Public perception of carbon capture (utilization) and storage projects: world experience and the situation in Russia

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Abstract: At present, one of the major global environmental problems is the greenhouse effect, which is caused by carbon dioxide emissions. One of the most innovative methods to combat the greenhouse effect is the introduction of CC(U)S projects, involving the implementation of CC(U)S technologies, aimed to carbon capture (CC), storage in underground facilities (S), and sometimes utilization (U). This paperexamines foreign experience of applying CC(U)Stechnologies, which have shownthat some projects have been canceled due to negative public reaction because of low awareness. To understand the prospects for the implementation of CC(U)S projects in Russia, student surveys were conducted among St. Petersburg universities in order to determine the level of awareness of Russian society about this issue. As a result, recommendations were developed to increase awareness level of society of CC(U)S technologies The study is based on publications of Russian and international experts in different scientificjournals. The research methodology includes desk studies, methods of comparative analysis and systematization, a sociological study, a method of generalization, and grouping.

1 Introduction

For many years, numerous scientists and experts have been concerned about the topic of global climate change, which implies an increase in the average annual temperature, which causes glaciers to melt and sea levels to rise [1-4].

Many experts associate climate change on the planet with the emission of anthropogenic greenhouse gases, which include carbon dioxide (CO_2). In this way, many states, companies, and communities are greatly interested in the problems of CO_2 emissions, as well as the development of technologies that can reduce them [5-8]. According to the Analytical Center under the government of the Russian Federation (Analytical Center under the government of the Russian Federation Report 2019),the total global CO_2emissions in 2018 reached 33.9 billion tons, an increase of 1.9% (the maximum growth rate over the past seven years). Emerging economies made the largest contribution to the increase in emissions, while countries in the European Union reduced emissions.

An innovative measure to tackle carbon emissions is the use and spreading of CC(U)S (carbon capture, utilization, and storage) technologies [9-11]. These technologies can significantly reduce greenhouse gas emissions, which lead to global warming. The CC(U)S

technologies represent the process of CO_2 capture at the source of its emission, transportation,and long-term storage with mandatory monitoring of storage facilities (traps) and sometimes utilization (Global CCS Institute 2019).

These technologiesare characterized by the following features: 1) Economic: high capital and operating costs [12,13]; 2) Technological: complexity, point testing of technologies (at this stage of technology development, it is often impossible to implement projects) [13]; 3) Environmental: CC(U)S issues cause ambiguity of opinions about the safety of projects in terms of CO_2 storage (not enough experience in implementing similar projects, a short period during which gas behavior has been observed in underground placement) [12,14]; 4) Social: positive public perception of suchtechnologiesis hard to achieve, as people doubt about the safety of CO_2 storage [15,16].

The fact that CO_2 injection into underground tanks can cause accidents and leaks is used as an argument by opponents of this technology. Doubts about the safety of this way of dealing with the problem of global warming lead to a negative perception of society, which has already caused the cancellation of several projects around the world [11,17-20].

At present, none of the world CC(U)S projects is being implemented on the territory of the Russian Federation; however, for a number of reasons, their implementation is quite promising and may lead to economic and social effects in the future.

In this regard, the study of public perception of such complex technologies as CC(U)S is relevant.

This article attempts to study the problems of public perception of CC(U)S projects and to develop recommendations for raising the awareness of Russian society about such projects.

2 Review of literature

CC(U)S technologies are actively studied by the Global Institute of of Carbon Capture and Storage [21], National Energy Technology Laboratory, World Energy Council, International Energy Agency, Carbon Capture and Storage Association [22].

English scientist Mhairi Aitken [13], a group of scientists from Canada [23], a group of scientists from the Netherlands [24], and many other researchers are engaged in studying of public perception of CC(U)S technologies [25,26].

A large number of researchers highlight the technological side of CC(U)S [27]. Many publications deal with issues related to the commercial effectiveness of technology applications [10,28,29].

In Russia, this technology is studied by a scientific team of Mining University under the guidance of Professor A. Cherepovitsyn [6,30] and other Russian scientists [31-33].

Nevertheless, despite a large number of different publications on the research topic, some aspects, namely, the social side of the application of CC(U)S technology has not been adequately studied.

Thus, this study analyzes the prospects for the application of CC(U)S technology in Russia, specifically, the social aspects of the issue: the public perception of such projects, identifying the level of public awareness.

