

# Renewable Energies and Economic Performance: What Interactions Exist in the Moroccan Economy?

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## ABSTRACT

This study analyzes the interactions between the development of renewable energies and the economic performance of Morocco over the period 2007-2024. Using annual data from various national and international institutional sources, the study employs an econometric approach based on linear regression models to assess the impact of renewable energies on economic growth, inflation, unemployment, energy dependence and CO<sub>2</sub> emissions.

The results show that the development of renewable energies has a significant impact on certain energy and environmental dimensions of the Moroccan economy. In particular, increased renewable energy production contributes to a significant reduction in energy dependence and CO<sub>2</sub> emissions. However, no statistically significant effect was observed on economic growth and inflation during the period studied. Furthermore, the results reveal a positive relationship between renewable energies and unemployment, suggesting that the impact on employment remains limited in the short term.

These results highlight the strategic role of renewable energies in strengthening Morocco's energy security and environmental performance. They also underscore the need to support the energy transition with industrial and training policies capable of maximizing the economic and social benefits of investments made in this sector.

**Keywords:** Renewable energy; economic growth; energy dependence; CO<sub>2</sub> emissions; unemployment; Morocco.

**JEL classification:** Q42, Q43, O13, C2

## INTRODUCTION

The transition to a sustainable energy model is now a major imperative for emerging economies facing both volatile international hydrocarbon markets, increasing environmental pressures, and energy security requirements. In countries heavily dependent on energy imports, fluctuations in oil and gas prices have a direct impact on economic growth, inflation, and industrial competitiveness.

At the same time, the need to reduce CO<sub>2</sub> emissions, in response to international climate commitments, reinforces the urgency of adopting a cleaner and more diversified energy mix.

Morocco is at the heart of these dynamics. With an energy dependency rate exceeding 90%, the country remains highly exposed to fluctuations in international oil prices, which increases its energy bill and is often responsible for a significant portion of the trade deficit. This external vulnerability exerts inflationary pressures, weakens macroeconomic stability, and limits the capacity to finance development. At the same time, the Kingdom is demonstrating growing ambition in the area of climate: reducing CO<sub>2</sub> emissions, developing low-carbon infrastructure, and strengthening energy resilience.

To address this, Morocco has launched an ambitious energy strategy based on the massive expansion of renewable energies. Flagship projects such as the Noor solar power plant, the Tarfaya and Midelt wind farms,

and the future green hydrogen sector illustrate the country's commitment to structurally transforming its energy model. Beyond their environmental benefits, these investments also aim to reduce energy costs, decrease dependence on fossil fuels, stabilize prices, and improve the external balance. Thus, Morocco's energy transition is part of a multidimensional approach, combining economic performance, energy security, and environmental sustainability.

Despite its growing importance, few studies have analyzed in an integrated manner the interactions between renewable energy, CO<sub>2</sub> emissions, energy dependence, energy costs, and key macroeconomic indicators such as growth, inflation, and the balance of payments. The literature often remains fragmented: some studies focus on growth, others on environmental impacts, and still others on external balance, without offering a unified view of these mechanisms. For a country like Morocco, however, this integrated approach is essential to understanding how the energy transition simultaneously influences economic performance and macro-financial stability.

In this context, this article proposes an empirical examination of the interactions between renewable energy development, economic performance, and the environmental and energy dimensions of Morocco. Using an econometric framework and annual data covering the period [2007-2021], the study analyzes the direct and indirect effects of renewable energy on economic growth, inflation, CO<sub>2</sub> emissions, and the dependency ratio. The objective is to provide a comprehensive understanding of the mechanisms by which the energy transition contributes to strengthening the country's macroeconomic and environmental resilience.

## IN-DEPTH LITERATURE REVIEW

### Renewable energy and economic growth

The question of the impact of renewable energies on economic growth has generated increasing interest in the economic and energy literature. According to endogenous growth theory (Romer, 1990), technological innovation, energy efficiency, and infrastructure investment are essential drivers of productivity and economic development. Renewable energies fit within this framework by enabling diversification of the energy mix, reducing long-term costs, and improving the efficiency of the production system.

