RENEWABLE ENERGY CONSUMPTION AND EXPANSION OPPORTUNITIES

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Abstract. In the context of accelerating climate change, energy security challenges, and global commitments to sustainability, the shift from fossil fuels to renewable energy has gained unprecedented urgency. Renewable energy consumption is steadily increasing worldwide, driven by technological innovation, falling production costs, and growing public and political awareness of environmental issues. This study provides a comprehensive analysis of the current status and future expansion opportunities of renewable energy consumption, focusing primarily on solar, wind, hydroelectric, and bioenergy resources.

The research first outlines global consumption trends and examines regional variations, identifying the socio-economic and policy-related factors influencing adoption rates. It further analyzes how energy transition dynamics differ between developed and developing economies, highlighting capacity, infrastructure readiness, and investment climate as critical differentiators. Barriers such as intermittent energy supply, lack of grid integration, and limited financing mechanisms are also addressed in detail.

The study then explores expansion opportunities, particularly in emerging markets and underutilized geographic areas. Key enablers of growth include advancements in storage technologies, digital grid systems, government incentives, and international climate finance. Ultimately, the research argues that a coordinated, multi-sectoral approach is essential to unlocking the full potential of renewable energy. It concludes with strategic recommendations for policymakers, investors, and energy planners to enhance the accessibility, affordability, and resilience of renewable energy systems in line with global decarbonization goals.

Keywords: *energy consumption, renewable energy resources, economic effects, social effects, sustainable development.*

Introduction

Today, energy consumption is increasing. Increasing consumption further strengthens environmental problems. This situation necessitates the reduction of fossil-based energy sources that pollute the environment and the widespread use of renewable energy sources that harm the environment less. Renewable energy is considered an important energy source in terms of the different effects it exhibits. Here, we can include differences according to the type of source, environmental effects, cost, resource continuity, economic and social effects. For example, renewable energy is much more convenient than traditional energy according to the type of source [1,2]. Since this type of energy is produced from natural and continuously renewable sources, it is always found in nature and is not in danger of depletion. Renewable energy has very little carbon emission. This feature can be considered the most important factor in the fight against climate change. In other words, renewable energy sources cause very little damage to the environment [3,4]. For this reason, researchers are conducting various studies in the field of renewable energy resource consumption and trying to determine the factors that prevent its use [5-7]. By determining these factors, various policies are implemented to encourage renewable energy sources.

Energy consumption: socio-economic importance

Energy consumption affects the country's economic development and industrialization level. It also reflects many factors, including the country's standard of living, population size, and industrial development. Using this data, it is possible to examine the general situation and future prospects of any country.

The growth and development rate that the economy wants to achieve is directly related to energy efficiency and energy intensity. In other words, the high energy efficiency achieved by the country reflects a strong economy. Namely, the economic sectors that develop and contribute to development in the country - industry, agriculture, service sector and others - demand high energy [8-10].

When we compare countries in general, it is seen that more industrialized countries consume more energy. In other words, it is possible to evaluate the industrial capacity and development level of that country by looking at its energy consumption. One of the reasons that makes the evaluation of

