

The role of investment in renewable energy in influencing Algerian economic growth during the period 1990 to 2022.

Ihssan Tounes Youkana ^{1*}, Farid Abba ²

¹ LFBM Laboratory, University of Biskra, (Algeria),

ihssan.youkana@univ-biskra.dz

² LFBM Laboratory, University of Biskra, (Algeria),

farid.abba@univ-biskra.dz

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Abstract:

The study explores the influence of renewable energy investments on Algeria's economic growth from 1990 to 2022, using the (ARDL) model. Gross Domestic Product (GDP) is the dependent variable, while renewable energy consumption and gross fixed capital formation act as independent variables. The research examines both short-term and long-term relationships among these elements to uncover their interactions. Results reveal a strong positive long-term link between renewable energy consumption and GDP, indicating that increased investment in renewable energy can boost economic growth. Furthermore, gross fixed capital formation also positively impacts GDP, supporting the idea of economic progress.

Keywords: *renewable energy, economic growth, GDP, gross fixed capital.*

1. INTRODUCTION

The global renewable energy market is experiencing remarkable growth, driven by advancing technologies and supportive government policies. Among the various sectors, solar photovoltaic and wind energy stand out as particularly promising due to their large market potential, cost-effectiveness, and profitability. In recent years, Algeria has prioritized investments in renewable energy. To facilitate this growth, the Algerian government has

*** Corresponding author**

implemented a comprehensive framework of legal and regulatory measures aimed at streamlining the investment process. This initiative not only encourages domestic investment but also invites new private sector partners by offering a range of incentives and support to foster engagement in renewable energy projects.

The present study aims to explore the impact of renewable energies on economic growth in Algeria. It examines how the legal and regulatory framework has been strategically enhanced to promote investment in renewable energy sectors. The findings of this study are assessed by analyzing the investment strategies and models implemented in various Wilayas (Provinces) in the southern region of the country, highlighting their contributions to fostering economic development through renewable energy initiatives. The study will address the following question:

Do investments in renewable energy significantly aid in attaining sustainable economic growth in Algeria from 1990 to 2022?

The important of this study is to investigate how renewable energy can help Algeria's economy grow. Algeria wants to move away from just relying on oil and gas, so figuring out how solar and wind power can help with this shift is key. These natural resources can create new jobs and boost the economy. By looking at how investing in renewable energy affects economic growth, leaders can make smart decisions to use these resources for the country's benefit. This research can show the best ways to start renewable energy projects, making sure Algeria has enough energy and keeps coming up with new ideas. Plus, understanding how renewable energy impacts the world can bring in more money from other countries and help Algeria work with others to fight climate change.

2. LITERATURE REVIEW

Many resource-rich countries in the world rely heavily on oil and natural gas exports for their economy, and Algeria and Saudi Arabia are among them. While these natural resources serve as significant income and economic growth sources, they can hinder economic diversification and innovation in Algeria. (Mahfoudi, Riache, & Louai, 2024, p. 2)

Renewable resources considered as the energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually

inexhaustible in duration but limited in the amount of energy that is available per unit of time.” (BOUKHARI & GRAMTIA , 2021, pp. 44-45) “Renewable energies are referred to as renewable sources of energy, as well as the optimal utilization of such assets diminishes ecological consequences, produces negligible subordinate leftover as well as is affordable depending on economic and community demands at present and in the future. Renewable energy solutions provide an unparalleled chance to offset greenhouse gas secretions and minimize global warming through the substitution of conventional bases of energy (fossil fuels)”. (Neha & Joon, 2021, pp. 2-3) Algeria possesses significant potential for renewable energy, particularly in solar energy. In contrast, its potential for wind, biomass, and geothermal energy is relatively limited. Consequently, Algeria has prioritized the implementation of large-scale renewable energy projects; however, the results have been modest when compared to initial forecasts.

Economic growth refers to the enhancement of an economy's capacity to produce goods and services, assessed over various timeframes. (Raisová & Čurpová, 2014) The long-term performance of economic growth is shaped by six key unintended factors that enhance per capita output, including physical capital accumulation, technological advancements, global economic integration, structural changes, economic size, and the availability of natural resources. (Meyer, Masehla, & Kot)

Researchers such (Nicholas Apergis, 2010) explores that the connection between renewable energy and economic growth is crucial for understanding how sustainable investments can aid in reaching long-term economic growth objectives (Formánek, 2020). In particular, they demonstrated this relationship by Gross Domestic Product (GDP) which is prominently represented by gross fixed capital formation, both in the short and long term. (Allam & Bou Nader, 2021)

3. DATA AND METHODOLOGY

3.1 Data descriptive and variables

In this study, we applied quantitative approach, utilizing econometric and descriptive analyses to accomplish the study's goals. The research was based on primary data collected from the National Office of Statistics, in

addition to a set of indicators derived from World Bank data. As for the scope of the study, it focused on Algeria during the period from 1990 to 2022. Table 1 provides a detailed explored throughout the research.

