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PROPAGATION PERSPECTIVES OF CO_2 SEQUESTRATION IN THE WORLD

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ABSTRACT

The article is dedicated to the analysis, summarization and systematization of information on implemented and planned projects of CO_2 sequestration differing in the scale, field, used technologies and geological conditions of storage. Information is given for the distribution of active, completed, suspended, stopped (upon management decision) CO_2 capture and storage projects and projects planned for implementation in various parts of the world. Special attention in the study is paid to the determination of administrative conditions, the identification of economic effects, the consideration of environmental aspects, the study of social perception and trends of projects analyzed. The obtained results allow for identification, systematization, and assessment of factors defining the propagation perspectives of CO_2 sequestration globally.

The study included desk research, systemic and comparative analysis, the analog method, author's modified PEST analysis, and root cause analysis. The theoretic and methodological basis of the paper is the studies of foreign and domestic authors, Internetresources, and projectdatabases.

Keywords: Global Warming, Climate Change, Greenhouse Effect, Carbon Dioxide, Global Experience, Perspectives, CO_2 Sequestration Projects, State, Society.

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1. INTRODUCTION

The discussions on global warming among leading scientists of the world have been ongoing since the middle of the previous century. Many specialists relate the climate change on the planet to the emissionof man-induced greenhouse gases that include carbon dioxide. However, some specialists, such as an international group of scientists of the Princeton

University (USA) and the Max Planck Institute for Chemistry (Germany), made an occlusion that global warming was related not to human activities but to carbon dioxide (CO_2) release from the Southern Ocean.

Nevertheless, most scientists relate climatic changes on the planet to greenhouse gas emissions, predominantly CO_2, that are caused by man-induced factors, which primarily include:

- production and combustion of oil, coal, gas and other minerals;
- primary processing of gas, oil refining,and enrichment;
- iron restoration;
- production and use of fertilizers.

To solve issues of global warming, a number of methods have been developed, which include: refusal to use organic fuel to generate power and satisfy other needs of the global economy; reducing the conventional coal-fired power industry; complete or partial transition to renewable power sources; development of the nuclear power field; CO_2 sequestration.

As specialists believe, carbon dioxide sequestration (carbon capture and storage – CCS) that consists in CO_2 capturing, preparation, transportation, storage, and monitoring, is critically important to inhibit the temperature growth on the planet to 1.5 ˚C. As estimated, the input of CO_2 sequestration technologies in the reduction of CO_2 accumulation by 2050 shall be at least 13% globally[1].

2. METHODS

The study hypothesis is based on the suggestion ofthe practicability and perspectives of large-scale implementation of CO_2 sequestration projects. It is suggested that CO_2 sequestration projects may significantly contribute to the reduction of CO_2 accumulation on a global scale.

The research was aimed to generalize, systematize information on implemented CO_2 sequestration projects and projects being implemented, identify and assess the significance of such projects, define the perspectives of their implementation in the world, develop recommendations to intensify this type of environmental measures based on a complex analysis.

In this relation, the following methods were used during the research: desktop studies that consisted in collection, analysis and processing of information on causes, specifics, and issues of CO_2 sequestration projects; systemic and comparative analysis; modified PEST analysis which revealed the factors promoting CO_2 projects' propagation in the world; cause and effect analysis that allowed making conclusions on relations between identified factors and implementation scales of CO_2 sequestration projects in the world.

The sources of primary and secondary data were Internet-resources of companies, projects' databases, Scopus scientific electronic library, fundamental works of foreign specialists, scientific works of domestic researchers.

3. LITERATURE OVERVIEW

The issues of the development perspectives of CO_2 sequestration projects are considered in a rather limited way from many aspects both in the works of foreign authors and in few works of domestic researchers [2-9]. The literature analysis in this area makes a conclusion that there is no comprehensive opinion on the propagation of the sequestration technology, and works analyze mainly technological [10-13] and some social issues [14-16] related to the implementation of this technology only. These works cover various subjects of research and

areas where the studies are carried out, which requires, as we believe, more detailed and complex studies in this topic.

