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The Role of Solar Energy in Strengthening National Energy Security in Albania

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Abstract

Energy security constitutes one of the most important components of national security and sustainable economic development. Albania relies primarily on electricity generation from hydropower plants, which makes its energy system vulnerable to climate change, hydrological fluctuations, and the need for energy imports during periods of low production. In this context, solar energy represents a strategic alternative for diversifying energy sources and strengthening national energy security. This study analyzes the contribution of solar energy to enhancing energy security in Albania by evaluating the development of photovoltaic capacities, their impact on reducing dependence on electricity imports, as well as the economic and environmental benefits resulting from the expansion of this sector. The methodology is based on the analysis of strategic documents, scientific literature, and statistical data from national and international institutions. The results indicate that the expansion of solar energy use contributes to the diversification of the energy mix, increased domestic energy production, improved supply reliability, and reduced exposure to external energy risks. The study concludes that solar energy represents an important instrument for strengthening national energy security and supporting Albania's long-term sustainable development objectives.

Keywords: energy security, national security, solar energy, photovoltaic systems, renewable energy, Albania.

1. Introduction and Background

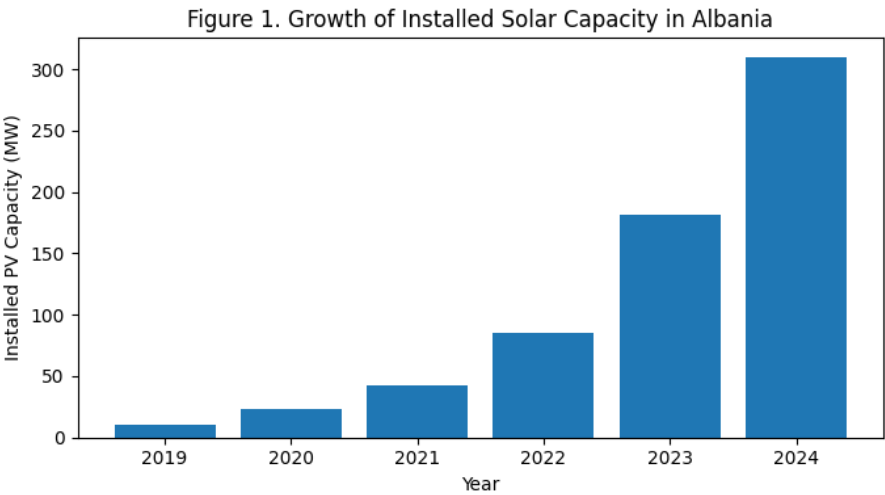
Energy constitutes one of the fundamental drivers of economic development, social stability, and the functioning of state institutions. Ensuring a secure, reliable, and economically affordable energy supply is considered a prerequisite for sustainable development and the preservation of national security. For this reason, the concept of energy security has gained particular importance in national and international policy agendas, especially in the context of increasing global energy demand, climate

