

Renewable Energy in Algeria: Current Challenges and Reform Prospects for Achieving Sustainable Development

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Abstract

This study addresses the topic of renewable energy in Algeria in terms of its concept and its economic, environmental, and social importance, in light of the state's efforts to diversify its sources of income and gradually reduce its almost complete dependence on hydrocarbon revenues. Since 2011, Algeria has launched an ambitious national program to develop this sector, supported by a legal and institutional framework, which has led to the completion of several solar and wind energy projects in southern regions, such as the Hassi R'Mel hybrid power plant and the Adrar and Ghardaia stations.

However, this path still faces a set of technical, financial, and regulatory challenges, most notably the high costs of investment, weak infrastructure, complex bureaucratic procedures, and the continued subsidization of conventional energy prices, which reduces the competitiveness of clean energy. The study concluded that achieving a real energy transition requires comprehensive legislative and institutional reform, the strengthening of international partnerships, and the development of specialized national competencies, along with the presence of genuine political will.

Keywords: Renewable Energy, Sustainable Development, Energy Security, Solar Energy, Energy Investment.

Introduction

Energy is considered the lifeblood of contemporary societies, as various aspects of economic and social progress depend on it. However, excessive reliance on traditional energy sources, such as oil and gas, has given rise to several problems, most notably price fluctuations, the possibility of the depletion of these resources in the long term, and their negative environmental effects, which contribute to worsening the climate change crisis.

In the face of these challenges, the search for clean and sustainable energy sources has become inevitable. In this context, renewable energy, or what is known as green energy, has emerged as a promising strategic option, given that it consists of permanent and environmentally friendly sources, in addition to its role in achieving energy security. This global trend has been reinforced by growing awareness of the risks of depleting traditional resources, which has prompted many countries to exploit alternative natural sources such as solar energy, wind

energy, and hydropower¹, in a way that achieves a balance between economic development and environmental protection.

Renewable energy is also of particular importance because it contributes to reducing dependence on traditional sources and supports the path toward sustainable development, especially in light of its diversity and great potential, which make it a fundamental pillar of the future of energy.

Within this framework, Algeria, as a country that relies heavily on hydrocarbon revenues, has been affected by fluctuations in oil prices, which has pushed it to adopt the option of diversifying energy sources. It has moved toward exploiting its enormous natural potential, especially in the field of solar energy, and has made it a central axis of its post-oil energy strategy.

In embodiment of this orientation, Algeria has begun adopting ambitious policies and programs to integrate renewable energy into its energy mix, particularly since the launch of the Renewable Energy Development Program in 2011, which aims to achieve a gradual transition toward a more sustainable economy that is less dependent on fossil fuels².

Investment in renewable energy is not merely a national option; rather, it falls within global transformations toward a green economy, as countries seek to reduce harmful emissions, provide clean energy, and create new investment and development opportunities. In this context, Algeria aspires to meet its domestic needs and strengthen its position in the international energy market.

Despite the efforts made, the development of renewable energy in Algeria still faces a number of technical, financial, and regulatory challenges, which requires strengthening the legal and institutional framework and developing investment and partnership mechanisms in order to ensure an effective and sustainable energy transition.

In this context, the core research problem emerges:

To what extent can Algeria, through the exploitation of renewable energy, achieve its objectives in sustainable development, and what are the main challenges that stand in the way of translating these objectives into tangible reality?

Answering this research problem requires addressing the subject from a specific perspective. The study begins by defining the general framework of renewable energy in Algeria and its importance in achieving sustainable development (Section One). It then focuses on clarifying the reality of renewable energy in Algeria between challenges and prospects for reform (Section Two).

1- It should be noted that Algeria has one of the highest solar fields in the world. The duration of sunshine across almost the entire national territory exceeds 2,000 hours annually and may reach 3,900 hours in the High Plateaus and the Sahara. See the website: <https://aapi.dz/ar/secteur-des-energies-nouvelles-et-energies-renouvelables-ar>

2- It should be noted that Algeria has adopted, within its energy policy, the option of developing renewable energies as a strategic direction, especially in recent years. It has strengthened this orientation by establishing a stimulating legislative and institutional framework aimed at exploiting this vital resource effectively and in an environmentally friendly manner. It has also begun to implement this path in practice by adopting a national renewable energy policy whose prospects extend until 2030. See: Nassib Nadjib, The National Policy for Promoting Renewable Energies in Algeria, Journal of Law and Human Sciences, Issue 1, 2024, p. 198.

In order to study this topic, the descriptive method was adopted to present the concepts related to renewable energy and clarify its importance. The analytical method was also adopted to analyze the reality of renewable energy in Algeria, the challenges facing this sector, and the prospects for reforming it.

Accordingly, the study was divided into two sections:

- The general framework of renewable energy in Algeria and its importance in achieving sustainable development.
- The reality of renewable energy in Algeria between challenges and prospects for reform.

1. The General Framework of Renewable Energy in Algeria and Its Importance in Achieving Sustainable Development

Renewable energy has become the focus of everyone's attention in recent years, and a topic whose importance is increasing day after day. The reason is clear: the environmental and economic changes we are experiencing strongly push us to search for sustainable alternatives, away from traditional energy sources. We have long relied heavily on fossil fuels, but this reliance has created major challenges, such as environmental pollution and the depletion of natural resources³. This has prompted many countries to change their policies and move toward clean and renewable energy sources.

