TECHNICAL AND ECONOMIC ASPECTS OF REDUCING CARBON DIOXIDE EMISSIONS INTO THE ATMOSPHERE

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Abstract

The article outlines the technical and economic aspects and relevance of reducing carbon dioxide emissions into the atmosphere in the Republic of Azerbaijan (AR). It is noted that transforming Azerbaijan into a clean environment is one of the priorities of the national program "Azerbaijan 2030". The main sources of carbon dioxide emissions into the atmosphere in the AR have also been studied. Several consequences of carbon dioxide emissions into the atmosphere and possible (necessary) actions to reduce them are given. The basics of carbon dioxide retention in the geological structures of the earth and the main criteria for assessing geological objects for their disposal are analyzed. It is indicated that in order to reduce the long-term consequences of global warming, the technology of capturing, transporting and recycling and (or) burying carbon dioxide is considered as one of the key technologies. It is noted that in order to create an underground storage facility for injection of carbon dioxide gas, the geological structure in the subsurface must meet certain criteria. It was revealed that the most suitable objects for creating projects for the disposal of carbon dioxide gas in the subsurface are the depleted oil and gas fields of the Apsheron Peninsula.

Keywords: carbon dioxide, atmosphere, burial, injection, geological structure, renewable energy sources

I. Introduction

The climate agenda, the rise of global energy consumption and the electricity costs reduction have led to a sharp increase in the production volume of renewable energy sources, and their market share has been growing steadily over the past few decades.

Transforming a country into a one with a clean environment is one of the priorities of the national program "Azerbaijan 2030". All issues listed in the Priorities are extremely important for the sustainable development of the country (Fig. 1). In recent years, the Republic of Azerbaijan has been making every effort to participate in the global processes of the "great energy transition of 2030" [1-4].

The Conference of the Parties to the United Nations Framework Convention on Climate Change, or the COP, is a large government-level meeting dedicated to developing a common climate strategy. The 29th COP is planned to be held in Azerbaijan in 2025. Holding the COP 29 in Baku is an endorsement of the country's contribution to environmental protection and the prevention of climate change at the national, regional and global levels. The UNO expressed confidence that the AR will hold the COP 29 at a high level, and this will be another great success for the country, as well as a contribution to slowing down climate change [4].

Figure 1: *Main priorities of social and economic development of the AR*

According to the International Energy Agency (IEA), global carbon dioxide (CDG) emissions will reach record levels in 2023. These emissions are energy-related, largely due to the increased use of fossil fuels. Greenhouse gases (carbon dioxide, CO2) are the most important source of climate change. They are estimated to be responsible for approximately 64% of global warming. The IEA notes that to achieve the global climate goals set in the Paris Agreement, sharp reductions in carbon dioxide emissions, in particular the combustion of fossil fuels, are necessary [5, 6].

The Paris Agreement on Climate Change adopted in 2015 (the COP 21) set participating countries goals to reduce greenhouse gas emissions and limit global warming to 1.5-2 degrees Celsius compared to pre-industrial levels (the period of 1850-1900) [7].

Azerbaijan is also a party to the Paris Agreement, and has made a voluntary commitment to reduce greenhouse gas emissions by 35% by 2030 compared to 1990, and by 40% by 2050. This agreement and all subsequent COPs are dedicated to the implementation of the key goal of this document – keeping the global average temperature rise to 2°C (global peaking) and continue efforts to limit the increase to 1.5°C (climate neutrality). Today, one of the main reasons for climate warming is "greenhouse" emissions into the atmosphere, among other gases, primarily carbon dioxide, the release of which is natural and anthropogenic, is leading (Fig. 2).

