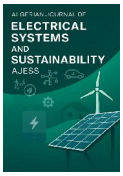
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Solar PV Development in Algeria: Status and Prospects

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Abstract

This article presents a comprehensive analysis of solar photovoltaic (PV) energy development in Algeria within the global renewable energy transition context. Algeria possesses one of the highest solar potentials, with annual irradiation reaching 2263 kWh/m² in southern regions. The country has launched an ambitious renewable energy program targeting 15,000 MW of solar electricity capacity by 2035, aiming for 30% renewable energy in the national mix. Through a methodological approach combining secondary data analysis and economic assessment, this study examines the evolution of installed PV capacity, which reached 356.1 MW by 2021, and analyzes the recent launch of 3000 MW PV parks in 2024. The research highlights a projected 57% decrease in installation costs by 2025 and discusses critical challenges related to grid integration, economic competitiveness, and energy subsidy impacts. The analysis concludes that despite existing obstacles, solar PV represents a crucial opportunity for Algeria's energy transition, with specific policy recommendations provided to support sustainable development goals.

Keywords

Solar photovoltaic; Renewable energy; Algeria; Grid integration; Cost analysis; Energy policy.

1. Introduction

The global energy landscape is undergoing a profound transformation driven by climate change imperatives and energy security concerns. Renewable energy, particularly solar photovoltaic (PV), has emerged as a cornerstone of this transition, with record-breaking capacity additions year after year [1, 2]. In 2023, renewable electricity capacity additions reached approximately 507 GW, representing nearly 50% growth, led predominantly by solar PV [2]. The development of future technical skills in this sector is crucial for sustaining this growth [3].

Algeria, a country with substantial fossil fuel reserves, faces a dual challenge: meeting growing domestic energy demand and diversifying its economy away from hydrocarbon dependence. The country is endowed with an exceptional solar resource, receiving up to 3900 hours of sunshine annually in the Sahara region [4]. This positions solar PV as a strategic asset for its energy future. The design and optimization of energy systems, as explored in rehabilitation system implementations [5], provide valuable insights for large-scale PV projects.

Despite launching an initial renewable energy program in 2011, Algeria's progress has been slower than anticipated. The original target of 22,000 MW by 2030 was revised down to 15,000 MW of solar electricity by 2035, highlighting significant implementation hurdles. However, the recent launch of large-scale PV projects in 2024 signals a critical turning point.

This paper aims to provide a holistic analysis of Algeria's solar PV journey. It seeks to: (1) assess the evolution and current state of the national PV program, (2) analyze the cost competitiveness and economic viability of solar projects, (3) identify and discuss the key technical challenges for grid integration, and (4) provide recommendations for policymakers and stakeholders. The primary contribution of this work is its integrated

approach, combining policy analysis with technical and economic evaluation to offer a nuanced perspective on the opportunities and obstacles facing Algeria's solar ambitions.

2. Methodology

This study employs a qualitative methodology based on secondary data analysis. Data were collected from multiple sources: (1) reports from international agencies (IEA, IRENA), (2) strategic documents from the Algerian government and Sonelgaz reports, (3) recent academic literature on the subject. The analysis combines a descriptive review of the evolution of installed capacity with an economic assessment using the Levelized Cost of Electricity (LCOE) framework. This approach enables a comprehensive evaluation of the potential, progress, and challenges of solar PV deployment in Algeria (Fig.1).