Empirical studies generally confirm this positive relationship. Apergis and Payne (2010), in an analysis of 20 emerging economies, demonstrate the existence of a cointegrating relationship between renewable energy consumption and economic growth, with a positive long-term effect. Similarly, Sadorsky (2009) shows that for the BRICS countries<sup>1</sup>, increased renewable energy consumption stimulates growth by reducing dependence on fossil fuels and stabilizing production costs.

However, the literature highlights that this effect is not uniform. Sebri and Ben-Salha (2014) point out that the impact of renewables depends heavily on the level of development of electricity infrastructure, the quality of institutions, and the regulatory framework. In some cases, initial investment costs can temporarily limit the positive effect on growth.

### Renewable energy and inflation

The relationship between renewable energy and inflation remains less explored but is of particular importance for economies dependent on energy imports. Traditional economic literature, notably Hooker (2002) and Hamilton (2009), shows that fluctuations in oil prices have a significant impact on inflation in importing economies, due to their dependence on fossil fuels.

In this context, the development of renewable energies appears as an effective way to reduce the sensitivity of inflation to external shocks. Streimikiene and Štreimikis (2020) emphasize that energy diversification through renewables mitigates the transmission of international energy price increases to domestic prices. By reducing

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<sup>1</sup>The BRICS comprise 11 developing economies (Brazil, Russia, India, China, South Africa, Egypt, Ethiopia, Iran, Saudi Arabia and the United Arab Emirates, Indonesia and Vietnam).

the volatility of energy costs, renewables contribute to stabilizing inflation and strengthening macroeconomic resilience.

However, some studies warn of short-term inflationary effects related to initial investments, network pricing, or support policies (IEA, 2021). The overall impact therefore depends on the degree of technological maturity and the structure of the national energy sector.

### **Renewable energies and CO<sub>2</sub> emissions**

There is broad consensus on the crucial role of renewable energies in reducing CO<sub>2</sub> emissions. The work of the IPCC (2022) emphasizes that decarbonizing energy systems is one of the most effective levers for achieving international climate goals. Renewables allow for the gradual replacement of fossil fuels, which are responsible for the majority of greenhouse gas emissions.

Apergis and Payne (2014) show that in OECD countries<sup>2</sup>, renewable energy consumption contributes directly to CO<sub>2</sub> emission reductions. In emerging economies, Rafiq, Salim, and Nielsen (2016) highlight a similar impact, although this is contingent on the level of economic development and the structure of the energy mix. Recent literature (Salahuddin et al., 2018) confirms that increasing the share of renewables in electricity production leads to a measurable reduction in carbon intensity.

### **Energy bills, energy dependence and macroeconomic vulnerability**

Energy dependence and energy costs are among the major determinants of macroeconomic vulnerability in hydrocarbon-importing countries. Several studies show that high energy dependence exposes economies to fluctuations in international oil prices, directly influencing inflation, production costs, public spending, and economic stability (Baffes et al., 2015).

The International Energy Agency (IEA, 2019) emphasizes that economies with high energy bills exhibit greater external vulnerability and less resilience to shocks. The transition to renewable energy reduces fossil fuel imports, thereby improving energy security and stabilizing domestic costs.

In the MENA region<sup>3</sup>, Charfeddine and Kahia (2019) demonstrate that energy diversification contributes to reducing oil dependence, strengthening economic stability, and improving overall energy performance. The literature also suggests that renewable energies play a key role in reducing exposure to geopolitical disruptions affecting oil markets.

### **Specificities of the Moroccan case in the literature**

Studies on Morocco highlight several structural characteristics. Historically, the country has an energy dependence rate exceeding 90% (AMEE, 2021), making its economy vulnerable to fluctuations in international energy prices. The energy bill represents a significant portion of the trade deficit, putting pressure on foreign exchange reserves and domestic prices (BAM, 2020).

