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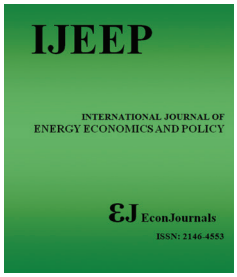

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Opportunities and Prospects for Hydrogen Production in Azerbaijan: Steps towards the Transition to a Hydrogen Economy

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ABSTRACT

Hydrogen plays a key role in reducing greenhouse gas emissions, enabling decarbonization of the energy, transport and industrial sectors. Its importance in the energy balance will increase for several reasons. Firstly, in the modern world there is a transition to carbon-free energy, which stimulates the use of hydrogen. Secondly, a balanced system based on renewable energy sources is important to ensure stability and reliability of energy supply. The purpose of the study is to study the prospects for hydrogen production for the transition to sustainable development of the Azerbaijani economy. During the study, research methods such as graphical analysis, comparison of blue and green hydrogen production scenarios, analysis and synthesis method, and dynamic comparison method were used. The results of the study showed that in order to transition to a hydrogen economy in Azerbaijan, it is preferable to start with the production of blue hydrogen. There is potential for this in the form of rich natural gas reserves (confirmed gas reserves are 2.6 trillion cubic meters). With the advent of new technologies and lower production costs, a transition to green hydrogen will be possible. For this purpose, the country has a technical potential for renewable energy sources amounting to 135 GW on land and 157 GW at sea. The conclusions are that in order to transition to a hydrogen economy in Azerbaijan, it is necessary to adopt a strategy for transitioning the economy to a hydrogen basis, developing infrastructure, attracting investments in the modernization of chemical enterprises, and switching public transport to the use of hydrogen.

Keywords: Decarbonization, Emissions, Energy, Hydrogen, Natural Gas, Production, Renewable Sources, Azerbaijan
JEL Classifications: Q42, Q48, O44

1. INTRODUCTION

Electricity and heat production is one of the key sectors of the economy that influences greenhouse gas emissions. According to various estimates, its share is approximately 25-30% (IPCC, 2022). Therefore, the first and most obvious step to achieving carbon reduction goals in the economy is to increase the share of renewable energy sources with minimal carbon emissions and reduce the share of thermal generation using coal in electricity production. In today's world, against the backdrop of growing environmental problems and the search for sustainable energy sources, the hydrogen production is attracting more and more attention. Hydrogen (H_2) has the potential to become a key element in the transition to clean energy sources and reducing dependence on hydrocarbon fuels.

The hydrogen economy is a system that includes the production of hydrogen from various energy sources, its storage for later use, transmission through pipelines, and conversion into heat and electricity. This concept is future-oriented and is currently being tested in various sectors such as electricity, building and household heating, industry, transport, raw materials production. To achieve this goal, various countries are developing their energy strategies, including hydrogen-based energy production, storage and distribution.

Azerbaijan, along with rich fuel and energy resources, has significant potential for the use of renewable energy sources, such as solar and wind. These sources can be used to produce electricity, which can then be used in the electrolysis process to produce hydrogen. This method of hydrogen production is becoming increasingly efficient and environmentally friendly. However, the main problem is the high cost of producing hydrogen from renewable energy sources. In addition, Azerbaijan currently lacks the necessary infrastructure for hydrogen production. The capacity of power plants using renewable energy sources is 16.5% of the total electricity generating capacity, which is a small percentage compared to the existing potential of the republic.

2. LITERATURE REVIEW

In order to combat such a global problem as climate change, an intercountry agreement was adopted in Paris in 2015 within the framework of the UN Climate Change Conference (COP 21). The goal of the Paris Agreement is to reduce greenhouse gas emissions to limit global warming to 1.5-2°C this century (UNFCCC, 2015). Hydrogen is included in discussions as a potentially important element of emissions reduction strategies. In 2020, A Hydrogen Strategy for a Climate Neutral Europe was adopted in Brussels, developed by the European Commission, which aims to create a green hydrogen economy in Europe (European Commission, 2020). This strategy focuses on using hydrogen produced using renewable energy sources. Within the framework of the World Economic Forum in 2017, the Global Hydrogen Council is a global initiative bringing together industry, science and government to actively promote the role of hydrogen in energy and reducing CO_2 emissions (Hydrogen Council, 2017). These initiatives highlight the commitment to sustainable development and the promotion of technologies that can reduce the negative impact on the climate. Regional and national authorities can also develop their own strategies and agreements to deploy hydrogen and reduce greenhouse gas emissions in the context of their unique energy and environmental goals.

