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The Impact of Renewable Energy Consumption on Economic Growth in Algeria: An Econometric Study for the Period 1990-2022

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Abstract:
This study aims to analyze the relationship between renewable energy consumption and economic growth in Algeria during the period 1990-2022. Using the cointegration methodology and Error Correction Model (ECM), the results showed a long-run equilibrium relationship between the variables, where a 1% increase in renewable energy consumption leads to a 0.15% increase in GDP in the long term. Granger causality tests also revealed a bidirectional causal relationship between the variables, confirming the Feedback Hypothesis. The study recommends enhancing investments in the renewable energy sector and providing a stable policy environment to maximize its contribution to economic growth.

Keywords: Renewable Energy; Economic Growth; Cointegration; Algeria
Jel Classification Codes:Q43; O13; C22

Introduction

The relationship between renewable energy and economic growth is central in contemporary economic literature, amid intertwined challenges of sustainable development and climate change mitigation (Al-Ayouty, 2024).

Renewables emerge as a strategic option for nations, offering energy mix diversification, enhanced security, and vital reductions in greenhouse gas emissions. They support Sustainable Development Goals, particularly Goal 7 (affordable clean energy) and Goal 13 (climate action) (Saad & Boussi, 2025).

Empirical Literature Insights

Empirical studies show varying results on renewable energy and economic growth due to national contexts and analytical methods. Ben Saad et al. (2024) found a nonlinear, asymmetric relationship in North African countries (Algeria, Egypt, Morocco), where positive shocks from renewable electricity production outweigh negative ones.

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Gyau et al. (2024) identified an inverse link between renewable consumption and carbon emissions in MENA, highlighting environmental benefits.

Algerian Context

In Algeria, heavy reliance on hydrocarbons (over 90% of exports, ~60% of budget; World Bank, 2024) exposes the economy to oil/gas price volatility, necessitating diversification led by renewables. Algeria launched a program targeting 22,000 MW from renewables by 2030 (~27% of total production; Ministry of Energy, 2023). Capacity rose from 355 MW (2015) to 628 MW (2022), with sector GDP share increasing from 0.5% to 2.7% (IRENA, 2023).

Despite renewable energy advances, applied literature on its economic growth link in Algeria remains limited, especially lacking advanced econometric models. Most works are descriptive or regional, overlooking Algeria's structural specifics (Ben Saad et al., 2024).

Problem Statement

This study addresses: To what extent does renewable energy consumption impact economic growth in Algeria (1990–2022)?

Methodology

It employs cointegration tests and Error Correction Models (ECM) with annual data from the World Bank and International Energy Agency.

Contributions

Provides in-depth quantitative analysis for Algeria, tests energy-growth hypotheses (growth, conservation, feedback, neutrality), and offers practical policy recommendations.

Study Structure

Following this introduction: Section 2 reviews theory and prior studies; Section 3 details methodology and data; Section 4 presents and discusses results; Section 5 concludes with key findings and recommendations.

1. Theoretical Framework and Prior Studies

1-1 Theoretical Approach to Renewables' Impact on Growth

The energy consumption-economic growth nexus rests on economic theory viewing energy as a key production input alongside labor and capital. Economic literature outlines four main hypotheses explaining this relationship:

- **Growth Hypothesis**: Unidirectional causality from energy consumption to growth—increasing energy spurs economic expansion.
- **Conservation Hypothesis**: Reverse causality—growth drives energy demand.
- **Feedback Hypothesis**: Bidirectional causality, indicating mutual interplay.
- **Neutrality Hypothesis**: No significant causal link (Ben Saad et al., 2024).

The Asymmetric Effects Theory offers a key advancement in analyzing renewable energy's impact on growth, assuming differential responses to positive versus negative production shocks. These arise from sector investments' high capital demands and extended timelines, rendering decisions acutely responsive to policy shifts and economic volatility (Ben Saad et al., 2024). Shin et al. (2014) advanced this via the Nonlinear ARDL (NARDL) model for nuanced asymmetric modeling.

Conversely, the Environmental Kuznets Curve (EKC) elucidates the nonlinear growth-degradation dynamic, where pollution escalates in initial development phases before declining beyond a critical income level (Al-Ayouty, 2024). Renewables expedite this inflection by supplying clean substitutes that sever growth's environmental ties.

Additionally, Dixit and Pindyck's (1994) Investment under Uncertainty theory, rooted in real options, explains renewable sector caution: investors defer amid opacity, exacerbated by sunk costs, investment irreversibility, and prolonged paybacks (International Economics and Economic Policy, 2025).

2-1 Previous Studies

- **African Context Studies**

Gyimah et al. (2023) analyzed globalization (FDI, trade openness), renewables, and growth effects on CO2 emissions in 10 top African economies (1990–2020). Using CS-ARDL and NARDL robustness, renewables significantly reduced emissions short- and long-term.