Amid this transformation, Algeria is moving steadily toward strengthening the role of renewable energy in its development plans. It possesses enormous natural wealth, especially in the field of solar and wind energy, and seeks to exploit it optimally. This orientation is not only aimed at achieving economic growth, but also at protecting the environment and reducing dependence on hydrocarbons, which still constitute the backbone of the national economy.

Therefore, it is important to become closely acquainted with renewable energy: What is its concept? What are its characteristics? And how can it contribute to addressing the current challenges in Algeria? In this context, we will attempt to define the nature of these energies and their basic characteristics (Subsection One), and then shed light on their vital role in supporting the path of sustainable development in our country (Subsection Two).

1.1 The Concept and Characteristics of Renewable Energy

Renewable energy has become a topic that cannot be ignored in today's world. With the environmental and economic changes we are experiencing, the search for sustainable and environmentally friendly alternatives has become a necessity rather than an option. Our reliance on traditional sources, especially fossil fuels, is no longer a practical solution in the long term, given their negative effects on the planet and their limited resources.

Therefore, let us closely examine the concept of renewable energy: What exactly is it? What are its various forms? From solar and wind energy to biomass and others, they are all natural sources that are constantly renewed. More importantly, what distinguishes them from

3- The meaning of the depletion of natural resources is the exhaustion or running out of economic and environmental resources at a rate that exceeds nature's ability to renew or replace them. This depletion undermines sustainable development, increases pollution, and imposes economic and social challenges on future generations. For further clarification and details, see the website: www.unescwa.org

traditional energy? This may be in terms of sustainability, their impact on the environment, or even their economic feasibility.

In this context, we will address the subject by clarifying the meaning of renewable energy and reviewing its different types (Branch One), then highlighting its most prominent characteristics, through which it surpasses fossil energy sources (Branch Two).

1.1.1 Definition and Types of Renewable Energy

Renewable energies are natural sources of energy that do not run out, as they are constantly renewed, unlike limited fossil fuels that may one day be depleted. The Algerian legislator has defined renewable energies as the various forms of energy produced from renewable natural sources such as the sun, wind, water, and biomass, in addition to technologies that contribute to saving energy consumption⁴. These energies are characterized by being sustainable and non-polluting, as they contribute to protecting the environment and human health without harming the natural balance or depleting resources.

These energies are derived from elements of nature such as the sun, wind, and water, which makes them part of an integrated ecosystem that ensures their continuity in the long term. They are considered clean energies that do not produce waste harmful to the environment; therefore, they have been called green energy⁵. For this reason, they have become an important strategic option in confronting the energy challenges we face today.

Renewable energies have become increasingly important in modern energy policies. They represent a practical alternative that reduces our dependence on fossil fuels, and they are also considered a fundamental pillar of sustainable development, as they balance the need to meet the requirements of economic growth with the preservation of the environment. This growing interest has prompted many countries to develop their technologies and expand their use.

Among the most prominent types of renewable energy is solar energy, which is one of the most abundant sources, especially in sunny regions⁶. We benefit from it by converting sunlight into electricity through solar panels, or into thermal energy, as in household water heaters. These applications range from individual use in homes to large-scale projects such as electricity generation stations in deserts.

4- Article 3 of Law No. 04-09 of 14 August 2004, relating to the promotion of renewable energies within the framework of sustainable development, Official Gazette of the People's Democratic Republic of Algeria, No. 52, issued on 18 August 2004, provides that: Renewable energies, within the meaning of this law, are defined as follows: forms of electrical, mechanical, thermal, or gaseous energy obtained from the conversion of solar radiation, wind power, geothermal heat, organic waste, hydropower, and biomass-use technologies; and all methods that allow significant energy savings through the use of bioclimatic architecture techniques in construction.

5- Radhia Younsi and Ahlam Younsi, *Renewable Energies in Algeria Between Reality and Expectations*, Al-Midan Journal of Humanities and Social Sciences, Issue 1, University of Djelfa, 2023, p. 30.

6- Algeria occupies a distinguished global position in the field of solar energy, as it is classified among the top three solar fields in the world, alongside Iran and the U.S. state of Arizona. This position derives its strength from its vast Sahara, which covers more than two million km², with an average sunshine duration of 3,900 hours annually and solar radiation ranging between 4 and 7 kWh per day. See: Saida Tayeb and Meriem Bougroua, *The Possibility of Exploiting Solar Energy in Generating Electrical Energy in Algeria*, Dafater Bawadex Journal, Issue 1, 2021, p. 21.

Wind energy is also an important source, as air movement is converted into mechanical or electrical energy using turbines⁷. Examples of this can be seen in wind farms spread around the world, as well as in traditional uses such as windmills, which are used to pump water or grind grain in some villages, especially in the Netherlands.

The most important wind energy projects in Algeria constitute a new pillar within the state's efforts to diversify sources of electricity generation and reduce dependence on fossil fuels, which have remained the main basis of its economy for decades. Although Algeria's installed wind energy capacity does not exceed 10 megawatts so far, estimates reveal enormous potential along the coasts and in the desert, making this Arab state located in North Africa a candidate to become a prominent player in the clean energy sector during the coming decade.

Today, the most important wind energy projects in Algeria stand out within the country's national renewable energy program, which aims to produce 15,000 megawatts by 2035, including more than 5,000 megawatts from wind energy alone. Work is also underway with the World Bank to study a 1,000-megawatt project distributed across 10 promising sites.