The hydrogen economy is the concept of using hydrogen as a key energy carrier for a variety of purposes, including the production of electricity, heat and transport fuel. It is based on the idea that hydrogen, as a clean energy source, can be an important element in the transition to a more sustainable and clean energy sector (Dou et al., 2023).

Hydrogen can be produced from a variety of energy sources, including renewable (e.g., solar and wind) and non-renewable (e.g., natural gas, coal). Currently, the main sources of hydrogen production are fossil fuels, which are not always considered environmentally friendly. Approximately half of all hydrogen produced comes from natural gas, 30% from oil, and 15% from coal (Karayel and Dincer, 2024).

The process of producing hydrogen from renewable energy sources with minimal carbon emissions is called "green" hydrogen, while using non-renewable carbon sources can result in greenhouse gas emissions.

There are several types of hydrogen, depending on how it is produced and what percentage of purity it has: Grey, green, blue (Yu et al., 2021).

2.1. Gray Hydrogen

This type of hydrogen is produced from natural gas through a steam reforming process in which carbon is oxidized and released into the atmosphere as carbon dioxide (CO_2). This is the most common method of producing hydrogen today, but it produces significant CO_2 emissions, making it unsuitable for addressing climate change (Howarth and Jacobson, 2021).

2.2. Green Hydrogen

Green hydrogen is produced by electrolysis of water using renewable energy sources such as solar or wind power. At the same time, the process is not accompanied by carbon emissions and is considered one of the most environmentally friendly methods of hydrogen production (Hassan et al., 2024). The use of green hydrogen can facilitate a rapid transition to clean and renewable energy sources, while improving the sustainability and reliability of energy systems (Risco-Bravo, 2024).

2.3. Blue Hydrogen

This type of hydrogen is also produced from natural gas, but the carbon emissions are processed and contained using carbon capture and storage (CCS) technologies. As a result, much of the CO_2 that would normally be emitted during gray hydrogen production is not released into the atmosphere. However, this technology requires significant investment and development of appropriate infrastructure (Bauer et al., 2022).

Green hydrogen is considered the most environmentally friendly and preferred option, but its production is currently limited by high costs. Thus, the cost of hydrogen production is estimated at $4.55/1 kg for high temperature electrolysis and $4.32/1 kg for the metal oxide cycle with a production capacity of 2500 tons/year (Restrepo et al., 2022). For hydrogen to become a widely used energy source, its production costs need to be reduced (Abdalla et al., 2018). Over the long term, hydrogen production costs in Europe are projected to fall to around US$3/kg (Burton et al., 2021). By 2050, the minimum cost of producing hydrogen from renewable energy sources could drop to US$1.5/kg and even below US$1/kg in some regions under optimistic scenarios (Brändle et al., 2021). Blue hydrogen using CCS may represent a transitional phase in the development of the hydrogen economy until green hydrogen production technologies become more accessible and cost-effective.

Using renewable energy to produce green hydrogen has a significantly lower environmental impact than using natural gas to produce blue hydrogen. However, green hydrogen has a drawback that relates to other aspects of its environmental impact. These disadvantages include human toxicity, particulate matter emissions, mineral resource consumption, land use, and water supply decline. These impact aspects are 2-29 times higher compared to blue hydrogen production (Shen et al., 2024).

The main challenge in the coming decades is to create a completely new industry and market based on the production of hydrogen

without carbon emissions, its large-scale storage and transportation over significant distances using pipelines and ships, as well as the introduction of large-scale use of this resource in various sectors from energy and transportation to industry, including steel mills, chemical plants, large gas turbine plants, and even domestic energy sources for homes, businesses, and the military, ranging from trucks to unmanned aerial vehicles (Zapantis, 2021). In this direction, the study of Koilo (2020) is of scientific interest, in which the author examines the prospect of using hydrogen ships. This is because hydrogen, compared to batteries, has a higher energy density and is therefore suitable for large ships (Koilo, 2020).

