

The State of Renewable Energy in Algeria: Performance Indicator Analysis and Development Implications 2020–2024

Kada BOUDOUR*

Laboratory of Human capital and
economic transformation,
University of Naama, Algeria
boudour.kada@cuniv-naama.dz

Mebarka ABDELLI

Laboratory of Human capital and
economic transformation,
University of Naama, Algeria
abdelli@cuniv-naama.dz

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Abstract:

This study examines the evolution of renewable energy in Algeria over the period 2020-2024, using installed capacity as a structural indicator of renewable energy infrastructure development. It analyses growth trends and the technological composition of the national energy mix. A development-oriented perspective is incorporated through the use of the watts per capita indicator (W/capita), allowing for a more accurate assessment of renewable energy performance in relation to population dynamics. Consistent with SDG indicator 7.b.1 the analysis relies on IRENA statistical publications, using secondary time-series data on renewable installed capacity combined with population data within an international per capita framework.

The Results indicate modest and volatile growth in renewable installed capacity, largely dominated by solar power, with limited contribution from wind energy. Furthermore, no sustained improvement is observed in per-capita capacity, mainly due to population growth which offsets infrastructure expansion.

Key Words: Installed capacity; renewable energy; renewable energy mix ; performance indicators; sustainable development; watts per capita; Algeria.

JEL Classification : Q42, Q48, O13

* Corresponding author: Boudour Kada (*boudour.kada@cuniv-naama.dz*)

Introduction:

The global energy sector is undergoing rapid transformations, with the integration of renewable energy emerging as a strategic priority within modern power systems. This shift is driven by several factors, including the need to reduce exposure to volatility in oil and gas markets, enhance energy security, and diversify electricity generation sources to mitigate the risk of supply disruptions. It also reflects long-term environmental and economic sustainability objectives, particularly through reducing emissions, improving resource efficiency, and supporting sustainable growth. In addition, investment in renewable technologies such as solar and wind energy contributes to infrastructure modernization, job creation, and broader

development outcomes.

In this context, Algeria possesses significant natural potential for renewable energy, particularly in solar resource, making it a relevant case for analysis. Accordingly, assessing the development of this sector in recent years has become essential, from both a scientific and practical perspective. From a scientific standpoint, it allows for the examination of performance trends and the evolution of installed capacity. From a practical standpoint, it helps identify structural strengths and weaknesses and determine the necessary measures to improve sector performance through measurable and monitorable approaches. Beyond measuring progress, it is also important to evaluate whether current development are sufficient to meet actual energy needs and align with the country's energy transition objectives.

Building on these perspectives, the renewable installed capacity per capita indicator is used to assess the level of renewable infrastructure relative to population size. This approach is increasingly relevant for quantitative analysis, particularly when linked to the Sustainable Development Goals, notably SDG indicator 7.b.1. it enables more consistent cross-country comparisons, especially among countries with different population sizes, and provides a more accurate assessment of national performance by transforming absolute values into relative measures that better reflect real access to energy and future expansion potential.

Problematic: In light of the foregoing, the research problem may be formulated in the following main question: **What is the status of renewable energy, based on an analysis of installed capacity and the performance indicators derived therefrom, over the period 2020-2024 in Algeria?**

Building on this main problem, the following sub-questions are posed:

- How did the installed capacity of renewable energy evolve during the study period?
- What were the type and pace of annual capacity additions, and how did they influence the structure of the renewable energy mix by technology?
- To what extent does the analysis of renewable capacity on per-capita basis contribute to understanding the developmental implications of this trajectory?

Study Hypothesis: Based on these questions, the study proposes the following hypotheses:

- The installed capacity of renewable energy experienced limited growth during the period 2020-2024.
- The pace of annual additions was characterized by volatility over the study period.
- There is a technological concentration in favor of solar energy compared with other technologies, reflecting limited diversification in the renewable energy mix.

Study importance: The significance of this research lies in analyzing the trajectory of renewable energy development in Algeria over the period 2020-2024. Its moves beyond a purely descriptive approach toward a rigorous quantitative assessment based on measurable and trackable indicators. The study employs installed capacity as a structural indicator, complemented by derived performance indicator that enhance the precision of the evaluation. It also uses standardized tools particularly the renewable capacity per capita indicator to enable a more consistent interpretation of change over time and to align the analysis with the sustainable development goals, specifically SDG 7.b.1. in addition, the study provides practical insights for decision-makers and stakeholders involved in energy planning.