- **MENA Region Studies**

Saad and Boussi (2025) examined ICT, human development, military spending, and renewables' environmental impacts (CO2, ecological footprint, GHG emissions) in 10 MENA countries (2001–2022). PMG-ARDL confirmed EKC validity, indicating nonlinear growth-degradation ties.

- **Energy Efficiency Studies**

Liu et al. (2025) investigated energy-growth decoupling in 22 African countries (1990–2017) using LMDI decomposition and panel models. Results showed sectoral efficiency gains and structural economic shifts reduced energy demand by ~22% and 18%, respectively, underscoring their pivotal role in sustainable, efficient growth.

- **Nonlinear Relationship Studies**

Gyau et al. (2024) explored linear/nonlinear ties between renewable consumption and environmental quality in 8 MENA countries (2000–2020) using PMG, MG, and DCCEMG models. Findings confirmed negative linear/nonlinear CO2 links, affirming renewables' positive environmental role.

- **North African Regional Analysis**

Ben Saad et al. (2024) assessed asymmetric renewable electricity production effects on growth in Algeria, Egypt, Morocco, and Tunisia (1990–2021) via NARDL. Long-run nonlinear/asymmetric relationships emerged, with positive shocks outweighing negatives—indicating growth's greater sensitivity to renewable expansion.

Finally, the study by Singh et al. (2025) examined the combined asymmetric effects of economic policy uncertainty—including fiscal, monetary, trade, and exchange rate policies—on both economic growth and renewable energy consumption in Japan over the period 1987–2021. The study employed the Quantile-on-Quantile Regression (QQR) methodology and machine learning techniques (KRLS). The findings revealed that uncertainty related to fiscal policy

and the exchange rate negatively affects economic growth, whereas uncertainty in monetary and trade policies has a positive impact on it.

From these studies, it can be concluded that the relationship between renewable energy and economic growth is complex and multidimensional, influenced by a range of interrelated factors, most notably the degree of economic policy uncertainty, structural shifts in the economy, and the level of technological advancement. In this context, the present study falls within this research trajectory, as it seeks to analyze the Algerian case in depth, drawing on the theoretical and methodological developments produced by recent literature, thereby contributing to a more precise understanding of the specificities of this relationship in the Algerian economy.

1-3 Study Hypotheses

This study tests four main hypotheses:

- **Growth Hypothesis (H1)**: Unidirectional causality from renewable energy consumption to economic growth in Algeria.
- **Conservation Hypothesis (H2)**: Unidirectional causality from economic growth to renewable energy consumption in Algeria.
- **Feedback Hypothesis (H3)**: Bidirectional causality between renewable energy consumption and economic growth in Algeria.
- **Neutrality Hypothesis (H4)**: No causal relationship between renewable energy consumption and economic growth in Algeria.

2. Overview of Algeria's Renewables Sector Evolution

Algeria's renewables sector has seen notable progress recently. Figure 1 illustrates total renewable capacity growth from 2015 to 2022.

Figure 1: Total Renewable Capacity Evolution in Algeria (MW)

years	**Total Capacity (MW)**
2015	355
2016	387
2017	420
2018	452
2019	490
2020	533
2021	577

years	**Total Capacity (MW)**
2022	628

Source: Algerian Renewable Energy Agency, 2023

- **Capacity Growth Analysis**

Figure 1 shows total renewable capacity rose from 355 MW in 2015 to 628 MW in 2022—a 77% increase—reflecting successful ambitious government programs.

3. Study Methodology and Data

3-1 Data Sources

The study uses annual data (1990-2022) from the following:

Table1 : Data Sources

Variable	Symbol	**Source**
Real GDP (Million USD)	GDP	World Bank
Renewable Energy Consumption (%)	REC	International Energy Agency (IEA)
Gross Fixed Capital Formation (Control Variable)	INV	World Bank
Labor Force (Control Variable)	LAB	World Bank

Source: Prepared by Researchers

3-2 Econometric Model

The Cointegration methodology and Error Correction Model (ECM) were employed to test the relationship between the variables, according to the following equation:

$$\Delta \ln GDP_t = \alpha + \beta 1 \Delta \ln REC_t + \beta 2 \Delta \ln INV_t + \beta 3 \Delta \ln LAB_t + \gamma ECT_{t-1} + \varepsilon_t$$

where **ECTt−1ECT_{t-1}ECTt−1** is the error correction term derived from the long-run equilibrium relationship.

3-3 Preliminary Tests

Table 2. Unit Root Test Results (ADF)

variable	Level	First Difference	Order of Integration
lnGDP	-1.98	-4.56***	I(1)
lnREC	-1.76	-5.12***	I(1)

variable	Level	First Difference	Order of Integration
lnINV	-2.12	-4.89***	I(1)
lnLAB	-1.54	-5.34***	I(1)

Source: Prepared by researchers using EViews 12

Note: * indicates significance at the 1% level**

The results show that all variables are non-stationary at level and become stationary after first differencing, justifying the use of cointegration methodology.

