



Energy Transition in Algeria: An Analytical Study of the Role of Investment in Renewable Energy in Achieving the Dimensions of Sustainable Development

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Abstract:

The current study analyzes the role played by renewable energy investments in the habitat of sustainable development in Algeria. Apart from having abundant solar and wind energy potential, the practical deployment of these resources is still at a low level due to weak institutions, a lack of regulation, little engagement by the private sector, and very little research investment. This makes progress excruciatingly slow and reflects a severed link between energy policy and sustainability goals. A coherent national strategy calling for reforms, investments, and connecting research with policymaking is required to enable Algeria to move towards a low-carbon, resilient, and diversified economy.

Keywords : Energy Transition; Renewable Energy; Sustainable Development; Investment; Algeria.

JEL Classification Codes: Q42, Q01, O13, O55, E22

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1. INTRODUCTION

Renewable energy is one of the essential pillars through which nations achieve sustainable development, as it provides an alternative and clean source of energy compared to fossil fuels, thereby reducing environmental pollution and carbon emissions. With the growing global needs for energy in response to economic growth and technological advances, there is now an increasing need for investment into renewable energy sources to ensure the sustainability of energy resources and to achieve energy security in the long run.

In this context, Algeria is endowed with immense potential in renewable energy because of its geographical position with great endowments of natural resources such as solar energy and wind energy, but even so, the transition to a renewable-energy-based economy still faces many challenges, the most critical of which are the need for clear policies and strategies that would support investment in this area and strengthen research and development in clean energy technologies.

Hence, this study attempts to analyze the reality of renewable energy in Algeria, taking into account challenges and opportunities in fast-tracking energy transition. Therefore, the problem to be analyzed can be expressed in the following questions: What is the reality of energy transition in Algeria and to what extent investment in renewable energies contributes to sustainable development in all its dimensions?

Research Hypotheses:

The hypotheses directed towards the central research question are as follows:

- There exists a great potential in Algeria to advance its transformation into a renewable energy environment, which requires supportive policies and sustainable investments.
- Investment in renewable energy focuses its contribution toward the economic, social, and environmental dimensions of sustainable development.
- Challenges that are faced in Algeria include dependence on conventional energy sources and late investment in renewable options.

Research goals:

The purpose of this paper is to:

- Understand the guiding concepts of renewable energy and sustainable development;
- Investigate the current status of renewable energy and energy transition in Algeria;
- Incorporate an argument concerning the role of investment in renewable energy in fostering economic and social growth;
- Accelerating clean energy development, the concerned forces should be those of good policies and strategies.

Research Methodology:

This research was adopted as a thorough scientific approach, mixed in terms of descriptive and analytical methods. Key concepts on sustainable development and renewable energy are presented using the descriptive method, while the analytical method would look at Algeria's opportunities in advancing a more sustainable energy model.

2. Theoretical Framework of the Study

2.1 Fundamentals of Sustainable Development

2.1.1 The Concept of Sustainable Development

The idea of sustainable development occupies a central place in both economy and environment studies. This idea was particularly accorded international attention during the decade of the 1970s, particularly at the 1987 United Nations Conference on Human Development dealing mainly with environmental issues in the industrialized countries of the Global North, as influenced by the outcome of industrial development and rapidly increasing consumption rates.

Sustainable development has recently come to be defined as “development that meets the needs of the present without compromising the ability of future generations to meet their needs,” which remains a major talking point in modern writings on sustainability (Mensah, 2019). Implicitly these definitions underscore the core need for development strategies to balance economic, social, and environmental dimensions so as to ensure equity between and across generations.

It is, in essence, the humanization of earth, all its natural

resources, and the human capital, in time with rights for the future generations to enjoy the use of natural resources. This will ensure the security-development balance that matches present and future demands expectations, thus enabling future generations to meet their own aspirations. (Baydi, 2021, p 672). Thus, sustainable development is a term used to achieve the equilibrium between the economic growth, environmental protection, and social justice, where current generations fulfill their needs without compromising those to come.