The objective of developing the most important wind energy projects in Algeria is not limited to producing electricity; rather, it also extends to creating job opportunities, developing remote areas, and strengthening the country's regional position on the renewable energy map through an integrated path that combines the economic and developmental dimensions⁸.

As for biomass energy, it depends on converting organic materials, such as waste and agricultural residues, into energy, whether in the form of biogas or fuel⁹. For example, some farms use animal manure to produce energy, which helps reduce pollution and provides an economic return at the same time.

Renewable energies also include hydropower, which exploits the movement of water through dams to generate electricity and is one of the oldest sources used. They also include geothermal energy, which benefits from the heat of the earth's interior for heating and electricity generation in certain areas¹⁰.

Thus, we see that renewable energies are not merely theoretical ideas, but practical solutions that we experience daily in our homes and in our major projects. They are a sustainable and effective alternative to traditional energies, and through their diversity and potential, they prove that they are capable of meeting our needs in various fields.

7- United Nations, What Is Renewable Energy?, available at: <https://www.un.org/ar/climatechange/what-is-renewable-energy>

8- See the website: www.attaqa.net, 2026.

9- It should be noted that biomass is considered a renewable energy source based on converting organic materials, such as wood and agricultural waste, into thermal or electrical energy. This is done through processes such as combustion or gasification, which release the solar energy stored within these materials. Published on the website: <https://ar.kindle-tech.com/faqs/how-does-biomass-work-as-a-renewable-energy>

10- Naima Zaarour and Saliha Djouahra, Renewable Energy Programs in Algeria: Reality and Challenges, Journal of Economic and Administrative Research, Issue 24, Faculty of Economic, Commercial and Management Sciences, University of Biskra, 2018, p. 321.

1.1.2 The Distinctive Characteristics of Renewable Energy Compared to Fossil Energy

What distinguishes renewable energy is that it never runs out, as it relies on resources that are constantly renewed in nature, such as the sun, wind, and water, unlike fossil fuels, which may one day be depleted due to excessive use¹¹. Imagine that the sun rises every day without interruption, while oil and gas reserves are continuously decreasing.

One of its most important advantages is that it is environmentally friendly. It does not pollute the air or release greenhouse gases in the large quantities produced by burning coal and oil. Solar panels and wind turbines operate quietly without any direct emissions, while coal-fired power plants fill the atmosphere with carbon dioxide, which contributes to global warming¹². It is worth noting that its sources are diverse, which allows each country to choose what suits its natural conditions. Sunny countries rely on solar energy, coastal countries exploit wind energy, while countries that have rivers benefit from hydropower¹³.

Although the costs of establishing renewable energy plants may be high at the beginning, they are economical in the long term. After installing solar panels, for example, operating costs become low compared to traditional power plants, which require the continuous purchase of fuel.

Renewable energy also strengthens countries' energy independence. Instead of importing fuel from abroad, countries can rely on available local sources. This reduces dependence on foreign suppliers and achieves greater energy security.

We should also not overlook the new job opportunities it creates in the fields of technology, research, and maintenance, from installing solar panels to operating wind power plants, which contributes to the economic and social development of communities.

Another distinctive feature is flexibility, as renewable energy can be used in large-scale projects or on a small scale. A hydropower plant may supply an entire city with electricity, while a small solar panel may be sufficient to meet the needs of a household.

Finally, renewable energy is less likely to provoke international conflicts compared to oil and gas, which are concentrated in specific regions of the world. Renewable energies are available almost everywhere, which encourages cooperation rather than competition in this vital field¹⁴.

11- Zahra Rouaikia, *Improving Energy Use Efficiency in Order to Achieve Sustainable Development in Arab Economies*, doctoral thesis submitted for the third-cycle doctorate degree, Faculty of Economic, Commercial and Management Sciences, University of Guelma, 2018–2019, p. 106.

12- Renewable energy is energy derived from natural sources that are constantly renewed, such as the sun and wind. It is characterized by low carbon emissions compared to fossil fuels, which are the main cause of the climate crisis. In addition to being the least expensive in most countries of the world, it provides three times more job opportunities than fossil fuels. See the website: <https://claude.ai/chat/c3bb23a1-68a9-4f9d-b0a7-9468aa95830c>

13- It should be noted that renewable energy is inexhaustible and environmentally friendly because it does not produce greenhouse gases such as carbon dioxide. It also provides low operating costs, strengthens economic independence, creates job opportunities, and preserves public health. See the website: <https://nhm.uobaghdad.edu.iq/?p=23828>

14- In addition to solar energy, wind energy, and hydropower, there is also geothermal energy, which is obtained by extracting energy found in the soil for use in the form of heating or electricity. There is also hydrogen energy, whose cells are considered a promising technology to serve as a source of heat and electricity for buildings and vehicles. For this reason, automobile companies have manufactured means of transport powered by fuel cells, which contain an electrochemical device that uses

1.2 The Importance of Renewable Energy in Algeria

In light of the global transition toward a green and sustainable economy, renewable energy in Algeria emerges as one of the major challenges that deserves attention. Given the Algerian state's heavy reliance on hydrocarbons as a main source of income, the shift toward clean energy has become not merely an option, but an urgent necessity. This transition aims not only to ensure our energy security, but also to promote economic development and protect our environment at the same time.

The importance of renewable energy in Algeria is not limited to providing energy alone; rather, it extends to broader economic, environmental, and social dimensions. Therefore, in this context, we will examine how these energies can contribute to diversifying our national sources of income (Branch One), and how they play a central role in protecting the environment and achieving sustainable development that serves society as a whole, making them a fundamental pillar for building a more balanced and prosperous future (Branch Two).