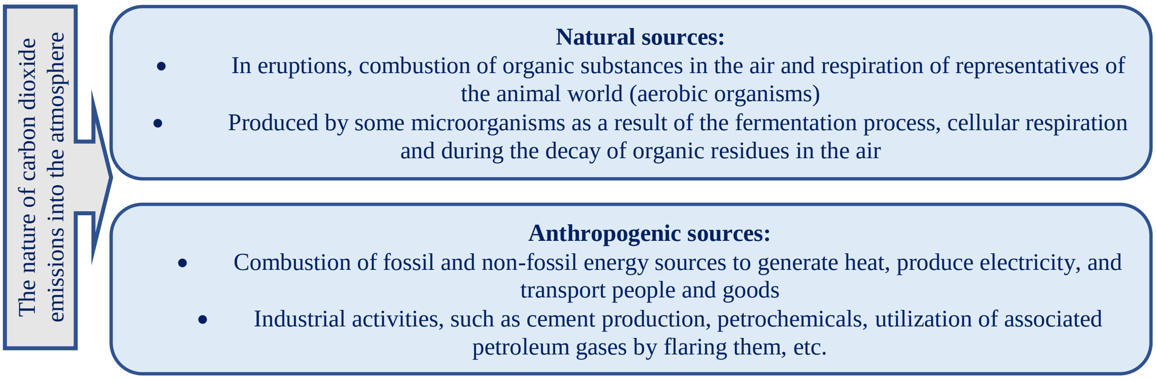

Figure 2: *Nature of carbon dioxide emissions into the atmosphere*

As is known, the main anthropogenic sources of carbon dioxide emissions into the atmosphere are of an industrial (energy) nature (Fig. 3).

II. Methods

The study used the analytical method, the method of comparison. Methods for collecting, processing and analyzing information were determined by the specific objectives of the study based on a systematic approach. Based on the analysis of extensive material, a review of existing options for the utilization and storage of carbon dioxide in the subsurface has been prepared.

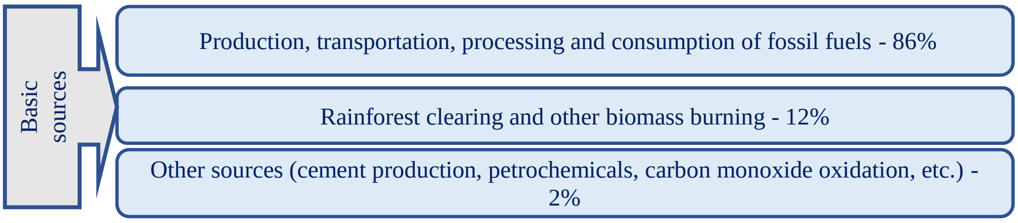

Figure 3: *Main sources of carbon dioxide emissions into the atmosphere*

III. Research results and discussion

According to the IEA, in 2022 alone the volume of emissions amounted to 36.8 billion tons and in 2023 from the energy sector they increased by 410 million tons, or 1.1%, reaching 37.4 billion tons. The increase in carbon dioxide emissions into the atmosphere has serious consequences (Fig. 4). The main volume of about 70% of global CDG emissions comes from electricity and heat generation and transport [5, 8, 9].