The table below provides an overview of the variables used in a study. These variables were chosen because they are critical indicators for analyzing the effect of the independent variable on the dependent variables .

Table N⁰(01) :description of the variables.

Variables	Acronym	Proxy	Source
Gross Domestic Product Growth	GDP	Gross Domestic Product Growth (% annually)	World Bank
Renewable Energy Consumption	ER	Renewable Energy Consumption (% of total final Energy Consumption)	World Bank
Gross Fixed Capital Formation	C	Gross Fixed Capital Formation (% annual growth)	World Bank

Source: prepared by the researches

3.2 Model formulation

The analytical framework employed to assess the connection between investments in renewable energy and economic growth is outlined as follows:

$$GDP_t = \alpha_0 + \beta_1 ER_t + \beta_2 C_t + \varepsilon_t$$

All variable proxies utilized in the analysis were predetermined and established beforehand, with the exception of the error component. In this context, t denotes the duration of the sample, β_0 signifies the intercept, while β_1 , β_2 , represent the respective coefficients.

3.3. Bounds Testing Procedure for the Autoregressive Distributed Lag Model

In this study, we used a technique called Autoregressive Distributed Lag (ARDL) to look at how certain things affect a country's economy. We wanted to see both short-term and long-term effects on Gross Domestic Product (GDP) growth. we do a bounds test, to see if two things are connected in the long run.

The bounds test is a method used to determine if there is a long-term relationship between two variables. We use an F-test to compare the null and alternative hypotheses. The key steps are:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$$

$$H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$$

Upper Bound (I(1)): If the F-statistic exceeds this upper bound, it indicates a long-term relationship exists.

Lower Bound (I(0)): If the F-statistic falls below this lower bound, it suggests no cointegration is present.

4. ANALYSIS RESULT AND DISCUSSION

4.1. Unit root test

Consistent integration of series is essential to prevent bias in econometric analysis, especially for long-run relationships like cointegration. The unit root test is crucial for determining whether variables are stationary at the I(0) level or need differencing to achieve I(1). Accurate assessment of data stationarity is fundamental for models like the ARDL and VECM.

Table N⁰(02): Unit root test result.

UNIT ROOT TEST RESULTS TABLE (ADF)				
Null Hypothesis: the variable has a unit root				
	At Level			
With Constant	t-Statistic	GDP -3.3942	ER -0.6027	K -3.6400
	Prob.	0.0187	0.8556	0.0103
With Constant & Trend	t-Statistic	-3.3542	-3.2406	-3.5924
	Prob.	0.0758	0.0953	0.0465
Without Constant & Trend	t-Statistic	-3.2659	-0.7233	-1.5551
	Prob.	0.0019	0.3948	0.1110
	At First Difference			
With Constant	t-Statistic	d(GDP) -8.7091	d(ER) -7.8542	d(K) -6.3777
	Prob.	0.0000	0.0000	0.0000
With Constant & Trend	t-Statistic	-8.5880	-8.1320	-7.7654
	Prob.	0.0000	0.0000	0.0000
Without Constant & Trend	t-Statistic	-8.8050	-7.9405	-6.4577
	Prob.	0.0000	0.0000	0.0000
Notes:				
a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant				
b: Lag Length based on SIC				
c: Probability based on MacKinnon (1996) one-sided p-values.				

Source: Eviews 10 output

The findings from the Augmented Dickey-Fuller (ADF) unit root test indicate that while the Gross Domestic Product (GDP) is stationary at its level in certain instances, the exchange rate (ER) and renewable energy consumption (K) do not show stationarity at this level. However, after applying first differencing to the variables, all become stationary, allowing