change, and geopolitical uncertainties affecting international energy markets (IEA, 2024; Yergin, 2006). Energy security is defined as the ability of a state to ensure a continuous and reliable supply of energy in sufficient quantities and at affordable costs for both the economy and consumers. However, in recent decades, this concept has evolved beyond the traditional dimension of energy supply to encompass environmental sustainability, resilience to crises, flexibility of the energy system, and the capacity to adapt to technological and economic developments (Ang et al., 2015; Sovacool & Mukherjee, 2011). International developments in recent years have clearly demonstrated the strategic importance of energy security. Geopolitical conflicts, fluctuations in fossil fuel prices, disruptions in global supply chains, and uncertainties in energy markets have prompted many countries to reassess their energy strategies and strengthen energy independence through the utilization of domestic resources. In this context, renewable energy sources are increasingly being regarded as strategic instruments for reducing import dependency and enhancing long-term energy security (IRENA, 2023; European Commission, 2023). Albania represents a distinctive case within the Western Balkans region due to its high dependence on hydropower generation. The majority of the country's electricity is produced by hydropower plants that utilize the water resources of Albania's major rivers. Although hydropower constitutes a clean and renewable source of energy, the strong dependence on hydrological conditions creates significant uncertainty for the national energy system. During periods of low precipitation and prolonged droughts, domestic electricity generation declines substantially, increasing the need for imports and exposing the country to price fluctuations in regional and international energy markets (ERE, 2024; INSTAT, 2024). In response to these challenges, the diversification of energy sources has become one of the primary objectives of Albanian energy policy. Among the most promising alternatives, solar energy offers considerable development potential due to favorable climatic conditions and high levels of solar irradiation. Albania benefits from an average of more than 2,400 sunshine hours per year, while most of its territory is characterized by favorable solar radiation levels, creating suitable conditions for the installation and operation of photovoltaic systems (IRENA, 2024; AKBN, 2024). Significant investments have been made in the photovoltaic sector in recent years, including the construction of utility-scale solar power plants and the expansion of self-generation installations by businesses and residential consumers. The growth of installed capacities has begun to contribute to the diversification of the national energy mix and the gradual reduction of dependence on electricity imports. Nevertheless, the further development of solar energy requires additional investments in energy infrastructure, the integration of energy storage systems, and the continuous improvement of the regulatory and institutional framework (Ministry of Infrastructure and Energy, 2018; EBRD, 2024). Within this context, the present study aims to analyze the contribution of solar energy to strengthening national energy security in Albania. Particular attention is devoted to the role of solar energy in diversifying energy sources, reducing dependence on imports, improving the reliability of electricity supply, and supporting sustainable

development objectives. Through an analysis of recent developments in Albania’s energy sector, the study seeks to identify the opportunities and challenges associated with the expansion of solar energy utilization as part of the national strategy for enhancing energy security and increasing the country’s energy independence.

2. Structure of the Energy Sector in Albania

The Albanian energy sector plays an important role in the country’s economic and social development. A reliable supply of electricity is a key factor for the operation of industry, services, transportation, and other economic activities. Albania differs from many countries in the region due to its heavy reliance on electricity generation from hydropower plants, which constitute the primary source of electricity production in the country (ERE, 2024; INSTAT, 2024). The Albanian power system has historically been built upon the exploitation of the hydropower potential of the country’s major rivers, particularly the Drin River. The Fierza, Koman, and Vau i Dejës hydropower plants form the backbone of national electricity generation. Although this model has provided relatively low-cost electricity with limited environmental impact, it has also created a significant dependence on hydrological conditions (AKBN, 2024; World Bank, 2024).



As illustrated in the figure, hydropower represents the dominant share of electricity generation in Albania. Other renewable energy sources, including solar energy, have begun to occupy an increasingly important position within the national energy mix; however, their contribution remains significantly lower compared to that of hydropower plants.

Table 1. Structure of Electricity Energy Sources in Albania

Energy Source	Share (%)
Hydropower	87
Solar Energy	8
Thermal Sources	2
Other Renewable Sources	3

The heavy reliance on hydropower makes the Albanian energy system particularly vulnerable to climate change. During years characterized by low precipitation, domestic electricity generation declines significantly, creating the need for substantial electricity imports. This situation directly affects the country's energy security and increases its exposure to price fluctuations in international energy markets (World Bank, 2024; ERE, 2024).

In response to these challenges, national energy policies have increasingly focused on diversifying energy generation sources. Within this framework, solar energy has been identified as one of the most promising alternatives for increasing domestic electricity production and enhancing energy security. Albania possesses favorable climatic conditions for the development of photovoltaic systems, with relatively high solar irradiation throughout the year and a considerable number of sunshine hours (IRENA, 2024; AKBN, 2024). The growth of investments in solar energy in recent years has gradually begun to transform the structure of Albania's energy sector. The installation of new photovoltaic power plants and the expansion of self-generation systems have increased the contribution of solar energy to national electricity production, creating more favorable conditions for energy source diversification and reducing dependence on imports (Ministry of Infrastructure and Energy, 2018; IRENA, 2024). In this context, analyzing the role of solar energy within the Albanian energy system is essential for understanding its potential contribution to strengthening national energy security and supporting long-term sustainable development objectives (IEA, 2024; European Commission, 2023).

