many examples when uncoordinated actions of one of the stakeholders led to the closure of such a project, and therefore it is necessary to develop a mechanism of interaction between them, taking into account the specifics of Russian conditions.

One of the least studied and controversial aspects of this interaction is to involve the public in the implementation of national carbon intensity programs and the local population in the implementation of a specific project. Research in this field has been conducted in the world over the past 14 years, which allowed the current research base to be used to develop fundamental principles for the development and promotion of CO_2 capture and storage technologies in Russia. Key factors affecting the perception of such projects by public were also analyzed and systematized. The research identified the main arguments for and against the development of CO_2 capture and storage technologies. The analysis made it possible to formulate key principles that should be considered when developing a strategy for the development of these technologies in Russia.

Key words: public perception; carbon dioxide capture and storage; enhanced oil recovery; geological storage of carbon dioxide

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Introduction. The problem of global warming, which has been widely discussed since the 70s of the last century, is one of the key challenges to modern society. The essence of the problem is that increase in concentration of greenhouse gases in the atmosphere leads to increase in the average temperature of the earth's surface. According to many sources, the average temperature of the earth's surface in 2017 was 1 °C higher than in 1951-1980 (Fig.1).

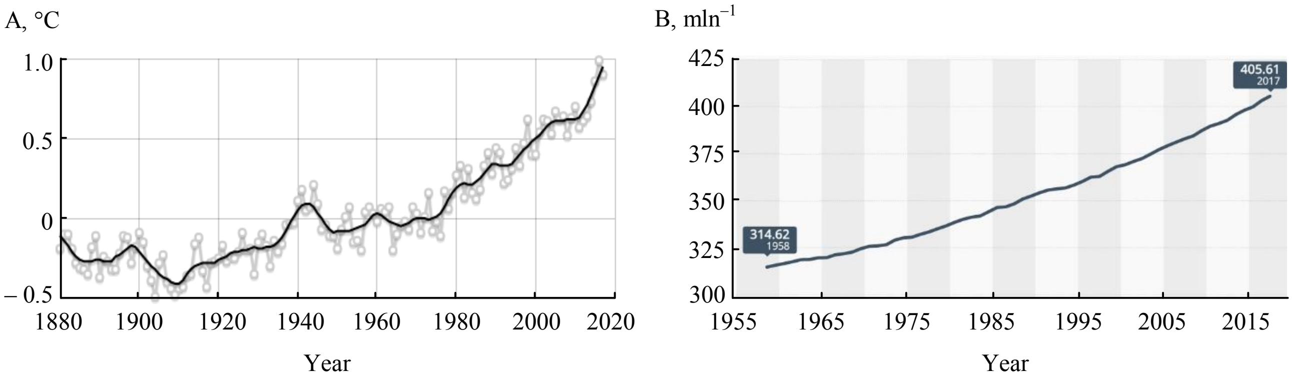

Fig.1. Absolute increase in the average annual temperature of the earth's surface A and CO_2 concentration in the atmosphere B [1, 3]