Study objectives: This study aims to:

- Provide an overview of the evolution of renewable energy installed capacity in Algeria over the period 2020-2024.
- Calculate derived performance indicators, including growth rates, technology-specific shares, and renewable capacity per-capita.
- Interpret the developmental implications of the findings and propose practical, implementable recommendations.

Methodology: this study adopts an applied quantitative approach to address the main research question; it relies on official secondary data to compute a set of derived performance indicators primarily based on installed capacity.

I. Previous study:

(bouznit et all , (2020)) Examined the potential of renewable energy development in Algeria by focusing on alternative electricity generation sources beyond fossil fuels. the study emphasized the significant investment made during the 2015-2030 period, which contributed to improving the investment climate in the renewable energy sector. It highlighted the importance of legislative framework, financial support mechanisms, incentive tariff systems and tax incentives in achieving the targeted energy mix.

(Mahmoudi et all, (2023)) analyzed the relationship between hydrogen (H₂) production and the development of the global gas industry. The study applied a proposed system to a site in Laghouat province, considering its geographical characteristics. based on climatic data classified according to the Koppen-Geiger system, the authors designed a hybrid energy system using the HOMER software, integration photovoltaic panels a battery bank and a diesel generator. The results showed that this configuration reduces energy production costs and improves energy balance and environmental performance although it is not fully optimal.

(Boke et all,(2022)) assessed the optimal renewable energy mix for electricity generation and the associated investment costs in Ethiopia using both a business-as-usual scenario and a domestic reform scenario, the study projected that electricity

the demand will increase significantly by 2050. It concluded that expanding installed capacity is necessary to meet future demand and support the energy transition, particularly for middle-and upper- income population groups.

1. Research gap:

Despite the valuable contributions of previous studies on renewable energy policies and development, limited attention has been given to short-term analytical assessments focusing on specific periods such as 2020-2024. Moreover, existing studies rarely employ performance indicators directly derived from installed capacity, including growth rates, technology-specific shares and renewable capacity per capita.

In addition, insufficient emphasis has been placed on interpreting the developmental implications of these indicators in a structured and measurable way. This Gap highlights the need for a more focused and indicator-based analysis, particularly in the Algerian context.

II. Conceptual Framework of renewable energy and installed capacity:

1. Definition of renewable energy and its types:

The United Nations Environment Program defines it as energy derived from nature and characterized by a stable stock, as it is replenished periodically at a rate faster than the pace of consumption (fatiha, 2023, p. 18) (Tayeb, 2019, p. 69)

Also refers to energy sources that are naturally replenished through continuous environmental cycles, such as solar, wind, hydropower and others, and are used to generate electricity to varying degrees depending on technical characteristics, available resources, and the national context. These sources can be classified and aggregated into standard technological categories, enabling international comparison and longitudinal monitoring (Amin, 2023, p. 3)

2. Installed capacity:

Installed capacity in the renewable energy sector refers to the total electricity generation capacity from renewable sources that is officially recorded and available at a given point in time, typically measured at year-end. It represents the maximum potential output of installed systems but does not necessarily reflect actual electricity generation (IRENA, 2024, p. 6).

Accordingly, this study adopts installed capacity as an input/structural indicator to track the expansion trajectory, and it reinforces it with derived indicators (growth trends, annual volatility, technology shares, and renewable capacity per-capita) to strengthen the explanatory power of the results (Ortiz, 2020, pp. 1-10).

3. Renewable energy mix: (IRENA, 2024)

The renewable energy mix refers to the relative distribution of different renewable energy technologies -such as solar, wind, and hydropower- within total renewable installed capacity. It reflects the degree of technological diversification in the renewable energy system.

4. Performance indicators in evaluating energy policies:

Performance indicators are used to evaluate energy policies and public programs by translating broad objectives into metrics that can be monitored and compared over time. This supports decision-making, improves resource allocation, highlights implementation gaps, and assesses the extent to which outcomes align with national targets or relevant international frameworks (IAEA, 2005, p. 45).

5. Renewable energy and sustainable development: Linking per-capita capacity to SDG 7:

The development of renewable energy is closely linked to sustainable development goal 7 (SDG 7), particularly target 7.b, which focuses on expanding infrastructure and upgrading technology to provide modern and sustainable energy services. For this purpose, SDG indicator 7.b.1 is used, defined as installed capacity for generating electricity from renewable sources divided by the total population, expressed in watts per-capita (W/Capita). According to the methodology of this indicator, capacity is measured as net maximum electrical capacity at year-end, while population is taken from mid-year estimates; the indicator is typically calculated by dividing end-of-year capacity by the mid-year population (usually 01 June), ensuring comparability and standardization across countries (UNECE).