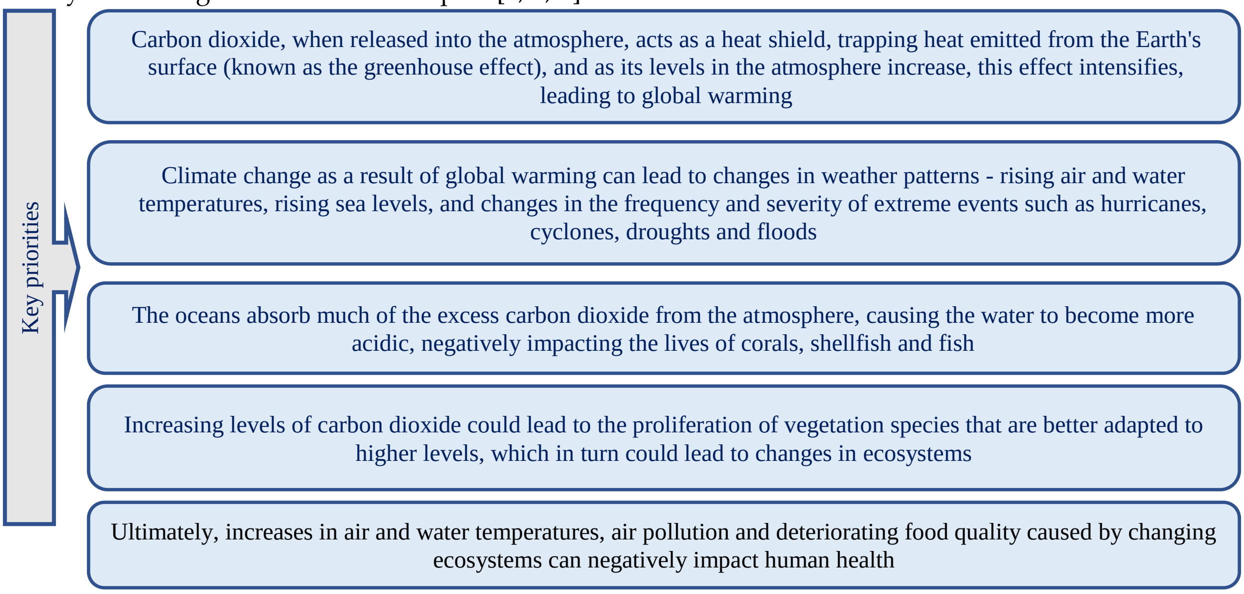

Figure 4: *Some consequences of carbon dioxide gas emissions into the atmosphere*

To reduce greenhouse gas emissions into the atmosphere, the Republic of Azerbaijan is implementing a number of projects, including paying special attention to the production of renewable energy sources (RES). However, additional measures must be taken to reduce atmospheric carbon dioxide emissions (Fig. 5).

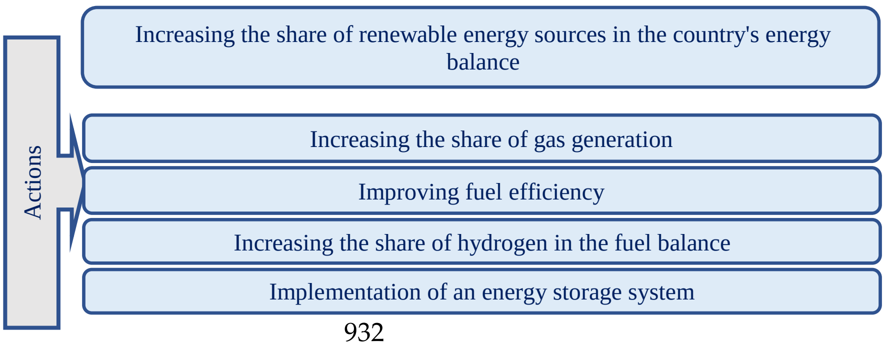

Figure 5: *Action is needed to reduce carbon emissions into the atmosphere*

The development of the petrochemical industry in the AR is accompanied by an increase in greenhouse gases that require disposal. One of the by-products of petrochemical production is carbon dioxide. According to the requirements of state supervisory authorities, production and industrial enterprises must limit the release of carbon dioxide.

The technology for CDG capturing, transporting and disposal (and/or recycling) is currently considered one of the key technologies for mitigating the effects of global warming [9-11]. A VOC removal technology can have two main goals: preventing new VOCs from entering the atmosphere or eliminating previous emissions. The technological chain of CCS elimination projects includes a number of processes [12-14]. (Fig. 6).

Burying CDG means pumping it underground to a depth of 800 meters or more. The geological properties of underground reservoirs determine the reliability of this storage. Porous rocks from depleted hydrocarbon deposits that have contained fossil fuels for millions of years are among the most suitable. Based on foreign experience, depleted hydrocarbon (HC) deposits and geological aquifer structures can be used as objects for disposal of hydrocarbons [15, 16].