3. Challenges to Energy Security in Albania and the Role of Solar Energy

Energy security constitutes one of the fundamental pillars of national security and sustainable economic development. It is closely associated with a country's ability to ensure a continuous, reliable, and economically affordable energy supply for citizens, businesses, and public institutions. In the case of Albania, energy security is influenced by a range of structural, economic, and environmental factors that have created persistent challenges for the energy sector (IEA, 2024; Sovacool & Mukherjee, 2011). Albania is considered one of the European countries with the highest share of electricity generation derived from hydropower plants. This model has provided significant benefits to the national economy through the utilization of natural water

resources and the reduced use of fossil fuels. However, the country's heavy dependence on hydropower has also created a considerable level of vulnerability, as electricity generation is directly dependent on hydrological conditions and precipitation levels (ERE, 2024; AKBN, 2024). During periods of low rainfall or prolonged drought, the country's major hydropower reservoirs experience significant reductions in water inflows, leading to declines in domestic electricity production. Consequently, Albania is compelled to import electricity from international markets in order to meet domestic demand. This situation increases the economic costs of the energy system and makes the country more vulnerable to price fluctuations in regional and European electricity markets (World Bank, 2024; ERE, 2024). In addition to hydropower dependency, climate change represents one of the most serious challenges to long-term energy security. International reports indicate that the Western Balkans region is experiencing significant climatic changes, including reduced precipitation levels, rising average temperatures, and an increasing frequency of extreme weather events. These developments directly affect the availability of water resources and, consequently, the country's hydropower generation capacity (IPCC, 2023; European Environment Agency, 2023). Another factor affecting energy security is the continuous growth in electricity consumption. Economic development, urbanization, the expansion of the tourism sector, and improvements in living standards have resulted in a gradual increase in electricity demand. Particularly during the summer season, when tourism activity reaches its peak, electricity consumption rises substantially due to the intensive use of air-conditioning systems, tourism-related activities, and the expansion of service-based businesses (INSTAT, 2024; Ministry of Infrastructure and Energy, 2018). Furthermore, energy infrastructure constitutes a critical component in ensuring energy security. The modernization of transmission and distribution networks, the integration of smart technologies, and the enhancement of operational flexibility are essential for meeting the future requirements of the energy system. As the share of renewable energy sources within the national energy mix continues to increase, the need for infrastructure investments becomes even more significant (World Bank, 2024; EBRD, 2024).

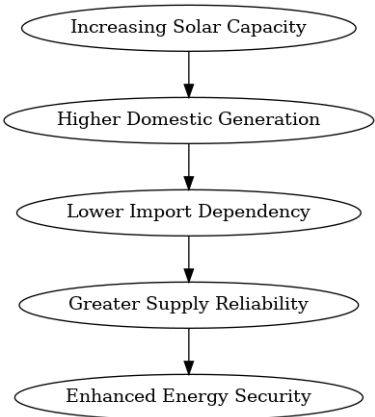


Figure 2. Main Factors Affecting Energy Security in Albania

Figure 2 illustrates the main factors affecting the level of energy security in Albania. As highlighted, dependence on hydropower and climate change represent the most significant risks to a reliable and sustainable electricity supply. At the same time, electricity imports and fluctuations in international energy market prices increase the country’s economic exposure. These challenges are further compounded by the growing demand for energy and the need to modernize energy infrastructure, both of which require continuous investment and long-term strategic planning.

Table 2. Main Energy Security Challenges in Albania

Challenge	Description	Level of Impact
Dependence on Hydropower	Electricity generation depends on hydrological conditions	Very High
Climate Change	Reduction in precipitation and water inflows	Very High
Energy Imports	Dependence on foreign energy markets	High
Price Fluctuations	Increase in energy supply costs	High
Growing Energy Demand	Need for additional generation capacity	Moderate to High
Energy Infrastructure	Requires modernization and investment	Average

Source: Author’s elaboration based on Albania’s national energy strategy documents.