This indicator enables a simplified development-oriented reading of the expansion of renewable infrastructure after controlling for population size. At the same time, it should be recognized as a useful “baseline” monitoring indicators that does not replace other measures -when available – such as actual electricity generation, service quality and the impacts of investments, which are needed for a more comprehensive assessment of outcomes (IAEA, 2005, p. 53).

III. Data and methodology:

1. data sources:

Renewable installed capacity data were drawn from IRENA databases on electricity-generation capacity from renewable sources for the period 2020-2024 (IRENA, 2024). In line with the United Nations methodology for SDG indicator 7.b.1 and international standards for compiling energy statistics, installed capacity is collected through a regular annual questionnaire cycle administered by IRENA in coordination with Member States, and the resulting figures are reviewed and validated against official national sources. Preliminary estimates are published and subsequently complemented with final figures following additional verification, which strengthens the reliability and accuracy of the time series used in the analysis (IRENA, 2024). Data for 2020-2023 were taken from the IRENA Renewable Capacity Statistics 2024 edition, while 2024 data were taken from the IRENA Renewable Capacity Statistics 2025 edition (updated series through end-2024) (IRENA, 2024).

2. Operational definitions of variables:

In this study, renewable installed capacity is operationally defined as the “net maximum electrical capacity at year-end” installed and available at the end of the year, as reported in the adopted source dataset. It is measured in (MV) and converted, when needed to (W) for the purpose of calculating the renewable capacity per-capita indicator according to the following formula:

$$\text{capacity per capita} = \text{renewable capacity (W)} \div \text{population (persons)}$$

this definition is used as a unified standard that enables comparability across years, while emphasizing that the indicator reflects available installed capacity rather than actual electricity generation (IRENA.2024).

the installed renewable installed capacity per-capita indicator is defined as total installed capacity (in watts) divided by the total population (mid-year estimate), with the result expressed in watts per-capita (W/Capita). This definition is formally adopted in United Nations methodological documentation for SDG indicator 7.b.1, and the indicator is used to interpret the development dimension of renewable capacity expansion through its direct linkage to the Sustainable Development Goals (Nations, 2024).

3. Construction of the adopted performance indicators:

The study adopted a set of derived performance indicators computed from installed capacity data in order to provide a multidimensional reading of sector performance (IAEA, 2005)

-Annual growth rate of installed capacity: calculated as

$$\text{Growth Rate}_t = \left(\frac{\text{Cap}_t - \text{Cap}_{t-1}}{\text{Cap}_{t-1}} \right) \times 100$$

Reflecting the percentage increase or decrease in installed capacity between two consecutive years.

-Average growth rate over 2020-2024: computed either as the arithmetic mean of the annual growth rates or as a cumulative/aggregated growth measure to capture the overall trend and its stability across the study period.

-Compound annual growth rate (CAGR) for 2020-2024: to measure the overall trend while accounting for compounding effects, CAGR is calculated as:

$$CAGR = \left(\frac{C_{t+n}}{C_t} \right)^{\frac{1}{n}} - 1$$

where C_t is installed capacity in the initial year, C_{t+n} is installed capacity in the final year, and n is the number of years between them (here, $n = 4$). (Investopedia)

-Technology shares of the total: the share of each renewable source (solar, wind, hydropower, other) in total installed capacity, used to assess the degree of diversification versus technological concentration in the renewable mix.

-Stability indicator: measured through the variability of annual growth rates -using either the standard deviation or the range of change (maximum minus minimum)- in order to distinguish steady, consistent expansion from intermittent and volatile expansion.

-Renewable capacity per capita indicator: calculated as

$$\text{capacity per capita} = (\text{total capacity (W)} \div \text{population})$$

providing a simplified development-oriented reading of the renewable expansion path that is consistent with SDG indicator 7.b.1.

These indicators provide a structured framework for linking statistical data to the interpretation of renewable energy development performance.

4. Results:

4.1. Evolution of total installed capacity (2020-2024):

Table 01: Evolution of Total Renewable installed Capacity in Algeria (2020–2024)

Year	Total capacity	Annual addition	Annual growth rate
2020	585	–	–
2021	506	–79	–13.5
2022	590	+84	+16.6
2023	601	+11	+1.86
2024	601	0	0.00
TOTAL	–	+16	2.74

(maximum net generating capacity; end-year installed and connected), Accessed on 09 /01/2026.