1.2.1 The Economic Role of Renewable Energy in Diversifying Sources of Income

Renewable energy is a vital strategic option on which Algeria can rely to diversify its sources of income, especially in light of its continued heavy dependence on the hydrocarbon sector. The shift toward the exploitation of clean energy creates new economic opportunities away from oil and gas, which contributes to stabilizing the economy and protecting it from fluctuations in the global market.

The importance of this orientation lies in breaking the cycle of dependence on hydrocarbon revenues, which are constantly affected by global price fluctuations¹⁵. For example, any decline in oil prices negatively affects state revenues, while solar and wind energy projects provide a more stable source of income through the production and sale of electricity or its local use¹⁶.

This sector also attracts significant foreign investments, as major international companies are increasingly moving toward investment in clean energy. Algeria possesses enormous natural potential, especially in the sunny southern regions, which makes it an ideal environment for establishing large solar power plants.

The matter does not stop there, as the development of renewable energy stimulates related local industries, such as the manufacture of solar panels and wind turbines. This reduces our need for imports and builds added value within the economy instead of merely exporting raw materials.

hydrogen and oxygen to produce electricity capable of running an electric motor that drives the vehicle. Najat Benfriha and Redouane Ansaad, *The Contribution of Renewable Energies to Supplying the World with Energy and Supporting Development: An Analytical Study of Renewable Energy Sources in the World and Algeria*, *Dafater Iqtisadiya Journal*, issued by Ziane Achour University of Djelfa, Faculty of Economic, Commercial and Management Sciences, Vol. 11, No. 01, Algeria, 2020, p. 15.

15- Radhia Younsi and Ahlam Younsi, *Op. Cit.*, p. 31.

16- Algeria's solar energy potential is equivalent to more than eight times the country's reserves, that is, approximately 37,000 billion m³ of natural gas. Djamel Ben Saadi and Wardia Bougaba, *Renewable Energies: A Strategic Direction for Diversifying the Algerian Economy Between Ambitious Objectives and Implementation Challenges*, *Tabna Journal for Scientific Academic Studies*, issued by Si El Haoues University Center, Barika, Vol. 07, No. 02, Algeria, 2024, p. 1060.

On the other hand, clean energy helps reduce the burden on the public budget by lowering the costs of importing fuel or subsidizing conventional energy prices. The greater our local production of renewable energy, the lower the expenditures allocated to energy, which improves the financial position of the state.

This sector also creates various job opportunities in the fields of installation, maintenance, engineering, and technical management¹⁷. Solar power plants, for example, require specialized technical teams to ensure their proper operation, which contributes to employing young people and reducing unemployment.

The exploitation of renewable energy also contributes to the development of inland and southern regions, which enjoy abundant sunlight and vast areas of land. Establishing energy projects in these regions improves infrastructure, revitalizes the local economy, and integrates these areas into the path of national development.

The broader vision remains for Algeria to become, in the future, an exporter of clean energy to Europe, especially with the growing global demand for green energy. This transformation will strengthen our international position and move us beyond the role of merely being a traditional exporter of hydrocarbons.

Accordingly, diversifying sources of income through renewable energy is not merely an economic step, but rather an integrated vision for rebuilding a more sustainable and resilient national economy, one that ensures a better future for coming generations and strengthens our economic independence.

1.2.2 The Environmental and Social Dimensions of Renewable Energy in Achieving Sustainability

Renewable energy is not merely a set of modern technologies; it has become a fundamental pillar for building a more sustainable future. It provides us with a practical solution that combines meeting development needs with preserving our environment, in a way that achieves the balance we aspire to.

From an environmental perspective, these energies help us reduce harmful emissions that cause global warming. Imagine, for example, that when we use solar panels to produce electricity, we do not release any direct emissions, and this helps reduce global warming¹⁸, unlike coal or gas power plants, which pollute the air we breathe.

In industrial cities where pollution problems are widespread, renewable energy can make a real difference. Replacing traditional thermal power plants with wind turbines or solar energy means cleaner air and better health for everyone.

We should also not overlook its important role in addressing climate change. The use of clean energy in transport and industry reduces the impact of our activities on the climate, and this is something we all need.

17- Nabil Wanoughi and Mounir Ben Azzouk, The Regulatory Framework for Renewable Energies and Their Role in Achieving Sustainable Development, *Journal of Contemporary Commercial and Economic Studies*, Issue 2, 2020, pp. 180–181, also cited by: Djamel Ben Saadi and Wardia Bougaba, *Op. Cit.*, p. 1060.

18- Nabil Wanoughi and Mounir Ben Azzouk, *Op. Cit.*, p. 182.

These energies also preserve our limited natural resources. The more we rely on solar energy, the less we deplete oil, gas, and coal, which means leaving more resources for future generations.

Even soil and water benefit, as clean energy projects do not cause oil spills or produce hazardous waste, as sometimes happens with fossil fuel projects.

At the social level, renewable energy improves our quality of life in a tangible way. Solar water heaters in homes reduce electricity bills and provide safe and clean energy for families¹⁹.

In remote areas that suffer from weak services, solar energy can be the solution. In southern Algeria, for example, solar projects can supply distant villages with energy independently, which can change people's lives there.