Several studies highlight Morocco's significant efforts to promote renewable energy, particularly through flagship projects such as the Noor solar complex and the Tarfaya wind farms. Ben Jebli and Ben Youssef (2015) demonstrate the positive impact of renewables on growth and the reduction of CO<sub>2</sub> emissions. Other studies emphasize the importance of the country's solar and wind energy potential for reducing energy dependence.

However, the literature remains fragmented: few studies simultaneously analyze the impact of renewable energies on growth, inflation, CO<sub>2</sub> emissions, energy bills, and energy dependence. This gap justifies the need for an integrated approach.

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<sup>2</sup>The Organisation for Economic Co-operation and Development is a strategic forum aimed at developing and promoting public economic and social policies.

<sup>3</sup>Middle East and North Africa represents the Middle East and North Africa region, generally extending from Morocco to Iran

A review of the literature reveals several findings:

- Renewable energies generally promote economic growth, but the magnitude of this effect depends on the institutional and technological framework.
- Renewable energies help to stabilize energy prices and reduce imported inflation.
- They are an essential lever for reducing CO<sub>2</sub> emissions and achieving climate goals.
- In importing countries like Morocco, renewable energies reduce macroeconomic vulnerability by lowering the energy bill and dependence on fossil fuels.

This study stands out by proposing an integrated approach jointly examining the effects of renewable energies on: economic growth, inflation, CO<sub>2</sub> emissions, energy bill, and energy dependency rate in Morocco.

This multidimensional approach allows for a better understanding of the mechanisms linking energy transition and macroeconomic performance.

### The theoretical framework

The theoretical framework of this study rests on a coherent articulation between endogenous growth theories, approaches to energy vulnerability, and the foundations of environmental economics. Together, these currents explain how renewable energies influence a country's overall economic performance across five key dimensions: economic growth, inflation, CO<sub>2</sub> emissions, energy bill, and energy dependence.

Table No. 1: Theoretical framework of the study

Theoretical dimension	Key concepts	Contributions from literature	Transmission mechanisms
<b>Endogenous growth theory: Romer 1990</b>	Innovation, productivity, investment	Growth is driven by technology, infrastructure, and knowledge.	Modernization of the energy system, green innovations, skilled jobs
<b>Energy vulnerability: Charfeddine /Kahia 2019</b>	Energy dependence, price volatility, energy security	Oil-dependent economies are vulnerable to external shocks	Reduction of energy imports; stabilization of supply
<b>Inflation and macroeconomic stability: Streimitene (2020)</b>	Imported inflation, energy prices, volatility	Fluctuations in oil prices strongly influence inflation in importing countries.	Diversification of the energy mix; stability of electricity costs
<b>Environmental economics: Tietenberg &amp; Lewis (2016)</b>	Negative externalities, CO <sub>2</sub> emissions, sustainability	Fossil fuels generate pollution and socio-economic costs.	Fossil fuel → renewable energy substitution; reduced carbon intensity
<b>Energy security and resilience: IEA (2019, 2021)</b>	Energy independence, geopolitical risks	Energy security strengthens economic and industrial stability	Domestic capacity building, diversification

In summary, the literature shows that:

Table 2: Summary of the literature review

Variables	Effect of renewable energies
Economic growth	↑ Positive
Inflation	↓ Reduction
CO <sub>2</sub>	↓ Reduction
Energy bill	↓ Reduction
Energy dependence	↓ Reduction

### Research hypotheses

In light of the theoretical foundations employed and the empirical results identified in the literature, this study aims to analyze the effects of renewable energy development on Morocco's economic and energy performance. Theories of endogenous growth, energy security, and environmental economics suggest that the energy transition can simultaneously influence several macroeconomic dimensions. In this context, the following hypotheses are formulated:

#### **H1: Renewable energies have a positive effect on Morocco's economic growth.**

This hypothesis is based on the work of Romer (1990), Apergis and Payne (2010) and Sadorsky (2009), according to which investments in renewable energy infrastructure promote innovation, stimulate productivity and create new job opportunities, thus contributing to economic growth.

#### **H2: The development of renewable energies contributes to the reduction of inflation.**

Renewable energies help reduce dependence on fossil fuel imports, the prices of which are highly volatile. By reducing exposure to international oil shocks, they contribute to stabilizing energy costs and limiting inflationary pressures.