Source: IRENA (International Renewable Energy Agency). Renewable Capacity Statistics 2025
<https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025>

Table 1 presents the evolution of total renewable installed capacity in Algeria over the period 2020-2024. The data show a generally modest and uneven growth trajectory.

Renewable installed capacity decreased from 585 MW in 2020 to 506MW in 2021, reflecting a significant contraction (-13.5%). This decline was followed by a strong rebound in 2022, with capacity increasing to 590MW (+16.6%), indicating a temporary acceleration in new installations.

In 2023, growth slowed considerably, with capacity reaching 601MW (+1.86%), suggesting a return to a low expansion pace. In 2024, installed capacity remained unchanged at 601MW, indicating a stagnation in renewable energy development.

Overall, the cumulative increase in installed capacity over the five-year period was limited, rising from 585MW to 601MW, representing a net addition of only 16MW. This corresponds to an average growth rate of approximately 0.68% per year, confirming the weak and unstable nature of renewable energy expansion in Algeria during the study period.

Note: CAGR (2020-2024) = $\sqrt[4]{(601/585)} - 1 = 0.00677 \approx 0.68\%$ per year, (after multiplying to convert to%).

4.2 Distribution of Renewable installed capacity by technology:

Table 02: Distribution of Renewable Installed Capacity by Technology and Relative Shares

Year	Solar	Solar share	Hydroelectric	Hydro Power share	Other	Another share	Winds	Winds share
2020	367	62.74	209	35.73	10	1.71	0	0
2021	367	72.53	129	25.49	10	1.98	0	0
2022	451	76.44	129	21.86	10	1.69	0	0
2023	462	76.87	129	21.46	10	1.66	0	0
2024	462	76.87	129	21.46	10	1.66	0	0

(maximum net generating capacity; end-year installed and connected), Accessed on 09 /01/2026.

Source: IRENA (International Renewable Energy Agency). Renewable Capacity Statistics 2025

<https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025>

Table 2 presents the distribution of renewable installed capacity in Algeria by technology and relative shares over the period 2020-2024, highlighting the structure of renewable energy mix.

The results indicate a strong and increasing dominance of solar energy. Solar capacity rose from 367 MV in 2020 to 462 MW from 2023 onwards, with its share increasing from 62.74% to 76.87% of total installed capacity. This confirms that renewable energy expansion during the study period was primarily driven by solar power development.

In contrast, hydropower experienced a significant decline, with its capacity decreasing from 209 MW in 2020 to 129 MW in 2021, and remaining unchanged thereafter. As a result, its share dropped sharply from 35.73% to 21.46%, reflecting a structural shift in the renewable energy mix in favor of solar energy.

The “other” category remained relatively stable at around 10 MW, with a marginal share fluctuating between 1.66% and 1.98%, indicating a limited contribution of alternative renewable technologies. Wind energy, on the other hand, recorded no installed capacity throughout the entire period, suggesting its absence from the operational renewable energy mix in Algeria.

Overall, the renewable energy mix in Algeria is characterized by a high level of technological concentration, with a clear dominance of solar energy and limited diversification across other technologies. This stricture indicates a lack of balance in the renewable energy system, which may reduce flexibility and limit the ability to address variability and seasonality in electricity generation.

4.3 Renewable installed capacity per capita indicator:

**Table 03: Renewable Installed Capacity per Capita in Algeria
(2020–2024)**

Year	Population	Total capacity mw	W/capita	Kw/capita
2020	44042091	585	13.283	0.0133
2021	44761099	506	11.305	0.0113
2022	45477389	590	12.974	0.0130
2023	46164219	601	13.019	0.0130
2024	46814308	601	12.838	0.0128

(maximum net generating capacity; end-year installed and connected), Accessed on 09 /01/2026.

UNECE (United Nations Economic and Social Commission for Western Asia). SDG Indicator 7.b.1: Installed renewable electricity-generating capacity, all renewables (indicator definition and methodology), Accessed on 09 /01/ 2026.

Source: IRENA (International Renewable Energy Agency). Renewable Capacity Statistics 2025

<https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025>

<https://w3.unece.org/SDG/en/Indicator?id=235>

Table 3 presents the evolution of renewable installed capacity per capita in Algeria over the period 2020-2024, providing a population-adjusted perspective on renewable energy development.

The results indicate an overall decline in renewable installed capacity per capita, from 13.283 W/capita in 2020 to 12.838 W/capita in 2024, representing a decrease

of approximately 3.35%. This decline occurred despite the relative stability and slight increase in total installed capacity over the same period.

