# Energy transition in Algeria: the reality of renewable resource and strategies for achieving security

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**Abstract:**

This study aims to highlight the current state and future prospects of renewable energy in Algeria, with a focus on its role in achieving energy security as one of the most prominent alternative energy approaches and optimal solutions to address the challenges posed by conventional energy sources facing the risk of depletion.

Recognizing the importance of this issue, Algeria has sought to develop plans, policies, and legislation to promote the renewable energy sector, enhance the diversification of its energy sources, reduce risks threatening its energy security mitigate income losses resulting from energy imports, and reduce energy import reliance.

The study concludes that despite numerous projects, Algerian renewable energy efforts remain insufficient and have not reached the level required to serve as an alternative to conventional energy or achieve energy security.

**Keywords:** Energy; Renewable Energies; Energy Security; Algerian Economy.

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1. **Introduction:**

Energy has long occupied a position of profound strategic importance within the global economy, owing to its indispensable and cross-cutting role across virtually all vital sectors. Precisely because of this centrality, energy prices in international markets remain in a state of chronic instability-a volatility that becomes particularly acute during periods of armed conflict or systemic geopolitical crises. Beyond its fundamental function as a catalyst for economic development-especially in nations endowed with substantial fossil fuel reserves in the form of natural gas or petroleum-conventional energy carries within it an inherent paradox: it is, by its very nature, finite. The inexorable trajectory toward depletion transforms what was once a matter of theoretical concern into an immediate and pressing existential threat. This looming reality has rendered the exploitation of diverse renewable energy sources—solar, wind, hydroelectric, and geothermal—not merely an attractive policy alternative but an ontological necessity without which sustainable energy security cannot be conceived, let alone achieved.

Consequently, ensuring energy security and sustainability has ascended to the forefront of national strategic priorities for a growing number of states. Simultaneously, and compounding this urgency, environmental anxieties attendant upon continued dependence on fossil fuel architectures have intensified considerably. Nations now find themselves navigating a complex imperative: stabilizing energy supply chains while maintaining price accessibility, all against a backdrop of ecological precarity and geopolitical uncertainty.

Algeria stands as a paradigmatic case among those states for which decisive alignment with this global energy transition is no longer optional but structurally mandated. This imperative has acquired particular acuity in light of persistently declining fiscal revenues derived from hydrocarbon exports-revenues that have historically constituted the bedrock of the national budget and the primary instrument of social redistribution. The country thus confronts not merely an energy policy question but a fundamental challenge to its prevailing developmental paradigm.

- **Research Problem**

In light of the foregoing considerations, the central problematic around which this inquiry revolves can be formulated as follows:

**To what extent can renewable energies substantively contribute to the realization of energy security in Algeria?**

- **Research Hypothesis**

In response to the aforementioned problematic, the guiding hypothesis advanced by this study posits that:

Renewable energies do, in fact, contribute to the Algerian economy precisely through their capacity to actualize energy security-rendering them not peripheral supplements but potentially constitutive elements of a reconfigured national energy architecture.

- **Research Objectives**

This paper aims to critically examine the current state of renewable energy development in Algeria, identify and evaluate the principal policy frameworks deployed to advance this sector, and interrogate the extent to which these resources effectively function as vectors for achieving durable energy security.

Research Methodology

The study adopts a descriptive-analytical methodology, commencing with a comprehensive exposition of theoretical contours surrounding renewable energy and energy security before proceeding to an empirically grounded analysis of their concrete manifestation within the Algerian economic context.

## 2. Theoretical Framework: Renewable Energy and Energy Security

### 2.1 Conceptualizing Renewable Energy

Renewable energy designates energy derived from natural resources that are fundamentally inexhaustible and continuously regenerated through natural processes. What fundamentally distinguishes these energy forms from their conventional counterparts resides not merely in their renewability but in their substantially reduced ecological footprint: they do not emit carbon dioxide or other greenhouse gases implicated in anthropogenic climate change, nor do they generate atmospheric pollutants associated with fossil fuel combustion (Ouaïba, 2019, p. 195).