#### **H3: The development of renewable energies contributes to reducing Morocco's energy dependence rate.**

Strengthening national renewable energy production capacities increases the country's energy independence and reduces its vulnerability to fluctuations in international energy markets.

#### **H4: The development of renewable energies contributes to reducing Morocco's energy dependence rate.**

The development of renewable energies reduces Morocco's energy dependence on hydrocarbon imports and limits its exposure to fluctuations in international energy prices. By strengthening energy security and reducing vulnerability to external shocks, renewable energies contribute to improving the country's macroeconomic resilience.

#### **H5: The development of renewable energies reduces CO<sub>2</sub> emissions in Morocco.**

This hypothesis is based on the principle of progressively replacing fossil fuels with clean energy sources. An increase in the share of renewable energies in the energy mix should therefore lead to a significant reduction in greenhouse gas emissions.

## RESEARCH METHODOLOGY

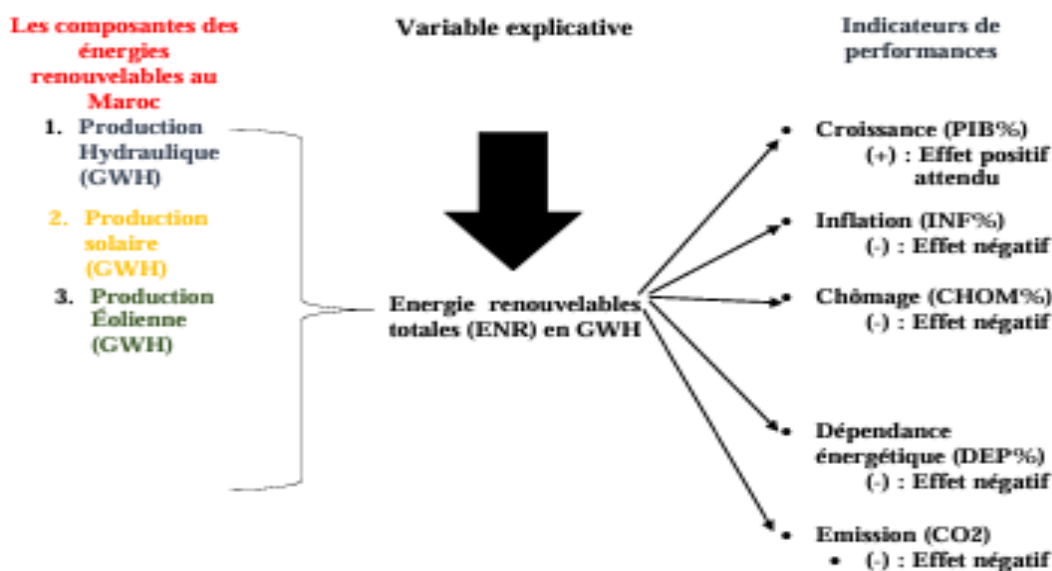
This study analyzes the interactions between the development of renewable energies and the economic performance of Morocco over the period 2007-2024. The approach adopted is based on the use of annual data from various national and international institutional sources.

The chosen analysis period (2007-2024) is justified by the availability of statistical data on renewable energy in Morocco. Indeed, information concerning renewable energy production has become more structured and regularly published since 2007. This constraint limits the sample to 18 annual observations and reduces the possibilities for using more sophisticated econometric models requiring longer time series. In this context, the study adopts an exploratory approach based on simple linear regressions to identify the main relationships between renewable energy and the indicators studied.

The objective is to assess the effect of renewable energies on several macroeconomic and environmental indicators, including economic growth, inflation, CO<sub>2</sub> emissions and energy dependence

The figure below presents the conceptual framework of the study in a structured and hierarchical form.

Figure No. 1: Conceptual model of the study



Hydroelectric, wind and solar power production constitute the main components of renewable energy in Morocco. They are grouped into a single synthetic variable, called **Total Renewable Energies (TRE)**, which represents the central explanatory variable of the research.