Solar energy can also be used in hotels and tourist facilities to generate electricity, thereby reducing dependence on traditional electricity networks and significantly lowering consumption costs. The use of wind energy, especially in coastal areas or regions with strong winds, also contributes to providing an additional source of energy that serves tourist facilities and enhances their sustainability²⁰.

Renewable energy also contributes to narrowing the gap between cities and rural areas through a fairer distribution of basic services, which promotes inclusive growth in disadvantaged communities²¹. It also raises society's awareness of the importance of the environment. When people see solar water heaters on their neighbors' rooftops, they become more willing to adopt sustainable behaviors.

On this basis, renewable energy is not merely a technical option, but an integrated social project. It is a project that aims to build a genuine development model that achieves a balance between our daily needs and our responsibility toward our environment and future generations.

2. The Reality of Renewable Energy in Algeria Between Challenges and Prospects for Reform

In recent years, renewable energy in Algeria has become a strategic issue receiving increasing attention, especially with the global transition toward a green economy and the search for sustainable alternatives to traditional energies. Algeria has made efforts through several national plans to develop this sector, benefiting from its promising natural potential, particularly in the fields of solar and wind energy. Nevertheless, this path still faces numerous challenges that hinder the full realization of its potential.

19- It has become necessary to move toward clean alternative energy, which is inexhaustible in its various forms. For further details, see: Khetir Chine and Warda Merzak, Investment in Renewable Energies as a Tool for Achieving Sustainable Development: A Review of Some Experiences of Oil-Producing Arab Countries in the Field of Investment in Renewable Energies, *Eliza Journal for Research and Studies*, issued by Illizi University Center, Algeria, Vol. 06, Special Issue, 2021, p. 22.

20- Abdelmottaleb Zidani, *The Role of Renewable Energies in Protecting the Environment and Achieving Sustainable Development*, thesis submitted for the third-cycle doctorate degree in law, specialization in environmental law, Faculty of Law and Political Science, University of Khenchela, 2024–2025, p. 216.

21- *North African Journal of Scientific Publishing*, available at: <https://najsp.com/index.php/home/article/view/688>

Despite all the efforts made to promote renewable energy, the actual reality reveals a gap between the declared objectives and their implementation on the ground, whether in terms of the scale of the projects carried out or the contribution of these energies to the national energy mix. This situation calls for an objective assessment of the Algerian experience in this field, in order to identify and strengthen its points of strength and address its weaknesses.

In this context, this section will address the reality of renewable energy development in Algeria (Subsection One), by reviewing its most prominent features. It will then analyze the main challenges facing it and conclude by anticipating its future development prospects (Subsection Two).

2.1 The Reality of Renewable Energy Development in Algeria

For years, Algeria has begun taking serious steps toward adopting a new energy policy aimed at diversifying energy sources and reducing its heavy dependence on hydrocarbons. This has been reflected in the gradual integration of renewable energy into national development plans. One of the most prominent steps in this path was the launch of the National Renewable Energy Program in 2011, which later underwent revisions and developments in an effort to exploit the country's enormous natural potential, especially in the field of solar energy.

The matter was not limited to setting policies and plans on paper; rather, these visions were transformed into tangible projects on the ground, including the establishment of various facilities in the fields of solar and wind energy. Therefore, in this part, we will address the national policies and programs launched to promote renewable energy (Branch One), then move on to review the most prominent projects and facilities that have been completed as a practical translation of those ambitious orientations (Branch Two).

2.1.1 Algeria and the Transition Toward Renewable Energy: A Long Path from Planning to Implementation

Since the beginning of the new millennium, Algeria has begun a gradual shift in its energy policies, giving greater priority to the integration of renewable energy sources²². This orientation did not emerge out of nowhere; rather, it was supported by a series of national laws and strategies aimed primarily at reducing dependence on hydrocarbons and diversifying energy sources. The National Renewable Energy Program of 2011 can be considered the milestone through which this path clearly defined its objectives.

The 2011 program is the first comprehensive strategic framework established by Algeria, and its ambition was clear: to produce a significant share of electricity from renewable sources by 2030²³, with a focus on exploiting the country's solar energy, wind energy, and biomass

22- In light of the rapid global energy transformations, Algeria has developed a proactive energy strategy aimed at achieving national energy security in the long term and consolidating its position as a reliable energy actor in African and European markets. This vision is based on establishing a balanced energy mix that increases the contribution of renewable energies, enhances energy efficiency and national integration in the electrical and gas industries, and adapts the sector's regulation to the requirements of digitalization and competitiveness. Sector operators are required to ensure that national energy demand is met under the best conditions, absorb peak consumption, and monitor the implementation of approved programs within the specified deadlines. Published on the website: <https://www.energy.gov.dz/ar/1590/national-energy-policy-ar>.

23- Nassib Nadjib, Op. Cit, p. 193.

resources. This program drew up a roadmap for a gradual transformation of the national energy mix.

This program was not created in isolation, as it was preceded by laws that paved the way for it. Law No. 99-09²⁴ on energy management and control laid the legal foundation for a policy of rationalizing consumption and encouraged the idea of resorting to alternative sources. It may therefore be considered one of the first legal texts to address energy efficiency in the country. Then came Law No. 04-09 on energy promotion, which strengthened this legal framework by explicitly emphasizing the need to integrate renewable energy into the national energy strategy and opened the door to encouraging investment in this field through various support mechanisms²⁵.