3 Research methods and materials

In the research, the following methods were used: 1) desk studies to collect and summarize information about various CC(U)S projects with the necessary information obtained from available sources, such as websites of companies and sequestration projects, the global database of the CCS Institute, the database of the National Energy Technology Laboratory

(NETL) and the theoretical basis of the study composed on publications of scientists and experts in scientific electronic and printed sources, such as *Notes of the Mining Institute, Energy Procedia, Energy Policy, Resources,* and others; 2) methods of comparative analysis and systematization to determine the nature of CC(U)S projects, as well as the specifics of perception of such projects in society; 3) a sociological study, i.e., a survey among students of St. Petersburg universities (Mining University, Polytechnic University, St. Petersburg State University), 4) a method of generalization and grouping to process the results obtained during the surveying.

4 Results

During the study, it was found out that public perception plays a key role in the spreading and implementation of CC(U)S projects at local and global levels. At the same time, public perception is a social institution consisting of three elements: 1) psychological (feelings, emotions), 2) ethical (morality), 3) relational (awareness) [10]. Using CC(U)S technologies is rather difficult and limited today because of the low awareness of nature and safety level [10,34].

At the international level, problems related to public perception are identified as one of the main issues hindering the implementation of technologically complex projects. In world practice, there are many examples where uncoordinated actions of a member of the public led to the closure of a project [10].

As an example of the impact of public opposition on the implementation ofCC(U)S projects, we can bring such projects as Schwartze Pumpe, Greenville, Barendrecht, CarbonNet, WESTCARB Cholla; MRCSP R.E. Burger; SECARB Escatawpa; WESTCARB Rosetta (Table 1) [24,30,35].

Table 1. Characteristics of CC(U)S CO_2 projects that were rejected due to public disapproval [24,30,35]

Name of the project	Location	Ultimate purpose of application	Reason of rejection
Schwartze Pumpe	Company «Vattenfall» (Germany), 2010	The coal-fired power plant uses sequestration technology	Rejected due to targeted action of non-governmental organizations, whose members make up about 40% of the government. They did not agree on laws on the use of sequestration technologies at the highest level.
Greenville	Greenville, Ohio (USA), 2010	Ethanol plant uses sequestration technology	Locals successfully opposed underground CO_2 storage due to a lack of confidence in the safety of sequestration technology.
Barendrecht	Netherlands, 2013	Storage of 10 million tons of CO_2 from the	The project was rejected due to collected petitions from the public Non-governmental

		Shell-Pernis refinery	organizations did not agree on the implementation of the project, as they were against using the sequestration technology.
CarbonNet	Victoria (Australia), 2009	Storage of CO_2 at the bottom of the sea	In 2012, this situation prompted the government not only to close this project but also to stop all such projects in the Netherlands
WESTCARB Cholla; MRCSP R.E.Burger; SECARB Escatawpa; WESTCARB Rosetta	USA, 2008	Storage of CO_2 at an ocean floor tank	Locals expressed concerns about the impact that CO_2 storage would have on the "untouched" environment and dissatisfaction with the level of information the government provided them. The project was rejected due to collected petitions from the public Due to the public, the project was cancelled at the integration stage. The project was rejected due to collected petitions from the public.

In addition to CC(U)S projects that were not implemented due to distrust of the public, there are examples of other projects that were not implemented precisely due to the same reason (Table 2) [10,23,36].

Table 2. Environmental projects that were rejected because of the public [10,23,36].

Name of the project	**Location**	**Ultimate purpose of application**	**Reason of rejection**
Solid waste management	Zhejiang, China	The burning of municipal solid waste, resulting in the generation of heat, which can be used in the form of energy	Locals residents were concerned about the harmful emissions that could result from burning substances. Thanks to signed petitions, the plants had to be closed.
Construction of wind farms	Finland, Europe	Use of wind turbines for energy use	At the stage of project integration, the local population was against the construction of wind power plants; protests were organized.

Based on the above examples and lessons learned, it becomes clear that the public reaction is closely linked to the possibility of implementing various kinds of projects. An important component, in this case, is the public perception of the project itself, the technologies used, its advantages and disadvantages, and possible consequences. In contrast to those projects that were canceled at the initiative of the publicbecause of low awareness, one can cite those that, on the contrary, there were implemented many projects with high support from the society. Such projects include Gorgon, Snøhvit CO_2 Storage Project; Petrobras Lula Oil Field CCS Project; Abu Dhabi CCS Project; In Salah Carbon Dioxide Capture and Storage Project [30,37-39].