The Intergovernmental Panel on Climate Change (IPCC) offers a more technically elaborated conceptualization, defining renewable energy as energy derived from solar, geophysical, or biological sources that are replenished by natural processes at rates equivalent to or exceeding their respective rates of consumption. It is generated from continuous and recurrent fluxes occurring within the natural environment encompassing biomass, solar radiation, geothermal heat, hydropower, ocean tidal and wave energy, and wind currents. Multiple technological pathways exist for converting these primary sources into usable energy carriers thermal energy, electrical power, and mechanical force through diverse technological configurations that ultimately deliver energy services including electricity and fuel (Hassina, Soltani, & Takrart, 2020, p. 91).

A complementary definition frames renewable energy as energy harvested from natural sources, generated through inexhaustible natural processes whose defining attributes include perpetuity and environmental benignity (Edward, 2017, p. 182).

Synthesizing these conceptual approaches, renewable energy can be understood as energy generated through natural processes substantially independent of human intervention, characterized by non-depletion, continuous regeneration, universal accessibility, and ecological neutrality. These resources impose no irreversible burden upon environmental systems but rather exist in fundamental compatibility with them, as exemplified by solar radiation, atmospheric circulation, hydrological cycles, and terrestrial heat flow.

### 2.2 Typology of Renewable Energy Sources

Renewable energies constitute an ensemble of naturally replenishing resources whose defining characteristic resides not merely in their quantitative abundance but in their qualitative distinction from fossil fuels: they are flow-limited yet virtually inexhaustible over human temporal horizons. Their primary sources are solar radiation, atmospheric circulation, hydrological cycles, and biological processes. A critical taxonomic examination follows.

- **Wind Energy**

Wind energy captures the kinetic energy of atmospheric motion through aerogenerators that convert rotational mechanical force into electrical power. This transduction occurs via turbine-driven generators, with electricity subsequently transmitted through grid infrastructure to consumption centers (Zina & Boukherouba, 2018, p. 58). Beyond this conventional conceptualization, contemporary analysis recognizes wind energy as an inherently intermittent yet geographically distributed resource whose integration necessitates sophisticated forecasting and grid management protocols. Algeria's Mediterranean coastline and high plateau regions exhibit wind corridors with significant velocity gradients amenable to utility-scale deployment . Current installed wind capacity remains nascent, though a 1 GW wind tender has been announced, signaling strategic diversification beyond solar dominance .

- **Solar Energy**

Solar energy exploits electromagnetic radiation emanating from the sun- a fusion reactor whose terrestrial energy flux dwarfs contemporary global demand by several orders of magnitude. Its applications span thermal utilization (domestic water heating, swimming pool thermal regulation, space heating) and photovoltaic conversion for electricity generation. The latter has emerged as the preeminent renewable technology globally, characterized by precipitous cost reductions and accelerating deployment curves (Kacem, 2021, p. 245). Algeria's solar endowment is among the most prodigious on Earth. The country receives an annual irradiance of 1,850–2,100 kWh/m², with sunshine duration exceeding 3,500 hours per annum across vast Saharan expanses. This represents a strategic asset of the first order. Yet the dialectic between resource potential and realized capacity reveals persistent implementation deficits. As of late 2025, Algeria's installed renewable capacity stood at approximately 446 MW-a figure incongruent with its solar patrimony. However, inflection may be imminent: nine photovoltaic plants aggregating 1,480 MW are scheduled for commissioning by August 2026, with two 200

MW installations at Laghouat (Biskra province) and Tendla (El Meghaier province) already operational as of January 2026. These deployments constitute the initial tranche of a 3,200 MW first-phase program, itself subordinate to a revised national target of 15 GW by 2035.

- **Hydroelectric Energy**

Hydroelectric power derives from the gravitational potential energy of water masses in motion-a continuous hydrological cycle driven ultimately by solar evaporation and atmospheric transport. Flowing water drives turbines coupled to generators, producing electricity with high-capacity factors and exceptional operational flexibility (Arous, 2015, p. 9). Unlike solar and wind, hydropower offers dispatch ability, though its geographic specificity and environmental externalities (ecosystem fragmentation, sedimentary interruption, methane emissions from reservoirs) complicate its sustainability calculus.

