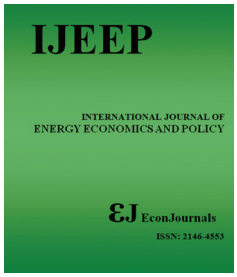

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What Advantages Arise from the Shift Towards Sustainable Energy Sources in Resource-Rich Economies? Empirical Insights from Azerbaijan

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ABSTRACT

Azerbaijan, a nation with abundant petroleum resources, aspires to harness the untapped potential of the Caspian Sea's renewable energy resources. The aim for the immediate future is to meet not only domestic energy requirements, but also to establish the nation as a green energy exporter. The nation expects to develop power installations utilizing renewable energy over the forthcoming decades to satisfy a portion of its domestic consumption and also cater to the European market. As part of this colossal project, Azerbaijan anticipates collaborating with international partners to install a 4-gigawatt (GW) power cable traversing the seabed of the Black Sea. The successful realization of these ambitious projects would bolster Azerbaijan's economic sustainability during its post-petroleum phase, while simultaneously enabling a reduction in carbon emissions, offering regional and global benefits. This manuscript seeks to probe the multidimensional implications—political, economic, sociocultural and environmental—of this shift towards wind-derived green energy for Azerbaijan and other nations in the region.

Keywords: Azerbaijan, Wind Energy, Marginal Abatement Cost, Export, Non-oil Sector
JEL Classifications: O44; Q48; Q42

1. INTRODUCTION

Azerbaijan has significantly upgraded its infrastructure, improved social welfare standards, strengthened its financial position, and built up strategic foreign exchange reserves that now outpace its GDP by capitalizing on the revenues produced by the effective implementation of its oil and gas production strategy in the Caspian Sea. Azerbaijan's successful oil and gas strategy over the past two decades (in 2002-2022) has led to a quadrupling of its GDP, a more than thirty-fold increase in budget revenues, a ten-fold increase in the volume of foreign trade (SSC, 2023), and a decrease in direct external debt to 10% of GDP (projected to decrease to approximately 7-7.5% by the end of 2024). The country's foreign exchange reserves currently exceed its direct foreign debt by a factor of ten, with investments surpassing US $300 billion over the last 30 years.

The biggest challenge presently confronting Azerbaijan is how to sustain economic development while positioning itself concurrently for the post-oil and gas era. Scholars like Huseyn (2011), Hasanov et al. (2022), Valiyev et al. (2022) have advocated for the diversification of the Azerbaijani economy in the post-oil era, emphasizing the importance of sectors like agriculture and tourism (Huseyn, 2023), as well as key areas like communication and financial services—as suggested by the World Bank (2009). The year 2021 marked a significant milestone, with the adoption of the National Priorities, by which the nation underscored its commitment to "green growth" as a primary objective. The

strategic goal within this objective will involve the utilization of sustainable, green energy sources to bolster energy security and augment exports, thereby preparing for the impending transition from the oil and gas era. To elucidate, while Azerbaijan's predominant exports are currently oil and gas extracted from the Caspian Sea, plans for the near future envision the incorporation of offshore wind energy into its repertoire.

The technical potential of Azerbaijan's proven renewable energy sources is estimated at approximately 292 GW, of which 157 GW is the wind energy potential of the Caspian Sea basin. Also, the International Energy Agency (IEA) has indicated that Azerbaijan possesses significant potential for the development of renewable energy. Azerbaijan aims to realize this offshore potential by using oil revenues and the opportunities provided by foreign investors. This will increase the production of green energy to meet domestic demand, as well as creating sufficient green energy to export to Europe. To accomplish this, the country intends to increase the proportion of renewable energy sources in the installed electricity generation capacity from 17.3% in 2021 to 24% by 2026 and 30% by 2030. At the same time, the country plans to turn the Karabakh and Eastern Zangezur regions into a green energy zone. The idea of establishing the Azerbaijan-Turkey-Europe Energy Corridor (GEZAP, 2022) for the export of green energy to be produced in Azerbaijan is already on the agenda.