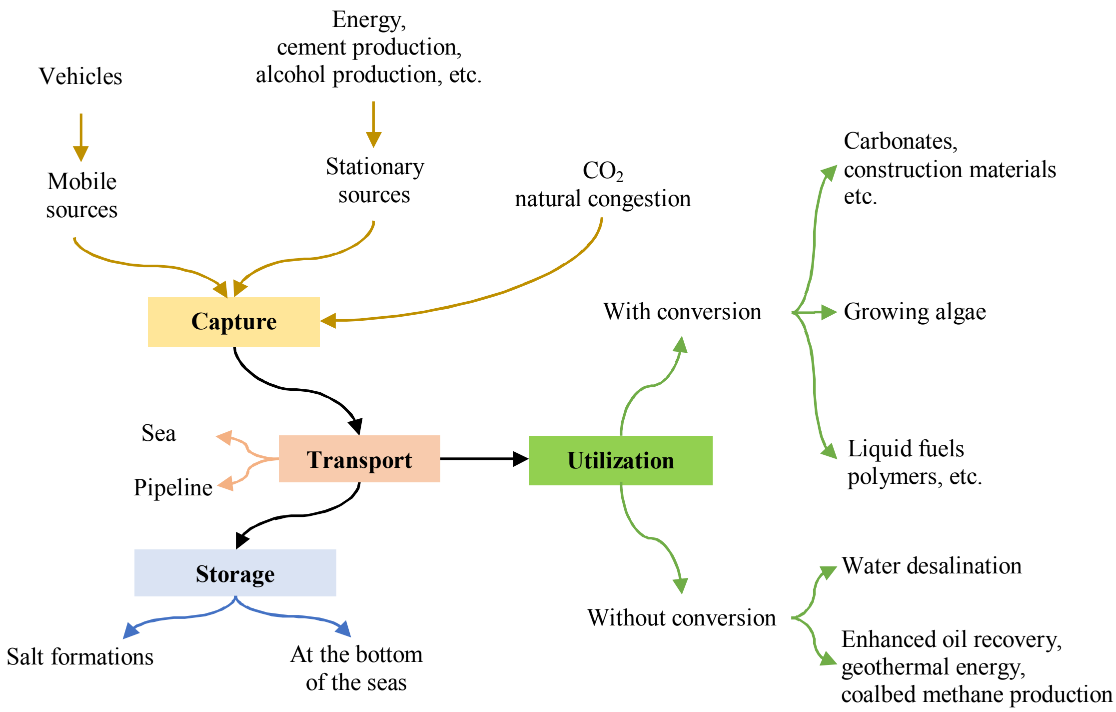

Fig.2. Schematic representation of CCS/CCU process chains

Many solutions have been proposed for the problem of global warming, the main of which are the following:

1. Refusing to use fossil energy sources, the share of which in the world energy balance is about 83-86 % and replacing them with renewable energy. Such a scenario is not feasible due to the imperfection of available technologies and their low competitiveness compared to oil and gas. Moreover, even in developed countries, the transition to renewable energy takes many decades, which does not allow to consider it as a possible alternative for a number of developing countries.

2. Large-scale modernization of the energy sector, which is the main issuer of CO_2. This option involves the creation of power generation facilities of the new generation equipped with systems for capturing harmful substances, as well as modernization of existing enterprises. Under this option, CO_2 capture and storage (CCS) or utilization (CCU) technology was proposed, which identified the main uses of captured gases and how to transport them from the source object to the consumer object [5].

The CCS technology represents a system of alternative process chains, the main of which are the capture, transportation and storage of CO_2 (Fig.2). Today, there are more than 88 pilot and 38 large-scale CCS projects, most of which are being developed in the USA, Canada and China [4].

The most efficient CCS technological chain, in terms of financial results, is the use of CO_2 for enhanced oil recovery (CCS-EOR) [9]. Today, 14 cost-effective large-scale CCS-EOR projects are being implemented over the world, and 9 projects are planned for launch by 2022 (Table 1). Based on this, we can conclude that such technological chains can be cost-effective under certain conditions, have the potential for industrial implementation, and are also technically feasible.

Since the CCS-EOR projects can be effective, we will consider the experience of the leading countries in this field, which shows the primary importance of issues related to the public perception of these technologies. They can be one of the main obstacles to the large-scale implementation of projects, since politicians and experts are often positive or have a neutral position [23].

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Table 1

Major global projects CCS-EOR

Country	Number of active projects	Number of planned projects	Total Capture CO_2, mln t/year	Average transportation distance CO_2, km
USA	8	2	27.1	241
China	1	5	4.91	108
Canada	2	2	1.44	219
UAE, Saudi Arabia, Brazil	3	0	2.6	43

Despite the fact that CCS projects are currently being implemented in many countries, the existing scientific base is mainly concentrated in two directions: the study of public perception of CCS (mainly in regions where there is some interest in these technologies, but projects are not yet implemented [21]); the discussion on the development of environmental technologies (in particular, CCS), conducted at the international level. The main problem in this regard is the lack of mechanisms for transition from the global to the local level [6].

A number of studies show that state policy plays the main role in implementing the transition mechanism, since CCS technologies, which have characteristics of innovation, can develop only with substantial government support [15, 22].