Algeria's hydroelectric endowment is modest relative to its renewable portfolio. Topographic and climatic constraints-principally aridity and limited perennial watercourses-circumscribe large-scale dam development. Hydropower consequently occupies a peripheral position in national energy strategy, supplanted by solar-centric planning.

- **Biomass Energy**

Biomass energy is derived from organic matter-photo synthetically fixed carbon subsequently liberated through combustion, gasification, or biochemical conversion. Feedstocks encompass fast-growing arboreal species, energy crops, cereal grains, vegetable oils, and agricultural residues, alongside animal by-products and municipal organic waste (Arous, 2015, p. 11). Contemporary bioenergy systems increasingly emphasize waste valorization and circular economy principles, transforming disposal liabilities into productive assets.

Algeria's bioenergy profile reveals untapped potential amid modest current utilization. In 2021, national bioenergy consumption reached 101.53 million metric tons, ranking 39th globally-marginally below Uganda's 111.05 million tons. Consumption has grown at a compound annual rate of 3.3% since 1975, with projected attainment of 111.05 million tons by 2026, representing 1.6% annualized growth. The forthcoming Algiers Bioenergy Exhibition 2026 signals nascent sectorial institutionalization, convening stakeholders across biofuels, biogas, waste-to-energy technologies, and carbon capture systems . Nevertheless, biomass remains underexploited relative to solar, constrained by collection logistics, conversion efficiency thresholds, and competition with alternative valorization pathways.

### 2.3 Conceptualizing Energy Security

Energy security is a polymorphic concept whose definitional boundaries have expanded considerably beyond early formulations centered exclusively on supply reliability. Contemporaneous scholarship recognizes its

multidimensional character, encompassing availability, accessibility, affordability, and acceptability-the so-called "four A's" framework.

The International Energy Agency (IEA) furnishes the most authoritative operational definition: energy security constitutes "the uninterrupted availability of energy sources at an affordable price". This formulation encompasses both temporal modalities: long-term security pertains to investments aligning supply with economic development trajectories and environmental imperatives, while short-term security denotes the energy system's adaptive capacity to restore equilibrium following supply-demand perturbations.

The World Bank advances an expanded conceptualization, defining energy security as "universal access to reliable, affordable, clean, and sustainable energy" (Moumen, 2021, p. 124). This iteration explicitly incorporates sustainability and environmental quality as constitutive elements-a normative evolution reflecting the integration of climate imperatives within energy governance frameworks.

Synthesizing these definitional currents, energy security emerges as a condition of supply stability that enables sustained economic growth and progressive improvement in living standards, insulated from disruptive contingencies or systemic threats. This condition presupposes not merely physical availability but institutional robustness, infrastructural resilience, and adaptive governance capable of navigating geopolitical turbulence and technological discontinuities.

For Algeria, energy security assumes particular valence given the hydrocarbon-centric architecture bequeathed by six decades of fossil fuel dependency. The imperative transcends mere supply continuity; it encompasses the managed reconfiguration of an entire productive apparatus, the diversification of fiscal revenue streams, and the preservation of strategic autonomy amid global energy realignment. Contemporary energy security in the Algerian context thus inscribes itself within a broader problematic: how to effectuate a just transition that neither compromises developmental aspirations nor reproduces external dependencies under new technological guises. The renewable energy program, evaluated through this lens, represents not merely an environmental or even economic project, but a political undertaking of the first magnitude-one whose success or failure will materially condition the nation's developmental trajectory for generations.

## 3. The Reality of Renewable Energies in Algeria

Algeria is characterized by immense potential in renewable energies, as it possesses diverse sources and is among the countries that have shown interest in renewable energy. It has sought to adopt the option of integrating renewable energies into the economic system to achieve energy security.