Table 2 Highlights that the most significant challenges to Albania’s energy security are associated with factors that directly affect domestic electricity generation. Dependence on hydropower and climate change represent the highest level of risk, as they directly influence energy availability. Meanwhile, energy imports and price fluctuations constitute economic risks, whereas growing energy demand and energy infrastructure present technical and operational challenges (World Bank, 2024; IPCC, 2023). In response to these challenges, solar energy emerges as one of the most effective alternatives for strengthening national energy security. Albania possesses considerable potential for the utilization of solar energy due to its favorable geographical location and the high number of sunshine hours throughout the year. According to assessments conducted by energy institutions, the Albanian territory benefits from high levels of solar irradiation, creating favorable conditions for the development of photovoltaic systems at both utility-scale and residential levels (IRENA, 2024; AKBN, 2024). Unlike hydropower plants, solar energy generation does not depend on water inflows or precipitation levels. For this reason, solar energy can serve as an important complementary source within the Albanian energy system. Particularly during the summer months, when electricity consumption reaches its highest levels and water reserves are more limited, photovoltaic power plants can make a significant contribution to meeting electricity demand (IRENA, 2023; IEA, 2024). Another important advantage of solar energy is the possibility of distributed generation. The installation of photovoltaic systems on residential buildings,

commercial facilities, public institutions, and industrial sites creates opportunities for self-generation of electricity and reduces the burden on the national grid. This enhances the flexibility of the energy system and reduces the risk of supply interruptions (European Commission, 2023; EBRD, 2024).

Figure 3. Albania Electricity Mix (2024)

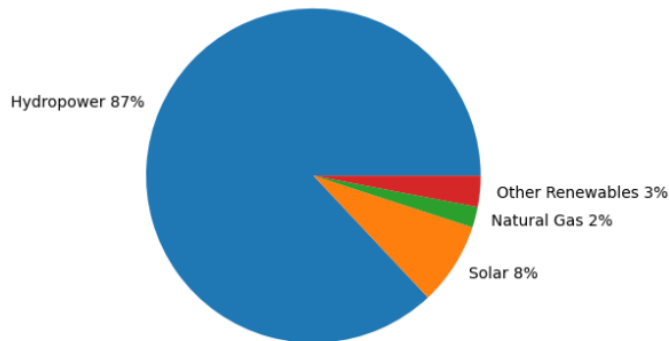


Figure 3. Contribution of Solar Energy to Strengthening Energy Security

Figure 3 illustrates how solar energy contributes to enhancing national energy security. The expansion of photovoltaic capacity leads to increased domestic electricity generation, reduced energy imports, diversification of the energy mix, and improved reliability of energy supply. At the same time, it contributes to economic development and reduces the environmental impacts associated with the energy sector.

From an economic perspective, investments in solar energy create new employment opportunities, stimulate private sector development, and reduce costs associated with electricity imports. Furthermore, the expansion of this sector attracts foreign investment and contributes to the transfer of modern technologies into the Albanian economy (EBRD, 2024; World Bank, 2024). From an environmental perspective, solar energy contributes to the reduction of greenhouse gas emissions and supports national objectives related to the energy transition and sustainable development. This makes solar energy not only an economic and technological alternative but also an important instrument of national security policy (IPCC, 2023; United Nations, 2015). In conclusion, the analysis demonstrates that Albania's energy security faces numerous challenges related to dependence on hydropower, climate change, energy imports, and increasing electricity demand. In this context, solar energy represents one of the most effective instruments for mitigating these risks and strengthening national energy security. The further development of photovoltaic capacities can make a significant contribution to building a more secure, resilient, and sustainable energy system that is less dependent on external factors (IEA, 2024; IRENA, 2023).