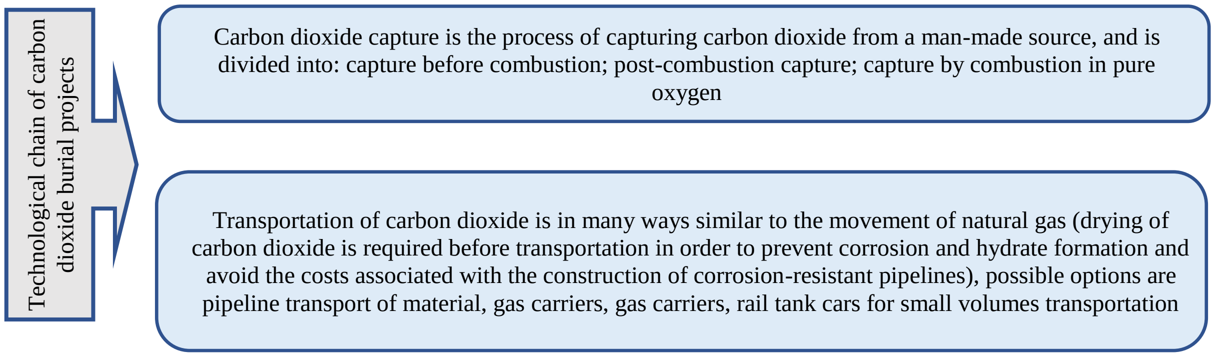

Figure 6: *Some consequences of carbon dioxide emissions into the atmosphere*

Norway was one of the first countries to implement projects to capture carbon dioxide from factories and pump it into subsurface storage facilities. The number of CDG phase-out projects around the world has grown rapidly in recent years, and there are currently 29 such projects (Table 1). The current capacity of CDG phased disposal projects around the world, amounting to about 40 million tons per year, can capture only slightly more than 0.12% of global carbon dioxide emissions [9, 17, 18].

Table 1: *Distribution of carbon capture, utilization and storage by regions (2022)*

Region	Active	In developing	Suspended	Total by region
North America	16	80	2	98
China	4	3		7
Europe	4	46		50
Persian Gulf	3	1		4
The rest of the world	2	11		13
Total	***29***	***141***	**2**	***172***

Four main mechanisms remain at the basis of the retention of CDG in the geological structures of the Earth (Fig. 7).

The principles of carbon dioxide retention in the geological structures of the Earth consist of four main provisions (Fig. 7), where the degree of carbon dioxide retention is determined by the potential of the underground storage (geological structure) [11, 17].

Special requirements must be placed on the geological conditions and characteristics of CDG storage tanks to ensure the safety of long-term storage of injected products. Leaks of CDG, even those to ensure the safety of underground sources of drinking water supply, as well as leaks to the surface must be excluded [11, 19, 20].

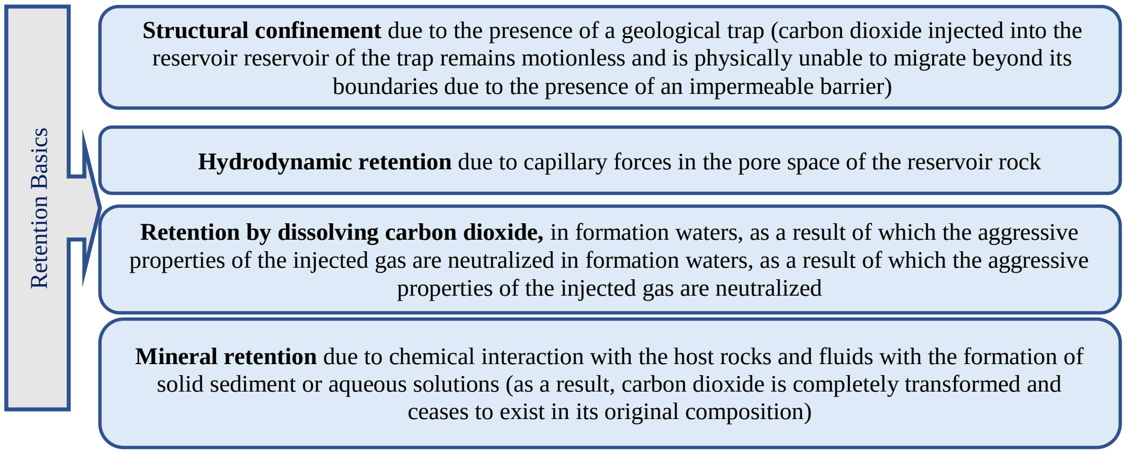

Figure 7: *Basics of carbon dioxide retention in the geological structures of the earth*

To create an subsurface facility for carbon dioxide injection, the geological structure in the earth interior must meet certain criteria (Fig. 8).