### 3.1. Algeria’s Solar Energy Potential:

Algeria is distinguished by its vast area, particularly the desert region, making it one of the largest solar energy fields in the world. The following table illustrates Algeria’s solar energy potential:

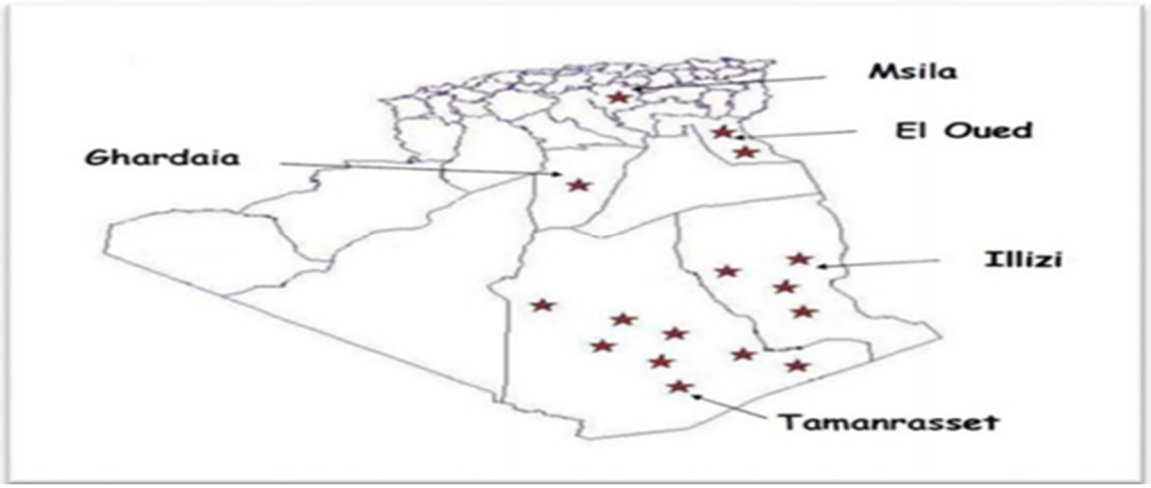
**Table 01: Algeria's Solar Energy Potential**

| Region | Coastal Area | Highlands | Desert |
|---|---|---|---|
| Area % | 04 | 10 | 86 |
| Average sunshine duration (hours/m²/year) | 2650 | 3000 | 3500 |
| Available solar energy (kWh/m²/year) | 1700 | 1900 | 2650 |

**Source** :(Bouzidi, Ben Omar, & Najib, 2017, p. 132)

The previous table represents Algeria's solar energy potential, with an average sunshine duration of 3,500 hours per m², reaching the equivalent of 2,650 kWh/m² in the desert region, followed by the highlands with an average of 1,900 kWh/m², and finally the northern region with 1,700 kWh/m².

