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ECONOMY-WIDE AND ENVIRONMENTAL BENEFITS OF GREEN ENERGY DEVELOPMENT IN OIL-RICH COUNTRIES: EVIDENCE FROM AZERBAIJAN

ABSTRACT: *Azerbaijan, which is an oil/gas-rich country, has been taking full advantage of its energy potential and taking steps towards creating green energy and turning it into an export. The Green Energy Corridor, in which Azerbaijan plays the main role, aims to connect Azerbaijan with Europe in its first stage. In the second stage, this corridor will connect Central Asia with Europe, which will involve the laying of an electric cable under the Black Sea and the Caspian Sea. This will allow Azerbaijan and other Central Asian countries to export zero-carbon electricity to the European market. If Azerbaijan is successful in this field, it will not only serve the sustainability of the country's economy in the post-oil era, but will also contribute to the reduction in carbon emissions, leading to global benefits. The aim of this article is to assess the socioeconomic, ecological, and political benefits of green energy deployment in Azerbaijan. An economic cost-effectiveness analysis was conducted for selected green energy projects (large-scale wind and solar power plants). We also argue that green transition projects, which seem expensive and difficult to realise today, will be justified in the near future.*

KEY WORDS: *green energy, Caspian Sea, wind energy, export of green energy, cost-effectiveness analysis.*

JEL CLASSIFICATION: Q42; Q47; Q48; Q49

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1. INTRODUCTION

Azerbaijan is a net energy exporter, exporting oil, natural gas, and electricity. It meets its own energy needs through domestic production, which currently relies largely on the exploitation of the country's hydrocarbon reserves. Azerbaijan has a 100% electrification rate (International Renewable Energy Agency [IRENA], 2019). The opening of the Serbia–Bulgaria gas interconnector in the Serbian city of Niš on December 10, 2023, has expanded the list of countries to which Azerbaijan exports gas (President of the Republic of Azerbaijan [PoA], 2023). Azerbaijan had been exporting its Caspian Sea gas to eight countries, six in Europe, and Serbia became the ninth country on this list. But Azerbaijan's main goal is related to renewable energy; it expects to export the green energy produced from its excellent wind resources in the Caspian Sea to Europe in the near future (IRENA, 2019).

Despite Azerbaijan's wealth in oil and gas, the country sees a future in the production and export of zero-carbon electricity. It is attempting to implement a mega project that involves laying a cable under the Black Sea to export renewable energy to Europe. At the same time, Azerbaijan is evaluating the possibility of green hydrogen production and export, as well as an increase in the supplying of gas through the Southern Gas Corridor, which will play a strategic role in diversifying gas supplies to Europe. By realising its green hydrogen potential, Azerbaijan may also support Europe's plans in this field. Also, it could play a role in Kazakhstan's hydrogen exports to Europe by taking advantage of transportation systems it develops. Consequently, Azerbaijan can play an important role in diversifying the energy supply for Europe. By the early 2030s, Azerbaijan aims to have installed production capacity for 7 GW of wind and solar energy and will start exporting green energy. Of this, 4 GW will be exported to Europe via the Caspian-European Green Energy Corridor, which will pass through the Black Sea, and 1 GW will be exported to Türkiye and Europe via Nakhchivan, which has been declared a *green energy zone*.

Azerbaijan is one of the countries with high potential for renewable energy sources. The technical potential of Azerbaijan's onshore renewable energy is 135 GW and offshore it is 157 GW (35 GW in shallow water and 122 GW in deep water) (World Bank [WB], 2022). However, 292 GW is a technical potential; the economic potential is the part of the technical potential that can be realised

economically (Azerbaijan Renewable Energy Agency [AREA], 2023). Azerbaijan aims to fully realise its green energy potential, meeting both domestic demand as well as exports to Europe. For this reason, it has planned to increase the percentage of renewable energy in its installed capacity of electricity production from 17.3% in 2021 to 30% in 2030. Other steps towards the creation of a green energy corridor with Europe include an agreement in 2022 on a strategic partnership in green energy development and transmission with Georgia, Romania, and Hungary (PoA, 2022b). This agreement references the undersea power cable planned for the Black Sea (capacity of 4 GW). Current plans aim to further expand this project, and Serbia and Bulgaria will also take part in it.

The Energy Transition Index of the World Economic Forum (WEF, 2023) shows that Azerbaijan was a top improver between 2022 and 2023 (rank 32, score 62) and was ahead of the global average. Azerbaijan has shown large improvements across several transition readiness parameters.

The purpose of this article is to examine the Caspian–European Green Energy Corridor, in which, in the first stage, the South Caucasus will be connected with the Balkans by laying the Black Sea cable and, in the second stage, Central Asia will be connected with the Balkans by laying a cable under the Caspian Sea. This article explains Azerbaijan's strategies for exporting zero-carbon electricity to the European market. Two green energy projects (wind and solar) in Azerbaijan have been chosen to evaluate their cost-effectiveness.