In [17], the authors assess the risk of a commercial CO_2 sequestration project with further CO_2 injection and identify various process parameters as key parameters (such as oil production rate, CO_2 injection rate, cumulative oil production, etc.). Based on statistical data for a single project (Morrow, Texas), a group of scientists makes an economic model CO_2-EOR projects' profitability analysis, which is a basis to conclude that the probable successful implementation of such projects is 31%.

By analyzing the environmental condition and atmosphere, the authors of [18] and [19] describe the need to implement CO_2 sequestration projects based on the results of environmental condition monitoring in China and Germany and results of implementing large-scale demonstration CCS projects.The authors also note that the implementation of such projects is possible with political support that is provided in these countries to such projects.

The authors of [16] study the issue related to regional cooperation when promoting the development of tests for efficient CO_2 sequestration projects in the USA.

The paper [20] is a study intended to determine efficient tools to solve potential issues of CO_2 migration from the geological storage to the subsurface zone. The paper [21] gives a systematic analysis of social, political and economic factors affecting the success of CO_2 capture and storage technology in China. Thepaper [22] defines the dependency between the perception of risks of sequestration projects and national predictors of the cultural level.

Based on the analysis of multiple publications in [15], the authors make a conclusion that wide propagation of CCS projects will depend on social context, and the success of projects dependsnot only on the level of technological achievements in this area and social processes, butalso on other factors, which must be defined in future studies.

There are multiple publications of foreign specialists on the stages, issues, specifics of implementation of CCS projects in various parts of the world, which indicates the urgency of such projects. However, the existing studies do not summarize the experience of CO_2 sequestration projects; they neither identify nor define factors affecting the perspectives and opportunities of large-scale geographic propagation of such projects.

4. RESULTS

According to the database of the National Energy Technology Laboratory (NETL) for CCS [23] as of April 2018, there are about 305 CCS projects in the world, whereas information on 299 projects is publicly available. These projects are implemented in more than 30 countries of the world, 6 continents and include 76projects in carbon capture, 76 projects of carbon storage and 147 projects of both capture and storage. 93 projects of all the projects are active, 77 projects are frozen, 58 projects are stopped as decided by the management, 36 projects are planned to be implemented and 35 projects are suspended.

To define factors promoting the propagation of CO_2 projects, the studies included the analysis of various types of projects implemented in all regions of the world, with special attention paid to global projects.

As a result of analyzing capture, storage and both capture and storage projects, including the above, a conclusion can be made that all projects differ in their scale, field, used technologies and geological storage conditions.

Table 1 gives an analysis of global CCS projects aimed at defining administrative conditions of their implementation, revealing the economic effect, studying environmental aspects and defining the social perception and orientation.

The obtained results allowed identifying, systematizing and assessing the significance of factors defining the propagation perspectives of such projects (Figure 1).