**Map No. 01: Wilayas benefiting from electrical energy generated from solar power.**

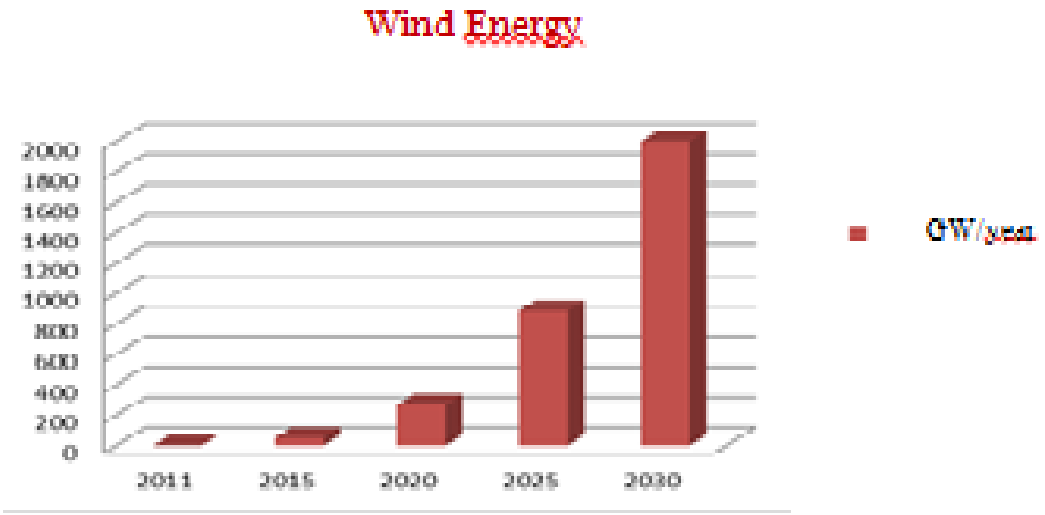



**Source**: (Rachid & Ben Ramadan, 2020, p. 312)

**.3.2. Algeria's Wind Ennery Potential:**

Wind energy in Algeria varies from one place to another due to the diversity of its climate. In the north, bordered by the Mediterranean Sea, wind speeds are relatively low, unlike the southern region, which experiences higher wind speeds, particularly in the southwest, reaching 4 m/s and exceeding 6 m/s. This energy is suitable for water pumping, especially in the high plateaus. Accordingly, ten specialized meteorological stations have been installed, and a demonstration program has been planned for areas where wind speed exceeds 4 m/s, including Biskra, Tindouf, and Timimoun. As for the technical reserve of wind energy in Algeria, it is estimated at 172 TWh/year, of which 37 TWh is economically exploitable (Ali & Cheikhi, 2018, p. 306).

**Figure No. 02: Expected wind energy project shares from the National Renewable Energy Program in Algeria 2011–2030.**




**Source**: Prepared by the researchers based on: Arab Union for Electricity, Arab Electricity, a specialized periodical issued by the General Secretariat of the Arab Union for Electricity, Issue No. 18, 2012, p. 64.

From the figure above, we observe that wind energy projections are continuously increasing between 2011 and the forecasted year 2030, reaching expectations from 0 to 2000 GW/year.

### 3.3. Algeria's Hydropower Potential:

Other energy sources in Algeria are not as productive as wind and solar energy. Although they are exploited, they do not match the output of the aforementioned sources.

Regarding hydropower, its share in electricity generation stands at around 5%, due to the insufficient number of irrigation sites. In this context, the "Bziema" hydroelectric plant in Jijel was rehabilitated with a capacity of 100 MW (Akouba & Salmani, 2017, p. 506).

## 4. Efforts and Means for Developing Renewable Energies in Algeria

Numerous laws have been enacted to regulate renewable energy in Algeria, such as Law No. 99-09 on the consolidation of energy efficiency and environmental protection, and Law No. 02-01 on electricity and public gas distribution. The National Fund for Renewable Energies was also established. Furthermore, Algeria has prioritized scientific research to make renewable energies a driver for national industrial development, creating research and development institutions such as the Center for the Development of Renewable Energies (CDER), the Solar Energy Development Unit (UDES), and the National Institute for Renewable Energies (IARE). In 2015,

the National Program for the Development of Renewable Energies and Energy Efficiency was launched, the content of which will be presented in the following table:

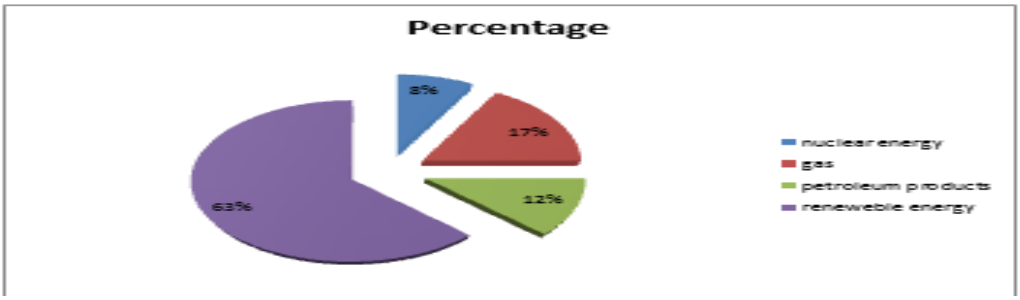
**Table No. 02: National Program for the Development of Renewable Energies and Energy Efficiency (2015–2030).**

| Sector | First Phase (2015–2020) MW | Second Phase (2021–2030) MW | Total MW |
|---|---|---|---|
| Photovoltaic energy conversion | 3000 | 10575 | 13575 |
| Wind | 1010 | 4000 | 5010 |
| Solar heating | - | 2000 | 2000 |
| Cogeneration | 150 | 250 | 400 |
| Biomass | 360 | 640 | 1000 |
| Geothermal | 05 | 10 | 15 |
| Total | 4525 | 17475 | 22000 |