Following this introductory section, the potential of Azerbaijan in green energy will be discussed briefly. The literature review is in Section 2, and Section 3 provides the data and the methodology. Section 4 presents the results and discussion. Finally, Section 5 contains the conclusions and policy implications.

2. LITERATURE REVIEW

A wide range of studies exist that aim to measure green energy development and the economic, social, and ecological impacts on the selected country. Most scholars view renewable energy investments as an essential part of reducing greenhouse gas emissions, and they consider renewables as a positive. Scientists are studying the problems presented by the transition to green energy, and these studies are widely represented in the literature. For example, Dimitrov (2021) has

stressed that there are some considerations, which include economic and financial barriers, that need attention.

In particular, researchers have begun to pay particular attention to the development of green energy in resource-rich countries (Aslani et al., 2012; Bahrami & Abbaszadeh, 2013; Mohammed et al., 2013; Tlili, 2015; Zell et al., 2015; Noorollahi et al., 2021; Issayeva et al., 2023) and the opportunities and problems that exist. Ahssein Amran et al. (2020) examined green energy production in Saudi Arabia according to the Saudi Vision 2030; Almasri & Narayan (2021) researched green energy sector developments in the resource-rich Gulf Cooperation Council countries (Bahrain, Kuwait, Oman, Qatar, Kingdom of Saudi Arabia [KSA], and the United Arab Emirates). Almasri & Narayan (2021) show that the green energy sector has the potential to create jobs for a large portion of the population across the Gulf Cooperation Council countries, resulting in essential gains in terms of new employment opportunities, fuel savings, and emission reduction.

There are also a number of studies dealing with the potential, production, and consumption of green energy in the resource-rich countries of the Caucasus and Central Asia (Gulaliyev et al., 2020; Zhakupova et al., 2021; Mustafayev et al., 2022; Huseynli, 2022; Vakhguelt, 2017). Shakeyev et al. (2023) analysed renewable energy projects in fossil fuel-dependent Kazakhstan and stressed the urgent necessity to shift towards renewable energy sources.

There is also some research on renewable energy development in Azerbaijan. This research shows that Azerbaijan is a country with vast potential for renewable energy development. The country has excellent wind and solar resources and significant prospects for biomass, geothermal, and hydropower (IRENA, 2019). However, the issue of green energy export is also new for Azerbaijan. It is true that in the Strategic Road Map (SRM, 2016) of Azerbaijan the question of electricity exports and the European market are reflected. But these studies were not related to the export of green energy. For example, the issue of laying a cable along the bottom of the Black Sea and the Caspian Sea for the purpose of exporting green energy is new and has not yet been examined. The main discussion of this topic began in 2022 and is included in Gasimli's (2024) study.

In summarising the literature, it becomes evident that numerous researchers have examined the topic of green energy development. Since we do not have enough studies for Azerbaijan, we include studies from other areas. However, there is as yet no research on the green energy corridor that will connect Central Asia with Europe through Azerbaijan. Therefore, this article is one of the first studies written on this topic.

3. RESEARCH METHODS AND DATA

In this study, we use both qualitative and quantitative methodology to assess the benefits of the green transition. In the qualitative approach, we used focus group discussions to evaluate the potential benefits of green energy projects, also the cost-effectiveness and co-benefit analysis and a cost-effectiveness analysis has been used as a quantitative assessment of green energy-related projects.

3.1 Focus group discussion

Two focus group discussions took place to focus on the development potential of green energy in Azerbaijan. Discussions were organised at the Centre for Analysis of Economic Reforms and Communication in May and Septmember 2023. About 10 green energy experts participated in each focus group discussion.

It should be noted that the "Country of Green Energy" working group was established by the Azerbaijani government in June 2023. The members of this working group participated in the focus group discussion held in September.

3.2 Economic assessment

In this study, we focus on the cost-effectiveness of wind and solar power projects in Azerbaijan. While doing this, we follow the methodology applied by Ma et al. (2013), Xue et al. (2015), and Jiang et al. (2020) with some modifications. This analytical approach is instrumental in identifying the most economically efficient option to attain predefined objectives. Explicitly, the focus of this study was to quantitatively assess the economic efficiency of lowering emissions through wind and solar power deployment.