Table 1 Analysis of implementation specifics of CO_2 sequestration projects

Project	Administrative conditions	Environmental effect	Social perception and orientation
Sleipner CO_2 Storage Project (Norway) [24]	CO_2 tax implemented in 1990. Funding of project monitoring from the public fund	CO_2 storage monitoring showed environmental efficiency. Project support by environmental organizations (Bellona, Zero). However, Greenpeace Norway is against any type of storage and disposal	Social acknowledgment of the project efficiency, popularization in scientific literature, awards
Snøhvit CO_2 Storage Project (Norway) [25]	CO_2 tax implemented in 1990. Partial funding of project monitoring by the European Union (CO2ReMoVe program)	Constant monitoring of CO_2 storage to avoid gas leakage from storages (leakage was possible in 2011)	Popularization in scientific literature
Petrobras Lula Oil Field CCS Project) (Brazil) [14]	According to the Brazilian law, violation of environmental regulations implies a fine of up to 50 mln reals ($12.8 mln), activity prohibition, cancellation of tax concession and credit lines	Specifics of oil occurrence caused concerns about no ability to use the CO_2 sequestration technology and the risk of environmental calamity. However, successful experimental work carried out in 2011 allowed continuing the project	The project created the need for professional personnel, which provided workplaces for specialists in this area
Abu Dhabi CCS Project (United Arab Emirates) [26]	Funding is provided by means of the research program of combined projects by Masdar and Adnoc, as well as money of the Mudala government. The Abu Dhabi Sustainability Group (ADSG) actively supports this project	CO_2 storage monitoring showed the environmental efficiency	This project is implemented under the population life improvement program by providing clean air in the industrial district
In Salah Carbon Dioxide Capture and Storage Project (Algeria) [27]	Funding of the project monitoring, funding of the program of scientific studies and developments in order to take a decision to revive the project by the European Commission and the US Department of Energy	The analysis of seismic and geomechanical data required the adoption of a decision to suspend CO_2 injection in 2011. There were risks of possible vertical leakage of CO_2	Availability of information on the project monitoring to the public
Gorgon Carbon Dioxide injection project (Australia) [28]	Financial support by the Australian government in the amount of $60 mln that were allocated from a special fund supporting CCS demonstration projects. Stiffening of requirements of the Australian government in environmental protection	Project delay due to technological issues, which resulted in large CO_2 volumes emitted to the atmosphere	Availability of information on the project implementation issues to the public
Boundary Dam Carbon Capture Project (Canada) [29]	$240 mln were received from the federal government; the project is implemented by SaskPower public company	According to unofficial data, almost half of emissions are discharged to the atmosphere during capture and injection into an oil field	The negative financial result of the project caused higher prices for power for the population
The Quest CCS Project (Canada) [30]	Partial funding of the project by the governments of Canada (Clean Energy Fund $120 mln) and Alberta Province (CSS Support Fund, $745 mln). Under the agreement, the governments of Canada and Alberta Province, as well as Shell, are the right holders of CCS technologies	The project showed its environmental efficiency, and underground water, soil,and atmosphere are constantly monitored	Certificate of an international risk management organization. Availability of information on the project implementation to the public
Great Plains Synfuel plant and Weyburn-Midale project	Project funding (CO_2 capture) by the US Department of Energy. For additional studies, the USA and Canada governments allocated	Constant monitoring of stored CO_2.Early in 2011, suggestions for CO_2 leaks were made, but the specialists concluded that the	Availability of project monitoring data to the public, reports on project implementation

Project	Administrative conditions	Environmental effect	Social perception and orientation
(USA, Canada) [14]	additional funding of $5.2 mln	leakage was associated with natural biological processes in the ground.	
Enid Fertilizer CO_2-EOR Project (USA) [31]	Lawmaking projects to improve environmental component in the USA create a favorable atmosphere to implement sequestration projects. A large fine is envisaged for violations of water, air quality and wastes laws, as well as imprisonment up to 2 years	According to Koch, CO_2 emissions at the Enid factory reduced by 11% per 1 ton of ammonia. According to the U.S. Environmental Protection Agency (EPA), USA ammonia and carbamide producers reduced greenhouse gas (GHG) emissions by 4.5 mln tons of CO_2 equivalent within 1990 to 2006	This project provides a lot of workplaces and meets the environmental regulations
Shute Creek Gas Processing Facility (USA) [32]	Monitoring of compliance with the Air Quality Law is done by the administration of Wyoming, which somewhat facilitates the procedure to obtain a permission to operate for operators on whose activity the state budget depends	The controlled freezing zone technology implemented under the project can make CO_2 capture and storage more available and efficient in reducing greenhouse gas emissions	Involving professional specialists to develop improved technologies in natural gas treatment
Century Plant (USA) [33]	In 2010, the Environmental Protection Agency (EPA) started to regulate the air quality in Texas. It stiffened the requirements to emissions and restricted the operation of many companies in the state.	Immense volumes of CO_2 sequestration (almost 8.5 mln per year) prove the large-scale environmental effect of project implementation	The company develops health care and safety in the region
Petra Nova Carbon Capture Project (USA) [34]		Many violations of the air quality law by many operators were found in Texas, so many companies did not obtain a permission to operate. However, this project permitted the company to continue its activities without damages to the environment	Preserving workplaces in the region
Air Products Steam Methane Reformer EOR Project (USA) [14]	The Department of Energy supports this pioneer project in this area within a long-term program called Demonstration of CO_2 Capture and Steam Methane Sequestration for Large-Scale Production of Hydrogen.	The project is intended to solve the issues of climate change, increasing the economic and energetic safety and proved its environmental efficiency during the implementation period	The projected has prompted implementation of similar projects, which requires a lot of human resources