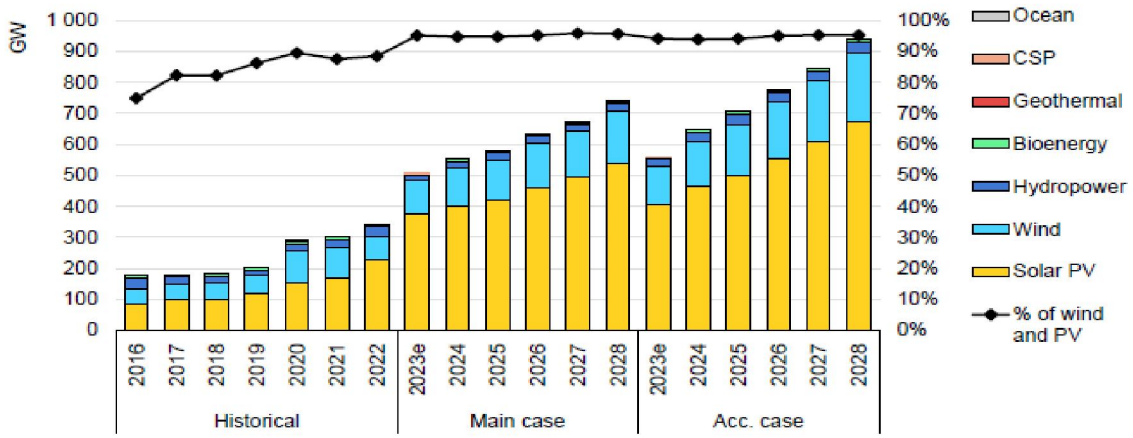


Fig. 1. Increase in renewable electricity capacity by technology and segment [2]

3. Global Renewable Energy Context

3.1. Worldwide Trends

The evolution of renewable energies in recent decades has been remarkable. From once being considered marginal and costly solutions, renewables have become essential pillars of modern energy systems worldwide. According to IEA data presented in Fig. 1, renewable electricity capacity additions reached about 507 GW in 2023, representing approximately 50% growth compared to the previous year [2]. The development of energy-efficient systems and controls [6] plays a crucial role in optimizing these renewable energy integrations.

3.2. Renewable Energy as Main Electricity Source

From the beginning of 2025, renewables surpass coal as the main source for global electricity generation. By 2028, the potential capacity for renewable electricity generation is expected to increase by nearly 70% compared to 2022, reaching about 14,400 TWh [2]. The evolution of electricity generation by technology, illustrated in Fig. 2, shows this significant transition.

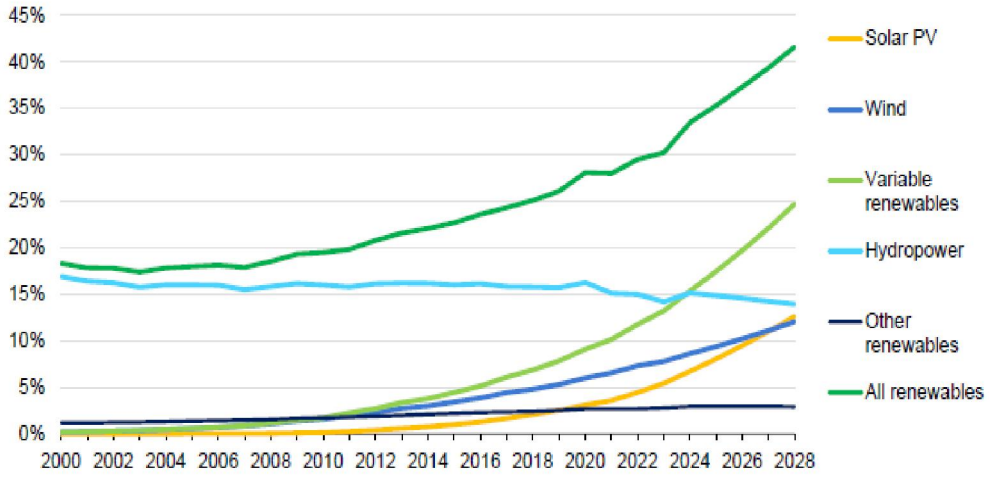


Fig. 2. Electricity generation by technology, 2000–2028 [2]

4. Algerian Context and Development Program

4.1. Solar Potential

Algeria benefits from considerable solar potential due to its privileged geographical position, offering one of the largest global solar deposits. Sunlight duration generally exceeds 2000 hours per year across the entire territory, reaching 3900 hours in the highlands and Sahara. This abundance translates into energy received daily on a horizontal surface of 1 square meter, estimated at about 5 kWh in most regions, with nearly 1700 kWh/m²/year in the north and 2263 kWh/m²/year in the south of the country [4]. The maps in Fig. 3 illustrate the annual average of global irradiation received on a horizontal surface in Algeria, as well as the annual duration of sunshine.