The model assumes that increased renewable energy production has effects on several economic and environmental dimensions. On the one hand, it can foster economic growth through investment, job creation, and improved energy security. On the other hand, it helps reduce Morocco's energy dependence on fossil fuel imports.

From an environmental perspective, the development of renewable energies should lead to a reduction in CO<sub>2</sub> emissions through the gradual replacement of conventional energy sources. Finally, the effects on inflation and unemployment can be positive or negative depending on economic conditions, energy production costs, and the returns on investments in the sector.

Thus, the variables **GDP**, **INF**, **CHOM**, **DEP**, and **CO<sub>2</sub>** are considered dependent variables whose evolution can be influenced by the development of renewable energies in Morocco. This framework forms the basis of the econometric analysis that will be developed later in the study.

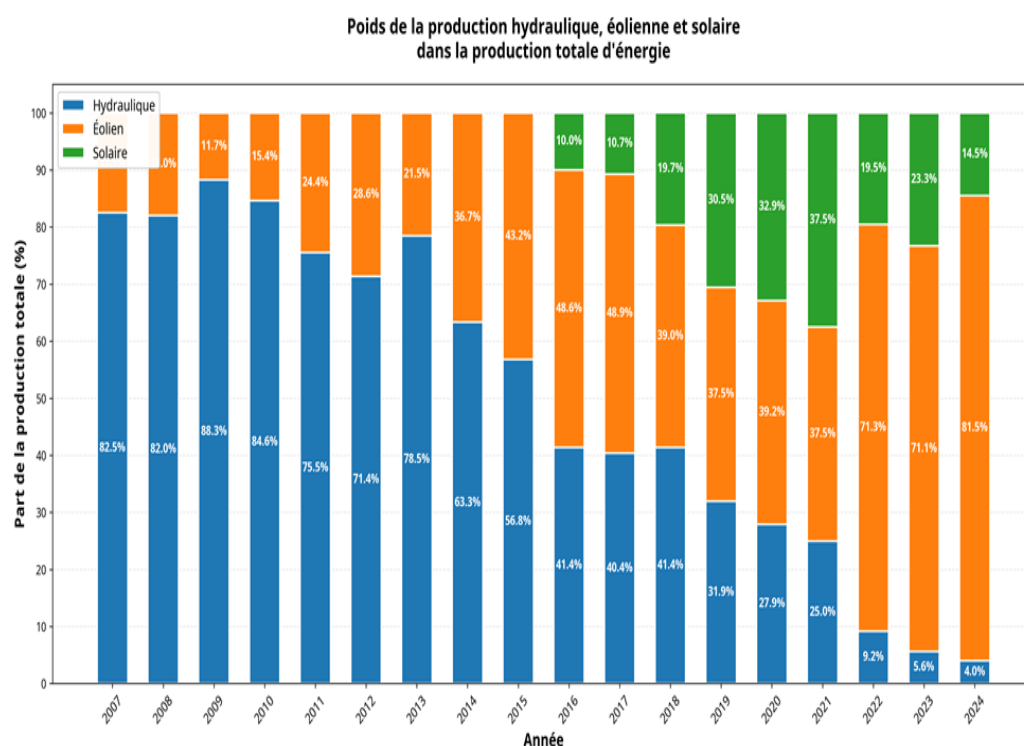
The empirical analysis is carried out in two stages. The first consists of presenting descriptive statistics to understand the general characteristics of the variables studied. The second relies on the estimation of econometric models to identify the impact of renewable energies on the different indicators selected.

The study uses annual data covering the period 2007-2024, representing 18 observations. Given the relatively small sample size, the use of regression models adapted to small-dimensional time series will be preferred.

## The data analysis

### A. Analysis of the share of renewable energies in overall electricity production.

Analyzing the structure of renewable energies allows us to assess the respective contributions of hydropower, wind power, and solar power to total renewable electricity production in Morocco. To better understand the evolution of the national energy mix, it is relevant to present the distribution of these different sources year by year over the period 2007-2024.