Another aspect of transition from the global to the local level is the need to improve public perception of CCS, including population of the project region. The effectiveness of this process is directly related to the consolidation of the efforts of the government, industry and non-governmental environmental organizations [20]. It should be noted that organization of such open interaction is an extremely time-consuming and multifaceted task compared with the bilateral «stakeholder – local population» interaction [8]. This is mainly due to different points of view on the process of implementing individual elements of the project [19]. Nevertheless, public perception of CCS directly depends on the effectiveness of this interaction, as well as the method of distribution of responsibility between stakeholders [25]. In addition, it is important whether stakeholders and the local population agree on what effects should be gained from the project implementation [12].

Finding a balance between the interests of all parties is possible within the framework of public discussions [26], which will also allow to formulate the measures necessary for increasing attractiveness of CCS, as well as to increase predictability of some project risks [11, 14].

Formulation of the problem. The Russian oil industry, which is the backbone of the national economy, is experiencing significant difficulties due to the deterioration of hydrocarbon reserves, the increasing share of hard-to-recover reserves and the low recovery rate at existing fields (Fig.3). The development of CCS-EOR technological chains is one of the solutions to these problems, which would also reduce the growth rate of CO_2 emissions by the Russian industry [18]. According to some estimates [24], at the current rate of growth in industrial production by 2030, CO_2 emissions in Russia may exceed 2 million tons/year, which is comparable to India's emissions recorded at the end of 2017.

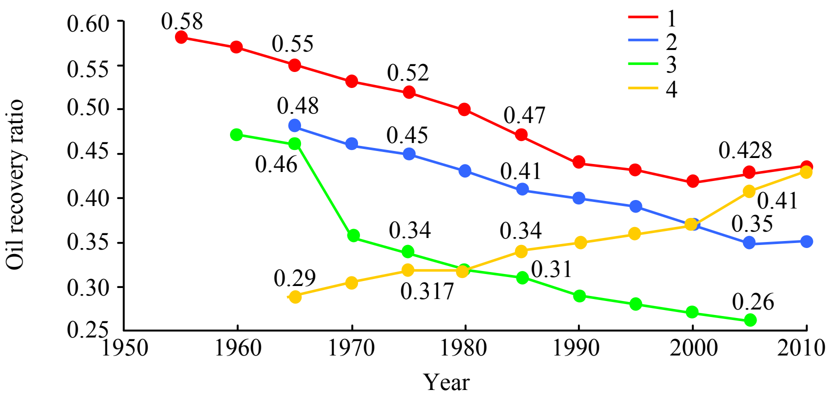

Fig.3. Dynamics of oil recovery ratio in the regions of Russia and in the USA [2]
1 – Tatarstan; 2 – average in Russia; 3 – average in the USA;
4 – Khanty-Mansiiysk autonomous district

Despite the intensive development of CCS-EOR technologies, as well as a significant

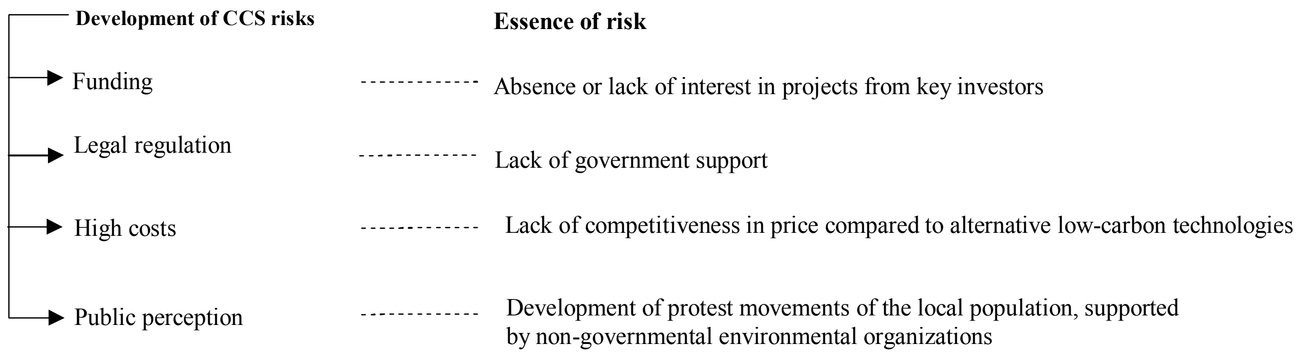

Fig.4. Four key problems of large-scale development of CCS technologies [17]