The net annual cost (NAC) of a project is composed of three elements. In particular, NAC equals the annual project cost (APC) plus the annual fuel

(natural gas) cost saving (CAFC) and the annual on-grid energy sales revenue (ASR). The equation is given below:

$$NAC = APC + CAFC + ASR \tag{1}$$

CAFC from equation (1) can be calculated using the following formula:

$$CAFC = AFA \times \mathrm{FP}, \tag{2}$$

where AFA is the annual fuel consumption amount of natural gas-fired power and FP is the natural gas price. According to the information provided by the Ministry of Energy of Azerbaijan, a wind project provides an opportunity to save 220 million cubic metres of natural gas per year whereas a solar power plant project has the potential to save 110 million cubic metres of natural gas per year.

The annual project cost (APC) is calculated using the figures for the annual maintenance cost including the average annual operating cost (AMC), discount rate (r), total investment cost (TIC), and a service life (n):

$$APC = \frac{TIC \times \mathrm{r}}{1-(1+r)^{-n}} + AMC. \tag{3}$$

Lasltly, the cost-effectiveness (CE) is calculated with the following equation, where the net annual cost of a wind power project (NAC) is divided by the wind power project's annual reduction in the amount of CO2 equivalent (ARA) compared to natural-gas-fired power:

$$CE = \frac{NAC}{ARA}. \tag{4}$$

In contrast to natural gas-fired electricity generation plants, wind and solar energy generation exhibits a remarkably lower release of CO2 equivalent. ARA is defined as per year saving of the CO2 equivalent in both projects times service life of the project. It is estimated that the annual CO2 equivalent saving from the wind and solar power plant would be 400 and 200 thousand tons of CO2 equivalent, respectively.

The main sources of data for the analysis were from the State Statistical Committee of Azerbaijan, the Ministry of Environment and Natural Resources of Azerbaijan, the Ministry of Energy of Azerbaijan, and the Central Bank of Azerbaijan. Two projects were selected as a case study: a 240 MW wind power project in the coastal region of the Caspian Sea and the 230 MW Garadakh solar power plant. The total investment cost of the first project is 300 million USD whereas the second project`s total cost is 262 million USD. The two projects are expected to have a lifespan of 25 years each. It is anticipated that, on an annual basis, the wind power plant will generate approximately 1 billion kWh of electricity, while the solar power plant is expected to produce around 0.5 billion kWh. This indicates that, throughout the duration of their separate operating periods, the wind project is expected to add a total of 25 billion kWh to the energy grid and the solar project roughly 12.5 billion kWh.

Using wind energy offers a practical way to address several environmental issues. This study measures the additional advantages of wind energy, looking at them from the standpoint of affordable mitigation techniques. The following formula summarizes the previously given analysis:

$$ECB = CE \times ARA. \tag{5}$$

where ECB is the economic co-benefits of wind power project.

4. RESULTS AND DISCUSSION

4.1. Realisation of green energy potential

Azerbaijan is taking its initial steps in expanding the development of renewable energy potential with its first large-scale onshore wind facility (the 240 MW Khizi-Absheron Wind Power Plant) and solar power plant (the 230 MW Garadag Solar Power Plant). In 2023, the Garadag Solar Power Plant, the largest solar power plant in the Caspian region, began operations, and in 2024, the Khizi-Absheron Wind Power Plant will begin operations.

The State Oil Company of Azerbaijan (SOCAR) and Masdar (Abu Dhabi Future Energy Company, an Emirati state-owned renewable energy company) have already signed a joint development agreement for a 2 GW offshore wind and

hydrogen project in Azerbaijan, as well as a joint development agreement for a 1 GW solar photovoltaic and 1 GW onshore wind project (Azertac, 2023). The cooperation with the company started with a 230 MW solar power station and is being expanded with wind, solar, and green hydrogen projects; the production of 3 GW of wind and 1 GW of solar energy is targeted for 2027. A public-private partnership with Fortescue Future Industries (FFI), an Australian company, is also planned for the production of 12 GW of wind and solar energy. An executive contract was signed with the company ACWA Power for the implementation of a wind project of up to 1.5 GW offshore and the creation of a 1 GW wind farm onshore. In addtion to these power generating plants, projects for the creation of energy storage systems in Azerbaijan are in the planning stages with this company. At the same time, Fortescue Future Industries has started research and implementation of renewable energy and green hydrogen projects in Azerbaijan with a capacity of up to 12 GW.

The company BP will participate in building a 240 MW solar power plant in the Jabrayil district. Negotiations are also under way for the construction of a 500 MW solar power plant in the Nakhchivan Autonomous Republic.

In addition, there will be a cooperation with the China Gezhouba Group Overseas Investment Co., Ltd on a 2 GW renewable energy project in Azerbaijan. In addition, the Turkish company Baltech is collaborating on a 50 MW solar power plant project in Nakhchivan and a 200 MW wind power plant project in the Eastern Zangezur and Karabakh economic regions.