Political factors	**Legal factors**
1. Paris Agreement 2. Direct financial support of CCS project implementation by means of various funds and government institutions 3. Organization of governmental and industrial scientific and research programs	1. Imposition of a tax for CO_2 emissions 2. Stiffening environmental law (water and air quality and waste laws) 3. Introducing regulations and standards in reducing CO2 emissions
	Economic factors
	1. Oil prices 2. Capital and operational expenses for project implementation
Organizational factors	**Process factors**
1. Orientation to using conventional energy sources 2. Substitution of conventional power sources with alternative ones 3 Geological formations to store CO_2 near sources of emissions 4. Oil fields near sources of emissions which require enhanced oil recovery methods 5. Implementation of demonstration projects	1. Support programs for CCS technologies 2. Creating advanced centers to promote CCS technologies 3. International cooperation to promote CCS technologies
	Environmental factors
	1. Significant CO_2 emissions in the country (region) 2. High morbidity in the country (region) 3. Support for projects by environmental organizations 4. Possibility of CO_2 leaks from geological formations
	Social factors
	1. Perception of projects by the society 2. Deficiency of workplaces in the region

Figure 1 Factors determining the propagation perspectives of CCS projects

5. DISCUSSION

The analysis allows for a conclusion that among the identified factors, the political and legal factors are determinant in taking a decision to implement CCS projects. For the last 20 years, state and social institutions of various countries of the world have stimulated the implementation of environmental technologies, including CCS, by means of specific administrative conditions and financial support. The most efficient measures are CO_2 tax and stiffening of environmental laws.

A huge role in the promotion of CCS projects is played by process factors. In some countries, advanced centers are created with the support of the government to promote sequestration technologies where various companies reveal information on the specifics of projects from a process, economic, social, etc. viewpoints.

In some countries, projects were stopped due tonegative perception by the society of CO_2storage in Earth's interior.

Of paramount importance for CCS projects' propagation are the economic practicability and environmental safety of their implementation. Expanding the portfolio of CCS projects and availability of information on implemented technologies in a number of countries have a determinant importance to reduce both capital and operational expenses, improve technologies, and minimize negative environmental consequences.

6. CONCLUSION

The analysis of implemented projects has shown that the global portfolio of CCS projects is still expanding and developing in a flexible manner. The number of implemented large-scale CCS projects has almost reached 20, and a number of projects are planned for implementation in the nearest future. The scales of CO_2 storage projects are also growing and the largest in the world factory producing liquefied natural gas in Gorgon (Australia) is expected to increase CO_2 storage volumes to 3 mln tons per year. The global portfolio of CCS projects now includes such projects as: Boundary Dam Carbon Capture Project – the project whose implementation was the first to permit the use of CCS technology in a coal power station (Canada, Saskatchewan Province); Abu Dhabi CCS Project – a project where the CCS technologies were first to be implemented in a steel-making factory (United Arab Emirates, Abu Dhabi), as well as CCS projects in gas processing, hydrogen generation, fertilizers' production and coal gasification plants.

Despite the current acknowledgment of contribution of CCS technologies to the struggle with global warming, a significant progress was achieved in the propagation of technologies by means of creating specific administration conditions and financial support of the government and funds. This circumstance caused wide propagation of CCS projects in the USA, Canada, Norway.

Further large-scale propagation of CCS projects will depend on:

- development of more demonstration CCS projects around the world, using various technologies and geological storage objects.
- development of CCS technologies in rapidly developing countries producing oil in large amounts such as China, India,and Russia, which cannot be achieved without governmental involvement;
- increasing current expenses for research by all developed countries;
- improvement of the legal framework.