number of pilot and commercial projects, research on these issues in Russia is extremely limited. The number of Russian-language scientific publications on CCS over the past decade has been exhausted by several dozen, which is about 1 % of the global number of publications in this field.

World experience shows that implementation of CCS projects involves a whole range of problems and risks (Fig.4). In Russia, they are aggravated by insufficient knowledge of the specifics of Russian conditions, in particular public perception of large-scale projects.

Experience of leading CCS countries shows that without development of an integrated approach to proactive interaction with the local population, even cost-effective projects can be closed. An example is the Barendrecht project (the Netherlands) [10], the implementation of which was planned by Shell. However, among the local population, due to the lack of confidence in the project's key stakeholders, active protests began resulting in the government banning the implementation of this and subsequent CCS projects, including storage of CO_2 on land. The presented example demonstrates the need for pre-project research, aimed, on the one hand, at forming a positive image of CCS technologies, on the other hand, at assessing the level of awareness of the essence of these technologies and analysis of public perception of them.

Methodology. The aim of this research is to analyze factors that determine public perception of CCS technologies. To achieve this goal, the following tasks were solved: analysis of world experience in implementing large-scale CCS projects; identification of key prerequisites determining the public perception of such projects; justification of basic principles of the development of CCS technologies, considering the need to popularize them in society. In solving these problems, methods of generalization, systematization, comparative and system analysis were used.

Discussion. The use of CCS technologies, in particular CCS-EOR, has both strengths and weaknesses. They are actively discussed at various levels around the world, ranging from the local population to international meetings of government representatives. In individual countries and regions where CCS projects are already being implemented or planned for implementation, extensive argumentation maps have been developed, substantiating or refuting the expediency of using these technologies. As a rule, they distinguish the following groups of issues: environmental, energy, technological, economic and social. Given the absence in Russia of any research related to the study of public perception of CCS, let us present some arguments for and against the implementation of such projects (Table 2).

The development of CCS public perception research in Russia should be based on already existing world experience in implementing CCS projects (Fig.5):

1. Awareness of the problem of global warming implies that population has the necessary amount of information on technical, environmental and economic aspects. An important role in raising awareness is played by the state environmental policy, an element of which should be a long-term educational strategy, closely associated with modern environmental, low-carbon, energy- and resource-saving technologies.

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Table 2

Arguments for and against the Implementation of CCS Projects in Russia

Arguments for CCS	Field	Arguments against CCS
There are industries where CCS has no alternatives (cement production, steel industry, etc.) CCS can prepare a platform for the transition to alternative energy	Climate	CCS may not be able to reach the stage of maturity to solve global warming problems in a timely manner CCS diverts significant financial resources that can be directed to the development of alternative energy
The use of CCS increases the life of coal and gas power plants	Power industry	CCS significantly reduces the energy efficiency of production
CCS will reduce CO_2 emissions without reducing roduction growth Russia has significant potential for CO_2 storage	Technology	Given current and potential emissions, underground storage capacity may not be enough The technology of long-term storage of CO_2 in underground tanks is still not fully learnt
Russia, given the existing mineral and raw material potential, should not lose the opportunity to trade on the carbon market	International relationships	Russia has no international obligations to reduce CO_2 emissions, and domestic obligations at the level of 15-20 % can be achieved without the introduction of CCS
CCS-EOR projects provide additional financial benefits through enhanced oil recovery The infrastructure of Russian oil and gas fields is well developed, which will save on their preparation for the injection of CO_2	Economy	The cost of electricity in the case of the introduction of CCS will increase dramatically There are no guarantees that the additional effects of enhanced oil recovery will exceed the costs of CO_2 capture, transportation and storage