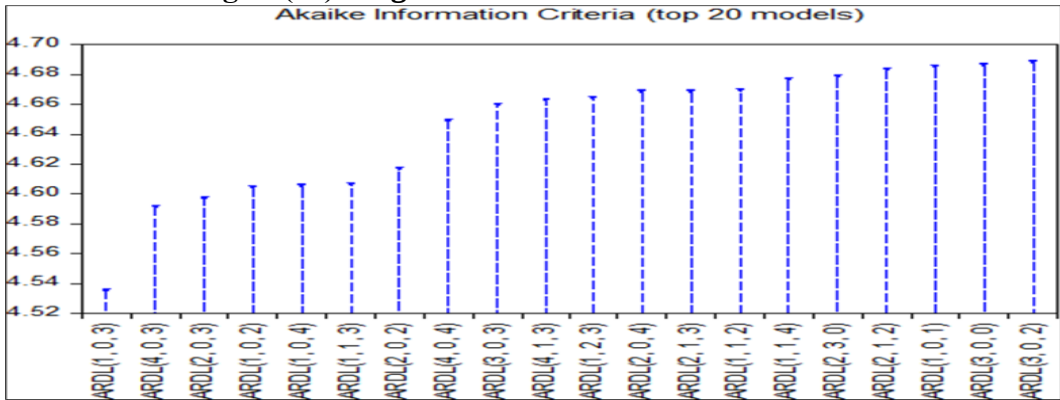
for the rejection of the null hypothesis regarding the presence of a unit root. Consequently, the use of the ARDL model is suitable in this context, as it effectively handles variables that achieve stationarity at the first difference (I(1)).

4.2. Lag length selection

For the selection of lags, we relied on the value of the Akaike Information Criterion (AIC), with a score of (AIC, 197.4).

$$AIC = \hat{\sigma}^2 \exp \left[2 \left(\frac{p+q}{N} \right) \right]$$

Fig N⁰(01): Lag Order Selection Criteria result.



Source: Eviews 10 output

The graph displays the Akaike Information Criterion (AIC) values for the top 20 ARDL models, where the horizontal axis represents the different models and the lag lengths for each variable, and the vertical axis represents the AIC values. The smaller the AIC value, the more optimal the model. The model positioned at the far left provides the best fit, ARDL (3,2,4,4), is the best as it has the lowest AIC value, making it the most suitable model in terms of balancing the number of lags and prediction accuracy.

The findings in Figure 1 recommend the adoption of the ARDL (3,2,4,4) model to investigate time series analysis technique in the long-run and short-run relationships between variables. The model structure of this study is:

$$\Delta \text{GDP}_t = C_0 + \sum_{i=1}^3 \alpha_1 \Delta \text{GDP}_{t-1} + \sum_{i=1}^2 \alpha_2 \Delta \text{ER}_{t-1} + \sum_{i=1}^4 \alpha_3 \Delta \text{C}_{t-1} + \beta_1 \text{GDP}_{t-1} + \beta_2 \text{ER}_{t-1} + \beta_3 \text{C}_{t-1} + \varepsilon_t$$

Where Δ signifies the difference operator; C_0 represents the intercept;

coefficients 1-4 reflect the long-run and short-run relationships between variables, respectively; and the term is the error component.

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The bounds test investigates the long-term association between renewable energy consumption, GDP, economic growth, and employment size. As illustrated in Table 4, the results demonstrate that at a 5% significance level, the computed F-statistic (7.242916) exceeds the upper critical threshold of 2.

Table N⁰(03): Bounds testing to evaluate the cointegration relationship

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	7.242916	10%	2.63	3.35
k	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5

Source: Eviews 10 output

The table above shows the F-Bounds test which is utilized to determine whether the relationship in the long-term exists among the variables our model. The computed F-statistic of 7.24 is greater than the upper bounds (I(1)) at the 10%, 5%, and 1% significance levels. Because this value exceeds the critical upper bounds, the null hypothesis, indicating the absence of a long-term relationship between the variables, can be rejected. This result confirms the existence of a cointegrating relationship among the selected variables. Following this outcome, the long-term connection between GDP emissions and the independent variables was estimated. Additionally, the Akaike criterion for information was employed to select the ARDL (3,2,4,4) model.

4.3. Estimates of the Long-Term Relationship

After establishing a long-term cointegration connection among the variables examined in this study, the factors influencing this relationship are detailed in the table below, with significance levels of 5% and 10%.

Table N⁰(04) : Estimates of the Long-term Relationship.

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ER	7.225781	2.114680	3.416961	0.0025
K	0.316918	0.069099	4.586412	0.0001
C	-2.769846	0.817577	-3.387874	0.0026
EC = GDP - (7.2258*ER + 0.3169*K -2.7698)				

Source: Eviews 10 output.