The evolution of the relative shares of different renewable sources highlights an increasing diversification of the national energy mix. At the beginning of the period, hydropower represented nearly 78% of total renewable production in 2007. However, its relative share gradually decreased to reach only 18.5% in 2024.

Meanwhile, the share of wind power increased from 21.7% in 2007 to 55% in 2024, confirming its central role in Morocco's energy transition. As for solar power, its contribution rose from less than 1% in 2010 to 26.5% in 2024 thanks to investments in photovoltaic and thermodynamic power plants.

This transformation is a key indicator of the success of Morocco's energy policy. Diversifying renewable energy sources reduces the risks associated with dependence on a single technology and improves the resilience of the electricity system to climate change. It also contributes to strengthening the country's energy security by limiting reliance on fossil fuel imports .

Ultimately, the analysis of the share of renewable energies in overall electricity production reveals a major structural shift in the Moroccan energy system. Total renewable energy production increased from 1,597 GWh in 2007 to 11,357 GWh in 2024, with wind and solar power becoming the main drivers of this growth. This increase, combined with the continued availability of hydropower, demonstrates the progress made in the

Kingdom's energy transition and confirms the strategic role of renewable energies in achieving sustainable development and green growth objectives.

### B. Descriptive data analysis

The following table presents the main descriptive statistics relating to renewable energy, economic growth, inflation, unemployment, energy dependence and CO<sub>2</sub> emissions in Morocco over the period 2007-2024.

Table No. 4

Variable	Average	Median	Maximum	Minimum	Standard deviation
RES (GWh)	4,591.91	4,016.15	11,357.00	1,597.00	2,494.36
GDP (%)	0.032	0.033	0.082	-0.080	0.033
Inflation (%)	0.019	0.014	0.066	0.002	0.018
Unemployment (%)	0.103	0.096	0.133	0.089	0.015
Energy dependence (%)	0.929	0.936	0.975	0.850	0.031
CO <sub>2</sub> (g/kWh)	729.45	731.80	826.80	620.00	49.56

The results show that the average renewable energy production amounted to 4,591.91 GWh over the period studied. The relatively high standard deviation (2,494.36 GWh ) reflects a strong increase in renewable energy production in Morocco, linked in particular to the development of hydroelectric, wind, and solar infrastructure.

Economic growth averaged 3.2%, with significant variability ranging from a low of -8% to a high of 8.2%. This dispersion reflects the Moroccan economy's exposure to various economic shocks, including international crises and climatic conditions affecting certain strategic sectors.

Inflation remains generally under control, averaging 1.9%. However, some periods have seen more significant inflationary pressures, as indicated by the observed peak of 6.6%. The low standard deviation nevertheless suggests relative price stability for most of the period.

Regarding the labor market, the unemployment rate averages 10.3%, with relatively limited fluctuations around this figure. This situation reflects the persistence of structural employment challenges despite efforts at economic modernization.

Energy dependence remains high at an average of 92.9%, confirming Morocco's historically strong reliance on energy imports. Although this dependence has tended to decrease gradually thanks to the development of renewable energies, it remains at a significant level throughout the period.

Finally, CO<sub>2</sub> emissions average 729.45 g/kWh. The difference between the maximum (826.8 g/kWh) and the minimum (620 g/kWh) suggests a gradual improvement in the environmental performance of the Moroccan energy system. This trend can be attributed to the increasing integration of renewable energies into the national energy mix.

Overall, these descriptive statistics highlight the rise of renewable energies in Morocco and their potential role in reducing energy dependence and carbon emissions, while contributing to strengthening national economic performance.

### C. Correlation analysis

Table 5: Correlation Analysis

Variables	ENT	GDP	Inflation	Unemployment	Energy dependence	CO <sub>2</sub> emissions
ENT	1,000	-0.115	0.350	0.796	-0.911	-0.753
GDP	-0.115	1,000	0.062	-0.189	0.217	0.052
Inflation	0.350	0.062	1,000	0.074	-0.052	0.040
Unemployment	0.796	-0.189	0.074	1,000	-0.745	-0.403
Energy dependence	-0.911	0.217	-0.052	-0.745	1,000	0.754
CO <sub>2</sub> emissions	-0.753	0.052	0.040	-0.403	0.754	1,000

Analysis of the correlation matrix reveals several important relationships between the variables studied. First, renewable energy production (REE) is strongly and negatively correlated with energy dependence ( $r = -0.911$ ), meaning that an increase in renewable energy production helps reduce reliance on energy imports. This relationship aligns with the objectives of Morocco's energy strategy, which aims to strengthen national energy independence.