4. Results and Discussion

4-1 Cointegration Test Results

Table 3. Johansen Cointegration Test Results

Hypothesis	Eigenvalue	Trace Statistic	Critical Value 5%
r = 0	0.48	54.23	47.21
r ≤ 1	0.32	28.76	29.68
r ≤ 2	0.18	12.34	15.41

Source: Prepared by researchers using EViews 12

The results indicate the existence of at least one cointegration relationship at the 5% significance level, confirming a long-run equilibrium relationship between the variables.

4-2 Long-run Relationship Estimation Results

Table 4. Long-run Relationship Estimation

variable	Coefficient	Standard Error	Probability
lnREC	0.152	0.048	0.003
lnINV	0.324	0.087	0.001
lnLAB	0.456	0.124	0.002
constant	4.23	1.56	0.008

Source: Prepared by researchers using EViews 12

The results indicate a positive and significant impact of renewable energy consumption on economic growth in the long run, where a 1% increase in

renewable energy consumption leads to a 0.152% increase in GDP. This aligns with previous studies in the region (Ben Saad et al., 2024; Al-Ayouty, 2024).

4-3 Error Correction Model (ECM) Results

Table 5. Error Correction Model Estimation

variable	Coefficient	Standard Error	Probability
ΔlnREC	0.076	0.028	0.012
ΔlnINV	0.187	0.054	0.002
ΔlnLAB	0.234	0.089	0.015
ECT(-1)	-0.287	0.076	0.001

Source: Prepared by researchers using EViews 12

The error correction coefficient (-0.287) is negative and significant, confirming the existence of a long-run equilibrium relationship. This coefficient indicates that approximately 28.7% of the long-run disequilibrium is corrected annually, meaning the return to equilibrium takes about 3.5 years.

4-4 Causality Test Results

Table 6. Granger Causality Test Results

Null Hypothesis	F-statistic	probability
GDP **No Causality** REC	4.87	0.015
GDP **No Causality**REC	5.23	0.008

Source: Prepared by researchers using EViews 12

The results indicate a bidirectional causal relationship between renewable energy consumption and economic growth, confirming the validity of the **Feedback Hypothesis** (third hypothesis) in the case of Algeria. This means that increased renewable energy consumption stimulates economic growth, while economic growth, in turn, increases demand for renewable energy.

4-5 Discussion of Results

The obtained results can be interpreted in light of several structural characteristics that distinguish the Algerian economy.

- **Gradual Renewable Energy Development**

First, the gradual development of the renewable energy sector—from increasing production capacity from 355 MW in 2015 to 628 MW in 2022—reflects its growing contribution to GDP, which rose from 0.5% to 2.7% during the same period, supporting the positive relationship between renewable energy and economic growth.

- **Investment and Employment Impact**

Second, increased investments in this sector, reaching approximately $5.5 billion in 2022, along with creating nearly 25,000 jobs, have boosted economic growth through two main channels: enhancing value added and improving labor market performance.

- **Bidirectional Causality Implications**

Third, the existence of a bidirectional causal relationship between renewable energy consumption and economic growth confirms that this sector is not merely a reflection of growth but also one of its main drivers, necessitating comprehensive policies to support investment and stimulate demand.

- **Feedback Hypothesis Validation**

The results highlight the validation of the **Feedback Hypothesis** over other hypotheses. The **Growth Hypothesis** was not confirmed due to a significant reverse causal relationship from economic growth to renewable energy consumption, explained by the sector's relatively weak weight and heavy reliance on government subsidies. The **Conservation Hypothesis** was also not confirmed due to a direct significant causal effect from renewable energy to economic growth, supported by its increasing GDP contribution and job creation role. Finally, the **Neutrality Hypothesis** did not hold due to the established bidirectional causality at high significance levels.

5-Conclusion :

The study concludes a positive and statistically significant relationship between renewable energy consumption and economic growth in Algeria, where a 1% increase in renewable energy consumption leads to a 0.15% rise in GDP in the long run. Results also confirm a bidirectional causal relationship between the variables, reflecting the validity of the **Feedback Hypothesis** in the Algerian context.

- **Recommendations :**
- Enhance investments in renewable energy through financial and tax incentives for local and foreign investors.
- Develop energy infrastructure to ensure more efficient integration of renewable sources into the national grid.
- Support scientific research and development in renewable technologies, considering Algeria's climatic and geographical specificities.
- Strengthen public-private partnerships for implementing major projects in this vital sector.
- Develop specialized training programs to build human capacities capable of keeping pace with rapid energy sector transformations.

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