Azerbaijan is making substantial progress in the establishment of a sustainable energy route connecting to Europe. In 2022, Azerbaijan signed a strategic partnership agreement for the increased production and transmission of green energy with Georgia, Romania, and Hungary. In the mega project that Azerbaijan aims to implement with its partners, it is planning to lay a 4 GW power cable across the bottom of the Black Sea. This will allow Azerbaijan to export green energy to the European market. According to forecasts by the Ministry of Energy, Azerbaijan will produce 7 GW of wind and solar energy by the early 2030s, and more than 70% of it will be exported through the "Caspian-European Green Energy Corridor" and the "Azerbaijan-Turkey-Europe Energy Corridor." With expanded capacity for harnessing wind energy, particularly in the Caspian Sea, export opportunities in the non-oil sector will increase.

This article emphasizes the fact that the Caspian basin is not only rich in oil and gas, but also has great green energy potential. Thus, it is expected that exploring this potential will lead to multiple benefits for the country. The purpose of this article is to examine the political, economic, social and environmental benefits of the transition to green energy in the case of Azerbaijan. Azerbaijan's example will also be useful for other oil-rich economies.

Following this introductory section, Azerbaijan's potential for green energy will be discussed briefly in Section 2. The next section reviews the literature covering the research in the field. The political, social, economic and environmental benefits of transition to green energy are discussed in Section 3. Methodology and data sources are covered in Section 4, whereas the last section discusses the results, and we conclude the paper by providing a summary of the research findings.

2. LITERATURE REVIEW

Green energy has achieved recognition as a promissing and competitive energy option. Over the past few years, even oil-rich nations have intensified their efforts to transition to it. Advances in renewable energy are especially important for countries abundant in resources. Concomitantly, there has been a noticeable rise in the quantity of research being carried out in this field.

Given the scarcity of research studies pertaining to Azerbaijan, we have incorporated relevant findings from other studies that cover resource-rich countries for a comprehensive presentation.

Ansari et al. (2020) researched the consequences of green transformation on the Chinese coal sector and Middle Eastern and Latin American crude oil sectors; they stress that uncertainty exists for these sectors. Their study found that China is more inclined to undergo a green transition when compared to other countries. Furthermore, according to Zhang and Lis (2020), the Chinese government is favorably disposed towards green energy, with biofuels being an integral component of its long-term strategy for a green transition.

An et al. (2023) assessed the development of renewable energy in Belt and Road Initiative countries (47 countries/regions) based on empirical data during the period 2009-2017 and found that there were some similarities in the development of renewable energy in oil-rich Kazakhstan and Russia. Both nations possess substantial per capita advantages in terms of renewable resource availability. Also, Laldjebaev et al. (2021) researched the development of renewable energy in resource-rich Central Asia countries. They found that while Kazakhstan is at the forefront in terms of aligning policies and implementing renewable energy strategies in Central Asia, the primary obstacles to the adoption of renewable energy in the country stem from ongoing support for domestic fossil fuel usage and the sluggish transformation of policy concepts into tangible actions. Karatayev and Clarke (2016) also conducted research on Kazakhstan's potential for sustainability and renewable energy. Jianzhong et al. (2018) found that Kazakhstan had great potential to produce renewable energy, especially from wind sources. The country's adoption of wind power, however, faces a number of challenges, particularly the continuing reliance of the energy sector on fossil fuels, the persistence of conventional energy sources, significant institutional and financial barriers impeding the development of wind power, and a lack of investor interest in the environmental advantages of green energy.

Noorollahi et al. (2021) examined energy transition in oil-rich Iran and emphasized that in oil-rich economies the focus on improvement of energy efficiency is extremely low among both energy system planners and end consumers, primarily because of low energy prices. They also found that a decrease in total primary energy supply in oil-rich nations leads to an increase in energy supply on the international market, subsequently alleviating the global pressure on oil and gas prices. Also, Naqash et al. (2021) researched the potential of wind energy along the Red Sea coast of the oil-rich Kingdom of Saudi Arabia.

The transition of energy systems towards a greater reliance on renewables in resource-exporting countries is progressing at a sluggish pace. According to Fadly's (2019) study, the reliance on fossil fuels has a significant impact on the adoption rate of renewable energy sources in developing nations. Ultimately, the prospect of earning revenues from fossil fuels acts as a stronger obstacle to investing in renewables than their mere consumption.

Konyeaso et al. (2022) demonstrated that in oil-producing African countries an increase in per capita renewable energy generation promotes economic growth, highlighting the significance of harnessing Africa's substantial renewable energy resources. Specifically, a 1% rise in per capita renewable energy output leads to a 0.062% increase in per capita GDP in oil-rich African countries.