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REFERENCES

[1] International Energy Agency. Carbon Capture & Storage: The Solution for Deep Emissions Reductions, 2015, pp. 12. http://www.iea.org/publications/freepublications/publication/CarbonCaptureandStorageThesolutionfordeepemissionsreductions.pdf

[2] Babayev, S.N., Khlebnikov, V.N., Men Lyan, Likhacheva, N.V. Vliyaniefizicheskogososotoyaniya CO2 na emkostglubokozalegayushchegovodonosnogogorizontaprizakhoroneniiparnikovogogaza [Effects of CO2 Physical Condition on the Capacity of Deep Aquifer in Greenhouse Gas Storage]. Trudy RGU Neftiigaza (NIU) imeni I.M. Gubkina, 1(286), 2017, pp. 66-77.

[3] Lavrechenko, G.K., Kopytin, A.V.Perspektivysovershenstvovaniyaishirokogoispolzovaniya CCS-tekhnologii[Perspectives of Improvement and Wide Use of CCS Technologies]. Tekhnicheskiegazy, 2, 2015, pp. 3-15.

[4] Rogozin, M.Y., Ivanchenko, D.S. Chem opasenparnikovyieffekt [Why Is Greenhouse Effect Dangerous]. Molodoiuchenyi, 51(185), 2017, pp. 120-124.

[5] Sidorova, K.I. Razrabotkatekhniko-ekonomicheskoimodeliulavlivaniya CO2 dlyaenergeticheskogosektora [Development of a Technical and Economic Model of CO2 Capture for Power Sector]. EkologiyaipromyshlennostRossii, 12, 2014, pp. 20-25.

[6] Cherepovitsyn, A.E., Sidorova, K.I., & Smirnova, N.V. Tselesoobraznostprimeneniyatekhnologiisekvestratsii CO2 v Rossii [Practicability of Using CO2 Sequestration Technologies in Russia]. Neftegazovoedelo, 5, 2013, pp. 459-473.

[7] Cherepovitsyn, A.E. Ekonomiko-sotsialnyeaspektyrazvitiyatekhnologiizakhvataizakhoroneniya CO2 v neftegazovomkomplekseRossii [Economic and Social Aspects of Developing CO2 Capture Technologies in the Oil and Gas Industry of Russia]. ZapiskiGornogoinstituta, 211, 2011, pp. 125-130.

[8] Cherepovitsyn, A., Fedoseev, S., Tcvetkov, P., Sidorova, K., Kraslawski, A. (2018). Potential of Russian Regions to Implement CO2-Enhanced Oil Recovery. Energies, 11(6), 2018. https://www.mdpi.com/1996-1073/11/6/1528/pdf

[9] 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), 2016 pp. 19-23. http://www.jeeng.net/prospects-of-ccs-projects-implementation-in-russia-environmental-protection-and-economic-opportunities,62282,0,2.html

[10] Figueroa, J.D., Fout, T., Plasynski, S., McIlvried, H., Srivastava, R.D. Advances in CO2 Capture Technology – The U.S. Department of Energy's Carbon Sequestration Program. International Journal of Greenhouse Gas Control, 2(1), 2008, pp. 9-20.

[11] Herzog, H.J. What Future for Carbon Capture and Sequestration? Environmental Science and Technology, 35(7), 2001, 2001, pp. 148-153.

[12] Yang, H., Xu, Z., Fan, M., Bland, A.E., & Wright, I. Progress in Carbon Dioxide Separation and Capture: A Review. Journal of Environmental Sciences, 20(1), 2008, pp. 14-27.

[13] White, C.M., Smith, D.H., Jones, K.L., Morsi, B.I., & Schroeder, K.T. Sequestration of Carbon Dioxide in Coal with Enhanced Coalbed Methane Recovery – A Review. Energy and Fuels, 19(3), 2005, pp. 659-724.

[14] International Energy Agency. 20 years of Carbon Capture and Storage. Accelerating Future Deployment, 2016, pp. 115. https://www.iea.org/publications/freepublications/publication/20YearsofCarbonCaptureandStorage_WEB.pdf

[15] L'OrangeSeigo, S., Dohle, S., Siegrist, M. Public Perception of Carbon Capture and Storage (CCS): A Review. Renewable and Sustainable Energy Reviews, 38, 2014, pp. 848-863.