This trend suggests that the expansion of renewable installed capacity did not keep pace with population growth, which averaged approximately 0.78% annually. As a result, the availability of renewable energy capacity per person has effectively decreased.

From a developmental perspective, this indicates growing pressure on renewable energy infrastructure relative to population needs, highlighting limitations in the current expansion trajectory. This finding is consistent with SDG indicator 7.b.1, which emphasizes the importance of increasing renewable capacity in proportion to population growth.

4.4 Summary of results:

The results indicate that renewable installed capacity in Algeria experienced only limited cumulative growth over the period 2020-2024, with a net increase of +16MW (+2.74%), reflecting modest structural expansion.

From a technological perspective, this growth was primarily driven by solar energy, which recorded an increase of +95 MW (+25.89%), becoming the dominant component of the renewable energy mix. In contrast, hydropower declined significantly (-80 MW, -38.28%) before stabilizing, while wind energy recorded no installed capacity throughout the study period. The “other” category remained marginal, confirming the lack of technological diversification.

From a developmental perspective, the renewable installed capacity per capita indicator shows a decline from 13.283 W/capita in 2020 to 12.838 W/capita in 2024, indicating that capacity expansion did not keep pace with population growth. This suggests increasing pressure on renewable energy infrastructure relative to population needs.

Overall, the results highlight a pattern of slow, uneven, and weakly diversified expansion, with growth occurring through intermittent increases rather than a sustained upward trajectory.

IV. Discussion:

1. Reading the overall growth trend:

The results indicate that the expansion of renewable installed capacity was limited at the aggregate level and characterized by year-to-year volatility. This pattern reflects a slow and uneven development trajectory, suggesting that the dynamics of capacity additions have not yet produced a clear structural shift in the renewable energy sector (Tayeb, 2019, pp. 70-73).

2. Significance of the solar focus:

The dominance of solar energy, exceeding 76% since 2023, indicates that renewable energy expansion has largely relied on a single technology. While this focus may be justified by Algeria's strong solar potential, it also increases the need for flexibility mechanisms, such as grid upgrades, storage systems, and load management (Boumediene, 2018).

3. Decline in hydropower and the meaning of subsequent stability:

The decline in hydropower capacity between 2020 and 2021, followed by stabilization until 2024, suggests limited new additions in this component compared with solar energy. This has reduced its relative share in the renewable energy mix and weakened its role in balancing the energy system (Brazza, 2020, pp. 2-6).

4. Interpreting the per capita capacity indicator (W/Capita) and assessing the development gap:

The renewable installed capacity per capita indicator shows that capacity expansion did not keep pace with population growth. This highlights a development gap, as the increase in total installed capacity was insufficient to improve renewable capacity availability per person. Therefore, per-capita indicators provide a more accurate assessment of development performance than total capacity alone.

5. Practical and policy implications:

The findings suggest that future renewable energy policy should move from limited and intermittent expansion toward a more regular, diversified, and measurable development path. Priority should be given to accelerating capacity additions, diversifying the renewable energy mix, strengthening grid infrastructure, and integrating SDG indicator 7.b.1 into national monitoring frameworks (Bakdi, 2025, pp. 299-305)

Conclusion:

This study concludes that the evolution of renewable installed capacity in Algeria over the period 2020–2024 has been characterized by limited growth and year-to-year volatility, alongside a clear concentration in favor of solar power, which became the dominant component of the renewable mix by the end of the period. In contrast, hydropower capacity declined at the beginning of the period and then stabilized at a lower level, while no effective wind capacity contribution was recorded in the adopted series, and the “other” category remained constant at a marginal level. Finally, the watts per capita (W/Capita) indicator underscores the importance of assessing expansion after controlling for population growth, supporting the conclusion that increasing capacity alone is insufficient unless accompanied by a higher pace of additions and a more diversified mix.

Recommendations:

- Accelerate the pace of annual additions in solar installed capacity while integrating flexibility solutions (storage/control/forecasting) so that solar dominance does not become a source of operational vulnerability.
- Launch a concrete pathway to diversify technologies, particularly through wind projects where feasibility is demonstrated, to strengthen the mix and reduce reliance on a single source.
- Preserve existing hydropower capacity and improve its operational management where possible, given its potential role in flexibility, while avoiding assumptions of major expansion in hydropower unless enabling conditions are in place.
- Adopt SDG indicator 7.b.1 within an annual national monitoring dashboard, as it links capacity expansion to population and improves interpretation of development impacts.
- In future assessments, complement installed-capacity evaluation with operational indicators (actual generation and capacity factor) to build a more comprehensive picture of performance.

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