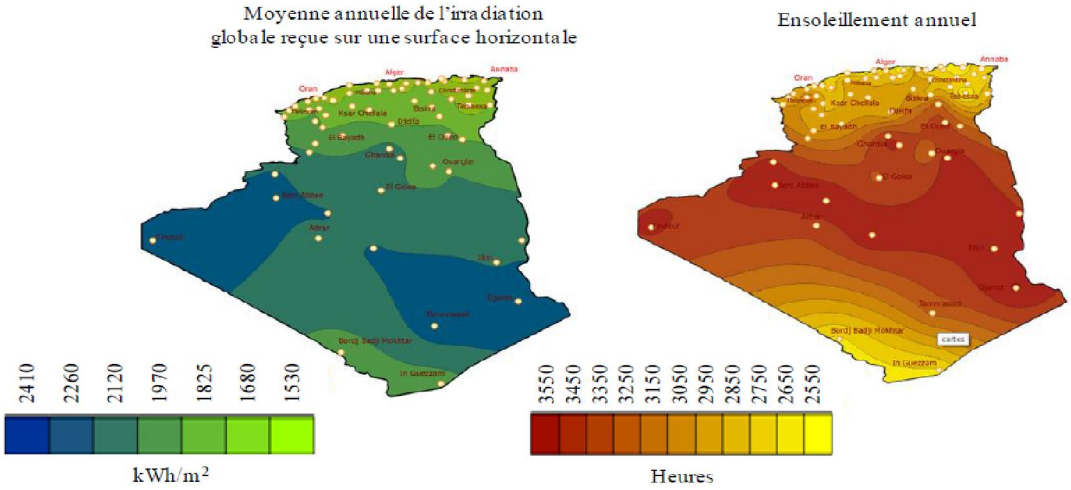


Fig. 3.Global irradiation and annual sunshine duration in Algeria [4]

4.2. National Renewable Energy Program

Algeria, through its renewable energy program (EnR), aims to become a major player in electricity production from solar sources. The target set for 2030 is that 37% of installed capacity and 27% of electricity production for national consumption come from renewable sources [4, 7]. The program consistency for the national market over the period 2015-2030 was initially 22,000 MW but was revised to 15,000 MW by 2035 [4, 7], distributed as follows:

- Solar PV: 13,575 MW
- Wind: 5,010 MW
- CSP: 2,000 MW
- Biomass: 1,000 MW
- Geothermal: 15 MW
- Cogeneration: 400 MW

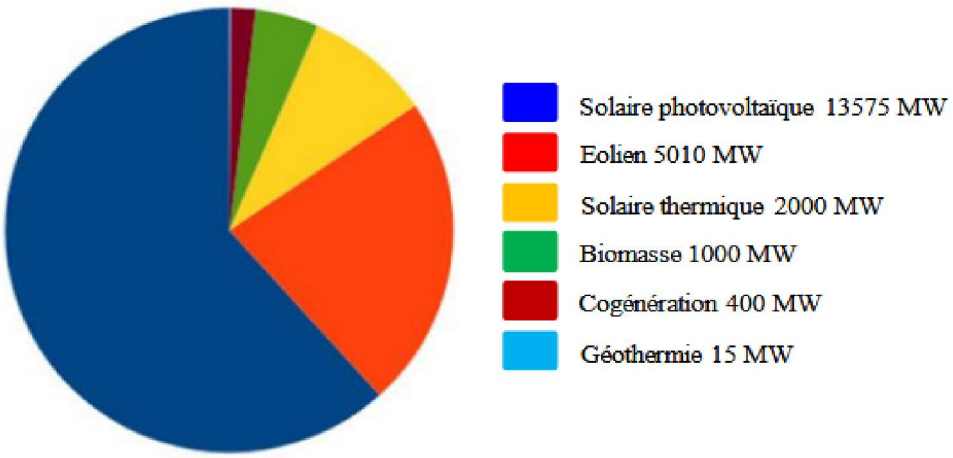


Fig. 4. Targets by sector of the Algerian Renewable Energy Program by 2030 [4]