Summarizing all the above, we can conclude that there are:

a) Factors that contributed to the rejection of CC(U)S projects often include negative public opinion, caused by low awareness of organizations, the local community, the media, the general population about the nature and features of projects, and a lack of work with interested parties; b) Factors that contributed to the implementation of CC(U)S projects, such asclose interaction with stakeholders, especially with the local population, the government, involvement of stakeholders in the decision-making process of the project (for example, involving environmental communities in the environmental assessment of the technology used).

At present, none of the global CC(U)S projects is being implemented in the Russian Federation; however, the implementation of CC(U)S projects involving the injection of CO_2 into underground reservoirs, for example, into depleted hydrocarbon deposits, is perspective and can lead to economic and significant social effects in the future: 1) It helps to reduce carbon dioxide emissions, 2) Depleted oil fields can be used to reduce technogenic impactof CO_2emissions (there are opportunities for storage), 3) CC(U)S technology will increase oil recovery and oil quality.

The main constraint for the development of CC(U)S technologies is the public concern about the potential for leaks of buried CO_2. Since many CC(U)S projects on a global scale have been canceled at the initial stage of implementation due to public opinion, the next stage of the study was to determine the level of awareness of the Russian society on the implementation of CC(U)S projects. To understand the awareness of Russian society about this problem, surveys among Russian students, teachers, as well as representatives of scientific organizations and industry, were planned.

At the initial stage, a questionnaire was developed and surveys were conducted at several universities in St. Petersburg (Mining University, Polytechnic University, St. Petersburg State University). The survey was conducted using the Google form and the statistic program. The sample size of respondents amounted to about 5% of all students in the university. In total, about 3 941 students of 1-5 grades, as well as postgraduate students, took part in the survey of St. Petersburg universities.

After analyzing the answers, it became clear that only 47.1% of students of Mining University express serious concerns regarding the issue of carbon dioxide emissions, while about 40% of students from other universities have rather vague ideas about this problem and do not express serious concerns (Figure 1).

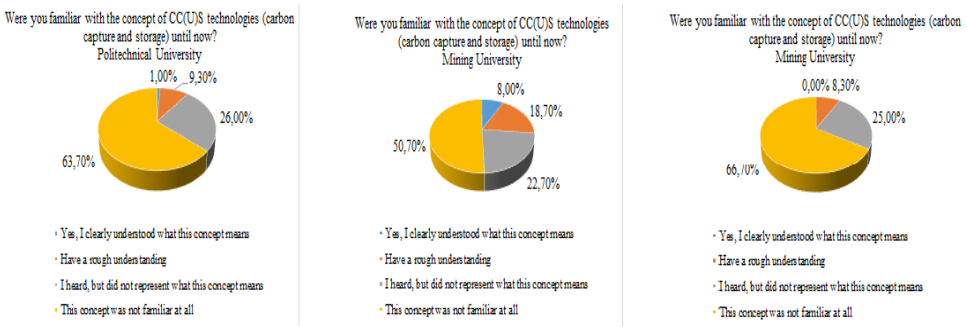

Fig. 1. Students' attitudes toward greenhouse gas emissions (created by the authors).

Regarding the perception of respondents about such method as carbon capture (utilization) and storage of carbon dioxide, half students of Mining Universityhave no idea about CC(U)S projects, and only 8% are aware of this technology, and 90% of students of the other universities are not aware of this technology at all (figure 2).

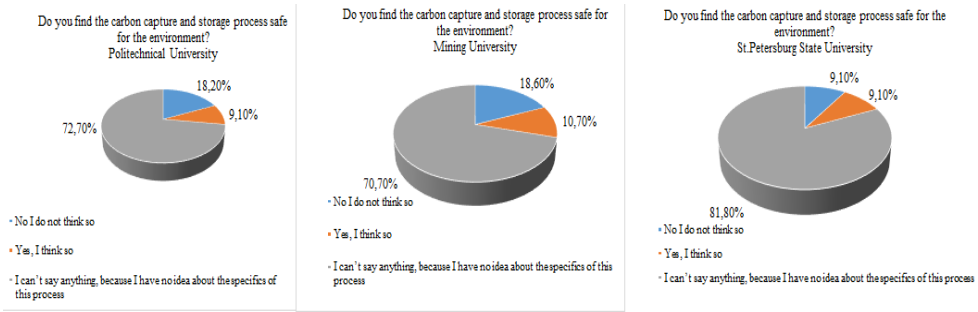

Fig. 2. Students Awareness of the Concept of CC(U)S projects(created by the authors).