[16] Rodosta, T., Aljoe, W., Bromhal, G., Damiani, D. U.S. DOE Regional Carbon Sequestration Partnership Initiative: New Insights and Lessons Learned. Energy Procedia, 114, 2017, pp. 5580-5592.

[17] Dai, Z., Viswanathan, H., Xiao, T. CO2 Sequestration and Enhanced Oil Recovery at Depleted Oil/Gas Reservoirs. Energy Procedia, 114, 2017, pp. 6957-6967.

[18] Jafari, M., Cao, S.C., & Jung, J. Geological CO2 Sequestration in Saline Aquifers: Implication on Potential Solutions of China's Power Sector. Resources, Conservation and Recycling, 121, 2017, pp. 137-155.

[19] Mennicken, L., Janz, A., Roth, S. The German R&D Program for CO2 Utilization – Innovations for a Green Economy. Environmental Science and Pollution Research, 23(11), 2016, pp. 11386-11392.

[20] Leroux, K.M., Azzolina, N.A., Glazewski, K.A. Lessons Learned and Best Practices Derived from Environmental Monitoring at a Large-Scale CO2 Injection Project. International Journal of Greenhouse Gas Control, 78, 254-270.

[21] Chen, Z.-A., Li, Q., Liu, L.-C., Jia, L., & Liu, G. A Large National Survey of Public Perceptions of CCS Technology in China. Applied Energy, 158, 2018, pp. 366-377.

[22] Karimi, F., Toikka, A. General Public Reactions to Carbon Capture and Storage: Does Culture Matter? International Journal of Greenhouse Gas Control, 70, 2018, pp. 193-201.

[23] The National Energy Technology Laboratory. Carbon Capture and Storage (CCS) Database. https://www.netl.doe.gov/research/coal/carbon-storage/worldwide-ccs-database

[24] Carbon Capture and Sequestration Technologies. Sleipner Fact Sheet: Carbon Dioxide Capture and Storage Project. https://sequestration.mit.edu/tools/projects

[25] Heiskanen, E. Snohvit CO2 Capture & Storage Project. 2006.https://www.researchgate.net/publication/237551719_Case_24_Snohvit_CO2_capture_storage_project

[26] Global CCS Institute. Abu Dhabi CCS Project. https://www.globalccsinstitute.com/projects/abu-dhabi-ccs-project-phase-1-being-emirates-steel-industries-esi-ccs-project

[27] Eiken, O., Ringrose, P., Hermanrud, C., Nazarian, B., Torp, T. Lessons Learned from 14 years of CCS Operations: Sleipner, In Salah and Snøhvit. Energy Procedia, 4, 2011, pp. 5541-5548.

[28] Gorgon Carbon Dioxide Injection Project. Fact Sheet. https://australia.chevron.com/-/media/australia/publications/documents/gorgon-co2-injection-project.pdf

[29] Global CCS Institute. Boundary Dam Carbon Capture and Storage. https://www.globalccsinstitute.com/projects

[30] Quest Carbon Capture and Storage Project, Alberta. https://www.hydrocarbons-technology.com/projects/quest-carbon-capture-and-storage-project-alberta/

[31] The Fertilizer Institute. The U.S. Fertilizer Industry and Climate Change Policy. http://www.kochfertilizer.com/pdf/TFI2009ClimateChange.pdf

[32] Carbon Capture and Sequestration Technologies. La Barge Fact Sheet: Carbon Dioxide Capture and Storage Project. https://sequestration.mit.edu/tools/projects/la_barge.html

[33] Occidental Petroleum Corporation. Permian EOR. https://www.oxy.com/OurBusinesses/OilandGas/UnitedStates/Permian/Pages/permianeor.aspx

[34] Petra Nova Is One of Two Carbon Capture and Sequestration Power Plants in the World. Independent Statistics and Analyzes. 2017. https://www.eia.gov/todayinenergy/detail.php?id=33552