It should be taken into account that countries with rich energy resources are not interested in using renewable energy sources. Thus, Ahmadov and Borg (2019) conducted a study covering the period from 1997 to 2015, in which this statement was empirically confirmed. The oil and gas rich country faces two problems. First, the transition to a hydrogen economy deprives the country of traditional resource income, forcing it to introduce diversification. Secondly, the transition to renewable energy sources is more difficult compared to countries that do not have rich natural resources. This is due to the need to reform the economy and adapt the management system to new conditions (Ahmadov, 2021). More than 20 countries and over 50 companies have begun long-term programs to develop hydrogen technologies, receiving support in the form of incentives, funding from various budgets and international technological cooperation (Guliyev, 2022).

Despite the rich natural resources, renewable energy sources have been highlighted as one of the important priorities for achieving a new socio-economic and diversified development course for Azerbaijan until 2030, as well as a clean environment. According to the International Renewable Energy Agency, the installed capacity of renewable energy sources in Azerbaijan amounted to 17% of the total capacity (IEA, 2022). Electricity production from environmentally friendly energy sources accounted for 7.3% of total production (IEA, 2023). Considering that the expansion of the use of renewable energy sources has been identified as a priority by the government of the Republic of Azerbaijan and the goal has been set to increase the share of electricity to 30% by 2030, a lot of work is being carried out in this area (The Government of the Republic of Azerbaijan, 2021). The first regulatory document was the bill "On the use of renewable energy sources in the production of electricity," adopted in May 2021 (Law of the Republic of Azerbaijan, 2021). In addition, Azerbaijan has committed to reducing greenhouse gas emissions by 35% by 2030, by 40% by 2050 and creating a zero-emissions zone in the liberated territories (Azerbaijan COP 26 Statement, 2021).

In recent years, the interest of researchers in the prospects for the use of renewable energy sources in Azerbaijan has been increasing. Thus, the features of choosing renewable energy sources for various regions of Azerbaijan were analyzed by Nuriyev et al. (2022). The work of Abdurahmanov (2023) explored the potential of wind energy in Karabakh and proposed several scenarios for the effective development of wind energy in the region. Despite the high potential of solar and wind energy, the use of renewable energy sources in Azerbaijan is at a low level due to a relatively weak legal framework and little experience in this field (Mustafayev et al., 2022).

Azerbaijan has the capabilities not only to produce low-carbon hydrogen, but also to create a hydrogen value chain, including transport, storage and use of hydrogen within the country (Guliyev, 2023). At the same time, in the hydrogen chain, which includes the production, storage, transportation, refueling and use of hydrogen fuel, the hydrogen production stage is of particular importance. This stage has the greatest impact on the possible applications of hydrogen (Zhang et al., 2021).

However, research on the production and use of hydrogen in Azerbaijan is currently represented by a small number of publications on this topic and a number of reports from international organizations (Vidadili et al., 2017; IEA, 2021; UN Economic Commission For Europe, 2023). Considering this fact, this article is relevant and is of scientific and practical interest. Thus, Azerbaijan, rich in energy resources, is beginning to look at the prospects of using hydrogen energy as a clean source capable of meeting growing demand and promoting sustainable development.

The purpose of this study is to explore Azerbaijan's capabilities in the field of hydrogen production. To achieve this goal, an analysis of various segments of the energy sector was carried out to assess the national potential for hydrogen production and the possibilities for increasing it in the future; assessing prospects for hydrogen exports; identifying possible areas of local use of hydrogen; identifying areas for potential pilot projects.

2.4. The Study Includes

Analysis of the current state of the gas industry of the complex; assessment of renewable energy sources; overview of activities in the field of hydrogen economy. The study drew conclusions regarding the potential for hydrogen production and export and identified priorities for future national hydrogen strategies.

To conduct this study, open sources of information were used, including the latest reports from international expert centers specializing in the field of energy, as well as national regulations relating to energy and renewable energy sources.