Students' awarenessof the implementation of CC(U)S projects in the world also has a low rate. About 74% students of Mining, St. Petersburg State, and Polytechnic universities do not know whether such projects were implemented.

To the question "AreCC(U)S projects safe?" the majority of respondents answered, "I can't say anything, because I have no idea about that."

Therefore, as described above, due to ignorance, lack of information about CC(U)S projects, the safety of this phenomenon, people may be against using such innovative technology and potentially oppose the implementation of such projects (Figure 3).

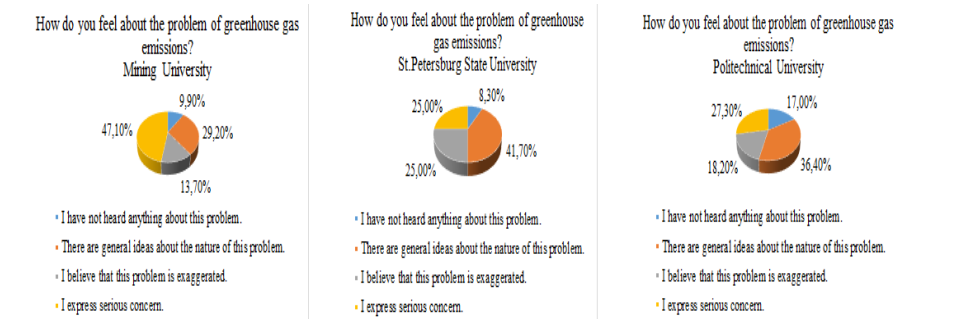

Fig. 3. Perception of safety of using carbon capture (utilization) and storage technology (compiled by the author).

More than a half, 51.4% of students, expressed interest in the topic of carbon capture and disposal. They would like to understand what carbon capture (utilization) and storage of carbon dioxide are, to learn more about it.

Comparing the results of surveys of students from different universities, it is clear that the awarenessof students of Mining University is higher than at other universities. It can be explained by the fact that at Mining University the discipline of environmental studies is broadly taught, and students have the opportunity to get acquainted with environmental problems. The awarenessof students of St. Petersburg State University and Polytechnic University about the problem of greenhouse effects, methods of reducing the amount of carbon dioxide emissions (sequestration) is much lovwe than that of students of the Mining University. Moreover, the lack of information affects their perception regarding the safety of this technology, which can lead to a negative reaction in the case of CC(U)S project implementation.

5 Conclusion

The study presents characteristics ofCC(U)S projects that have been rejected at the initiative of society, examines concepts of public perception, and surveys a large number of students of St. Petersburg universities, which is sufficient to draw conclusions about how the younger generation understands the problem of greenhouse gas emissions, methods for reducing emissions, and current trends in this area. Surveys among students showed that although many people are aware of the environmental problem of greenhouse emissions, not everyone knows what methods exist to deal with it. If we talk about CC(U)S, only a few students know what it is, while others are not informed and cannot be sure of its safety. As part of the study, the following recommendations were made to increase the awareness of Russian society aboutCC(U)S projects:

1) As the rejection of CC(U)S projects is associated with a negative public reaction due to low awareness, it is necessary to raise public awareness as follows:

- Present information to the preschool generation about existing technologies with the help of pictures, comics
- Conduct special lessons at schools on environmental issues, methods to combat them
- Arrange conferences to inform about existing technologies that help to combat emissions of carbon dioxide
- To increase the interest of students and teachers with the topic of protection and preserving of the environment, as well asCC(U)S technologies, in order to develop scientific activities in this field
- To include sections on environmental protection and environmental education in the educational programs of a number of disciplines in all universities

2) In the process of project integration and planning, involve stakeholders, especially the local population, in the decision-making process on the implementation of the project: take into account their opinion, hold meetings to increase public awareness of CC(U)S technologies, their safety, and create a positive public opinion.

The task of raising people's awareness of environmental problems, of the technologies used to eliminate them is essential. Awareness-raising awareness is vital from an early age to instill public confidence in technology. After all, if this is not be done, the implementation of many projects that will help solve environmental problems will become impossible.

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