The analysis has yielded the following findings regarding the long-term dynamics between the dependent variable and the independent variable:

- There exists a strong and positive correlation between the growth rate of renewable energy. Consumption (ER) and Gross Domestic Product (GDP) over the long term, with a significance level of 5%. In particular, a 1% increase in Renewable Energy Consumption is linked to an estimated 7.23% growth in GDP in the long run. Utilizing renewable energy can boost export competitiveness, which in turn stimulates production and fosters economic growth. This growth is influenced by several factors; for instance, utilizing renewable energy reduces reliance on conventional energy sources, which tend to be pricier and more damaging to the environment. Furthermore, increased renewable energy consumption improves production efficiency and decreases industrial costs, making local goods more competitive in international markets and boosting exports. This dynamic leads to greater investments in fixed capital, enhancing production capabilities and upgrading economic infrastructure, which in turn fuels long-term growth. For instance, it indicates that a 1% rise in renewable energy consumption correlates with a 7.23% increase in GDP, reinforcing its role in fostering economic growth.
- The negative coefficient of the constant (-2.769846) suggests that, without other variables like renewable energy consumption and capital, GDP would decline by approximately 2.77 units. This association is significant at the 5% threshold (Prob = 0.0026), indicating that the lack of these elements results in a decrease in GDP. Essentially, the constant C represents the underlying conditions or other significant factors that contribute to economic growth. In their absence, the economy would experience a state of imbalance. The findings of our research highlight the critical role of economic factors, such as renewable energy, in achieving economic stability and growth.

4.4. Estimation of Short-Term Effects

The Error Correction Model (ECM) illustrates the short-term relationships among the variables being analysed. As indicated in Table 6,

the findings from this estimation show that all variables in the study are significant at the 5% threshold.

Table N⁰(05) : Outcomes of the short-term dynamic model.

ARDL Error Correction Regression Dependent Variable: D(GDP) Selected Model: ARDL(1, 0, 3) Case 2: Restricted Constant and No Trend Date: 09/03/24 Time: 17:38 Sample: 1990 2022 Included observations: 29				
ECM Regression Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(K)	0.016061	0.061206	0.262403	0.7955
D(K(-1))	-0.309129	0.088130	-3.507655	0.0020
D(K(-2))	-0.138930	0.063753	-2.179209	0.0403
CointEq(-1)*	-1.276865	0.222536	-5.737800	0.0000
R-squared	0.594250	Mean dependent var		0.193850
Adjusted R-squared	0.545560	S.D. dependent var		2.859655
S.E. of regression	1.927755	Akaike info criterion		4.278032
Sum squared resid	92.90600	Schwarz criterion		4.466624
Log likelihood	-58.03146	Hannan-Quinn criter.		4.337096
Durbin-Watson stat	1.861378			
* p-value incompatible with t-Bounds distribution.				

Source: Eviews 10 output

The results of the Augmented Dickey-Fuller (ADF) test for unit roots reveal that the economic variables examined show specific characteristics regarding their stationarity (GDP, renewable energy consumption ER, and capital K) display varying characteristics concerning stationarity at both the level and first difference. For GDP, the probability values suggest that it is stationary at the level across all scenarios (with constant, with constant and trend, and without constant or trend), signifying that this variable does not exhibit a unit root at the level. Conversely, the ER variable (renewable energy consumption) remains non-stationary at this level in all instances, indicating the presence of a unit root. Regarding the K variable (capital), it is stationary at the level when a constant is included and in the case that includes both constant and trend, but it shows non-stationarity when neither a constant nor a trend is present.

Upon taking the first difference of all variables, the results indicate that GDP, ER, and K become stationary, as their probability values fall significantly below 1%. These variables demonstrate a unit root at the level but achieve stationarity when the first difference is calculated. we conclude

that the study variables are first-order integrated, which means that only one difference between them is necessary to achieve stationarity.

4.5. Results from the diagnostic tests

To confirm the reliability of our findings, we performed several diagnostic tests. As detailed in Table 7, our model shows no issues with serial correlation, heteroscedasticity, or incorrect functional form at the 5% significance level. Additionally, the Jarque-Bera statistic reinforces that our model follows a normal distribution.

Table N⁰(06) : Diagnostic test.

Specification	F.Statistics	Probability value
Breusch-godfrey LM test	0.263940	0.7707
Breusch-pagan (hetroscedasticity)	0.748333	0.6172
Jarque-Bera (normality)	1.1410251	0.565172

Source: Eviews 10 output

In addition, the model's stability is affirmed by the results presented in Figures 2 and 3, which illustrate the CUSUM and CUSUMSQ plots, respectively.