**Source:** (Zouhal & Yahyaoui, p. 54).

From the table above, we observe that the program aims to generate 22,000 MW of electricity to meet national needs during the period (2015–2030). Consequently, this program will significantly develop the conversion of solar energy into electrical energy, as well as wind energy. In each phase, a clear increase in all processes is noted. If this program is managed in an organized manner, a substantial reduction in the use of primary resources or traditional energy sources in Algeria will be achieved.

**Figure No. 03: Energy Projections in Algeria by 2050**




**Source :** https ://www.google.com/url?sa=t&source=web&rct=j&url=htpp://library.fes.de/pdf

## 5. Major Completed Projects in the Field of Renewable Energies in Algeria

### 5.1 . Solar Photovoltaic (PV) Projects

- **. Early Pilot and Rural Electrification Projects (2000–2016)**

| Project | Capacity | Location | Year |
|---|---|---|---|
| First solar PV rural electrification | ~2 MW | 20 villages in the Hoggar and Tassili | 2000–2010 |
| Ghardaïa PV plant | 1.1 MW | Ghardaïa | 2011 |
| Electrification of 16 villages | 2,554 homes | South & High Plateaus | 2011–2015 |
| Five PV plants | 19 MW | Illizi, Tindouf, Tamanrasset | 2015–2016 |

**Source:** Prepared by the researcher based on: CDER, 2011, Farid & Bahyani, 2018, Farid & Bahyani, 2018, Ali & Cheikhi, 2018

- **First Large-Scale Program (2017–2021)**

Following the creation of the Ministry of Environment and Renewable Energies (2017), Sonelgaz's renewable energy subsidiary commissioned 22 photovoltaic plants:

| Feature | Detail |
|---|---|
| Total capacity | 343 MW |
| Geographic distribution | High Plateaus and Southern wilayas |
| Commissioning | 2017–2019 |
| Operator | Sonelgaz Renouvelables |

**Source:** Akouba & Salmani, 2017; Farid & Bahyani, 2018.

### 5.2.Recent Solar Tenders and New Capacities (2022–2026)

a) 1,000 MW Solar Tender (2022–2024)

- 13 plants, total 1,000 MW.
- Locations: Béchar (80), Biskra (150), El Oued (120), M'sila (100), Ouargla (200), Touggourt (80), Laghouat (50), and others.
- Status: Under construction, commissioning 2026–2027.( Sonelgaz Renouvelables, 2025; Ministry of Energy, 2025.)
- b) 2,000 MW Solar Program (2024–2025)
- Two phases of 1,000 MW each.

- Prequalification opened in 2024; international and national bidders.
- **Expected commissioning : 2027–2028.**
- **Source: CEREFE, 2024; Africa Energy Portal, 2025.**

c) 1,500 MW Solar Tender (2025)

- Launched in early 2025.
- Part of the accelerated 15,000 MW solar target by 2030.
- Commissioning forecast: 2028–2029.
- Source: Ministry of Energy Transition, 2025.
- d) 2026 Outlook
- A further 2,000–3,000 MW tender is under preparation for 2026, targeting completion by 2030.
- Source: CEREFE Annual Report, 2025 (forthcoming).
- Wind Energy Projects 2.2. New Wind Programme (2024–2029)
- Five new wind farms, total 1,000 MW.
- Sites : Adrar (expansion), Tindouf, Béchar, Naâma, El Bayadh.
- Status: Feasibility studies, wind measurement campaigns (2024–2026).
- Commissioning : 2027–2029.
- Source: Ministry of Energy Transition, 2025.

**5.3. Hybrid and Innovative Projects**

- Hassi R'mel Integrated Solar Combined Cycle (ISCC)

**6.Green Hydrogen Pilot Projects**

Algeria adopted its National Green Hydrogen Strategy in 2023. Ongoing initiatives:

- Pilot electrolysis unit – 50 kW, Arzew (Sonatrach/CRT), 2024.
- Feasibility study for a 2 GW export-oriented project with German and Italian partners, 2025.
- Target: 10–15 GW electrolysis capacity by 2030; 20–30 GW by 2040.
- Source: Ministry of Energy Transition, 2023, 2024.