Furthermore, renewable energies show a strong negative correlation with CO<sub>2</sub> emissions ( $r = -0.753$ ). This result confirms that the development of clean energy sources helps to reduce the carbon intensity of the Moroccan energy system and support the country's environmental objectives.

The correlation between renewable energy and unemployment is positive and relatively high ( $r = 0.796$ ). This result suggests that, during the period studied, the increase in renewable energy production was accompanied by a rise in the unemployment rate. This relationship can be explained by the highly capital-intensive nature of renewable energy projects and their limited impact on short-term job creation.

In contrast, the correlations between renewable energy, economic growth ( $r = -0.115$ ), and inflation ( $r = 0.350$ ) remain weak. These results indicate that variations in renewable energy production do not appear to have had a significant impact on these two macroeconomic variables during the period 2007–2024.

Finally, energy dependence and CO<sub>2</sub> emissions show a strong positive correlation ( $r = 0.754$ ), indicating that greater dependence on fossil fuels is generally associated with higher levels of polluting emissions. Overall, this analysis confirms that the main benefits of renewable energy in Morocco are more evident in energy and environmental terms than in short-term economic dimensions.

### Econometric results and validation of hypotheses

To test the research hypotheses regarding the impact of renewable energy on Morocco's economic and environmental performance, five linear regression models were estimated. Each model examines the effect of renewable electricity (RES) production on a specific variable.

#### A. Model 1: Impact of renewable energies on economic growth “Hypothesis 1”

##### Model results:

- $PIB_t = \beta_0 + \beta_1(ENR_t) + \varepsilon_T$
- $PIB_t = 0.038568 - 0.0000153(ENR_t)$

Table 6: Results of the Impact of Renewable Energies on Economic Growth

Dependent Variable: GDP		
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Method: Least Squares				
Included observations: 18				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.038568	0.017097	2.255831	0.0384
ENT	-1.53E-06	3.29E-06	-0.463809	0.6490
R-squared	0.013267	Mean dependent var		0.031556
Adjusted R-squared	-0.048404	S.D. dependent var		0.033073
S.E. of regression	0.033863	Akaike info criterion		-3.828520
Sum squared resid	0.018348	Schwarz criterion		-3.729590
Log likelihood	36.45668	Hannan-Quinn criter.		-3.814879
F-statistic	0.215119	Durbin-Watson stat		2.737721
Prob(F-statistic)	0.649032			

The estimation of the model linking renewable energy to economic growth shows that the coefficient associated with the ENT variable is negative (-0.00000153) but not statistically significant (t = -0.4638; p-value = 0.6490). This result indicates that the data do not allow us to establish the existence of a significant impact of renewable energy on Morocco's economic growth during the period 2007-2024. The coefficient of determination ( $R^2 = 0.0133$ ) reveals that only 1.33% of GDP variations are explained by variations in renewable energy, reflecting the model's weak explanatory power. Furthermore, Fisher's exact statistic ( $F = 0.2151$ ; p-value = 0.6490) shows that the model is not globally significant. Finally, the Durbin-Watson statistic ( $DW = 2.7377$ ) suggests the absence of positive autocorrelation of the residuals. Under these conditions, **hypothesis H1, according to which renewable energies have a positive effect on Morocco's economic growth, is not validated .**

**B. Model 2: Impact of renewable energies on inflation "Hypothesis H2"**

**Model results:**

- $Inft = \beta_0 + \beta_1(ENR_t) + \varepsilon_T$
- $Inft = 0.006967 + 0.00000254(ENR_t)$