Three hydrogen production scenarios were considered: Scenario I - blue hydrogen production; Scenario II - production of gray hydrogen; Scenario III - production of green hydrogen.

Scenario I - production of blue hydrogen. The most common method is steam reforming of natural gas. Before reforming, natural gas is purified to remove impurities such as hydrogen sulfide (H_2S) and carbon dioxide (CO_2), which can negatively affect catalysts in subsequent stages of production. Pure methane is steam reformed, resulting in a gas mixture containing hydrogen (H_2) and carbon dioxide (CO_2). The reaction looks like this:

$$CH_4 + H_2O \rightarrow CO + 3H_2 \quad (1)$$

$$CO + H_2O \rightarrow CO_2 + H_2 \quad (2)$$

Here: CH_4 - methane, H_2O - water, CO - carbon monoxide, H_2 - hydrogen, CO_2 - carbon dioxide.

The resulting synthesis gas undergoes additional purification, resulting in pure hydrogen. After purification, the hydrogen is compressed to the required pressure for ease of transportation and use. This blue hydrogen production process is widely used in industry, and blue hydrogen (produced using CCS technologies) is considered one of the potential sources of hydrogen for future low-carbon technologies (Massarweh et al., 2023).

Scenario II - gray hydrogen production. Gray hydrogen is produced by reforming natural gas without CCUS (carbon capture, utilization and sequestration). Therefore, such production releases large amounts of carbon dioxide into the atmosphere, which contributes to global warming. This method is the most common hydrogen production in the world.

Scenario III - green hydrogen production. This production involves the use of renewable energy sources such as solar or wind energy. One of the key methods for producing green hydrogen is water electrolysis. The process proceeds as follows. First, electricity is generated from renewable sources such as solar panels or wind turbines. This electrical energy is then sent to water electrolysis, which splits water molecules (H_2O) into hydrogen (H_2) and oxygen (O_2). The process can be represented by the following equation:

$$2\ H_2O + \text{electricity} \rightarrow 2\ H_2 + O_2 \quad (3)$$

The released hydrogen is collected and then subjected to a purification process to remove possible impurities to obtain pure hydrogen. After purification, the hydrogen is compressed to the required pressure for ease of transportation and use. The hydrogen-water energy cycle has a number of advantages, including the fact that water is a widespread resource, allowing large amounts of energy to be stored with minimal environmental impact (Berna-Escriche et al., 2022).

Producing green hydrogen using renewable energy is considered more environmentally sustainable than producing blue hydrogen because the process does not emit carbon into the atmosphere. Green hydrogen plays an important role in strategies to reduce dependence on carbon-based energy sources and contribute to the transition to cleaner energy sources.

3. METHODOLOGY

The study was conducted using several methods, including the scenario method, graphical analysis and dynamic comparison method. The scenario method was used as a basis, which is used to make decisions on a long-term basis. It allows you to describe possible future scenarios taking into account likely preferences. Such scenarios are usually presented in three versions:

- Optimistic (production of green hydrogen)
- Pessimistic (production of gray hydrogen)
- Expected (production of blue hydrogen).

The probability of a complete coincidence with optimistic or pessimistic scenarios is extremely low, so the most likely is a combination of positive and negative events. For this, the most likely scenarios are highlighted. It is considered optimal to develop such a strategy when the results achieved would be favorable under any considered scenario for the development of the situation.

When analyzing the dynamics of natural gas production, data from 1990 to 2022 were used, i.e. the period from the beginning of the declaration of independence of Azerbaijan to the present. When analyzing electricity produced from renewable sources, a 10-year period was used.

To analyze the data, statistical materials and reports from The International Energy Agency, State Statistical Committee of the Republic of Azerbaijan, Energy Charter, and Ministry of Energy of the Azerbaijan Republic were used.

4. RESULTS

Azerbaijan has significant natural gas potential for the production of blue hydrogen (according to the scenario I), which plays an important role in the country's economy and its energy strategy. The total proven gas reserves of the Republic of Azerbaijan amount to 2.6 trillion cubic meters (Table 1).