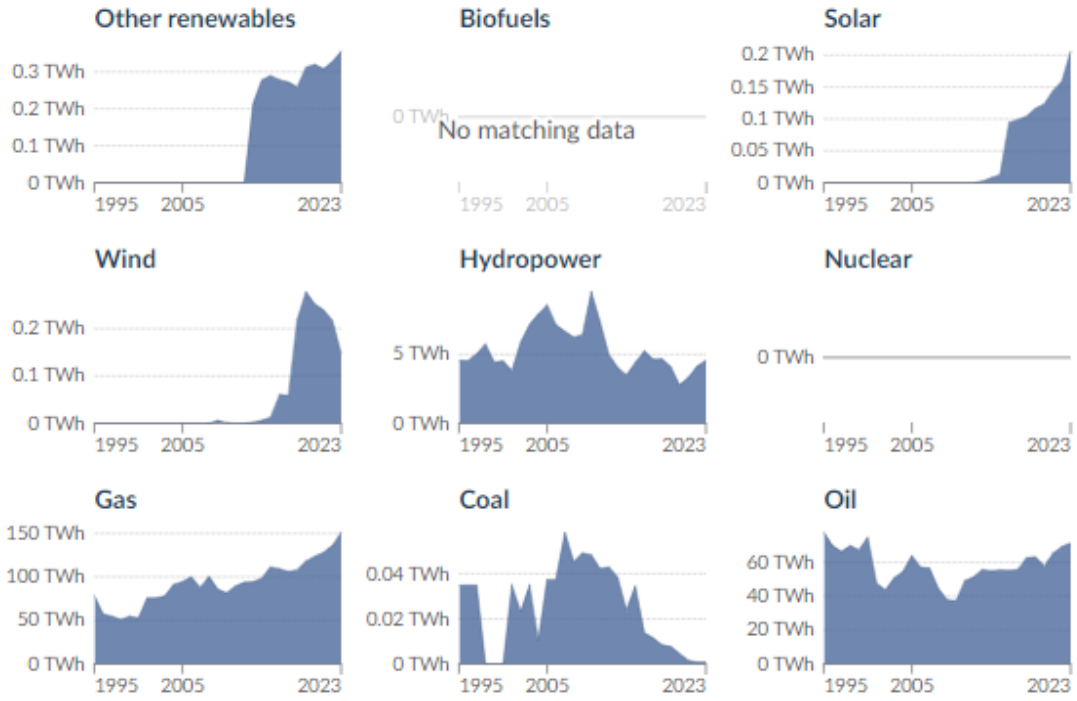
energy consumption important is related to the standard of living. A high indicator is an indication that individuals have a better quality of life. In particular, different areas that reflect the welfare level of the society, such as people's housing and transportation, are evaluated here. One of the factors affecting energy consumption is the population. The larger the population, the more energy can naturally be used. Energy demand is also high in countries with dense populations. In other words, a country's energy consumption reflects its social welfare as well as its economic activity [11].

Energy efficiency in a country is also associated with technological development. High energy consumption in a country does not mean that it is not used efficiently. Technological development allows for more production using less energy. It should also be noted that the level of energy consumption also reflects the level of access to energy resources in that country. Energy-rich countries consume more energy.

In short, a country's energy consumption allows for the examination of economic activities or social welfare indicators in that country. In addition, the role that high energy consumption plays in sustainable development should be considered and evaluations should be made in this regard.

Energy consumption in Azerbaijan

Energy production in Azerbaijan consists of different sources. Some energy sources constitute the vast majority in total consumption (Graph 1). As can be seen from Graph 1, the largest energy sources in the country have been gas, oil and hydropower over the years.

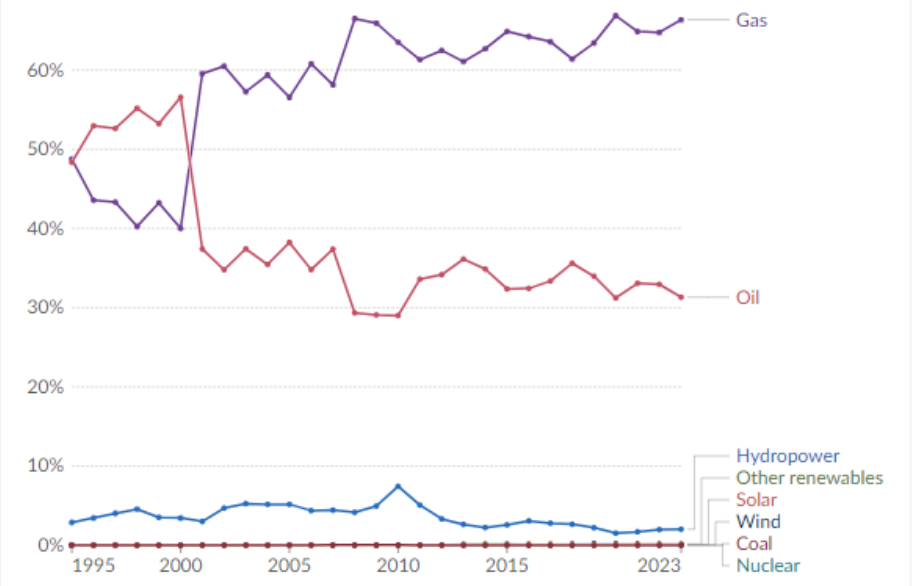


Graph 1. Energy consumption by source, Azerbaijan
Source: [12]

In 2023, oil, gas and coal were consumed more among energy sources worldwide. Oil consumption was 54,564.00 TWh, coal consumption was 45,564.93 Twh, and gas consumption was 40,101.74 TWh. In Azerbaijan, the share of gas in total consumption reached 66.37% in 2023, while the share of oil reached 31.31%. Hydropower was 2.01%, solar 0.09%, wind 0.06%, and other renewables 0.16%. Share of primary energy consumption from fossil fuels was equal to 97.68% in 2023 (Graph 2).