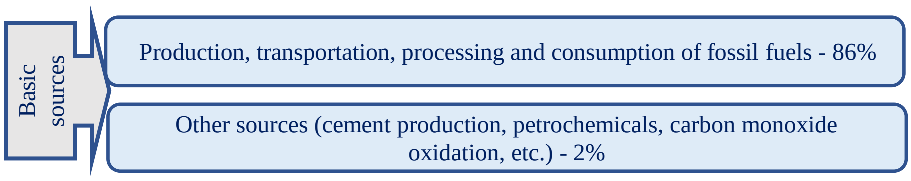

Figure 8: *Basic criteria for assessing geological sites for carbon dioxide disposal*

Natural geological structural traps (reservoirs) with certain thermobaric conditions ensure the safety of the injected CDG at reservoir pressure at the end of injection of a given volume to the initial reservoir pressure. One of the problems regarding the process under consideration is the distribution and distribution speed of the CDG throughout the volume of the natural trap.

Disposal of CDGs in depleted deposits must be carried out not only while maintaining the tightness of the underground reservoir, but also while ensuring the absence of lateral flows of CDGs along the roof of the trap. Therefore, when injecting carbon dioxide into a reservoir, monitoring the distribution of carbon dioxide throughout the reservoir becomes an urgent problem.

Monitoring techniques, first of all, must meet the requirements of accuracy and reliability of determining the gas-water contact. However, an important factor is the simplicity and cost-effectiveness of the technique. Accordingly, the choice of a suitable monitoring technique can specified through choosing the simplest and most economical one, in order to then consider the degree of its reliability and draw a conclusion about the validity of its application One of the simplest and most economical techniques is gravimetric monitoring, based on recording changes in the Earth's gravitational field. When carrying out gravity surveys, data are obtained that describe the gravitational field created by the underlying strata of the earth. In order that the obtained data from gravimetric studies be the most representative, they must be carried out with confidence in the established regime in the formation. This approach will eliminate the anomalous pressure increase in the reservoir associated with the inhibited propagation of the hydrocarbon gas in the reservoir, since without identifying the increase in pressure there is a high risk of reducing the tightness of old wells [21-23].

When making a qualitative interpretation of gravimetric monitoring data, it is necessary to mention the possibility of registering the threat CDG may cross the trap's closing isohypsum using the proposed technique. By controlling the distribution of carbon dioxide throughout the reservoir using gravimetric monitoring, it is possible to stop its injection in time to prevent the flow of carbon dioxide through the structural trap.

To justify the selection of promising geological objects for placement (creation of an underground reservoir) on the basis of depleted deposits for the placement of CDG, it is necessary:

- to identify promising facilities for carbon dioxide storage;
- to assess the potential for carbon dioxide storage in selected facilities;
- to perform a technical and economic analysis of the transportation of CDGs in various ways to selected storage facilities.

Based on a technical and economic analysis of different methods of transporting the projected volume of CDG emissions, it is possible to recommend appropriate geological structures as the subsurface part of operational disposal facilities. The results obtained will be used to substantiate the initial data for the technological design of the construction of an operation facility for the disposal of carbon dioxide gas.

IV. Conclusion

Achieving global goals for economic decarbonization is impossible without implementing projects to capture, transport and use (or) bury carbon dioxide. One of the most important factors for these projects to be successful is the availability of geological facilities for safe long-term storage of carbon dioxide. At the same time, the accumulated experience in the gas business (transportation, underground storage, etc.), including sour gases, as well as access to extensive geological information gives the oil and gas industry a global advantage, allowing it to exploit the AR potential in the field of CDG disposal in the earth interior. According to preliminary estimates, the most suitable sites for creating projects for the use and storage of greenhouse gases in the Azerbaijan interior are located in traditional oil and gas production areas, mainly on the Absheron Peninsula.

The current tasks of developing a new technology for the AR are a targeted geological study of various conditions for storing carbon dioxide in the subsurface and the development of uniform regulatory requirements for the geological parameters of underground carbon dioxide storage structures. In addition, it is important to examine the long-term liability issues associated with establishing ongoing geological monitoring of possible leaks from underground carbon dioxide storage in the subsurface. The gravity monitoring technique allows monitoring the condition of the field into which carbon dioxide is injected.

Azerbaijan's potential in terms of the use and burial of carbon dioxide underground is quite high, but it has not been fully assessed yet, and today there are no industrial projects for the burial of carbon dioxide in the bowels of the country. Additional actions are necessary to implement the above-described project to reduce greenhouse gas (carbon dioxide) emissions into the atmosphere.

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