The main natural gas field in Azerbaijan is Shah Deniz - one one of the largest natural gas fields in the region, located in the Caspian Sea. This field is a key component for the supply of natural gas to a number of countries, including Turkey and Europe. The Shah Deniz project represents a large-scale collaboration between various energy companies and states.

Oil and gas production in Azerbaijan has a centuries-old history. Figure 1 shows the dynamics of gas production starting from the period of declaration of independence of the republic.

The above chart clearly demonstrates the steady increase in gas production. Gas production in the republic in 2022 was 4.7 times higher than natural gas production in 1990 and 8.3 times higher than natural gas production in 2000.

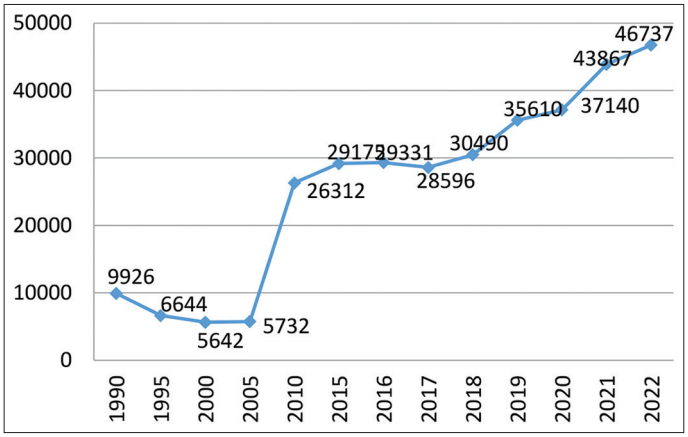
Azerbaijan actively exports natural gas, which contributes to the diversification of its economy and provides additional income. Project Southern Gas Corridor, which includes the TANAP and

Table 1: Gas reserves by fields of Azerbaijan

Field	Gas volume
Total gas reserves of Azerbaijan	2.6 trillion cubic meters
Developed deposits	
Shahdeniz	1.2 trillion cubic meters
Absheron	3 5 0 billion cubic meters
Promising deposits	
Shafaq-Asiman	500 billion cubic meters
Nakhchivan	300 billion cubic meters
Umid-Babek	200 billion cubic meters
Garabagh	13 billion cubic meters
Ashrafi	13 billion cubic meters

Source: Azerbaijan Energy Profile (IEA, 2023)

Figure 1: Natural gas extraction, million cubic meters



Source: State Statistical Committee of the Republic of Azerbaijan (2023). Energy of Azerbaijan. p.131

TAP gas pipelines, is aimed at transporting Azerbaijani gas to Turkey and further to Europe.

Azerbaijan's natural gas potential is an important element of its strategy to ensure energy security and diversify the economy in the face of changing global energy trends.

Under Scenario II, Azerbaijan could use the world's most common method for producing gray hydrogen. Despite the prevalence of this method, this method is the most polluting method, resulting in the release of greenhouse gases.

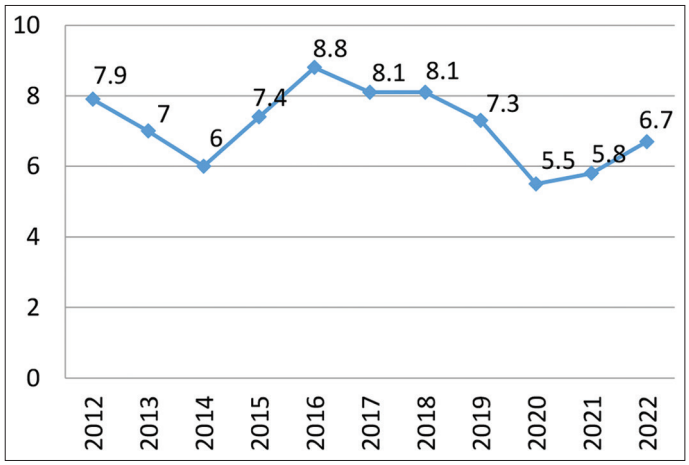
Azerbaijan is one of the countries with high potential for renewable energy sources, which can be used for hydrogen production (according to the scenario III). Thus, the technical potential of renewable energy sources in our country is: 135 GW on land, 157 GW at sea. The economic potential of renewable energy sources is estimated at 27 GW, including (Table 2).