Fig N⁰(02): CUSUM Plots

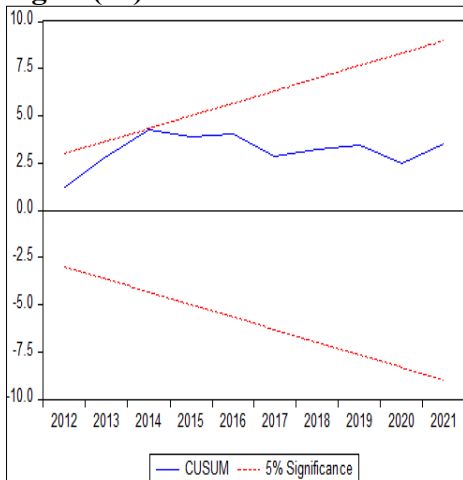
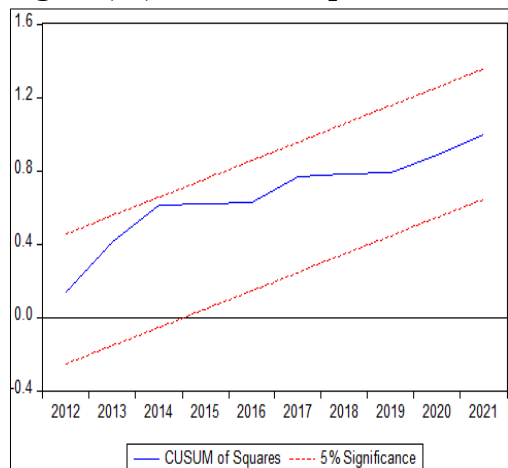


Fig N⁰ (03): CUSUM Square



Source: Eviews 10 output

Based on both the CUSUM of squares and the plots of the CUSUM test graph, which shows the level of importance of model stability at 5% (smashed red line), it is clear that the CUSUM (blue line) curve did not

exceed critical limits throughout the period 2012 to 2021. This stability indicates that the applied statistical model is stable and does not indicate any significant or unexpected changes. In the relationship between GDP and renewable energy consumption alongside capital (C), the model's reliability is demonstrated by its stability regarding the economic variables involved. The stabilization of renewable energy consumption indicates that this resource consistently supports the economy by ensuring a steady energy supply, which in turn contributes to the stabilization of GDP growth. Capital stability, on the other hand, reflects ongoing investments in infrastructure and technology, which foster balanced economic growth. Based on this analysis, we can conclude that the relationship between GDP, and renewable energy consumption and capital is stable. This stability demonstrates a steady and equitable use of resources aimed at promoting sustainable economic growth over the long term.

5. CONCLUSION

in conclusion, this research reveals the intricate relationship between investments in renewable energy and economic development in Algeria. The findings indicate that, despite facing short-term challenges related to the initial expenses of renewable energy systems, these investments are essential for promoting sustainable economic growth in the long run.

The study identifies two primary mechanisms through which investments in renewable energy influence economic growth. The first mechanism, known as the Substitution Effect, involves a shift toward renewable energy that reduces dependence on conventional energy sources like fossil fuels. This transition improves energy efficiency and supports economic stability. However, it requires significant investments in fixed capital and cutting-edge technologies.

The second mechanism is the Growth Effect, which arises from the increased economic activity associated with the growth of renewable energy utilization. This expansion boosts productive capacity and creates new employment opportunities, thereby contributing to sustainable economic development. Nonetheless, this growth needs to be managed carefully to ensure resource conservation and minimize environmental impact.

In light of the study's findings, the following recommendations are offered for policymakers in Algeria:

- The government should strengthen policies that promote investment in renewable energy by offering financial incentives and tax breaks for businesses and investors, which would encourage the implementation of clean energy technologies and the enhancement of associated infrastructure.
- Increasing investments in fixed capital and advanced technology necessitates the allocation of sufficient financial resources, as the transition to renewable energy requires significant investments in these areas.
- Enhancing the regulatory and environmental framework requires improving environmental regulations aimed at reducing carbon emissions and limiting industrial pollution, along with strict oversight of companies relying on conventional energy to encourage their transition to renewable energy sources.
- Developing environmental awareness programs through national campaigns aimed at informing the public and businesses about the significance of renewable energy and its contribution to sustainable economic development. This will promote the effective use of energy while minimizing environmental impacts.
- Stimulating innovation in the field of clean energy by promoting research and advancements in renewable energy technologies to ensure a sustainable transition to this sector.

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