Recently, a wide range of papers has focused on renewable energy in Azerbaijan. Vidadili et al. (2017), Guliyeva et al. (2018), Nuriyev et al. (2019), Hamidova et al. (2022), Gasımlı et al. (2022), Mustafayev et al. (2022), Mukhtarov (2022), Guliyev (2024) and Huseynli (2023) study the potential trends in development, challenges and risks of renewable energy in Azerbaijan. Hasanov et al. (2023) focus on renewable energy consumption and reducing CO_2 emissions in Azerbaijan. They have identified a long-term negative association between increased consumption of renewable energy and CO_2 emissions, although this relationship did not attain statistical significance. Their rationale for this observation is that while renewable energy consumption exhibits an inverse connection with CO_2 emissions, its cumulative impact remains insufficient in magnitude. But this study approaches the subject from a different angle. Azerbaijan, which exports oil and gas extracted from the Caspian basin mainly to European countries, can become one of the green energy suppliers for the "old continent" in the near future. Azerbaijan has taken significant strides towards harnessing the wind energy potential within its designated area in the Caspian Sea. However, this question has not yet received adequate scrutiny in academic research.

3. RESEARCH METHODOLOGY AND DATA SOURCES

Both qualitative and quantitative techniques have been applied in this study.

To evaluate the political and social advantages, a qualitative methodology was employed, specifically through two focus groups, which included experts from the energy and climate change domains. Furthermore, in order to gauge the environmental benefits, marginal abatement cost curves were constructed to analyze the potential for generation of renewable energy. The assessment process incorporated data from reputable sources, such as the State Statistical Committee and the Ministry of Energy of the Republic of Azerbaijan, in order to enhance the reliability of the results.

An extensive body of scholarly work exists on the subject of MAC, one of the most notable contributions being from McKinsey Company (2007), which presents their findings in the graphical representation known as the MAC curve. This schematic categorizes technologies according to their cost-effectiveness in reducing emissions per ton of carbon dioxide equivalent. In this configuration, technologies that offer the most cost-effective reductions are depicted on the left of the curve, while those with higher associated costs for comparable emission reductions are represented on the right.

Another relevant study by Timilsina et al. (2017) introduced a method for evaluating the marginal cost of abatement in Georgia's energy efficiency strategy in the construction sector. They found that applying energy-saving measures in the residential and commercial building sector could decrease CO_2 emissions for the period between 2015 and 2035 by 16.4 $MtCO_2eq$ and 6.2 $MtCO_2eq$, respectively. Muangjai et al. (2020) assessed the MAC of electricity generation from renewable energy in Thailand. They discovered that the MAC, varying in size and type, ranged from −4,780.80 to 5,248.32 Thai Bath/tCO_2eq for natural types, and −4,913.28 to 134.29 Thai Bath/tCO_2eq for forms of bioenergy. The factors impacting the MAC for each kind of renewable energy revealed mixed outcomes, but the primary determinants were investment related costs, geographical location and size, as well as plat factor.

Xiong et al. (2016) made an attempt to estimate the MAC curve for wind power in China. Their findings demonstrated that wind energy could serve as a highly competitive option for mitigation in China, with the capacity to facilitate a reduction of 500 million tons of CO_2 emissions at an average abatement cost of 75 RMB per ton of CO_2 mitigated. The difference in the costs of emission reduction and the potential to lower carbon emissions in the different provinces could be beneficial for national planning and for determining the distribution of investments.

In this paper, the MAC is expressed through an equation, showing the differential between the cost of electricity production in policy and baseline scenarios, and subsequently divided by the difference in GHG emissions between the baseline and policy scenarios. Costs include both the investment and operational costs. The investment cost data was sourced directly from the Renewable Power Generation Cost 2021 report, which is the latest published report of the International Renewable Energy Agency (IRENA). The MAC equation can be articulated as follows:

The MAC for each alternative method for electricity production was calculated using a step-by-step method, where the advantages and expenditures of the baseline scenario (fossil fuel) and the low carbon emissions scenario (renewable technologies) were evaluated. Equation (1) shows the method used to ascertain the MAC:

$$MAC = \frac{NAC_{low\,CO2} - NAC_{ref}}{AG_{ref} - AG_{low\,CO2}} \quad (1)$$

Where:

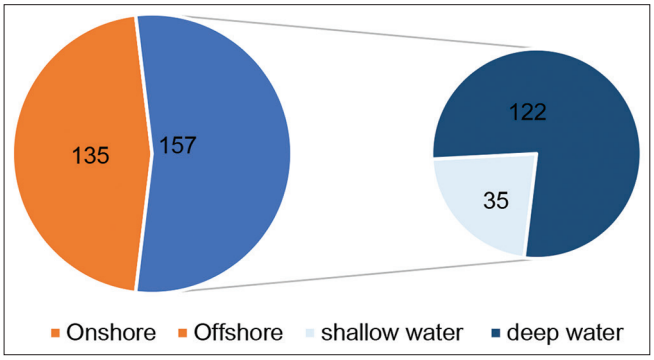
The MAC is defined as the abatement cost for each assessed alternative energy source, the NAC is defined as the net cost of the alternative, and AG is the annual greenhouse gas emissions.

The average MAC value for each application is computed by taking into account the annual reduction in emissions (up until 2030) and implementing an annual discount rate of 10%. This discount rate is utilized to adjust the MAC values across the whole period into a Net Present Value (NPV) for each alternative.

4. RESULTS AND DISCUSSION

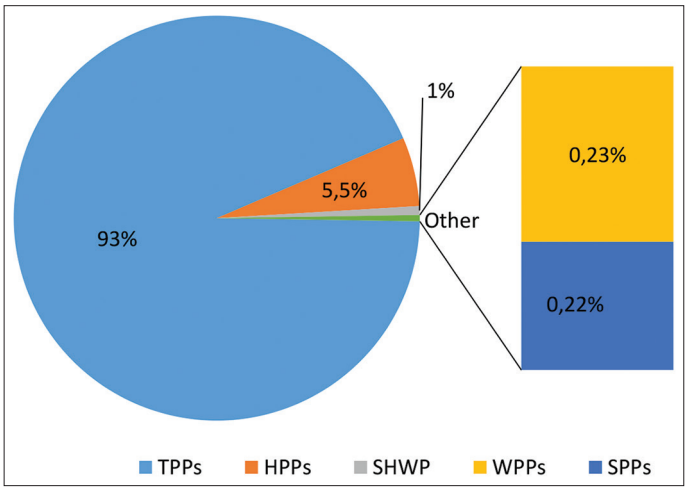
This section outlines a plethora of advantages linked to Azerbaijan's transition to sustainable energy sources. With a particular emphasis on political stability, economic growth, social development, and environmental preservation, the subsequent analysis explores the wide variety of benefits resulting from this paradigm shift. By delving into the nuanced implications within these contexts, a comprehensive understanding of the transformative potential and positive outcomes of Azerbaijan's green energy trajectory emerges.

Figure 1: Technical potential of renewable energy of Azerbaijan, GW



Source: AREA, 2023

Figure 2: The share of renewable energy in energy production in Azerbaijan in 2022



Source: MoE, 2023b

4.1. Green Energy Potential of Azerbaijan

Azerbaijan emerges as one of the nations possessing substantial potential for the harnessing of renewable energy sources. The technical potential of onshore renewable energy conduits has been quantified at 135 GW. The economic potential, which pertains to renewable energy sources that are economically viable and technically feasible, is estimated to be approximately 27 GW. This includes 3 GW of wind energy, 23 GW of solar energy, a bioenergy potential of 380 MW, and 520 MW derived from mountain rivers (MoE, 2023f). In addition, the technical potential of wind energy of the Azerbaijani sector of the Caspian Sea is 157 GW (Figure 1). According to the Energy Sector Management Assistance Program (ESMAP), inaugurated by the World Bank Group, this technical potential is estimated at 35 GW in shallow water locales and 122 GW in deep water environments (AREA, 2023). The estimated potential of the liberated areas is 7.2 GW of solar and 2 GW of wind energy(Shahbazov, 2021).

Note that 292 GW is a technical potential. Technical potential delineates the quantity of renewable energy that is conceivable, contingent upon a certain degree of advances in technology, and forms a portion of the overall potential. Two pivotal factors are considered: The exclusion zone and the loss incurred through transformation (AREA, 2023). The economic potential pertains to that segment of the technical potential that can be economically actualized. In calculating the economic potential, all corresponding expenditures and socio-economic factors are meticulously considered; thus this potential includes avenues that are economically tenable for implementation (AREA, 2023).

Azerbaijan is expanding its activities in the use of renewable energy. In this regard, the cooperation that began in 2022 with the laying of bases for the 240 MW Khizi-Absheron Wind Enegry Facility by the Kingdom of Saudi Arabia's ACWA Power and the 230 MW Garadag Solar Power Plant by Masdar (the United Arab Emirates) has entered a new stage.