3.1 Policies and Investments for the Development of Solar Energy in Albania

The development of solar energy in Albania is not solely the result of the country's natural potential but also of the public policies and investments implemented in recent years. Within the framework of the energy transition and Albania's commitments to the European Union regarding the increased use of renewable energy sources, Albanian institutions have undertaken a series of measures aimed at promoting the development of the photovoltaic sector (European Commission, 2023; Ministry of Infrastructure and Energy, 2018). One of the primary objectives of national energy policy is the diversification of electricity generation sources. For many years, Albania's energy system relied almost exclusively on hydropower plants, creating a high level of dependence on climatic conditions. For this reason, strategic energy sector documents have identified solar energy as one of the most important alternatives for ensuring long-term energy security (Ministry of Infrastructure and Energy, 2018; IEA, 2024). In this regard, the organization of competitive auctions for the construction of photovoltaic power plants represents one of the most significant instruments of Albanian energy policy. These auctions have created opportunities for attracting private investment and developing large-scale photovoltaic projects that meet international standards. Projects such as the Karavasta photovoltaic power plant and the planned investments in the Spitalla area are considered among the most important investments in Albania's energy sector during the last decade (AKBN, 2024; EBRD, 2024). In addition to utility-scale projects, the number of photovoltaic systems installed by businesses and residential consumers has increased significantly. This trend has been driven by declining photovoltaic technology costs, rising electricity prices, and growing interest in self-generation. Rooftop installations have created opportunities to reduce electricity consumption from the grid and lower the operating costs of businesses and households (IRENA, 2024; World Bank, 2024). International financial institutions have also played an important role in the development of solar energy. The European Bank for Reconstruction and Development (EBRD), the World Bank, the European Union, and other international organizations have provided financial and technical support for renewable energy projects in Albania. This support has contributed to the creation of a more favorable investment environment and to improvements in the sector's regulatory framework (EBRD, 2024; European Commission, 2023). Nevertheless, despite the progress achieved, the sector continues to face several challenges. These include administrative procedures, limited grid capacity in certain areas, the need for investments in energy storage systems, and the need to enhance professional capacities within the sector. To fully capitalize on the country's solar potential, continued reforms and stronger cooperation among public institutions, the private sector, and international partners are required (World Bank, 2024; IRENA, 2023).

Table 3. Major Photovoltaic Projects in Albania

Project	Capacity (MW)	Status
Karavasta Solar Park	140	Operational
Spitalla Solar Park	100	Under Development
Private Photovoltaic Projects	>50	Operational
Rooftop Photovoltaic Systems	Increasing	Active

Source: Author’s elaboration based on reports from the Ministry of Infrastructure and Energy, AKBN, and ERE.

Table 3 shows that investments in solar energy have been concentrated both in large-scale industrial projects and in distributed installations. This approach contributes to increasing domestic electricity generation and diversifying the national energy structure.

4. Future Prospects of Solar Energy and Energy Security up to 2030

The prospects for the development of solar energy in Albania are highly promising and are closely linked to national objectives related to energy security, energy transition, and sustainable development. Current trends indicate that solar energy will continue to increase its share within the national energy mix over the coming years (IRENA, 2023; Ministry of Infrastructure and Energy, 2018). One of the primary objectives is the gradual expansion of installed photovoltaic capacity. Considering the projects currently under development and the growing interest of private investors, solar energy is expected to account for a significantly larger share of national electricity generation by 2030. This development will contribute to reducing dependence on hydropower and improving the security of energy supply (IRENA, 2024; European Commission, 2023). An aspect of particular importance is the integration of energy storage systems. One of the main challenges associated with solar energy is that its generation depends on weather conditions and the daily solar radiation cycle. For this reason, the use of batteries and other energy storage technologies will play a key role in ensuring the flexibility of the energy system and enhancing supply security (IEA, 2024; IRENA, 2023). At the same time, the development of Smart Grids will create opportunities for more efficient management of electricity generation and consumption. The integration of digital technologies will enable real-time monitoring, reduction of technical losses, and optimization of energy resource utilization (European Commission, 2023; EBRD, 2024). From an economic perspective, the expansion of the photovoltaic sector is expected to generate new investments and create employment opportunities in the design, installation, operation, and maintenance of energy systems. Furthermore, the reduction of electricity imports will decrease costs for the national economy and improve the country’s energy balance (World Bank, 2024;

IRENA, 2024). From the perspective of national security, solar energy can be regarded as a strategic instrument for increasing Albania’s energy independence. The greater the share of energy generated from domestic and renewable sources, the lower the country’s exposure will be to international energy crises, price volatility, and geo