2.1.2 Objectives of Sustainable Development :

The objectives of sustainable development are evidently intended to pave the way for economic growth while still preserving natural resources for posterity. The stated objectives include integration between the economic, social, institutional, and environmental dimensions-aspects that will ensure a balanced progress. In this context, they would cover the following specific topics (Nations, 2022, p.447):

- Adopting sustainable economic growth by increasing resource-use efficiency, encouraging investment in environmentally-responsible production sectors, and reducing ecological degradation.
- Protection and conservation of natural resources through strict environmental laws directed to pollution-reduction and ecosystem degradation mitigation, as well as the existence of measures to support the sustainable use of water and energy.
- Moving toward the knowledge economy by stimulating innovations as well as developing all efficient alternatives that protect natural capital.
- Shifting to a low-carbon economy, responsible production and consumption such that renewable energy solutions would flourish and dependency on fossil fuels would dwindle.
- Improving social equity as well as mechanisms in the market to address poverty, creating fair resource distribution, and reforming unsustainable consumption and production.

2.1.3 Dimensions of Sustainable Development

Sustainable development consists of three boundaries into which relations are continually instituted: economic, social, and

environmental. All three dimensions need to be pursued and balanced for sustenance in the longer term of human well-being and resilience of the planet. **The economic dimension** refers to growth and productivity, the efficiency of resource utilization and their productive innovation, and accessibility to equity. **Social improvement** is the object pursued in people's lives with respect to education, including health, and with respect to a job: Some elements of equity and social justice. **The environmental dimension** that can be viewed as a maintenance of strong sustainability focuses on the preservation of natural systems, biodiversity, and ecological integrity to sustain human capacity to future generations.(Usubiaga-Liaño, 2024, p.52).

2.2 Investment in Renewable Energy

Investment in renewable energy has become fashionable due to the occasional rise in oil prices. Besides, there is always the threat of depletion of fossil fuels. Many now consider renewable energy sources as the primary energy sources globally besides conventional fuels and contribute to economic development through both production and consumption. Hence, energy transition has become a strategic goal for all countries that wish to develop their sectors of renewable energy.

2.2.1. Definition and Concept of Renewable Energy

Renewable energy sources are generally classified as energy coming from natural sources, which are constantly renewed over a human timescale. These natural sources include sunlight, wind, flowing water, biomass, and geothermal heat. They have been classified as inexhaustible because replenishment takes place faster than or at least keeps pace with the rate of use. Renewable energy is also referred to as clean energy since its harnessing normally causes little environmental pollution. (Nguyen, 2023, p.176).

In a real sense, that kind of energy is clean or ecologically friendly due to the little or absence of emissions produced in harnessing it. Renewable energy sources are those such as solar, wind, hydropower, biomass, and geothermal energy. They are positive areas for contributing to creating a low-carbon world.

2.2.2. Characteristics of Renewable Energy

Renewable energy offers specific characteristics that render this

option strategic for sustainable development and energy security:

- Available Universally: The renewable energy resources are uniformly distributed in all geographic regions which lessen reliance on imported conventional fuels and fortified national energy independence.
- Environment-Friendly: They cause no pollution to the environment and enhance human and ecological health with their low greenhouse gas emissions compared to fossil fuels, thereby alleviating climate change and minimizing environmental damage.
- Simple Technology and Low Cost: A number of renewable energy applications rely on simple and cost-effective technologies.
- Inexhaustible and Sustainable: They depend on permanent natural resources, involve relatively low production costs, improve living standards, diminish poverty, and generate new employment opportunities (Djebbari, 2023, p.107)

2.2.3. Importance of Renewable Energy

Most importantly, the main drive behind the thrust to discover alternative sources becomes environmental. Renewable energy increases energy security, reduces dependence on fossil fuels from external sources, and promotes development through job creation and technological advancements; otherwise, they will introduce lower long-term energy costs thanks to the free nature of resources.

2.2.4. Sources of Renewable Energy

The key sources include:

- Solar energy, the most widespread form of energy from sunlight.
- Wind energy, where turbines harness wind energy, performs well, in coastal and high places.
- Biomass, is generated when organic matter is converted into heat energy.
- From beneath the earth surface comes geothermal energy, whereby heat below the earth's surface is utilized.
- Hydropower, and tidal energy which exploits the movement of water to derive mechanical and electrical energy.

2.2.5. Concept and Importance of Energy Transition

The energy transition is a gradual transformation based on fossils into renewable energy models. It is very essential for long-term environmental sustainability and energy independence.