4.3. Current Installed Capacity

By 2021, Algeria had reached 356.1 MW of installed PV capacity distributed across three main grid systems [7], as detailed in Table 1. Analysis of Table 1 reveals several significant trends. The predominance of plants connected to the Northern Interconnected Grid (RIN - 266.1 MW) reflects an initial strategy of supplying the most populated and industrialized northern regions. The PIAT and RGS networks, although of lesser capacity, demonstrate the willingness to integrate remote Saharan regions into the national grid. It is also observed that newer plants (such as BADJI MOKHTAR and TIMIAOUINE, commissioned in 2021) show capacity factors and specific productions that could be optimized, indicating room for improvement in operational efficiency.

Table1. Means of production of the photovoltaic plant [7]

	Installed Power (MW)	***Commissioning Date***	***Production (GWh) in 2021***
Oued Nechou	1.1	10/07/2014	1,8
Ain el bel – Djelfa	53,0	06/04/2016	91,3
Lekhneg– Laghouat	60,0	08/04/2016	102,4
Oued El Kebrit	15,0	21/04/2016	22,9
Tlegh– Sidi Belabbes	12,0	29/09/2016	19,9
Labiadh Sid Cheikh	23,0	27/10/2016	40,5
Ain El Melh – M'sila	30,0	26/01/2017	35,6
El Hdjira – Ouargla	20,0	16/02/2017	51,7
Oued El Ma – Batna	2.0	31/12/2017	3,3
SedretL eghzel-Naama	20,0	03/05/2016	34,4
Ain Skhouna –Saida	30,0	05/05/2016	46,9
PV RIN	266,1		
ADRAR	20	28/10/2015	34.2
Kabertan	3	12/10/2015	4.5
Zaouiat Kounta	6	12/01/2016	10.4
Reggane	5	28/01/2016	8.5
Timimoune	9	07/02/2016	16.4
Aoulef	5	06/03/2016	9.2
In Salah	5	11/02/2016	9.1
PV PIAT	53		
DJANET	3	08/06/2015	5.1
TAMANRASSET	13	03/11/2015	19.8
TINDOUF	9	15/12/2015	13.4
BORDJ BADJI MOKHTAR	10	07/07/2021	6
TIMIAOUINE	2	12/07/2021	1.4
PV RGS	37		
TOTAL PV	356,1		588,6

5. Recent Developments: 2024 PV Park Projects

In 2024, Algeria marks a turning point in its energy transition with the launch of its first PV projects under the ambitious 15,000 MW solar electricity program, scheduled until 2035. The first kilowatt-hours will be produced by the end of the year, following the signing of contracts for the construction of 15 solar plants, totaling 3000 MW between the Sonelgaz group and national and foreign companies [7].

These projects, spread over 2024 and 2025, constitute the beginning of the program's implementation, which includes 6,000 MW to be installed between 2023 and 2027. Distributed across a dozen wilayas, with unit powers of 80 to 220 MW, these projects will reduce dependence on natural gas-based electricity in favor of solar energy.

6. Economic Analysis and Cost Trends

6.1. Cost Reduction Potential

Fig. 5 Fig. 5 shows the evolution of installation costs for large-scale PV systems. Beyond hardware cost reductions, the development of energy-efficient systems and controls [6] plays a crucial role in optimizing these renewable energy integrations. Module costs have decreased rapidly, representing 68% of the total reduction, while the share of non-system costs increased from 37% to 60%. For the 2015-2025 period, a reversal of this

trend is expected, with modules contributing about a quarter of the potential cost reduction [8]. A 57% decrease in installation costs for large-scale PV systems is anticipated by 2025, with additional reductions possible through accelerated deployment. Module costs are expected to drop by about 42% by 2025, and the main cost reduction opportunities lie in cell-module manufacturing [8].