The State Oil Company of Azerbaijan and Masdar have formally entered into a collaborative agreement to spearhead the development of 2 GW of offshore wind and hydrogen projects in Azerbaijan. Concurrently, a joint accord has been established to initiate a solar photovoltaic endeavor boasting a capacity of 1 GW, in tandem with onshore wind ventures, also set at a 1 GW capacity, within the Azerbaijani region. The cooperation that

Table 1: Trends in total installation costs, capacity factors, and levelized cost of electricity (LCOE) differentiated by technology (2010-2022)

	Total installed costs (2020 USD/kW)			Capacity factor (%)			Levelised cost of electricity (2020 USD/kWh)		
	2010	2022	Percent change	2010	2022	Percent change	2010	2022	Percent change
Solar PV	5 124	876	−83	14	17	23	0.445	0.049	−89
Onshore wind	2 179	1 274	−42	27	37	35	0.107	0.033	−69
Offshore wind	5 217	3 461	−34	38	42	10	0.197	0.081	−59

Source: IRENA (2023), Renewable Power Generation Cost in 2022, p. 15

had started with Masdar on the 230 MW Solar Power Station is being expanded with wind, solar and "green hydrogen" projects, and the production of 3 GW of wind and 1 GW of solar energy is targeted for 2027. In the medium term, the capacity of these green energy projects will be increased to 10 GW. A project is also planned for the production of 12 GW of wind and solar energy with Fortescue Future Industries, an Azerbaijani company. An executive agreement was finalized with ACWA Power for a wind initiative of up to 1.5 GW offshore, together with the establishment of a 1 GW wind farm onshore. Along with 2.5 GW wind power plants, work with this company is ongoing, with the goal of realizing projects to create energy storage systems in Azerbaijan (MoE, 2023d).

Plans also exist to build a 240 MW solar power plant in the Jabrayil and Zangilan regions with the participation of BP. Negotiations are in progress regarding the construction of a solar energy facility with capacity of 650 MW in the Nakhchivan Autonomous Republic by Nobel Energy Management (400 MW) and TotalEnergies (250 MW). TotalEnergies will construct onshore wind power plants of 250 MW. Also China Gezhouba Group Overseas Investment is planning to implement 2 GW renewable energy projects in Azerbaijan.

Co-operation with the above-mentioned companies in the creation of 28 GW of green energy and hydrogen capacity will contribute to the green energy transition nationally and globally (Shahbazov, 2023).

4.2. Political Benefits

A *Memorandum of Understanding on Strategic Partnership* in the field of energy between the European Union, represented by the European Commission, was signed between Azerbaijan and the European Union on July 18, 2022. One of the important points in this memorandum is the issue of collaboration in the realm of offshore wind energy and "green" hydrogen. The document in question can be considered one of the first steps towards the gradual transformation of Azerbaijan into a renewable energy supply partner for the European Union. Subsequently, on December 17, 2022, the *Agreement on a Strategic Partnership* in the field of green energy development and transmission between the Governments of Azerbaijan, Georgia, Romania and Hungary was signed in Bucharest, the capital of Romania, and this opens new prospects for Azerbaijan. This agreement will contribute to Europe's energy security and the transition to clean energy in the region, as it creates opportunities for Azerbaijan to export green energy sources. The project will help strengthen the continent's energy security by also enabling the export of green energy from Romania and Hungary to the European Union.

The deliberations held at the Green Energy Advisory Council on February 3, 2023 reveal that this initiative will further bolster the evolution of diplomatic and economic ties between Azerbaijan and the European Union. Enhancing collaborative endeavors on critical issues like enduring energy security, sustainability, diversity in sources of supply, and a transition towards green energy between these entities stands to effectively serve mutual objectives.

Azerbaijan aims to turn its liberated territories into a green energy zone and is taking concrete steps in this direction. The plan for measures for the years 2022-2026 has already been adopted by the Cabinet of Ministers (GEZAP, 2022). Within the framework of the Action Plan, suitable measures are anticipated by governmental and private entities to facilitate the implementation of green technologies and to adhere to energy efficiency stipulations. Those measures include the creation of the Azerbaijan-Turkey-Europe Energy Corridor passing through Zangazur and Nakhchivan (GEZAP, 2022). Taking into account the availability of sufficient renewable energy sources in the liberated territories, aiming to turn the area into a "green energy" zone, with the participation of the BP company in this process, has both political and economic benefits.