The most important stage has now been reached in negotiations with investors regarding the production of 10 GW of the targeted 28 GW of green energy, and agreements and memoranda of understanding have been signed. Even the State Oil Company of Azerbaijan is interested in the field of green energy and has established the SOCAR Green Company for this purpose. This company aims to implement solar and wind energy projects together with Masdar, ACWA Power, BP, and Energy China. In particular, this company will implement a 1 GW onshore wind and solar energy project in the initial phase with Masdar and a 240 MW solar energy project with BP.

4.2. Advantages of the transition to green energy

4.2.1. Geo-political advantage

Leading the transition from oil and natural gas, Azerbaijan can become an exporter of renewable energy and green hydrogen for Europe. The new Memorandum of Understanding on a Strategic Partnership in the Field of Energy was signed between Azerbaijan and the European Union on July 18, 2022 (PoA, 2022a). According to this document, Azerbaijan aims to double the volume of gas exports to Europe by 2027. While Azerbaijan gas exports to Europe amounted to eight billion cubic metres in 2021, this reached 11.8 billion cubic metres in 2023. The realisation of Azerbaijan's green energy projects will allow gas intended for domestic electricity production to be saved, and this will create the conditions needed for fulfilling export obligations.

On December 17, 2022, the Agreement on a Strategic Partnership in the Field of Green Energy Development and Transmission was signed in Bucharest, the capital of Romania (PoA, 2022b), between the governments of Azerbaijan, Georgia, Romania, and Hungary, and this opens new prospects for Azerbaijan.

Figure 1: Caspian-European Green Energy Corridor

Source: Authors' work

The above agreement is expected to ensure Europe's energy security by enabling the export of green energy from Romania and Hungary to the European Union. It will also aid the transition to clean energy in our regions and will create additional opportunities for Azerbaijan's exports of green energy (see Figure 1).

A project proposed by Azerbaijan for these exports is related to the creation of the Azerbaijan–Turkey–Europe Energy Corridor, which will pass through the Zangezur Corridor (Zangezur and Nakhchivan) (AP, 2022). The development of the Caspian–Black Sea–European Green Energy Corridor project, which began within the framework of the creation of a green energy corridor between Azerbaijan, Georgia, Romania, and Hungary, also has on its agenda the inclusion of Serbia and Bulgaria in this Black Sea submarine power line project. Azerbaijan is making a significant contribution to Europe's energy security with the Southern Gas Corridor infrastructure project, which is 3,500 kilometers long. If the Caspian–Black Sea–European Green Energy Corridor is implemented, it can fulfill the mission of connecting Central Asia with the Balkan countries in the field of green energy in the near future. That is, this mega-project will include eight countries: Uzbekistan, Kazakhstan, Azerbaijan, Georgia, Bulgaria, Romania, Hungary, and Serbia. Thus this project will also serve the development of political and economic relations between those countries.

Of course, energy projects will further strengthen the geo-political position of Azerbaijan. In addition, the existence of political stability and dynamic economic development in Azerbaijan will attract investors.

4.2.2. Economy-wide advantage

Renewable energy can play a role in supporting Azerbaijan's drive for economic diversification (IRENA, 2019). In particular, building a cable under the Black Sea will make the country a zero-carbon electricity exporter. The plan is to finalise the feasibility study for this project by the end of 2024.

When the above project is realised, Azerbaijan will have sufficient potential to use it to export green energy. According to forecasts, Azerbaijan will produce 7 GW of green energy by the early 2030s and 4 GW of it can be exported. Azerbaijan, Kazakhstan, and Uzbekistan have initiated plans to utilise the corridor to transmit green energy from Central Asia.

In addition, Europe plans to obtain 20 million tons of hydrogen by 2030, and Azerbaijan expects to export hydrogen to the European Union.

Including Serbia and Bulgaria may increase the importance of this corridor, as Serbia is Azerbaijan's new partner for the diversification of the gas market in Europe. Azerbaijan will supply up to 400 million cubic metres of gas annually to Serbia, with this volume expected to increase in the coming years.

At the initiative of Azerbaijan, with the participation of Uzbekistan and Kazakhstan, a project to construct an energy cable connecting the shores of the Caspian Sea is being discussed (Ministry of Economy of the Republic of Azerbaijan [MoEconom], 2023). The projects implemented in the field of green energy provide an opportunity to expand electricity production and export, and open further opportunities for the transportation of electricity from Central Asian countries to Europe through Azerbaijan (MoEconom, 2023). On November 14, 2023, Azerbaijan, Kazakhstan, and Uzbekistan signed a joint communiqué on cooperation in the development and export of green energy.