2.2.6. Concept of Investment in Renewable Energy

It refers to financing, human and technological resource deployment to develop and use those clean technologies. Its ultimate goal is to achieve in the future low-cost, sustainable energy with side benefits, such as environmental protection, energy security, and economic development.

2.2.7. Contribution of Investment in Renewable Energy to Sustainable Development

- Social dimension: It improves the quality of life by integrating electricity into the lives of people besides enhancing job opportunities and alleviating poverty, especially in areas that have little interfacing with society.

- Economic dimension: It will drive industrialization of the sectors, attract green investment, and help reduce import dependence on energy.

It means environmentally that it gets reduced greenhouse gas emissions significantly, and thus, it supports efforts worldwide of combating climate change and preserving ecological systems.

3. A Critical Analysis of the Importance of Investment in Renewable Energy in Algeria

3.1 Current Situation of Energy Transition in Algeria

One of the largest original Arab sources of fossil fuels, Algeria is extremely backward regarding the development of renewable energy projects. However, recently, the developments caused by the volatility and fall of oil prices have greatly impacted Algeria, putting energy investments in fossil fuels in serious jeopardy. The government has been compelled to hasten all its efforts towards diversifying its energy investments, embracing renewable energy, and using multiple strategies to support energy transition. Algeria thus launched ambitious programs to increase the contribution of renewable sources to its energy mix. Most notable of these programs include:

- Creation of the Renewable Energy Development Center (CDER) on

March 22, 1988, in Bouzaréah. CDER's primary mission is to carry out research programs focusing on the development of technologies for the exploitation and implementation of renewable energy systems. A test station for deep desert technologies was also established in the same year for promoting and producing solar equipment to the Saharan environment.

- Hybrid Power Plants built in Hassi R'Mel in 2010 in partnership with a Spanish company. The plant was said to be the first-ever worldwide hybridizing gas and solar energy. The total financing of the project reached €315 million to produce 150 megawatts.

- Algeria's very first wind farm in Tindouf, built with the French company Vergnet, was concluded in 2012, generating 10 megawatts.

- Photovoltaic Unit Manufacturing Plant under Construction in Rouiba, with an annual production capacity of 41,800 photovoltaic units.

- Solar Power Stations installed in M'sila in 2016 at a project cost of \$40 million with output exceeding 100 Megawatt-hours of electricity per day. In the same year, Algeria opened up the Laghouat solar power station, producing about 280 megawatt-hours per day. This plant will reach profitability starting in September 2025. Additionally, new solar power stations were commissioned that year in Djelfa, Batna, and Souk Ahras.

- National Program for Renewable Energy and Energy Efficiency which targets the generation of 22,000 megawatts of electric power by the year 2030, of which 27.5% is to come from renewable sources.

Table 1 . The Contribution of Renewable Energy to Energy Production in Algeria

Percentage%	Installed Capacity (Watt)	Application of Renewable Energy
57.49	1352800	Electricity Generation
12.25	288400	Water Pumping
2.06	48430	Public Lighting
21.16	498000	Telecommunications
7.04	165630	Other Uses
100	2353260	Total

Source: Ministry of Energy and Mines of Algeria

3.2 Future Strategic Objectives

The development of renewable energy in Algeria has received special attention from public authorities that seek to create a strong push for this sector as an alternative to the exhausting fossil resources. The Algerian government endorsed, on February 3, 2011, the National Program for the Development of New and Renewable Energy and Energy Efficiency (CREG, p. 01) towards the implementation of its strategies and objectives from 2011 to 2030. This program aims to generate 40% of the country's electricity from renewable energy sources by 2030, with a target production of 22,000 MW; of this, 12,000 MW would be for domestic consumption while 10,000 MW would be for export to boost public treasury revenues.

The situation with unemployment in Algeria is like those in several Arab countries whereby measures are being taken to either curtail unemployment or stimulate inclusive economic growth through large-scale investments in renewable energy. In a report for 2024, the International Renewable Energy Agency (IRENA, 2024) states that the expansion of renewable energy may have large potential in job creation for several other sectors, such as manufacturing, construction, operation, and maintenance. The renewable energy sector under consideration has the potential of creating hundreds of thousands of jobs, both direct and indirect, in Algeria by 2030, especially with solar and wind energy projects, which will consequently strengthen local development and economic diversification. ((IRENA)., 2024)

In addition, Algeria has taken steps toward electrifying remote villages. For instance, 20 villages in the deep south are receiving electricity from solar energy. The success of this project will have the government extending its vision to other remote areas with renewable energy electrification.