When we compare Azerbaijan's energy consumption resources with the world average, it is seen that gas consumption in Azerbaijan is much higher than the world average. Namely, this level

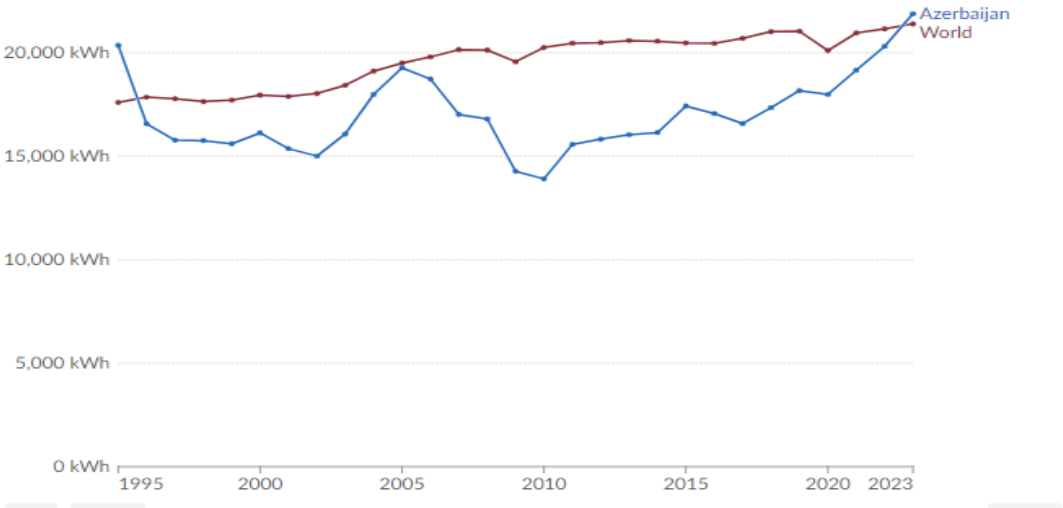
constituted 23.30% worldwide in 2023. Oil consumption was at the level of 31.70%. The share of oil consumption in Azerbaijan is very close to the world average. Coal consumption has been very low in Azerbaijan in recent years, while it was at the level of 26.47% worldwide.



Graph 2. Share of energy consumption by source, Azerbaijan
Source: [12]

Until the 2000s, gas consumption was below 50%, but in the following years it increased and exceeded 50%. On the contrary, oil consumption has decreased to 30% in recent years with a decreasing trend. When we look at the world average, while oil and coal consumption progress with a decreasing trend, gas consumption has increased over the years.

Another interesting indicator of energy consumption in Azerbaijan is per capita consumption. When we compare the total energy consumption of countries, it would be more useful to consider the population size in order to make a correct comment. In other words, it is more important to compare the differences in energy consumption per capita. Namely, since 2001, per capita consumption in the country has been increasing. In 2023, the consumption, which was 21,882 kWh, is slightly higher than the world average (21,394 kWh).