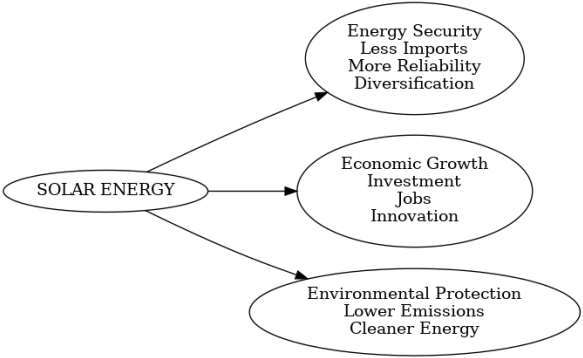


Figure 4. The Role of Solar Energy in Energy Security up to 2030

Figure 4 illustrates how the development of solar energy contributes to strengthening national energy security. Increased domestic electricity generation, diversification of energy sources, reduced dependence on imports, and the integration of modern energy technologies create the foundation for a more secure and sustainable energy system. In conclusion, the outlook for solar energy in Albania up to 2030 is highly promising. If accompanied by continuous investment, modernization of energy infrastructure, and consistent supportive policies, solar energy can become one of the main pillars of national energy security and the country’s long-term economic development.

5. Conclusion

This study analyzed the contribution of solar energy to strengthening national energy security in Albania by evaluating its role in diversifying energy sources, reducing dependence on imports, and improving the resilience of the energy system. The analysis was based on an examination of the structure of the Albanian energy sector, the identification of the main energy security challenges, and an assessment of the potential of solar energy as a strategic alternative for the country’s long-term development. The findings indicate that the Albanian energy system continues to be characterized by a high dependence on hydropower plants. Although hydropower represents an important source of renewable energy, the country’s almost exclusive reliance on this resource exposes it to risks associated with climate change and hydrological fluctuations. Periods of drought directly affect domestic electricity generation, increasing the need for imports and creating uncertainties in energy

supply. The study highlighted that solar energy offers considerable potential for strengthening national energy security. Favorable climatic conditions, high levels of solar irradiation, and a large number of sunshine hours throughout the year create substantial opportunities for expanding photovoltaic capacities across the country. The increase in investments in solar energy in recent years has gradually begun to transform the structure of Albania's energy mix and has laid the foundation for a more diversified energy system. One of the principal benefits of solar energy is the increase in domestic electricity generation. The development of photovoltaic power plants and self-generation systems reduces the need for energy imports and improves the country's energy balance. This contributes to lowering exposure to price fluctuations in international energy markets and enhances Albania's energy independence. Furthermore, solar energy plays a significant role in the diversification of energy sources. Its presence within the national energy mix reduces dependence on a single source of generation and increases the flexibility of the energy system. Such diversification is considered a key element in improving the system's resilience to energy crises and uncertainties caused by climatic or economic factors. From an economic perspective, investments in solar energy generate positive effects on national development. The expansion of the photovoltaic sector creates new employment opportunities, attracts private investment, and contributes to the development of technological and professional capacities. Moreover, the reduction of electricity imports has a positive impact on the national economy and on the financial sustainability of the energy sector. From an environmental perspective, solar energy contributes to the reduction of greenhouse gas emissions and supports national and international objectives related to the energy transition and sustainable development. This makes solar energy an instrument that not only enhances energy security but also supports environmental protection and improvements in quality of life. Nevertheless, the study indicates that the further development of solar energy requires addressing several challenges. Among the most important are the modernization of transmission and distribution networks, the integration of energy storage systems, improvements in the regulatory framework, and the establishment of sustainable support mechanisms for investors. Addressing these challenges will be essential for maximizing Albania's solar energy potential.

In conclusion, solar energy represents one of the most important instruments for strengthening national energy security in Albania. Its development contributes to increasing domestic energy production, reducing dependence on imports, diversifying energy sources, and improving the resilience of the energy system. In the context of climate change, growing energy demand, and uncertainties in international energy markets, solar energy can play a strategic role in building a more secure, competitive, and sustainable energy system for Albania.

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