The total electricity generating capacity of Azerbaijan is 7954 MW, the capacity of power plants using renewable energy sources, including large hydroelectric power stations, is 16.5% of the total capacity. There are 30 hydroelectric power stations, of which 20 are small hydroelectric power stations. Wind energy capacity was 66.1 MW, bioenergy 37.7 MW, solar energy 51.9 MW (Table 3).

Two hybrid power plants (Gobustan) are equipped with wind −2.81 MW, solar −3.8 MW and bioenergy −0.7 MW. The installed capacity of renewable energy sources excluding large hydroelectric power plants in 2022 amounted to 201.5 MW (2.5% of total electricity production capacity) (Ministry of Energy of Azerbaijan Republic, 2023a).

As can be seen from Figure 2, the share of energy from renewable energy sources in the total volume of electricity is low. During the Covid-19 pandemic, it dropped to 5.5%. In recent years there has been a slight increase, as evidenced by the data. Thus, in 2022, the share of renewable energy was 6.7%.

Figure 2: Share of electricity produced from renewable sources in total electricity production, percentage



Source: State Statistical Committee of the Republic of Azerbaijan (2023)

Table 2: Economic potential of renewable energy sources

S. No.	Types of energy	Power, MW	In percentages
1	Wind energy	3000	11.14
2	Solar energy	23,000	85.52
3	Bioenergy	380	1.41
4	Energy of mountain rivers	520	1.93
	Total:	27,000	100.00

Source: Energy Charter (2020), Aydin (2020)

Table 3: Energy capacity and number of stations, operating on renewable energy sources

S. No.	Types of energy	Power, MW	Total number of stations	Number of hybrid stations
1	Renewable power plants	1314.9	52	5
2	Hydropower	1159.2	30	-
3	Wind power	66.1	8	2
4	Bioenergy	37.7	2	1
5	Solar energy	51.9	12	2

Source : Ministry of Energy of Azerbaijan Republic (2023a)

5. DISCUSSION

Azerbaijan has long been dependent on the production and export of oil and gas. The introduction of hydrogen energy will provide an opportunity to diversify the country's energy mix and reduce dependence on traditional sources, which promotes energy independence.

As noted in our previous study, Azerbaijan has significant potential for the use of renewable energy sources such as solar and wind (Hamidova et al., 2022). Continuing the previous study, we note that these sources can be used to produce electricity, which can then be used in the electrolysis process to produce hydrogen. This method of hydrogen production is becoming increasingly efficient and environmentally friendly. The prospects for the production, processing and transportation of green hydrogen will be the subject of our future research.

According to the first scenario we proposed, Azerbaijan can produce low-carbon hydrogen from natural gas (blue hydrogen). This requires capture and storage of carbon dioxide (CCS) produced during the methane reforming process. Azerbaijan has developed oil and gas fields where carbon dioxide can be stored. In other words, the country has the potential to store CO_2 both in deposits and aquifers. The proposed scenario II is taken as pessimistic in the analysis, despite its prevalence throughout the world.

According to the third scenario, given the untapped potential of renewable energy sources, especially solar and wind, Azerbaijan has the capacity to produce hydrogen through electrolysis (green hydrogen). This involves using energy from renewable sources. This scenario in the analysis is considered optimistic.

In our opinion, at the present time it is more suitable for Azerbaijan to use scenario I (this is the expected, i.e. probable scenario). This is explained by the relative cheapness of processing blue hydrogen compared to green hydrogen, large proven reserves of natural gas, and existing experience in methane reforming. The costs of producing hydrogen from natural gas include natural gas production costs and CCS costs. For gas-producing countries, the cost of gas accounted for approximately 30% of the total cost of blue hydrogen (IEA, 2019). With gas production costs ranging from $59 to 67/thousand cubic meters, the cost of producing "blue" hydrogen can be estimated in the range of $0.8–1.2/kg of hydrogen (IEA, 2019).

In the future, after the cost of producing "green hydrogen" decreases due to the emergence of new technologies, it will be advisable to move to the second scenario. This will be facilitated by the conclusion of international agreements with leading organizations supporting the development of the hydrogen economy.