In general, the implementation of projects related to green energy will further strengthen the regional position of Azerbaijan. In the coming years, the political, economic and ecological importance of this project for the region and the continent will increase.

4.3. Economic Benefits

The megaprojects that Azerbaijan aims to implement in the field of green energy with its partners will contribute to the growth of the non-oil sector and at the same time will play a role in attracting foreign investments to the country and in creating new jobs. In particular, constructing a cable under the Black Sea will make the country a green energy exporter.

The participation of Azerbaijan increases the importance of this project. It was announced that 2.3 billion euros will be allocated for the construction of the Black Sea electric conduit connecting Georgia and the EU to implement the project. The Black Sea submarine cable project foresees the construction of a high-voltage submarine transmission network that will connect the energy systems of Georgia and Europe. If the project is implemented, a 1195 km-long cable (1100 km underwater and 95 km on land) will be connected to Romania (AIR Center, 2022). Initially, the cable was planned to have a capacity of 1 GW. However, as a result of Azerbaijan's active role in the process, a change in the proposal for the submarine cable project resulted in accepting a capacity of 4 GW, thus increasing the economic importance of the project. The South Caucasus will be connected to Romania with this electric cable, which will enable the export of green energy to Europe.

The Black Sea Strategic Submarine Electrical Cable, will contribute substantively to reciprocal resilience, while facilitating the exportation of sustainable energy from the South Caucasus to Europe.

If this project is realized, there will be sufficient potential for Azerbaijan to export green energy. According to forecasts, Azerbaijan will produce 4 GW of green energy by the end of 2028, and 80 % of it can be exported. In the coming years, with the export of 3 GW of green energy through the Black Sea submarine power line, Azerbaijan will be a country that plays a crucial role in the field of safeguarding the energy security of Europe with clean resources (MoE, 2023a). Europe plans to obtain 20 million tons of hydrogen by 2030. Therefore, Azerbaijan can also export hydrogen to the European Union (MoE, 2023c).

Actual results include the formation of the Green Energy Advisory Council. On February 3, 2023, the corresponding ministers from

Azerbaijan, Georgia, Hungary, and Romania convened in Baku for the inaugural meeting of the strategic partnership for the evolution and transmission of sustainable energy. The assembly resulted in a discourse on the conceptual framework for forthcoming activities. (MoE, 2023e).

Azerbaijan plans to create at least 6 GW of additional capacity by 2037 and will use this green energy to meet its domestic needs, in addition to exporting it. It is planned that the proportion of energy derived from the renewable sources in the installed capacity of Azerbaijan's electricity production will increase from 17.3% in 2021 to 30% in 2030 (SSED, 2022).

Informational note: The total electricity production capacity of Azerbaijan was 7538.4 MW in 2021. In the electric power system, there are 18 TPPs with a total capacity of 6237.7 MW and 25 HPPs with a total capacity of 1150.9 MW, a solid household waste plant with a capacity of 37 MW, 4 wind power plants with a capacity of 63.3 MW. There are eight solar and three hybrid (solar, wind and biogas) energy generation facilities with cumulative capacity of 7.4 MW (Shahbazov, 2021).

An examination of the statistical data from 2022 indicates that electricity generation in Azerbaijan amounted to 28,988.5 million kWh. In the same year, electricity generation at thermal power plants (TPPs) experienced a growth of 785.1 million kWh, culminating in 27,043.3 million kWh, while at hydroelectric power plants (HPPs), the increase was 318.5 million kWh, thus reaching 1,595.7 million kWh. With regard to other renewable sources, which include wind power plants (WPPs), solar power plants (SPPs), and a solid household waste plant (SHWP), electricity generation was tallied at 349.5 million kWh (WPPs generated 83.3 million, SPPs produced 60.9 million, and the SHWP contributed 205.3 million kWh of electricity) (MoE, 2023b).

The share of electricity produced in 2022 was: WPPs 0.2 %, SPPs 0.2 %, HPPs 5.5%, and SHWP 0.7% (Figure 2).

It is worth noting that Azerbaijan has abandoned oil for the production of electricity and primarily uses natural gas.