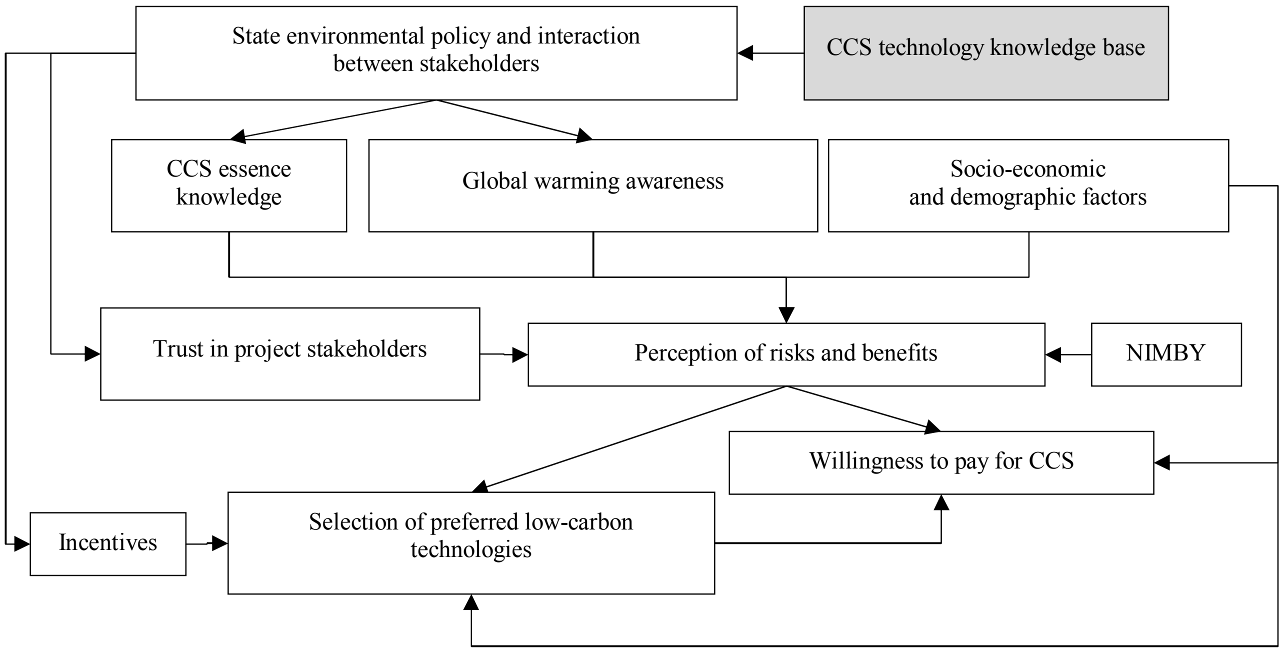

Fig.5. Key aspects of CCS public perception

2. The presence of objective knowledge of CCS technologies prevents the occurrence of various kinds of misconceptions regarding technical aspects of project implementation. For example, as noted in [27], one of the most common misconceptions is comparing an underground tank with a balloon that can explode. On the other hand, low level of knowledge about the long-term storage of CO_2 underground does not allow us to reliably answer all the questions in this field.

3. The «NIMBY» reaction (Not In My Back Yard) is the natural response of a person to the prospect of a project, characterized by certain environmental risks, in close proximity to their home. In world science, there are no methods that would completely eliminate the influence of this effect, but it can be smoothed out by providing the local population with additional economic incentives.

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4. Evaluation of risks and benefits from project implementation is an essential element of CCS perception by the population, which depends on all other factors. However, due to the lack of knowledge about technology, it is possible that when making an adequate and prudent decision, it is necessary to rely on the opinion of experts in this field.

5. Confidence in project stakeholders is formed on the basis of a positive experience of interaction with them, in connection with which certain difficulties may arise in Russia. One of the reasons for the closure of the «Barendrecht» project mentioned earlier was the lack of trust among the local population in Shell. A similar situation was observed in a number of regions of Germany (for example, the «Vattenfall» project in the Beskov region).