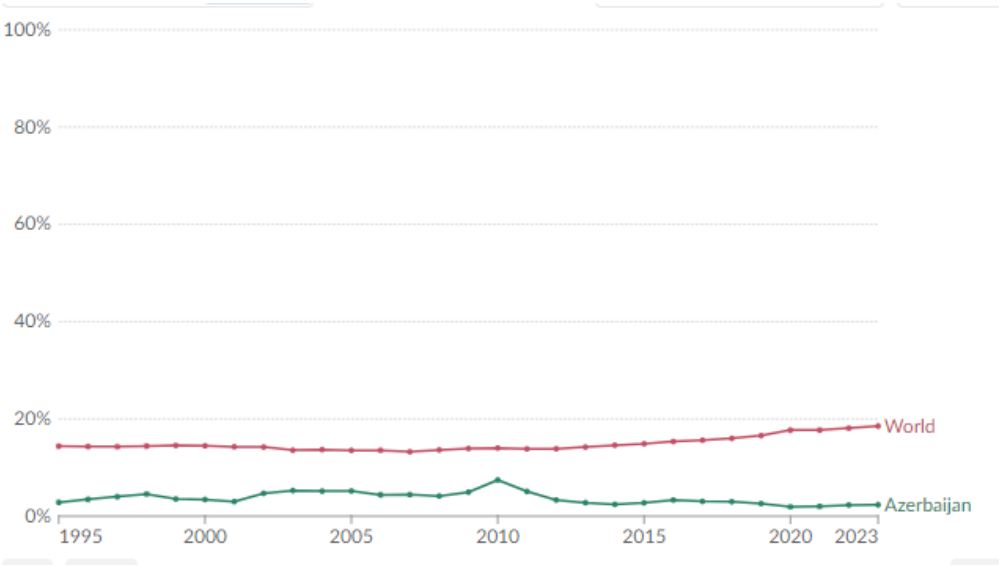
Graph 3. Energy use per person, Azerbaijan
Source: [12]

Renewable energy consumption in Azerbaijan and ways to increase it

Before moving on to renewable energy consumption, it should be noted that two basic concepts are used in literature. One of them is low-carbon energy resources, the other is renewable energy resources. Low-carbon energy resources is a broader concept and includes renewable energy resources. In other words, the sum of nuclear and renewable resources forms low-carbon energy.

Azerbaijan's energy sector is not completely dependent on fossil fuels. The country also has great potential in renewable energy. Azerbaijan is rich in resources such as wind, solar, hydroelectric and geothermal energy. The potential is especially great for wind energy and solar energy [13].

While energy consumption from low-carbon sources in Azerbaijan was 2.9% in 1995, this rate decreased to 2.3% in 2023. When we look at the world average, it is seen that the level of energy consumption from low-carbon sources increased in 2023 (18.5%) compared to 1995 (14.4%).



Graph 4. Share of primary energy consumption from low-carbon sources
Source: [12]

On the other hand, renewable energy consumption in Azerbaijan was 2.86% in 1995, while this rate declined to 2.32% in 2023. It should be noted that the highest indicator was observed in 2010 (7.45%). Compared to the world average, renewable energy consumption increased by 14.56% in 2023 compared to 1995 (7.87%).

Difficulties encountered in the use of renewable energy sources

The figures given above show that, despite the environmental and economic benefits provided by renewable energy, these energy sources are not used at a high level both in Azerbaijan and in the world average. There are various reasons that make it difficult to use such resources widely in the economy.

One of the factors that negatively affects the expansion of renewable energy consumption is due to the high initial costs. The use of renewable energy sources, especially solar and wind energy, is expensive. More precisely, it requires high costs at the beginning. For example, high investments are required for the purchase of solar panels and wind turbines, as well as the installation of energy storage systems. This high cost prevents developing countries or regions from making the necessary investments. The problem of energy storage is among the other important reasons. Renewable sources such as solar and wind energy produce energy intermittently because they are connected to nature. For example, solar energy cannot be produced at night, and the speed of the wind is variable. These features create difficulties in their own right.

The energy infrastructure of some regions has been designed considering traditional systems. However, the use of renewable energy sources requires the creation and expansion of its own infrastructure. The installation of wind turbines, solar panels or other renewable energy facilities requires a large amount of land. It is not possible to implement such facilities in every region. Various difficulties arise, especially in densely populated areas.

Conclusion

Various policies and actions are implemented in Azerbaijan for the development of renewable energy. In order to encourage the development of renewable energy in the country, various incentives and subsidies are provided by the state. Global cooperation is carried out in the renewable energy sector, and technology transfer is carried out through synergy. To expand the consumption of renewable resources in the country, more financial support can be provided, especially to regions with weak energy infrastructure, and the support applied to investors can be expanded for more investments. Such practices will help reduce high initial costs. In addition, as we mentioned above, one of the main obstacles to the consumption of renewable energy resources is the storage of energy. In other words, advanced energy storage systems are needed to solve this problem. For this purpose, the capacity of existing storage technologies should be increased. It will be useful to implement smart grid systems in the country and expand modern transmission lines.

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