**7.Research, Development, and Off-Grid Applications**

**7.1. CDER Research Projects**

- 28 socio-economic research projects supported by agreement with the General Directorate for Scientific Research (2017–2020).
- Source: Farid & Bahyani, 2018.

- 6.2. Off-Grid Solar Deployment
- Solar home systems and water pumping in Tassili N'Ajjer and Ahaggar national parks (Illizi, Tamanrasset).
- Strategic military and border posts equipped with PV-diesel hybrids.
- Source : CDER Activity Reports, 2018–2023.
- **Institutional and Regulatory Milestones**

| Year | Milestone | Reference |
|---|---|---|
| 2011 | National Renewable Energy Program (2011–2030) launched | Bouzidi et al., 2017 |
| 2017 | Ministry of Environment and Renewable Energies created | Farid & Bahyani, 2018 |
| 2020 | CEREFE (Renewable Energy and Energy Efficiency Commission) established | Law 20-09 |
| 2023 | Law No. 23-09 on renewable energy incentives | Official Journal No. 42 |
| 2024 | CEREFE becomes fully operational; first binding 5-year plan issued | CEREFE, 2024 |

- **International Cooperation Projects**

| Partner | Project | Amount | Period |
|---|---|---|---|
| World Bank | Grid integration and solar technical assistance | $30 million | 2023–2026 |
| African Development Bank | Desert to Power – Sahel solar corridor | €60 million | 2024–2028 |
| European Union | Capacity building / energy efficiency | €20 million | 2024–2027 |
| Germany (GIZ)Green | hydrogen feasibility€5 | €5 million | 2025–2027 |

## 6. Conclusion

Renewable energies are a crucial pillar for achieving energy security, particularly for countries that rely on oil exports, as petroleum resources are insufficient for future generations due to their limited quantities, in addition to their negative environmental impacts. Therefore, the world has sought alternative, clean, cost-effective, and environmentally friendly energy sources. Given that renewable energies possess these characteristics, efforts have been initiated to develop their exploitation in various forms—whether solar, wind, thermal, hydro, etc. This is not to deny the existence of certain drawbacks and shortcomings in the exploitation of renewable energies.

As for Algeria, it has sought to develop the renewable energy sector by encouraging its exploitation and investment in its various fields, most notably solar energy. The Algerian desert constitutes a reservoir of solar energy with excellent intensity, capable of covering the country's needs and ensuring energy security both now and in the future.

The study yielded the following findings:

- Renewable energies consist of clean, inexhaustible natural sources that are constantly renewed, making them a sustainable form of energy;

- Renewable energy sources are diverse, including solar energy, wind energy, hydropower, biomass, and others, and are characterized by several features, most notably abundance, sustainability, and positive environmental impacts;

- Renewable energies play a prominent role in advancing the economy and achieving energy security by providing job opportunities, combating unemployment, preserving the environment, and offering an inexhaustible energy supply;

- Renewable energies in Algeria receive significant attention, as reflected in the legislative and institutional frameworks established for their promotion and development;

- Algeria possesses enormous potential in renewable energy sources, the most important of which is solar energy due to its strategic location, which grants it one of the world's largest solar energy fields, making it a major source of electricity supply.

Based on the findings, this study proposes the following recommendations:

- Benefit from international experiences in the field of renewable energy investment and exploitation;

- Utilize advanced technology to achieve the objectives of national renewable energy programs in Algeria;

- Qualify and train human resources in the field of renewable energies, focusing on their education through Algerian universities;

- Develop scientific research in renewable energies by introducing related academic disciplines in universities and fostering coordination with leading international and regional institutions and organizations in this field;

- Raise national awareness of the importance of investing in renewable energies as an alternative to conventional energy sources;

- Review the investment climate and adapt it in a way that encourages investment in the field of renewable energies in Algeria.

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