

The Role of Renewable Energy in Enhancing Algeria's Economic and Security Position

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Abstract:

This scientific paper examines the critical role of renewable energy in enhancing Algeria's economic stability and energy security. It highlights the country's current over-reliance on hydrocarbons, which account for 97% of its energy mix, posing risks of resource depletion and economic vulnerability. The article aims to explore Algeria's potential for renewable energy development, particularly solar and wind power, given its abundant natural resources and strategic Mediterranean location. By 2030, Algeria seeks to generate 22% of its energy needs from renewables, diversifying its economy, reducing dependence on fossil fuel exports, and creating job opportunities. Despite challenges such as high initial costs and market structure limitations, the paper concludes that renewable energy adoption can secure Algeria's energy future while addressing environmental concerns, fostering sustainable development, and strengthening its position in the global energy market.

Keywords: Renewable Energy, Economic Stability, Energy Security, Algeria

I. INTRODUCTION

Energy plays an essential role for nations as they strive to sustain economic prosperity, uphold security, and improve the overall quality of life for their citizens. The energy systems across the globe, especially in developing regions, are predominantly characterized by a significant reliance on fossil fuels. Despite the longstanding dependence on these traditional sources, increasing pressures from both domestic and international stakeholders are compelling national governments to shift their energy policies in ways that carry broader national and environmental implications. The primary concern fueling this shift is the urgent need to reduce the financial burdens associated with fossil fuel imports. Additionally, there is an increasing requirement to mitigate the adverse environmental impacts that stem from the usage of fossil fuels for energy. Renewable energy stands out as a crucial alternative that not only addresses these pressing concerns but also fosters economic growth and contributes to various significant benefits on a global scale. There exist numerous compelling reasons to advocate for the incorporation of renewable energy technologies into contemporary energy policies. One of the foremost advantages is their potential to help preserve and enhance global environmental quality. Today, renewable energy technologies are more appealing than they have been at any point since the emergence of the petroleum age, demonstrating their viability as essential components of a sustainable energy future. Thanks to remarkable advancements in science and technology, renewable energy options are increasingly recognized as promising solutions to complex challenges faced in the quest for sustainable development. As technological innovations continue to flourish and environmental awareness rises, the momentum of renewable energy development is gaining speed on a global scale. Nonetheless, the past two decades have showcased a landscape marked by sporadic and inconsistent renewable energy policies and initiatives. This inconsistency raises concerns that, despite the push towards renewables, fossil fuels will still account for a substantial portion of the world's energy consumption for the foreseeable future. This situation necessitates a thorough examination of the renewable energy debate against the backdrop of today's tumultuous and swiftly evolving global energy landscape.

Research problem : "How can Algeria overcome the economic, technological, and political obstacles that hinder the development of renewable energy, and ensure the achievement of its goals in diversifying energy sources and enhancing economic and security stability by 2030"?

1 .Algeria's Current Energy Landscape

Algeria is experiencing an energy growth trajectory. Over the past decade, the country has made significant strides in modernizing its economic system and institutions, which has made it a country of interest to many investors. As a result of its stable economic infrastructure, it has experienced rapid population growth. Such an achievement, however, has resulted in unprecedented energy consumption and a subsequent increase in dependence on oil and natural gas to meet a rapidly growing share of its energy needs. Indeed, approximately 97 percent of Algeria's energy comes from hydrocarbons, which accounts for almost 97 percent of the exports and for 21 percent of the GDP, and over 60 percent of the state's financial resources. While natural gas and oil are essential to maintaining Algerian economic, social, and security gains,

they are still finite and exhaustible resources whose depletion will occur at a much faster rate than previously thought. (Imene)

The hydrocarbons market, meanwhile, has become incredibly competitive. Algeria is one of the largest natural gas producers and exporters, but it competes with countries such as Qatar, the United Arab Emirates, Nigeria, and Russia. Domestically, the cost of producing natural gas and oil has been increasing as fields are depleted and require a greater amount of energy to maintain or increase production. However, the cost to consumers is subsidized as the state pays a significant share of the cost. Consequently, the amount of oil and natural gas available for export has been diminishing as it is siphoned off to the domestic market – a trend that is expected to worsen by 2030. Additionally, Algeria's current energy model, with its dependence on the energy sector for the economy, is detrimental in several ways. (Bergougui, 2024)