One of such organizations is the European Bank for Reconstruction and Development (EBRD), which has expressed support for Azerbaijan in the initiative to produce environmentally friendly hydrogen. The Bank has committed to provide technical assistance in the preparation of hydrogen production projects following the results of a market study conducted by international consultancy Advisian in August 2023. The report's findings highlight Azerbaijan's significant potential to create renewable hydrogen. This resource not only contributes to local decarbonization, but can also meet high demand in regions such as the European Union (Dokso, 2023).

In the context of energy consumption in Azerbaijan, it is recommended to start using hydrogen in the transport sector, which accounts for 30% of the country's total energy consumption. The launch of pilot projects using hydrogen electric buses and the gradual development of hydrogen refueling infrastructure near hydrogen production facilities (including oil refineries) represent the initial steps in the development of a hydrogen economy, which is a trend around the world. Setting carbon neutrality targets and other energy policy measures related to the transport sector (combustion engine bans, emissions limits, parking incentives, traffic priority, subsidies, tax breaks) can create the regulatory environment for such initiatives.

Currently, Azerbaijan is planning and implementing projects to create 25 GW of renewable energy capacity with the expectation of exporting the generated electricity and using it to produce "green" hydrogen. An exchange of experience in the production of "green" hydrogen is being established with leading companies - Masdar (UAE), ACWA Power (Saudi Arabia), bp (UK), Fortescue Future Industries (Australia), etc. (Ministry of Energy of Azerbaijan, 2022; 2023b).

In the near future, the export of hydrogen through the Southern Gas Corridor to Europe is being considered. In December 2022, an Agreement on a strategic partnership in the field of development and transfer of green energy was signed in Bucharest between the governments of the Republic of Azerbaijan, Georgia, Romania and Hungary. The high potential availability of renewable electricity will facilitate the creation and export of a low-carbon hydrogen economy in Azerbaijan.

6. CONCLUSION

According to the purpose of the study, the possibilities and prospects for hydrogen production are related to Azerbaijan's rich experience in the oil refining, ammonia and methanol markets. The country has an extensive natural gas distribution network, ready for the transition to hydrogen production. Azerbaijan, leveraging its established position in ammonia and methanol production, can drive decarbonization by exploring opportunities to produce both blue and green hydrogen.

Another competitive advantage of Azerbaijan is its vast renewable resources, strategically located in close proximity to the Caspian Sea and in the eastern part of the country. The country has direct access to natural gas reserves, particularly the rich Shah Deniz field, making it an important player in the development of green and blue hydrogen production technologies. Blue hydrogen initiatives include exploring the possibility of storing CO_2 in depleted gas fields, which also addresses gas industry emissions and underscores Azerbaijan's commitment to an integrated energy transition.

The country's extensive natural gas infrastructure, including the Southern Gas Corridor, provides potential for integrating hydrogen into the gas network. This step could significantly strengthen the country's hydrogen capabilities and open up prospects for exporting hydrogen to world markets.

6.1. Recommendations for a Successful Transition to a Hydrogen Economy

1. For the effectively implementation of hydrogen energy, it is necessary to develop the appropriate infrastructure. Azerbaijan can invest in the creation of modern stations for hydrogen production and storage, as well as transportation and distribution systems. This will create conditions for the use of hydrogen energy both within the country and for export.
2. Hydrogen can become a key element in modernizing the transport system of Azerbaijan. The use of hydrogen fuel cells

in cars and public transport will not only reduce emissions, but also reduce dependence on imports of traditional fuels.

3. The transition to hydrogen energy opens up new prospects for economic growth. Investment in this sector can create new jobs, stimulate innovation and develop high-tech industries.
4. The government should develop a separate national hydrogen program that focuses on supporting technological progress, creating long-term demand and market, and encouraging international investment. A key factor for success will be engagement with existing international hydrogen communities and coordinated work between developers and domestic stakeholders.
5. Thus, Azerbaijan, based on its rich energy experience, can play an important role in the development of hydrogen energy in the region. This transition not only promotes environmental sustainability, but also opens up new opportunities to reduce dependence on traditional energy resources, ensuring stable and sustainable growth in the future.

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