6. Willingness to incur additional costs due to implementation of the project. Large-scale development of CCS, like any alternative low-carbon technology, will lead to an increase in electricity tariffs. Despite the fact that population of any countries, in general, negatively relates to the growth of tariffs, there are examples [7, 13, 16] when survey participants showed willingness to increase their expenses if this positively affects the environmental situation in the region.

7. The issue of preference for alternative low-carbon technologies is closely related to public awareness of the essence of these technologies. When comparing CCS with renewable energy, the choice is usually given to the second option. It should be noted that this is largely due to the misconceptions that renewable energy in the near future can completely replace fossil fuels. In addition, active promotion of these energy sources to the markets does not include the process of informing the public about the significant increase in electricity tariffs due to their use, which creates a false image from an economic point of view.

8. Social and demographic factors are essential in the interaction of stakeholders with the local population, as many studies have shown the need for a differentiated approach to different age, cultural and religious groups.

9. State policy in support of CCS and interaction between stakeholders is the main element of the CCS development system. Even in developed countries, where many such projects are already being implemented, it is noted that success has been achieved only thanks to a long-term and comprehensive state program of support for stakeholders of projects. At the same time, at the stage of implementation of pilot projects, it is the state that is the main stakeholder of the project and determines the order of involvement of other parties and their interaction.

Thus, the starting point for the development of CCS is a decision on their use at the state level. This is possible only on the basis of existing scientific and practical experience gained in the framework of the implementation of existing projects. Based on this, it can be concluded that the development of CCS on a national scale depends greatly on international cooperation. A number of key principles for the development of CCS-EOR technologies in Russia should also be highlighted, taking into account the need to improve the image of technology among public:

1. It requires the creation of a comprehensive and long-term state environmental protection program, which would include issues of raising public awareness of the problems associated with global warming.

2. It is necessary to provide ways to improve the image of state structures and large oil-producing companies among the population of Russia.

3. Public perception of CCS largely depends on the availability of economic incentives from the implementation of projects that can be achieved through increased oil production.

4. It is necessary to involve public in the early pre-project stages to identify the level of support for the project.

Conclusion. Based on the study, the following conclusions were made:

1. The interest for the promising group of technologies to reduce greenhouse gas emissions CCS in the world has been observed for several decades. More than 100 projects have been implemented, based on various combinations of source objects, transportation methods and geological repositories (disposal methods).

2. Economic efficiency of CCS projects mainly depends on the final stage of the technological chain – recycling. World practice shows that the most promising projects are CCS-EOR, aimed at enhanced oil recovery of depleted fields.

3. Development of CCS-EOR projects in Russia has a significant potential due to the presence of a significant amount of oil fields in the later stages of the life cycle. In addition, given the strong dependence of the Russian energy sector on fossil fuels, CCS may become a less capital-intensive alternative to the transition to an ecologically balanced industrial development than renewable energy.

4. Public perception plays a significant role in the development of CCS technology, which is mainly associated with certain risks of geological disposal and an increase in the cost of electricity tariffs during project implementation. World practice knows a number of examples when protest movements of local residents caused the project to be stopped.

5. There are a number of arguments for and against the large-scale development of CCS projects, which can vary greatly due to the specifics of the region under consideration. In Russia at this stage, the construction of a full argumentation map seems impossible due to the lack of a sufficient amount of scientific research in this area.

6. There are a number of factors that have a direct impact on the perception of CCS by public and that should be considered when developing a strategy for the development of these technologies. At the same time, the state acts as a key stakeholder of CCS projects, and its support is the guarantor of the development of these technologies, which are in essence innovative, capital-intensive and inter-sectoral.

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***Authors*: Sergey V. Fedoseev,** *Doctor of Economics*, *Professor*, *fedoseev1964@mail.ru* (*Institute of Economic Problems G.P.Luzin*, *Kola Scientific Center of the Russian Academy of Sciences*, *Apatity*, *Russia*), **Pavel S. Tcvetkov,** *Candidate of Economics*, *Assistant Lecturer*, *Tsvetkov_PS@pers.spmi.ru* (*Saint-Petersburg Mining University*, *Saint-Petersburg*, *Russia*).

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