These policies required implementation mechanisms. Therefore, the establishment of the National Agency for the Promotion and Rationalization of Energy Use (APRUE)²⁶ came as the executive body responsible for achieving energy efficiency and encouraging the use of renewable energy across all sectors.

The matter did not stop at supporting institutions, but extended to the main actors in the market. Sonelgaz, the key pillar in the field of electricity production and distribution²⁷, also included renewable energy projects in its strategy, especially promising solar projects in the south of the country²⁸.

By 2015, this path witnessed a new shift, as Algeria revised its national program, raising the ceiling of its energy objectives and clarifying the scope of its projects. The focus became greater on integrating modern technology and building international partnerships to enhance clean energy production.

To attract investors, incentive policies were adopted within the new Investment Law, which granted tax and customs advantages to projects related to clean energy, in a serious attempt to involve the private sector in this transition²⁹.

In order to regulate the market, executive decrees were issued defining the conditions for producing and selling electricity from renewable sources, which effectively allowed independent private producers to enter the national energy market.

24- Law No. 99-09 of 28 July 1999, relating to energy control, Official Gazette No. 51, issued on 2 August 1999.

25- Law No. 04-09 of 14 August 2004, relating to the promotion of renewable energies within the framework of sustainable development, Official Gazette No. 52, issued on 18 August 2004.

26- The National Agency for the Promotion and Rationalization of Energy Use (APRUE) was established on 25 August 1985, with the aim of preparing and implementing national programs designed to rationalize energy consumption and develop the use of renewable energies. The agency is also responsible for awareness-raising, technical support, and encouraging projects related to energy efficiency and environmental protection. See: Radhia Younsi and Ahlam Younsi, *Op. Cit.*, p. 34.

27- Law No. 02-01 of 5 February 2002, relating to electricity and gas distribution through pipelines, Official Gazette, No. 08, issued on 6 February 2002.

28- Naima Zaarour and Saliha Djouahra, *Renewable Energy Programs in Algeria: Reality and Challenges*, Journal of Economic and Administrative Research, University of Biskra, Issue 24, 2018, p. 326.

29- Law No. 22-18 of 24 July 2022, relating to investment, Official Gazette No. 50, issued on 28 July 2022.

Algeria moved from theorization to implementation, especially in the sun-rich south, where pilot programs were launched to establish major electricity generation plants, thereby confirming its seriousness in implementing what it had planned.

To ensure the sustainability of this transition, the state attached importance to encouraging scientific research and innovation in the field of renewable energy by supporting research centers and universities, such as the National Institute of Renewable Energy³⁰, in order to integrate modern technology into the development of effective energy solutions.

Accordingly, it can be said that the Algerian legal and political system in the field of renewable energy has come a long way, from general laws to integrated strategic programs. However, the real challenge always remains the extent to which these policies are actually implemented on the ground and their continuity is ensured in order to achieve the desired objectives.

Within the list of the most important future wind energy projects in Algeria, the Ministry of Energy and Mines is studying a major 1,000-megawatt project in cooperation with the World Bank. This project includes 10 sites in southern Algeria, including Tindouf, In Salah, and Adrar, which are areas shown by national atlases to have high wind resources. This project is a fundamental step on Algeria's path toward achieving its strategic objectives, as it seeks to raise electricity production from wind energy to 5,010 megawatts by 2030, before reaching 15,000 megawatts from renewable energies combined by 2035.

2.1.2 Existing Projects and Facilities in the Field of Renewable Energy: Algeria Steps Toward a Green Future

Algeria is moving steadily toward strengthening its reliance on renewable energy through a series of projects and facilities that have begun to materialize on the ground, especially in the field of solar energy. This movement comes in response to the National Renewable Energy Program, which was launched in 2011 and later developed, with the aim of gradually integrating these clean sources into the national energy system³¹.

One of the most prominent successful models in this regard is the Hassi R'Mel hybrid power plant, which is considered one of the leading projects of its kind in Africa. The plant combines the use of natural gas and solar energy, in a practical step that symbolizes the beginning of the transition toward mixing traditional and clean energy sources, as one of the first steps toward a green economy.

Several photovoltaic solar power plants have also spread across southern Algeria, such as those located in Adrar, Biskra, and Ghardaia, which convert sunlight directly into electrical energy.

30- Executive Decree No. 11-33 of 27 January 2011, establishing the Algerian Institute of Renewable Energies and defining its organization and functioning, No. 08, issued on 6 February 2011.

31- Investment in renewable energies is considered a strategic option for Algeria in light of the global transition toward clean energy, as it opens the way for major projects, especially in solar energy, in addition to the gradual move toward green hydrogen, which contributes to diversifying the economy and reducing dependence on oil and gas. At the global level, data from the International Renewable Energy Agency (IRENA) indicate that renewable energies represented about 28% of global energy consumption in 2023, with expectations that this share will rise to more than 50% by 2050. This is mainly due to the development of the solar and wind energy sectors and the decline in production costs thanks to technological progress. See the website: <https://www.erembusiness.com/energy/a1bew8u>

These plants are not merely technical facilities; rather, they represent a practical embodiment of the policy of investing in the natural wealth enjoyed by the country.

In the field of wind energy, areas such as Adrar have witnessed the launch of pilot projects using wind turbines to generate electricity. Although this field is still in the growth phase, it represents a promising step toward diversifying energy sources in our country.

Remote areas have not been neglected, as small solar energy projects have been implemented to supply isolated villages with electricity. This orientation forms part of a broader policy aimed at reducing the development gap between rural areas and cities³².