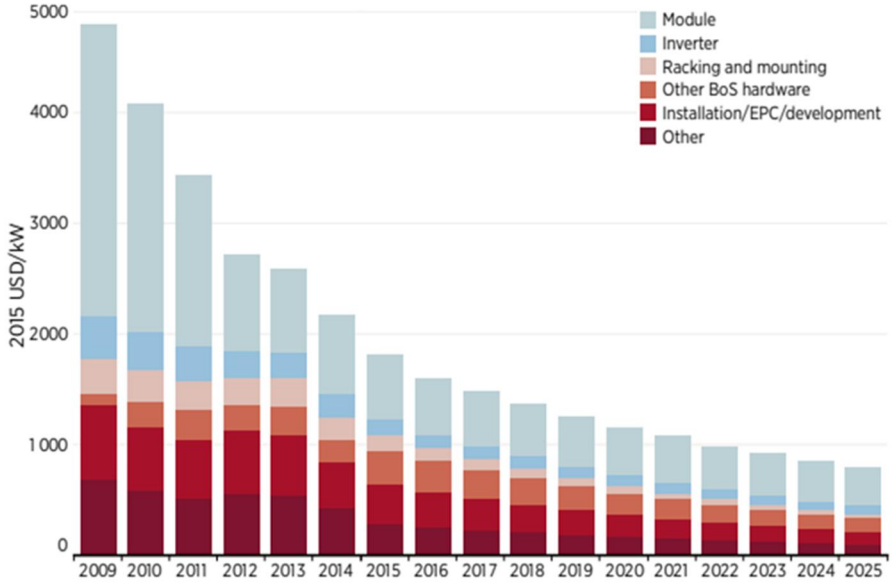


Fig. 5. Global weighted average PV installation costs, 2009-2025 [8]

6.2. Levelized Cost of Electricity (LCOE) Analysis

The calculation of the levelized cost of photovoltaic electricity (LCOE) is crucial in analyzing the financial viability of solar projects. This average discounted cost over the entire project lifetime depends on various factors such as the technology used, geographical location, and project-specific characteristics.

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \quad (1)$$

Where:

- LCOE : Average lifetime leveled cost of electricity production
- I_t : Investment expenditures in year t.
- M_t : Operation and maintenance expenditures in year t
- F_t : Fuel expenditures during year t.
- Et : Electricity production in year t.
- r : Discount rate.
- n : System lifetime.

The application of the LCOE model to the Algerian context must consider specific local parameters. The discount rate (r) should be adjusted to reflect country risk and local financing conditions. Furthermore, the absence of fuel cost (Ft ≈ 0) for PV represents a structural advantage compared to gas-fired power plants, but this advantage is partially masked by fossil fuel subsidies. Applying the LCOE model with local parameters (discount rate r = 8%, system lifetime n = 25 years, investment cost decreasing to 1.04 USD/W by 2025 [8,11,12]) yields an estimated LCOE of 0.025–0.035 €/kWh for utility-scale PV plants in southern Algeria. This compares favorably with the subsidized cost of natural gas-based electricity (approximately 0.04–0.05 €/kWh when subsidies are removed), demonstrating increasing competitiveness of solar PV. A sensitivity analysis of LCOE to variations in solar irradiation (particularly high in the South), initial investment cost, and discount rate would be highly instructive for investors.

7. Discussion: Critical Analysis of Challenges and Strategic Opportunities

7.1. Main Challenges

Algeria has not successfully implemented the 2015-2030 energy program, leading to its revision to target 15,000 MW by 2035, due to several factors. Beyond the identified challenges, the analysis reveals a structural problem of path dependency. The Algerian economy, historically structured around hydrocarbons, faces institutional barriers and socio-technical system inertia [9].

- **Financial difficulties:** Budget constraints and problems attracting foreign investment.

- **Economic dependence:** Heavy reliance on oil and gas revenues complicates the energy transition.
- **Grid integration:** Requires adapted infrastructure such as robust transmission networks.
- **Grid stability and intermittency management:** The variable nature of solar generation requires advanced grid management solutions and potential energy storage integration [10].
- **Technical skills:** Lack of specialized technical skills and qualified personnel.
- **Industrial limitations:** Weak local PV component industry leads to import dependency, affecting the balance of payments and limiting the creation of a national value chain.