1.1 .Overview of Algeria's Energy Mix

Renewable energy has increasingly emerged as a crucial alternative to conventional natural energy sources that are rapidly declining and nearing depletion. The focused development and exploitation of renewable energy resources have the potential to stimulate robust economic growth by generating numerous job opportunities and attracting significant foreign investments into the country. Algeria has established itself as a noteworthy player by securing the 25th position globally among the leading energy producers, while also being recognized as the eighth largest exporter of natural gas. Furthermore, the country holds the second position within the MEMA group regarding its primary energy consumption per capita, which stands at 1.5 tonnes of oil equivalent (toe), derived primarily from resources such as natural gas, oil, and other derivatives, utilized extensively for both electricity generation and heat production. (Tahchi, 2024)

Historically, the oil and gas sectors in Algeria have received the majority of the allocated governmental budgets, which has resulted in a substantial increase in revenues derived from energy exports. The current energy policy is multifaceted in nature; it seeks not only to safeguard and enhance the diverse existing resources but also aims to develop a remarkable capacity of up to 5 gigawatts (GW) of renewable energy for integration into the national grid by the year 2030. This ambitious plan involves the utilization of advanced solar photovoltaic technologies alongside concentrated solar power technologies, with a clear objective of exporting surplus energy effectively to European markets. (Zahraoui et al.2021)

Looking back at the past, Algeria was characterized by its self-sufficiency with access to abundant clean and renewable energy resources, with hydroelectric power, wind energy, solar energy, and even geothermal power contributing to an impressive 95% of total electricity production up until the 1990s. However, since that time, consumption rates have surged dramatically, resulting in a significant imbalance in the energy equation, which prompted Algeria to begin importing energy from international markets. In the year 2015, projections indicated an expected reserve of approximately USD 9.5 billion dedicated to ramping up electricity production, specifically targeting a capacity of 22 GW from renewable energy sources alone (Chabani et al.2021).

The ongoing transition geared towards the development of renewable energy resources, particularly through the deployment of solar and wind power technologies, is envisioned to help conserve the remaining fossil fuel resources. This initiative is essential to ensure a sustainable balance between energy demand and supply, while simultaneously providing security and preserving vital resources, which play a dominant role in shaping the economy of this North African nation. Additionally, projections show that the export of solar-generated electricity is anticipated to constitute 12.6% of the overall energy drop rate per annum, derived from export activities as well as the ongoing utilization of locally available oil and natural gas resources. (Bae & Yun)

1.2 .Challenges and Limitations

Renewable energy appears to provide a remarkable and promising solution to the deeply rooted intrinsic problems that are associated with traditional energy sources. Unlike conventional energy, it does not contribute harmful pollutants and greenhouse gases to the atmosphere, thus representing a significant solution to the negative externalities that arise from fossil fuels and other non-renewable sources. Additionally, renewable energy is generally recognized to be less vulnerable to future risks of resource depletion, enhancing its attractiveness for long-term energy strategies. The economic benefits of renewable energies are frequently underscored, especially in terms of job creation as well as the crucial reduction of dependency on foreign energy sources, which can often be politically sensitive. Moreover, beyond the clear tangible advantages, the production and adoption of renewable resources is believed to underpin and advance the concept of sustainable development, which emphasizes the need to meet present energy needs without compromising the ability of future generations to meet their own needs. Although most nations would likely find the shift towards renewable energy sources to be in their best interests, several persistent barriers and challenges exist which have historically opposed the widespread production and utilization of renewable energies, making the transition more complex than it might initially appear. (Byaro et al.2023)

Large capital costs coupled with low subsidy levels continue to present a formidable challenge for the energy sector. This situation creates an artificial constraint that does not effectively encourage utilities to consider renewable energy sources as a serious option for power production. An additional challenge, which is far more complex and difficult to address, lies in the need to enhance private institutional knowledge about renewable energies and establish a mutually acceptable level of confidence among stakeholders. Implementing flexible electricity market structures is essential, as it will provide significant incentives for the development and deployment of renewable energy resources. Furthermore, a suitable positive pricing mechanism must be established to increase both the quantity and quality of investments in renewable resources, ensuring a robust market for green energy. In parallel, for countries that have yet to liberalize their electricity markets, creating a power purchase obligation represents another viable method to stimulate and increase investments in renewable energy sources. Through these approaches, a more sustainable energy landscape can be cultivated, paving the way for a transition towards cleaner and more efficient energy production methods. (Qadir et al., 2021)