Production of 28.3 billion kWh of electricity and consumption of 24.3 billion kWh is predicted for Azerbaijan in 2025. The new TPP, with a capacity of about 1,300 MW, will start operating in 2025 (PoA, 2023). We predict that after 2025 all new power generation will utilize Azerbaijan's renewable resources. An important point is that the investment costs for renewable energy sources are quite high. For example, the total investment cost for the 240 MW Khizi-Absheron wind and 230 MW Garadagh solar power plants in Azerbaijan is more than US $500 million. At the same time, the total cost of the new TPP, with a capacity of about 1,300 MW, will be about US $400 million.

Therefore, the countries with the largest renewable energy capacity on a global scale -China, USA, Brazil, Germany, and Canada—also have significant investment opportunities. But the analysis shows that compared to 2010, spending on renewable energy installations decreased significantly in 2022, and the downward trend continues. In addition, it is currently more expensive to produce offshore wind energy than to produce onshore wind and solar energy (IRENA, 2023).

However, the decrease in the cost of electricity produced from renewable sources in 2022 compared to 2010 has started to make these projects attractive (Table 1).

Azerbaijan's success in this field will not only serve the stability of the country's economy in the post-oil era, it will create new jobs and will contribute to the reduction of carbon emissions, leading to global benefits.

4.4. Social Benefits

Greater attention to green energy and increasing global cooperation in this field will also lead to social benefits for Azerbaijan. Implementing mega projects in renewable energies will have a positive effect on unemployment and will lead to higher income levels for the population. For example, Azerbaijan is starting to cooperate with foreign companies in the field of green hydrogen production. Since the production, storage, transportation and end use of hydrogen requires the construction of extensive infrastructure, this will lead to the creation of permanent new jobs.

According to the International Renewable Energy Agency (IRENA), global employment in the renewable energy sector has experienced substantial growth—an increase of 700,000 positions during the period 2020-2021—to reach a cumulative total of 12.7 million positions. The sector showing the biggest growth has been the solar photovoltaic (PV) sector, especially in Asia, which employs 79% of workers globally in this field (WEF, 2023). The *Renewable Energy and Jobs: Annual Review 2022* report, produced in conjunction with the International Labour Organization (ILO), demonstrates that a growing contingent of nations are generating employment opportunities within the renewable energy sector. The report indicates that this surge in job creation has the potential to elevate global employment in renewable energy to over 38 million by the year 2030. In 2021, the wind power sector provided employment for 1.4 million individuals worldwide (IRENA and ILO, 2022).

Using the example of South Korea, the nation initiated a substantial offshore wind energy project. This venture, which required an investment of US $43 billion, has a total capacity of 8.2 GW (Ellichipuram, 2021). It is estimated that the construction and subsequent operational phase of the facility will generate approximately 120,000 employment opportunities. Consequently, it could be reasonably inferred that, in Azerbaijan, the realization of analogous large-scale projects within the realm of green energy may also spur a rise in employment rates. This suggests that the economic and social benefits derived from green energy initiatives are intrinsically interconnected, thereby contributing to the implementation of Azerbaijan's Socio-Economic Development Strategy for the period of 2022-2026 (SSED, 2022).

4.5. Environmental Benefits

As an additional voluntary commitment, Azerbaijan aims to reduce emissions by 40 percent by 2050 and create a "net zero emission"

zone in the liberated territories. "Green growth" is emphasized in the National Priorities of Azerbaijan. A goal for the next decade is to realize the development of social and economic conditions according to identified national level priorities, and one of them is "a clean environment and country of "green growth"(NP, 2021).

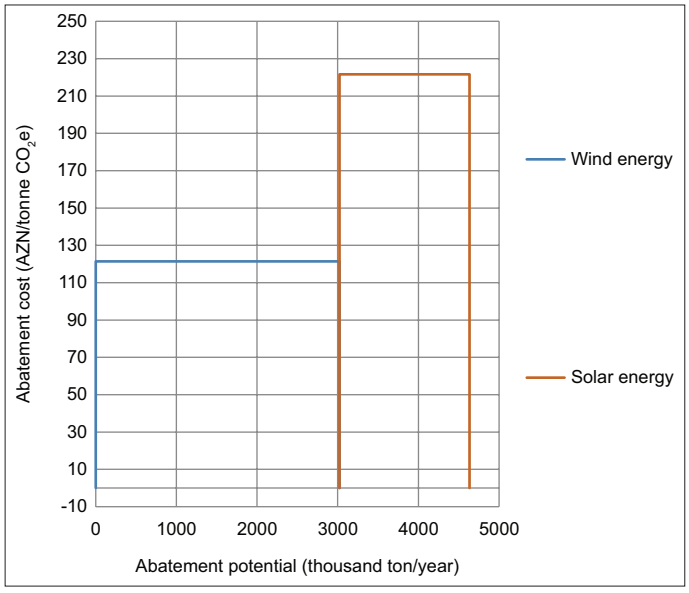
Estimating the marginal abatement cost curve for renewable energy generation options could provide a valuable insight for both environmental planner and policy maker. Assuming that the above-mentioned 4GW will be produced with 60% from solar energy and 40% from wind, it is relatively straightforward to derive the MAC curve of those two alternative energy generation options.