3.3 Challenges Facing Energy Transition in Algeria

Despite the attempts and achievements in the renewable sector, Algeria's energy transition faces various structural and regulatory challenges that limit the accomplishment of its targets on fast track. Major challenges are:

- Heavy dependence on fossil fuel resources: Oil and gas revenues are

still the backbone of the economy in Algeria, and a shift to renewable energy would impose very broad structural reforms of their economic policy.

- No investment and financing: Despite its abundant natural resources, investment in renewable energy is still restricted by a lack of financial resources and clearly defined incentive mechanisms for investors.
- Poor technological infrastructure: Strengthening research and development in renewable sources and making the electricity grid more accommodating to intermittent renewable energy sources is vital.
- Legal and regulatory framework: There exists supportive legislation, but implementation has remained sluggish due to cumbersome administrative procedures and slow reforms.
- Socioeconomic challenges: This involves training and upskilling the workforce on renewable energy technologies.

3.3.The Role of the Private Sector and Barriers to Its Participation in Renewable Energy Investment

Private participation is crucial for speeding up renewable energy because, besides direct investments, the private sector also comes in through innovations, efficiencies, and development of advanced technologies. For the case of Algeria, the private sector is quite limited due to a lot of structural and regulatory constraints. Among these are financial disincentives, complicated administrative procedures, and uncertainties with regard to policies on pricing of energy, which make them shy off from any long-term investments. At the same time, the constraints that arise from insufficient credit access, as well as inadequate public-private partnerships, prevent substantial investments in renewable energy projects from taking place. Institutional frameworks have thus to be improved, clear regulations established, and business environments created to encourage participation from the private sector in achieving national energy transition goal .(Kaci,2023, pp.45-47).

In addition to these structural and institutional barriers, private investors in Algeria subjectively face some general challenges which are an added hindrance to their participation in renewable energy development. The investment environment in this country is usually

characterized by bottlenecks, poor access to financing, and a lack of minimum transparency and stability of the existing legal frameworks. Besides, state-owned enterprise monopoly on insufficient technological infrastructure and poor public-private coordination is still high. All these factors are cumulatively suffocating investor confidence and delaying between an investment and an actual start. (Bouchakour, 2023).

3.4. Opportunities for Investment in Renewable Energy in Algeria

Algeria presents a great opportunity for investment in renewable energy, with many advantages, notwithstanding the challenges mentioned above: (Boughali, 2017)

- Geographic and climatic advantages: Algeria is one of the sunniest countries in the world, highly suitable for solar energy projects. Wind energy potential also exists along the coast and in the desert.
- Financial resources and government support: The Algerian government is offering tax and financial incentives to attract investments and is actively seeking foreign capital for its bigger projects.
- Regional and international collaborations: Algeria is in position to benefit from international partnerships for technology transfer and develop local renewable energy industries.
- Increasing domestic energy demand: The increase in demand for electricity necessitates the development of sustainable alternatives, thereby making investment in renewable energy strategic.
- Export potential: Algeria could emerge as a major exporter of renewable energy to Europe, especially in the context of the EU working toward reducing carbon emissions and increasing the share of clean energy.

3.5 Potential of Renewable Energy in Algeria

Algeria's vast territory and diverse landforms, climate, and strategic location as a link between the African continent and Europe enable it to possess large stores of both conventional and renewable energy resources. These include:

- Solar Energy: Algeria possesses the maximum solar energy potential in the Maghreb region and Mediterranean basin. Solar radiation is estimated to be received annually at the amount of 169,440 TWh/year

throughout Algeria, with daily average solar irradiance being in the range of 5 to 7 kWh/m². A report from the German Aerospace Center indicated that the Sahara in Algeria could be the biggest solar energy reservoir in the world since solar radiation is received for about 3,900 hours during a year.