2 .Benefits of Renewable Energy for Algeria

Algeria has been producing electricity through renewable energy sources such as hydroelectric plants and bioenergy generation; however, production levels remain modest. The exploitation of solar and wind power remains, at this stage, minimal. This occurs despite the fact that Algeria enjoys the third highest solar radiation exposure and one of the best wind potential resources in the world. Algeria is now planning to rapidly expand its current renewable energy production capacity. It aims to cover approximately 22% of national energy needs and provide up to 30% of the country's electricity generation by 2030 using renewable sources. The development and application of renewable energy systems will help to diversify energy sources and the economy, hence increasing energy security and economic stability. By investing in renewable sources and energy efficiency policies, Algeria can also reduce its over-reliance on fossil fuel exports. Algeria's economy depends mainly on petroleum and natural gas. It is important for Algeria to diversify its economy by investing in its large human capital. Up until now, the Algerian government has used its hydrocarbon revenue to invest in education and create social mobility in the country, thus creating a highly educated youth population. With the large investments required to propel Algeria out of the social, economic, and security doldrums, renewable energy can be used as a portal to bring Algeria forward and allow the country to better harness its resources and work toward self-reliance. (Zahraoui et al.2021)

2.1 .Economic Benefits

Algeria is undeniably one of the countries that has unfortunately found itself grappling with the formidable and multifaceted challenges posed by energy poverty, a complex issue that primarily stems from a significant scarcity of domestic resources that are essential for fostering energy sustainability. Historically speaking, the nation has relied heavily and almost exclusively on the export of hydrocarbons, a practice that, while it has provided short-term economic benefits, allows for the provision of high energy value services predominantly through the process of burning natural gas. This long-standing dependency on hydrocarbons has not only contributed to economic fluctuations but has also prompted the launch of a comprehensive and far-reaching diversification strategy that aims to utilize state funds effectively in the exploration of alternative energy sources and innovative solutions that could transform the energy landscape. Despite the substantial financial investments made and the considerable physical efforts dedicated to these initiatives and programs, the progress achieved in enhancing energy efficiency and transitioning towards a more balanced energy mix has been deemed modest at best. Currently, the energy mix reveals that hydrocarbons still constitute an overwhelming 98% of Algeria's energy profile, which is indeed quite concerning and highlights the urgent need for change; the remaining 2% is a shared contribution from hydro and nuclear energy sources that are also gradually being integrated into the broader energy framework. Furthermore, the ongoing evolution of global warming, coupled with the mounting impacts and repercussions brought about by climate change, is generating an accelerating awareness among the populace regarding the critical importance of adopting eco-responsible and sustainable practices in everyday life and governance. In order to effectively address these pressing concerns and make a concerted effort to harmonize the divergent and often conflicting energy interests that exist within the nation, the increased utilization of renewable energy is emerging as both a sustainable and promising

solution to the energy issues at hand. This proactive approach is crucial for achieving the energy independence that Algeria has ambitiously set out to prioritize, with a bold and clear objective established for the year 2030 that reflects the nation's commitment to improvement. Such aspirations underscore the urgent need for immediate action and strategic planning in the energy sector to safeguard the environment and secure the energy future of the country for generations to come. (Matori, 2024)

2.2 .Security Benefits

The energy security advantages that are associated with renewable energy sources tend to be less clearly articulated when compared to the more widely recognized economic and environmental advantages that are often highlighted. For nations that possess indigenous renewable resources, the primary benefit typically arises from a significant reduction in their exposure to the often volatile nature of fuel prices. This substantial reduction in exposure not only helps in stabilizing national economies but also extends to mitigate disruptions caused by various dramatic challenges, such as expropriation of resources, economic embargoes, marine transport interdictions, labor strikes, and even acts of sabotage that can severely impact the infrastructure of the fuel industry. Numerous comprehensive field studies have clearly demonstrated that the foremost security-related advantage of utilizing renewable resources lies firmly in their inherent availability within the geographic boundaries of the country where they are fundamentally needed. In stark contrast, when conventional energy sources are accessible solely from outside the geographical borders of a nation, their utilization introduces a multitude of energy security risks and vulnerabilities that can threaten national stability. By procuring energy from within the geographic territory in which the energy will ultimately be consumed, nations can, in most cases, facilitate the effective exploitation and management of those vital resources. Nevertheless, it is absolutely essential to note that a significant qualification exists in this context: the political stability of the nation that hosts the indigenous energy resource must not be in serious jeopardy for these substantial benefits to be fully realized and to ensure ongoing energy security in a reliable manner. Thus, while the advantages are clear, the landscape surrounding energy security is complex and requires careful consideration of multiple factors, including geopolitical stability, resource management, and evolving market dynamics. (Hattrem, 2024)