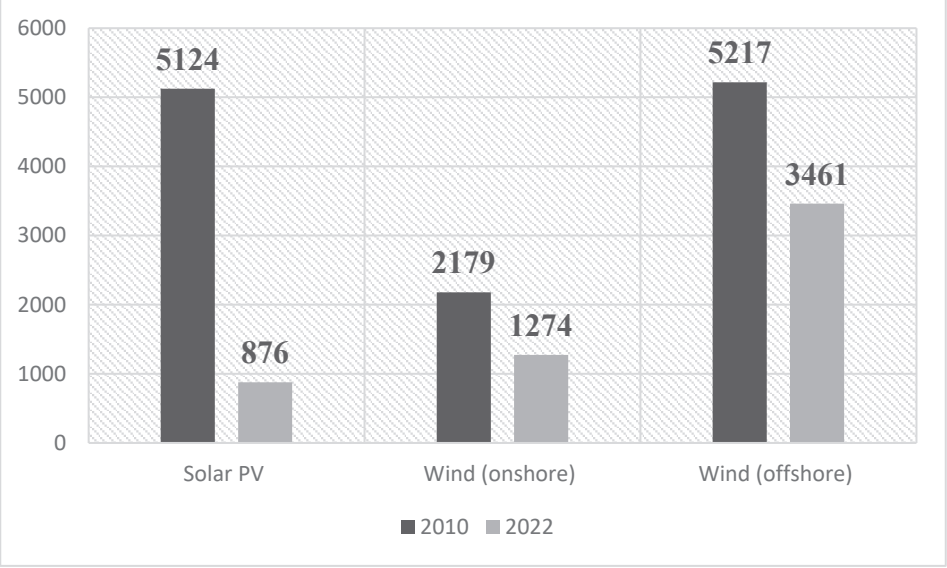
In 2022, the EU and Kazakhstan signed an agreement for the production and export of green hydrogen. The 50 billion USD deal calls for the construction of 20 GW of green power plants in Kazakhstan and the production of two million tons of green hydrogen through electrolysis. Kazakhstan will be able to supply 20% of the ten million tons of EU hydrogen imports in 2030 (Dezem, 2022). Its southern neighbor, Uzbekistan, is also taking major steps in the field of green hydrogen. And in Azerbaijan, the share of renewable energy sources in the installed electricity production capacity is expected to increase from 17.3% in 2021 to 30% in 2030 (Strategy of Socio-economic Development [SSED], 2022).

It is important to mention that Azerbaijan mainly uses natural gas in generating electricity. More broadly, total electricity generated in 2023 was about 29.3 billion kWh. A noteworthy 92.8% of this was generated from thermal power plants (TPPs). On the other hand, 1.8 billion kWh, or 6% of the total, came from hydroelectric power plants (HPPs). Furthermore, the share of other renewable energy sources was quite small, making about 1.2% or 359.0 million kWh of the total electricity produced in the same year (Ministry of Energy of the Republic of Azerbaijan [MoE], 2024).

In 2022, the production capacity of facilities utilising renewable energy was 131.2 watts per capita (State Statistical Committee of the Republic of Azerbaijan [SSC], 2023). The production capacity of hydroelectric power plants was 1,164.7 MW, the production capacity of solar power plants was 51.2 MW, and the production capacity of wind power plants was 64 MW (SSC, 2023). The share of renewable energy in the total final energy consumption was 1.3 % in 2022 (SSC, 2023).

For 2025, production of 28.3 billion kWh of electricity and consumption of 24.3 billion kWh of electricity is predicted for Azerbaijan. We think that after 2025 all new power generation in Azerbaijan will be created from renewable resources. Of course, it is important to note that the investment costs for renewable energy sources are quite high. However, the analysis shows that renewable energy installation costs by 2022 had decreased significantly compared to 2010 and that the downward trend is continuing.

Figure 2: Renewable energy installation costs, USD/kWh (2010/2020)



Source: IRENA (2023), Renewable Power Generation Cost, 2022

The decrease in the cost of electricity produced from renewable sources from 2010 to 2022 has begun to make these projects attractive.

The International Energy Agency (IEA, 2022) Stated Policies Scenario (STEPS) shows that the capital costs of solar photovoltaic (PV) and offshore wind installations in the EU and China are expected to more than halve by 2050 (Table 1).

Table 1: Electricity generation technology costs (Stated Policies Scenario)

	Capital costs (USD/kW) in the European Union			**Capital costs (USD/kW) in China**		
	2021	**2030**	**2050**	**2021**	**2030**	**2050**
Solar PV	810	530	410	630	410	300
Wind onshore	1,590	1,510	1,450	1,160	1,090	1,050
Wind offshore	3,040	2,000	1,500	2,860	1,840	1,380

Source: IEA (2022)

Note: All costs are expressed in year-2021 dollars and economic lifetime assumptions are 25 years for solar PV and onshore and offshore wind power.