These projects have received legal support through an executive decree defining the conditions for producing and selling electricity from renewable sources, which has opened the door to private sector participation. The new Investment Law, by granting tax and customs exemptions for clean energy projects, has also contributed to encouraging further initiatives.

National companies, foremost among them Sonelgaz, play a key role in implementing and operating these projects by building power plants and developing electricity transmission networks to connect production centers with consumption areas.

Accordingly, although the number of current projects does not reflect all the enormous potential available, the steps Algeria has taken in the field of renewable energy, especially solar energy, demonstrate a growing political will to expand this vital sector and increase its contribution to achieving sustainable development.

The aim of moving toward such projects is to reduce the almost total dependence on gas in electricity generation and to increase the share of renewable energy to 27% by 2030³³.

2.2 Challenges and Prospects for Developing the Renewable Energy Sector

The renewable energy sector is one of the fundamental pillars of energy transition, especially in light of global challenges related to energy security and climate change, which impose the need to reduce dependence on traditional sources such as oil and gas. Within this framework, many countries, including Algeria, have begun to adopt new energy policies based on diversifying energy sources and benefiting from available natural potential, especially solar and wind energy. However, the transition to a sustainable energy model is, of course, not easy, as this sector faces overlapping difficulties that affect the speed of its development and the effectiveness of its programs.

Nevertheless, this path faces a set of structural, legislative, and financial challenges that restrict its actual potential (Branch One). Accordingly, achieving energy sustainability requires the adoption of a comprehensive strategic vision based on an accurate diagnosis of the areas of dysfunction and the formulation of ambitious reform prospects (Branch Two).

32- Ali El-Absi and Bilal Cheikhi, *The Reality and Prospects of Wind Energy in Algeria*, *Al-Miqar Journal of Economic Studies*, issued by Ali Kafi University Center, Tindouf, Institute of Economic Sciences, Vol. 02, No. 01, 2018, pp. 301–309.

33- Zoubida Mohsen and Hocine Chenini, *The Reality of Investment in Wind Energy in Algeria to Achieve Sustainable Development: A Field Study of the Kabertene Project in Adrar*, *Journal of Economics, Finance and Business*, issued by the University Center of Mila, Institute of Economic, Commercial and Management Sciences, Vol. 02, No. 04, 2018.

2.2.1 Challenges Hindering the Development of Renewable Energy

Renewable energy faces a number of financial and economic challenges, as the cost of investment in projects, particularly solar and wind energy projects, remains relatively high compared to traditional energy sources³⁴. This situation is further aggravated by the difficulty of financing these projects by relying solely on the public budget or traditional public institutions. In addition, the continued subsidization of electricity and conventional fuel prices weakens the attractiveness of investment in clean energy and maintains the dominance of hydrocarbons within the national energy mix.

At the technical level, the electricity infrastructure suffers from clear shortcomings, as the national grid needs to be modernized and expanded in order to absorb renewable energies characterized by intermittency, such as solar and wind energy. Moreover, the weak development of local competencies in the fields of project design, maintenance, and technology transfer leads to increasing reliance on foreign expertise, which raises costs and limits the achievement of local added value.

From a legal and regulatory perspective, the multiplicity of actors involved in the energy sector creates a form of complexity and bureaucratic procedures that may delay project implementation. Added to this is the weakness of the system for encouraging investment in renewable energy, as the investment laws issued have not met the expectations of foreign investors, particularly in light of the legislator's adherence to the obstacle of the 51/49 rule in many sectors³⁵, in addition to issues related to international arbitration and guarantees for the protection of intellectual property.

There is also a weak regulatory environment, as the regulatory system lacks an independent supervisory authority in the strict sense, while licensing mechanisms suffer from severe delays that discourage investment initiatives and prolong project timelines.

With regard to institutional, administrative, and financial aspects, the national programs designed to develop renewable energy have not achieved their objectives as expected. This is due to weak coordination among sectors and shortcomings in strategic planning. The lack of specialized training in this field also reduces the ability of administrations to evaluate and monitor projects effectively.

In addition, subsidized fossil energy continues to dominate, as the price of electricity produced from hydrocarbons remains heavily subsidized by the state, which weakens the economic competitiveness of renewable energy and discourages demand for it³⁶.

These challenges also include a shortage of specialized competencies, as the sector suffers from a severe lack of engineering and technical expertise specialized in the design, maintenance, and management of projects. This is further deepened by the phenomenon of brain drain abroad.

34- Naima Zaarour and Saliha Djouahra, *Op. Cit.*, p. 336.

35- Dahbia Latreche and Dalal Arama, *Opportunities and Challenges of Investment in Renewable Energy to Strengthen Algeria's Position in Global and Regional Energy Chains: Solar Energy as a Model*, *Journal of Advanced Economic Research*, University of El Oued, Issue 1, 2023, p. 274.

36- Dahbia Latreche and Dalal Arama, *Op. Cit.*, p. 274.

There are also shortcomings in the research and development system; despite the existence of specialized research institutions such as the Renewable Energy Development Center (CDER), the gap between academic research and field application remains wide.

2.2.2 Prospects for Reform and Strategies for Promoting Investment and Achieving Energy Sustainability

Addressing the aforementioned challenges requires the adoption of a multidimensional reform approach, beginning with the availability of political will and translated into a package of integrated measures in both the legislative and executive fields.