3 .Policy Framework and Initiatives

The main objective of economic and social development and the fight against climate change implies that Algeria revise its energy strategy by progressively replacing fossil fuels, which are less used for domestic demand and incomes, with clean energies targeted towards the outside. Algeria should take advantage of internal resources resulting from the mobilization of all energies to achieve a high level of national added value, generating substantial growth in job creation to achieve real economic diversification and maintain the confidence of financial markets. Algeria has already initiated the transition to a green and then to a blue economy, but these must assume transparent strategic choices adapted to the evolution of energy technologies based on integrated policies in close consultation around the criteria of sustainable and equitable

economic growth. Algeria must promote the creation of a complete and diversified renewable energy sector, essentially intended for the external market, in order not to supply European countries, which are faced with both global economic and energy constraints, and continue to consume cheap fossil fuels for the foreseeable future, which they cannot produce due to their absence. In this perspective, the national society of the future will have to control technological choices and achieve a high level of added value while optimizing Algeria's integration into the international division of labor, suppressing import programs. The establishment of a consultative, highly specialized structure in charge of proposing an organization that establishes the shocks with local and short, medium, and long-term consequences from the national level offers feedback on the state of implementation of the energy strategy, promotes collaboration, and ensures compliance with national and international standards through services with high added value in training, influence, and certification of products and businesses. (Zahraoui et al.2021)

3.1 .Government Policies and Incentives

The national government has been very proactive in developing and encouraging renewable energy legislation. The government of Algeria has set a goal for the country to have 22,000 MW of installed clean and renewable energy by the year 2030. The Ministry of Energy and Mines has formed the Directorate of Renewable Energies, which implements the Algerian policy for the development of renewable energies. The Directorate of Renewable Energies then works through the National Development and Construction Agency of Renewable Energy to achieve the renewable energy goals of the country by creating a large number of projects. A major benefit for the solar and wind renewable energy markets in Algeria is the fact that several mechanisms are being proposed and implemented in order to increase the attractiveness of investing in these types of clean energy generation. (Imene)

Some of the projects that have been funded and are in their operational stages are the Hybrid Solar/Gas Power Plant where 400 km² of an area between Hassi R'Mel and Béchar will be used to construct a hybrid solar natural-gas-fired power plant with a capacity of 500 MW, the Adrar Wind Farm where the company delivered the turnkey public works contract and industries built 18 wind turbines at a cost of 850 billion dinars for a 15-16 MW wind farm, the 20 Emergency New Renewable Energy Photovoltaic Projects that invite leading national and international companies to bid for these projects in accordance with the rules laid down in the implementing decree issued in this connection, and the 12 Authorized Projects of Nine Companies to build twelve projects for the generation of electricity from renewable energy are now fully authorized after received assistance in application preparation and financial support instruments. (Adnan et al.2022)

3.2 .International Collaborations

This collaboration manifests itself through various associations, specifically developed within the framework of regional organizations dedicated to strengthening renewable energy initiatives. Numerous projects and networks are already established, spanning a diverse array of renewable energy sources including, but not limited to, solar power, wind energy, and innovative methods for energy recovery from waste materials. The multitude of existing associations and

projects holds significant potential to assist these countries in setting up an effective regional framework, thereby simplifying the process of maximizing the use of renewable resources available in the region. This strategic framework aims to mitigate the challenges posed by intermittent operations of energy sources, facilitate seamless electricity and fuel exchanges, and establish comprehensive connection logistics among participating countries. (Chabani et al.2021)Moreover, fostering the active participation of local actors, as well as the governments of neighboring nations, in regional cooperation programs is vital and can only be achieved through a broad and effective transfer of technology. Joint ownership of development projects and the shared utilization of natural resources and infrastructure are essential components of this collaborative approach. It is equally important to ensure a foundation of stability and mutual trust among countries, operating within various regional and sub-regional frameworks, to bolster energy security in the long term. Such stability is critical for encouraging the meaningful involvement of both energy consumers and producers involved in the generation of electricity and fuels. (Mantino, 2021)Once a robust level of trust and cooperation is established, allowing for the emergence of international energy markets, various economic mechanisms dedicated to energy management can be more effectively institutionalized. These include, among others, the processes of international standardization, comprehensive market integration, and the development of common infrastructure that supports these initiatives. Through these measures, a more interconnected and resilient energy landscape can ultimately be achieved, benefitting all participating nations and their respective economies. (Mohammadi, 2023)