Not only will succesful implimentation of the projects in green energy contribute to the stability of the country's economy in the post-oil era and create new jobs, these projects will also contribute to a reduction in carbon emissions, leading to global benefits.

Increasing attention to green energy and deepening global cooperation in this field will certainly lead to social benefits for Azerbaijan. Overall, implementing the mega-projects in this field will have a positive effect on unemployment and lead to an increase in the income level of the population.

The report by the International Renewable Energy Agency and the International Labour Organization (IRENA & ILO, 2023) finds that the global renewable energy sector employed 13.7 million people directly, as well as indirectly, in 2022. This report stressed that climate-safe pathways would create many millions of additional jobs in the next decades. The Global Wind Energy Council (GWEC, 2022) analysed the international experience of the onshore wind industry and found that typically a 1GW/year installation rate over five years could unlock nearly 100,000 new jobs and over the lifetime of onshore wind farms (25 years) could add 12.5 billion USD gross value to national economies. The calculation by GWEC (2022) shows that 5 GW of onshore wind farms could create 12,000 local jobs each year during the 25-year operational and maintenance phase; a total of

130,000 jobs would be created during the development, construction, and installation phase of these facilities.

The greater complexity of components like foundations, substations, cables, and installation vessels creates greater labour requirements for offshore wind farms than onshore installations. The World Bank (2022) low-growth scenario shows that by 2040, 19,000 full-time equivalent (FTE) years of employment will have been created by the offshore wind industry. In the high-growth scenario, it will be 3.9 times more and will provide employment to 69,000 people (Table 2).

Table 2: Impact of offshore wind in Azerbaijan under low- and high-growth scenarios, 2020 to 2040

Fraction of electricity supply in 2040	Low growth scenario 7%
	High growth scenario 37% (5.2 times higher)
Offshore wind operating in 2040	1.5 GW
	7.2 GW (4.7 times higher)
Electricity produced by 2040	55 TWh
	215 TWh (3.9 times higher)
Local jobs created by 2040	19 thousand FTE years
	69 thousand FTE years (3.6 times higher)
Local gross value added by 2040	2 billion USD
	7 billion USD (3.6 times higher)
CO2 avoided	27 million tonnes
	107 million tonnes (3.9 times higher)

Source: WB (2022)

Azerbaijan has been investigating the potential for solar energy along with onshore and offshore wind energy. According to the US Department of Energy (US DOE, 2022), 1 GW of production capacity (crystalline silicon [c-Si] modules) could generate between 1,085 and 2,020 direct jobs across the full value chain.

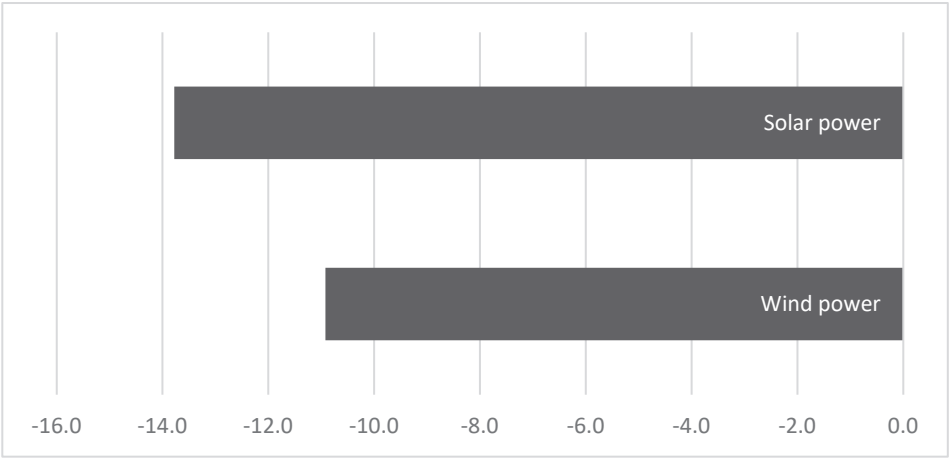
Thus, one can expect that, by implementing mega-projects in the green energy sector, Azerbaijan will also increase levels of employment. It is clear that the economic and social benefits of green energy projects are linked and will contribute to the realisation of Azerbaijan's strategy of socio-economic development (SSED, 2022). Furthermore, one of Azerbaijan's five national

priorities for socio-economic development in the period up to 2030 is "Country of Clean Environment and Green Growth".

When it comes to analysing cost-effectiveness (CE), it is critical to comprehend the consequences of the numerical values obtained from well-established equations in the above sections. An analysis of this kind that produces a positive CE (see equation 5) indicates that the project in question is probably going to cost the investor money. On the other hand, a negative CE indicates that the reduction in emissions in the project is economically beneficial.