Table 2 . Solar Energy Potential by Region in Algeria

Coastal	High	Sahara	Region
4	10	68	Percentage of Total Area %
2650	3000	3500	Sunshine Duration (Hours /
1700	1900	2650	Average Solar Energy Received (kWh/m ² /day)

Source: Ministry of Energy and Mines of Algeria

- **Wind Energy:** Algeria's wind energy potential differs from one region to another due to climatic diversity. South winds are stronger, reaching speeds of up to 7 meters per second, in contrast to north winds.
- **Hydropower:** Hydropower constituting a small yet vital source of renewable energy for Algeria. The International Energy Agency (IEA, 2023) has reported that Algeria has a huge hydrological potential, with an estimate of almost 65 billion cubic meters per year for total renewable water resources. However, only a small part is harnessed for electricity, approximately 5%. Thus, expanding hydropower utilization would enhance energy security, diversify the country's energy mix, and help fulfill its decarbonization targets ((IEA), 2023). The low exploitation of it has been attributed to the low number of plants producing and also to high ineffectiveness of energy generation from this resource.
- **Biomass energy:** Biomass energy in Algeria has its origin from two primary sources.
 - **Forestry Resources:** Roughly 10% of the total land area of the country is covered by forested areas, which together constitute an estimated total biomass resource equivalent to approximately 37 million tons of oil equivalent.
 - **Energy Resource from the Urban and Agricultural Waste:** The energy potential from these relatively unexploited waste sources is estimated

to be about 5 million tons of oil equivalent.

4. CONCLUSION

This study has highlighted the vital role of renewable energy investment in promoting sustainable development in Algeria. Conflict assures that, despite abundant solar and wind resources, the pathway toward a diversified clean energy system is slow and strewn with barricades. Findings indicate that in addition to technological and financial commitment, institutional governance, policy coherence, and active participation from the private sector must also be premised for the attainment of sustainable development. In conclusion, the analysis establishes that renewable energy has turned out to be a case of strategic economic choice for long-term stability and growth in Algeria. Consequently, the rapid adoption of a clear regulatory framework, a more enhanced input to research and innovation, and better public-private partnerships would undertake the acceleration of the national energy transition and bring it in line with global sustainable development.

The major research results can summarize:

- ✓ Clean and reliable energy service delivery remains a basis for sustainable development that promotes environmentally sound economic growth in Algeria.
- ✓ Renewable energy investments are best touted for promoting economic diversification while diminishing environmental damages.
- ✓ Algeria can claim high comparative advantage in solar and wind energies, even though this potential remains grossly underexploited.
- ✓ Energy transition is greatly limited by structural, institutional, and regulatory bottlenecks.
- ✓ Dependency on fossil fuels largely inhibits an effective transition to renewable alternatives.
- ✓ Fragile legal and institutional frameworks lower investor confidence and limit private sector participation.
- ✓ Financial and technological barriers-plants, high costs, inadequate funding instruments, and insufficient infrastructure-challenge renewable energy implementation.

- ✓ Profound obstacles are faced by the private sector in the form of red tape and absence of an effective incentive mechanism.
- ✓ Better governance and improved policy coordination are key to ensuring a successful and coherent energy transition.

Renewable energy generates not only environmental benefits but enhances job gains and sustainable economic growth. Based on the findings of the present study, the following recommendations are suggested:

- Funding for scientific research and technological development in renewables must be increased by direct government funding and by providing financing facilities for innovative projects.
 - Develop energy infrastructure to promote the integration of renewable energy sources into the national grid with enhanced efficiencies in transmission and storage.
 - Strengthening legal and regulatory regimes by establishing clear and investment-friendly legislation that guarantees transparency and stabilization of the market.
 - Activate public-private partnerships with universities, research centers, and local institutions for the manufacture of clean energy technologies.
 - Foster more partnerships regionally and internationally capable of technology transfer and capacity building for management of renewable energy projects.
 - Conduct high awareness campaigns through media and other sources to create environmental culture for energy transition and sustainable development.
 - Encourage interdisciplinary applied studies capable of assessing the economic, environmental, and social feasibility of clean energy sources in Algeria.
- Future research recommendations:
- study private sector financing models related to renewable energy projects in Algeria; analyze how legal and technical incentives have impacted the effectiveness of those projects in order to enhance private participation in the energy transition.
 - Identify barriers to private sector investment in renewable energy in

Algeria, with an emphasis on financial, regulatory, and institutional constraints.

- Assess the prospects for various renewable energy sources (solar, wind, hydro, biomasses, and geothermal) to facilitate the optimal investment site-specific in various regions in Algeria.
- Assessment of technological adoption within the renewable sector with respect to innovation in smart grids, energy storage, and digital monitoring solutions.

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