Figure 3 utilizes the projected cost savings, contemporary energy expenses, anticipated capital investments and forecast of reductions in CO_2 emissions to evaluate the net present cost of each emission reduction alternative and the cost-effectiveness per ton of reduction in CO_2. This data informed the creation of the MAC curve to map the economic efficiency of renewable electricity production (Figure 3).

A consideration of cost-effectiveness reveals a distinct hierarchy in the choice of renewable energy sources. From an economic perspective, the production of electricity utilizing wind turbines presents the greatest cost-effectiveness, at an estimated 121.4 AZN per ton CO_2e. On the other hand, energy generation from a solar power plant stands at 221.6 AZN per ton CO_2e.

Nevertheless, this analysis of cost-effectiveness is only one facet within a broader consideration. Another critical factor in selecting renewable energy alternatives is the projected annual reduction in volume of CO_2e emissions. In this regard, wind energy turbines emerge as a significant contender, anticipated to contribute the largest volume of CO_2e reduction at an impressive 3021 thousand tons per year. Solar power on the other hand is projected to save about 1610 thousand tons of CO_2e, respectively.

Figure 3: MAC curve of energy generation from renewable sources



Source: Author's work

This evaluation showcases the multi-faceted decision-making process required when selecting renewable energy sources. Cost-effectiveness is undeniably a critical factor to consider. Still, it should be coupled with an assessment of the environmental impact through CO_2 reduction to make a fully informed choice for cleaner methods of renewable energy production.

5. CONCLUSION

Azerbaijan is eager to implement megaprojects in the field of green energy and has expanded its activities in this field since 2022. The involvement of the world's largest companies in this process and the beginning of cooperation with the European Union on the export of green energy increase the likelihood of achieving its goals. It is true that the commissioning of wind and solar power plants with a production capacity of 7 GW (by the early 2030s) and relying upon foreign investments to do it is an ambitious goal. Even achieving half this goal would be considered a success for the country. Preliminary agreements have been reached with some of the world's leading companies (from Saudi Arabia, China, the UAE, the UK, etc.) on increasing the production capacity of green energy in Azerbaijan to 28 GW, which will contribute to diversifying its portfolio, reducing risk and achieving sustainable development in this area. Also, our research shows that the transition to green energy will have not only ecological but also political, economic and social benefits for Azerbaijan and the countries of the region.

The project will not only increase the production of green energy in Azerbaijan, but will also attract foreign investors and increase non-oil export opportunities. In addition, the implementation of green energy projects in Azerbaijan will also increase employment and the demand for qualified personnel in the field. The planned Azerbaijan-Turkey-Europe Energy Corridor (passing through the Zangezur and Nakchivan) will serve to strengthen peace in the region and increase the efficiency of the projects implemented in connection with the transformation of Karabakh and the Eastern Zangezur region into a "Green Energy Zone."

The first stage of Azerbaijan's attempts to attract foreign investors to create 28 GW of green energy power was successful. Azerbaijan has oil revenues, and if there are any difficulties in the next stage, these revenues will guarantee the continuation of projects. For example, Azerbaijan can take an active role in laying the electric cable across the bottom of the Black Sea, using this opportunity to train qualified personnel, as part of the support and infrastructure for green energy. Azerbaijan is also a reliable partner of international financial institutions and can seek loans for these purposes, if necessary (or it can rely on its own financial resources).

An analysis of the MAC curve shows that both options for alternative energy generation will lead to CO_2 savings and thereby serve as a pivotal resource for policymakers and environmentalists in the quest to reduce GHG emissions and drive the transition towards green energy. Implementation of the project will contribute to Azerbaijan's obligations in fulfilling the Nationally Determined Contribution.

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