7.2. Strategic Opportunities

The PV program offers significant opportunities. The PV program should be seen as a lever for industrial development and not only energy. The strategic opportunity lies in developing an integrated industrial sector, from module manufacturing to R&D adapted to desert conditions (resistance to sandstorms, thermal optimization) [5].

- **Economic diversification**: Creation of new industries and thousands of direct and indirect jobs
- **Gas conservation**: Potential to save billions of cubic meters of natural gas for export or local valorization
- **Environmental benefits**: Reduction of greenhouse gas emissions between 7% and 22% by 2030
- **Regional leadership**: Algeria's geographical position makes it a potential hub for green electricity exports to Europe and for green hydrogen production, opening new international markets.

Table 2 summarizes the quantitative evolution and future trajectory of solar PV development in Algeria. The data reveal a significant acceleration from a modest baseline of 1.1 MW in 2015 to 356.1 MW by 2021, primarily driven by the first phase of the national renewable energy program [4,7]. The projected leap to 13,575 MW by 2030 and 15,000 MW by 2035 underscores the strategic scaling-up envisioned in the revised national strategy [7].

Economically, the declining LCOE trend—from 0.12–0.15 €/kWh in 2015 to an anticipated 0.020–0.030 €/kWh by 2035—reflects global cost reduction patterns [8] and Algeria's high solar irradiation advantage [4]. This positions solar PV as increasingly competitive against subsidized natural gas, whose true generation cost is estimated at 0.04–0.05 €/kWh. Socio-economically, the program is expected to generate substantial employment, with job creation scaling from ~3,000 in 2021 to ~70,000 by 2035, supporting economic diversification goals. Environmentally, the projected CO_2 reduction of 12–15 Mt/year by 2035 aligns with Algeria's commitment to reduce greenhouse gas emissions by 7–22% under its Nationally Determined Contributions [7].

Table 2. Comparative analysis of solar PV development in Algeria

Parameter	2015 (Baseline)	2021(Current)	2030 (Target)	2035(Revised Target)
Installed PV capacity (MW)	1.1	356.1	13,575	15,000
PV share in electricity mix	<0.1%	0.8%	27%	30%
Estimated LCOE (€/kWh)	0.12–0.15	0.04–0.06	0.025–0.035	0.020–0.030
Job creation (direct+indirect)	~500	~3,000	~45,000	~70,000
CO_2 reduction (Mt/year)	-	0.3	8–10	12–15

8. Conclusion

This analysis demonstrates that Algeria possesses the natural assets and political will to make solar photovoltaic a pillar of its energy transition. The ambitious program of 15,000 MW by 2035, materialized by the launch of the 2024 projects, marks a point of no return. However, achieving these objectives requires moving beyond sectoral approaches to an integrated vision. The importance of advanced control techniques for grid-tied PV systems, such as those discussed in [10], should be considered in the national strategy.

To achieve the 15,000 MW target by 2035, Algeria needs annual investments of approximately 1.2–1.5 billion USD, creating an estimated 50,000–70,000 direct and indirect jobs. Specific quantified policy recommendations include:

1. Subsidy reform: Implement a progressive reform of fossil fuel subsidies with a gradual reduction of 20% annually, reallocating 300–400 million USD/year to renewable energy incentives.

2. Regulatory framework: Finalize and enact an attractive regulatory framework for Public-Private Partnerships (PPPs), including guarantees and administrative simplification to mobilize the required investments.

3. Skills development and capacity building: Launch a national training program for renewable energy professions, in partnership with universities and research centers, aiming to train 5,000 technicians and engineers in PV technologies by 2030.

4. Grid integration and investment: Accelerate investments in smart grid infrastructure and energy storage to manage intermittency, allocating 2–3 billion USD for smart grid infrastructure to enable 30% renewable penetration.

5. Local manufacturing: Achieve 40% local content in PV systems by 2030 through industrial partnerships, fostering job creation and technological transfer, and reducing import dependency.

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