From our analysis, wind power has a computed cost-effectiveness of -10.9 CO2 USD/ton, while solar power has a slightly larger economic advantage of -13.8 CO2 USD/ton (Figure 3). These numbers bear witness not only to the financial elements of these renewable energy sources, but also to their positive environmental effects. The economic benefits of reducing CO2 emissions are represented by the negative numbers in this context, highlighting the double advantages of such projects: economic feasibility and environmental sustainability.

Figure 3: Cost-effectiveness ratio of the wind and solar projects



Source: Authors' calculation

The study also adopts co-benefits analysis approach to adress several environmental problems, such as pollution and climate change. The equation (5)

indicates the financial benefits linked to the reduction of emissions of CO2 equivalent. Obviously, adoption of wind power reduces emissions and benefits the environment while simultaneously providing economic rewards. Projected contributions from wind and solar energy projects to the non-oil GDP generated in 2023 are estimated to be 0.11% and 0.07%, respectively. This certainly highlightes the dual advantages of wind energy for the environment and the economy.

4.2.4. Ecological advantage

Azerbaijan's greenhouse gas emissions were 79 million tons of CO2 equivalent in the base year of 1990, and according to the commitment under the Paris Agreement, it aims to reduce emissions by 35% by 2030, that is, a reduction to 51.3 million tons of CO2 equivalent in 2030. According to official information from 1990, greenhouse gas emissions decreased to 47 million tons of CO2 equivalent in 2010. However, as a result of the development of the energy sector in the following period, there was an increase in this area, and Azerbaijan's emissions amounted to 58.1 million tons of CO2 equivalent in 2021 (SSC, 2024). This means that in the coming years, Azerbaijan can achieve its commitment by reducing emissions of up to 6.8 million tons of CO2 equivalent. It will be the green energy projects that play an important role in Azerbaijan's achievement of this commitment.

Azerbaijan accounts for only 0.15 percent of global greenhouse gas emissions. It aims to reduce greenhouse gas emissions by 35 percent by 2030 and 40 percent by 2050 compared to 1990. In terms of installed capacity, this would require installing 1.2 GW of wind and 1.1 GW of solar by 2030 and 3.6 GW of wind and 4.1 GW of solar by 2050 (WB, 2023). In addition, Azerbaijan aims to create a "net-zero emission" zone in the liberated territories. Renewables also offer an important low-carbon solution to meeting Azerbaijan's climate targets (IRENA, 2019). According to the IEA (2022), solar PV and wind are the leading means of cutting electricity sector emissions: their global share of electricity generation will increase from 10% in 2021 to 40% by 2030 and 70% by 2050.

Among the national priorities of Azerbaijan, "green growth" is defined as an important issue in the coming decade. Therefore, in the next decade, as Azerbaijan realises its socio-economic developent according to the five national

priorities, "a Country of Clean Environment and Green Growth" will play an important role (SSED, 2022).

Considering the scale of global climate change, the national policy for this priority will reflect the importance given to the application of environmentally friendly technologies, the use of clean energy sources, recycling of waste, and the restoration of polluted areas. Within this priority, the achievement of two goals is of paramount importance: a *high quality ecological environment* and *spaces for green energy*. The research stresses that it is necessary to increase the share of alternative and renewable energy sources in primary consumption in all sectors of the economy and reduce their impact on climate change (SSED, 2022). The transition to green energy is of exceptional importance in this regard.

A great deal of work remains to be done when analysing the emission of greenhouse gases in Azerbaijan. A particular focus needs to be the energy sector, which has an 80 per cent share in the emission of greenhouse gases, and will thus require substantial investment in order to become low-carbon.

An increase in green energy production marks an important stage in Azerbaijan's transition to zero carbon emissions. One salient fact is that by the end of 2027, wind and solar power plants with a capacity of 1,862 MW are expected to be commissioned, which means a saving of more than one billion cubic metres of gas. On the other hand, SOCAR, which supports the implementation of green hydrogen projects, has accepted a voluntary commitment to reduce methane emissions to zero by 2035 and has signed the appropriate documents. Achieving net zero by 2060 would entail a major transformation of the energy system, and Azerbaijan would have to install approximately 30 GW of wind and solar photovoltaic power plants before 2060 (WB, 2023).

On the other hand, Azerbaijan is one of the countries facing water scarcity, and, in this regard, green energy production will be beneficial. The energy sector is currently the second largest water user in Azerbaijan (11 percent of total demand). A report by the World Bank (2022) stressed that wind farms required very little water and a 1 GW wind farm would save 65 billion litres of water per year (WB, 2022). A World Bank (2023) calculation shows that the large-scale deployment of wind and solar PV would lead to an 80 % reduction in the energy sector's water consumption over the period 2040–2060. A GWEC (2022)

calculation shows that the resulting 5 GW of wind energy should save 28.8 million litres of water annually. Among other benefits, over the lifetime of this onshore wind farm, 240 million metric tons of CO2 emissions would be saved (GWEC, 2022). Natural gas releases, on average, 500 metric tons of CO2 per GWh of electricity generated, and a typical 1 GW wind farm would save over 2.2 million metric tons of CO2 per year (WB, 2022).