4 .Case Studies and Success Stories

Algeria, a country rich in natural resources, has been achieving numerous success stories in the field of renewable energy through a concerted effort that emphasizes investing significantly and promoting extensive research, development, and demonstration projects focusing on various renewable energy technologies. The nation has not only made substantial investments in advancing renewable energy but has also focused heavily on deploying these technologies both domestically within its borders and abroad in other markets. Despite the challenges posed by declining revenues resulting from lost oil and gas income due to the upward price adjustments by producers, the situation reveals a silver lining, often referred to as the double dividend. This double benefit comes from providing crucial power to the central electricity transmission companies, which plays a vital role in offsetting the export of fossil fuel-generated electricity to the northern regions of the country. (Bergougui, 2024)

In light of these developments, Algeria has been diligently working towards the careful planning and implementation of hybrid energy projects. These projects are designed to create synergies and foster the development of coalition and consortium rights that link the Maghreb countries. This collaborative approach is seen as a realistic and strategic method for enhancing cooperation and securing financing for the electrical integration required for the ongoing development of renewable energy across these nations and throughout the southern region of the Mediterranean. The success stories arising from this collaborative initiative are clearly illustrated through the various utility projects that have been successfully implemented. (Weko et al.)

Renewable energy initiatives have become an integral part of the national framework of public-private partnerships. This includes a diverse array of arrangements such as joint ventures and independent power producers that contribute to the installed capacity of the energy grid. Furthermore, the contribution of renewables to the overall generating capacity within these public-private ventures is becoming increasingly significant, underscoring a strong commitment to sustainable practices in energy production and supply. (Zeggagh & Ziane, 2025)

conclusion

The preceding sections have highlighted the complementarity and compatibility of renewable energy development with Algeria's selected strategies and programs to address geo-economic and geopolitical challenges. For long-term strategies and programs, the long-term characteristics and advantages of renewable energy sources are highly desirable in order to contribute significantly to the achievement of the economic and security objectives of increasing natural gas revenue profitability, reducing CO₂ emissions, and promoting decentralization, economic diversification, political stability, and social and human development in underserved areas. Because of these characteristics and advantages, Action 10 of the Algerian National Energy Development Plan aims to increase the production of electricity from renewable energy sources to reduce the weight and ecological impact of fossil fuels on the national market and to contribute to guaranteeing the energy security of the country. Algeria has set an objective to develop 22 GW of electricity from solar and wind during the period from 2018 to 2030. Algeria's renewable energy potential is significant and aligns with the selected security strategy, positioned on political leadership and national competitive areas in the fields of geo-economics, diplomacy, and political relations within the African continent, in addition to joint initiatives at the worldwide level. In conclusion, solving the multiple problems associated with Algeria's economic petro-dependence requires that renewable forms of energy be used as an efficient and effective means of encouraging political leadership and economic actors to adopt win-win strategies offering accelerated profitable growth to each citizen capable of creating significant and durable value in such a way that they facilitate the shift towards the renegotiation of a new social contract. Fortunately, the potential of renewable energies in Algeria and their selection by the Algerian government as capitalization factors offer the opportunity to participate in the acceleration of the desirable modification process.

Recommendations

The government of Algeria has recognized the importance of renewable energy utilization over the last few years. This was demonstrated in 2002 with the ratification of the National Renewable Energy Programme for the period 2000 to 2010 by the National Assembly. The proclamation of this law constitutes a mainstay for the implementation of the new energy policy and provides a general orientation for non-conventional energy development to the other sectorial policies: local development, environmental protection, health and social causes, and the forms of aid. To go forward with NREP 1.0, it is necessary to improve the regulations and the procedures that coordinate the energy potential identification and the renewable energy facilities implementation. The responsibility for the implementation of the rules and the reinforcement of the renewable energy policy is assigned to the renewed energy sector, which is charged with

promoting and coordinating the measures to favor the use of renewable energy. Algeria should propose further initiatives for consolidating national and regional integration for renewable energy adoption, and at the same time, continue to work to mobilize assistance for the expansion of the development and regulatory framework for renewable energy. A greater commitment from the international scene is ultimately instrumental for the full realization of the National Renewable Energy Policy.

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