Therefore, updating the legal and regulatory framework, namely reforming the legislative and institutional system, emerges as a fundamental priority³⁷. This should be achieved by reforming energy market policies through the gradual liberalization of prices and the adoption of fair pricing mechanisms that encourage investment in clean energy without harming vulnerable groups. The legislation regulating investment in this field should also be reviewed in a manner that ensures transparency, clarity of procedures, and the protection of investors' rights, especially with regard to revising policies that restrict foreign direct investment in the sector and expanding the prospects for international partnerships on the basis of flexible contractual models that take sovereign sensitivities into account.

This also requires redesigning national programs and strategies by adopting an updated vision for renewable energy and energy efficiency that takes global transformations into consideration, while setting realistic objectives to increase the share of clean energy in the energy mix in the medium and long term. It is preferable to link these programs to local development plans in a way that contributes to creating a new economic dynamic, especially in areas with high natural potential.

Within the framework of promoting investment, encouraging the private sector and international partnerships is of great importance. This can be achieved by opening the way for foreign direct investment and providing the necessary legal guarantees, while ensuring the integration of local enterprises into the various stages of projects. Innovative financing formulas, such as public-private partnerships, can also be adopted in order to reduce the burden on public finances³⁸.

Energy development efforts should also go beyond completed projects in order to establish a solid national industrial base through the adoption of specialized training programs. Specialized vocational training programs in the field of renewable energy should be established in coordination with universities and technical centers, and partnership mechanisms with international institutions should be put in place to transfer advanced expertise and knowledge. Local content requirements may also be included in government contracts related to renewable

37- Nabil Wanoughi and Mounir Ben Azzouk, *Op. Cit.*, p. 182.

38- Mohamed Louchen, *Dimensions and Prospects of Algeria's Interest in Solar Energy as One of the Alternatives to Modern Renewable Energies: A Case Study of the Solar Energy Application Project in the Greater South of Algeria*, *Journal of Economic Studies and Research in Renewable Energies*, Issue 3, University of Batna, 2015, p. 88.

energy, particularly in the manufacture of solar panels and their support structures, while emphasizing the need for realism in order to avoid inflated costs.

In addition, industrial clusters should be supported, as the establishment of specialized industrial zones for renewable energy constitutes an organizing framework for strengthening the link between industry, research, and logistics services, thereby reducing production costs and increasing the competitiveness of the sector.

On the other hand, infrastructure development is a decisive factor. Electricity grids should be modernized and their capacities strengthened, alongside investment in storage systems and the improvement of transmission and distribution efficiency. Scientific research and specialized training should also be supported in order to prepare national competencies capable of leading this energy transition.

The path toward energy sustainability in Algeria requires the convergence of efforts at multiple levels and across various dimensions, including legislative and institutional reform, diversification of financing sources, the development of national industrial capacities, and the establishment of effective international partnerships. Despite the difficulty of this path, the strategic stakes it entails, such as diversifying sources of sovereign revenue, adapting to the requirements of the global energy transition, and preserving environmental balance, make it a non-negotiable option. The success of this strategy remains dependent on the availability of firm political will and on keeping the reform process away from political fluctuations.

If the state succeeds in overcoming the technical and financial challenges, it may become one of the most prominent regional actors in the renewable energy market, relying on an ambitious program that combines industrial generation with sustainable development.

Conclusion:

At the conclusion of this study, it becomes clear that renewable energy has become a strategic option that Algeria cannot do without. This is not limited only to addressing the environmental problems resulting from the intensive use of fossil fuels, but also includes ensuring its energy security and diversifying its economy. It is true that the country possesses enormous natural potential, especially in the field of solar energy, but the reality shows that the exploitation of these resources remains far below the required level, due to financial, technical, and regulatory obstacles.

The analysis revealed that Algeria, like many other countries, has begun to recognize the importance of shifting toward a sustainable energy model and has developed ambitious programs and strategies. However, achieving its objectives, especially by 2030, depends on its ability to overcome difficulties and improve the investment climate in this vital sector. For this transition to succeed, there must be genuine will and effective coordination among all parties, while benefiting from the experiences of leading countries.

Renewable energy now represents a real opportunity for Algeria to achieve balanced sustainable development that combines economic, social, and environmental dimensions and lays the foundation for an economy that is less dependent on hydrocarbons and more capable of adapting to global changes.

Based on the previously mentioned results, we present the following recommendations:

- Accelerate the implementation of national renewable energy programs, especially the 2030 program, while establishing effective monitoring and evaluation mechanisms.
- Improve and update laws and regulations related to investment in order to ensure transparency, facilitate procedures, and attract local and foreign investors, allowing a shift toward renewable energy in various sectors.
- Develop energy infrastructure, especially electricity grids, to facilitate the integration of renewable energy.
- Encourage international partnerships and benefit from the expertise of developed countries, while transferring and localizing technology.
- Effectively involve the private sector in this strategic orientation and give it priority in order to gain more experience, in addition to promoting international cooperation in major projects.
- Invest in scientific research and specialized training to develop national competencies capable of leading, encouraging, and advancing the energy transition in the field of renewable energy.
- Diversify renewable energy sources instead of limiting them to solar and wind energy, by developing bioenergy and geothermal energy.
- Raise public awareness of the importance of clean energy and rationalizing consumption.
- Support small and medium-sized enterprises to participate in renewable energy projects, which contributes to creating new job opportunities.

Naturally, in this manner and through this approach, implementing these recommendations can help overcome the current challenges and move Algeria toward achieving an effective and sustainable energy transition.

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