4. DISCUSSION

Diversifying Europe's energy supply and ensuring its energy security are of strategic importance. The idea of laying an electric cable across the bottom of the Caspian Sea became relevant later as the discussion of laying an electric cable across the bottom of the Black Sea evolved. If this happens, the opportunities for Central Asian countries to export green energy to Europe will increase. Azerbaijan aims to implement mega-projects in the field of green energy and has been expanding its activities in this field since 2022. The involvement of the world's largest companies in this process and the start of cooperation with the European Union on the export of green energy increase the possibility of achieving these goals. The findings of our study indicate that the transition to green energy will bring multiple benefits for the country, including geo-political, socio-economic, as well as ecological benefits.

Azerbaijan has signed a memorandum with the EU, and one of the important points in this memorandum is the issue of cooperation in the field of green energy. Azerbaijan's goals are to implement large energy projects with its partners that will contribute to the development of the non-oil sector and, at the same time, will play a role in attracting foreign investment to the country and in creating new jobs. The above project is expected to attract foreign investors and increase non-oil export opportunities.

Group discussions on the projects have stressed that the investment costs for renewable energy sources are quite high. On the other hand, these costs will decrease over the next ten years. Another very important point is that the reduction in oil production, which is expected in future years, will have a negative impact on Azerbaijan's economic growth.

However, the increase in green energy production and exports of zero-carbon electricity are of great importance from the point of view of the development of the non-oil sector in Azerbaijan. Ensuring the political stability of Azerbaijan and having foreign currency reserves in the country are also important in terms of attracting foreign investors to green energy projects.

A question that may arise here: does Azerbaijan have the experience to implement such huge projects?

Azerbaijan commissioned and successfully completed the 3,500-kilometre gas pipeline that runs from the fields in the Caspian Sea to Europe on time and is currently exporting gas to the old continent. It exported 11.4 billion cubic metres of gas to Europe in 2022, and this volume reached 11.8 billion cubic metres in 2023. It should certainly be possible to realise green energy projects. In the near future, it is feasible that the countries of Central Asia will export green energy to Europe through the Green Energy Corridor. Access of Kazakhstan and Uzbekistan to these corridors will strengthen the development of markets for electricity in these countries, as well as cooperation in the production and supply of green hydrogen, ammonia, and other products. Partnerships will develop for energy security and green projects within the framework of the Middle Corridor. In the coming years, increased attention will also be focused on Azerbaijan's green hydrogen potential and its export to Europe.

5. CONCLUSIONS

As the host country for COP29, Azerbaijan is taking important steps in the transformation to a green energy economy by using the rich potential of solar and, especially, wind energy in the Caspian Sea and coastal areas. Projects are being initiated in this field for investment by many of the world's leading energy companies, and preliminary agreements have been reached for the production of 28 GW of wind and solar energy. In addition, cooperation between Azerbaijan, Georgia, Romania, and Hungary is moving toward the implementation of the 4 GW capacity Black Sea submarine power line. Serbia and Bulgaria are considering participating in the Caspian–Black Sea–European Green Energy Corridor project. Azerbaijan has started preparations for the export of 5 GW of green energy.

In addition, at the initiative of Azerbaijan and with the participation of Uzbekistan and Kazakhstan, the construction of the energy cable connecting the shores of the Caspian Sea is also being discussed. Thus, the issue of green energy trade with Europe through the Green Energy Corridor of Kazakhstan and Uzbekistan is also on the agenda. These projects in the field of green energy create opportunities to expand the production of electricity and increase export potential by opening significant prospects for the transportation of electricity from Central Asian countries to Europe via Azerbaijan. Green energy projects with a capacity of 28 GW, which Azerbaijan is trying to implement by attracting foreign investors, have already started to have regional importance and will also bring social and economic benefits, as well as ecological benefits.

A cost-effectiveness analysis of green energy projects in Azerbaijan suggests that there are numerous opportunities to cut greenhouse gas emissions through solar and wind power projects that are both economically and environmentally beneficial. This study also highlights the increasing understanding that making investments in renewable energy can be a wise strategic move that balances financial gain with environmental responsibility. This change in perspective represents a major advancement in the fight against climate change and in the direction of sustainable development.

This study emphasizes how important renewable energy initiatives are to improving the country's economic climate, especially in industries unrelated to the production and distribution of oil and gas.

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