Table 7: Impact of renewable energies on inflation

Dependent Variable: INFLATION_RATE				
Method: Least Squares				
Included observations: 18				
Variable	Coefficient	Standard Error	t - Statistics	Prob.
C	0.006967	0.008812	0.790564	0.4408

ENT	2.54E-06	1.70E-06	1.494267	0.1546
R-squared	0.122462	Mean dependent var		0.018611
Adjusted R-squared	0.067616	S.D. dependent var		0.018075
S.E. of regression	0.017454	Akaike info criterion		-5.154095
Sum squared resid	0.004874	Schwarz criterion		-5.055165
Log likelihood	48.38685	Hannan-Quinn criter.		-5.140454
F-statistic	2.232835	Durbin-Watson stat		1.529095
Prob(F-statistic)	0.154565			

The estimation results show that the coefficient associated with renewable energy is positive (0.00000254), suggesting that an increase in renewable energy production is accompanied by a slight rise in the inflation rate. However, this coefficient is not statistically significant at the conventional 5% threshold ( $t = 1.494$ ;  $p\text{-value} = 0.1546$ ). Thus, the data do not allow us to conclude that renewable energy has a significant effect on inflation in Morocco during the period 2007–2024. The coefficient of determination ( $R^2 = 0.122$ ) indicates that only 12.25% of the changes in inflation are explained by changes in renewable energy production, reflecting the model's weak explanatory power. Furthermore, Fisher's exact statistic ( $F = 2.233$ ;  $p\text{-value} = 0.1546$ ) confirms the overall lack of significance of the model. Finally, the Durbin-Watson statistic ( $DW = 1.529$ ) suggests the absence of significant autocorrelation of the residuals. Consequently, the hypothesis that the development of renewable energies **contributes to reducing inflation in Morocco is not validated**.

**C. Model 3: Impact of renewable energies on unemployment “Hypothesis H3”.**

**Model results:**

- $CHOM_t = \beta_0 + \beta_1(ENR_t) + \epsilon_T$
- $CHOM_t = 0.81572 + 0.00000464(ENR_t)$

Table 8: Impact of renewable energies on unemployment

Dependent Variable: UNEMPLOYMENT_RATE				
Method: Least Squares				
Sample: 2007-2024				
Included observations: 18				
Variable	Coefficient	Standard Error	t - Statistics	Prob.
C	0.081572	0.004586	17.78580	0.0000
ENT	4.64E-06	8.83E-07	5.255842	0.0001
R-squared	0.633228	Mean dependent var		0.102889
Adjusted R-squared	0.610305	S.D. dependent var		0.014552

S.E. of regression	0.009084	Akaike info criterion	-6.460172
Sum squared resid	0.001320	Schwarz criterion	-6.361241
Log likelihood	60.14154	Hannan-Quinn criter.	-6.446530
F-statistic	27.62388	Durbin-Watson stat	1.444860
Prob(F-statistic)	0.000078		

The estimation results show that the coefficient associated with renewable energy is positive (0.00000464) and statistically significant at the 5% level ( $t = 5.256$ ;  $p\text{-value} = 0.0001$ ). This result indicates that an increase in renewable energy production is associated with a rise in the unemployment rate in Morocco over the period studied. Quantitatively, a 1,000 GWh increase in renewable energy production would lead to an average increase of approximately 0.46 percentage points in the unemployment rate. The coefficient of determination ( $R^2 = 0.633$ ) shows that 63.32% of the changes in unemployment are explained by changes in renewable energy, reflecting a relatively high explanatory power of the model. Furthermore, Fisher's exact statistic ( $F = 27.624$ ;  $p\text{-value} = 0.000078$ ) confirms the overall significance of the model. Finally, the Durbin-Watson statistic ( $DW = 1.445$ ) suggests a slight positive autocorrelation of the residuals. These results lead to the rejection of the hypothesis that the development of renewable energies reduces unemployment in Morocco, as the observed relationship is positive and statistically significant .

This result may seem paradoxical given the literature, which generally links investments in renewable energy to job creation. Several explanations can be offered in the case of Morocco.

Firstly, renewable energy projects are highly capital-intensive and require significant investments in infrastructure and technology, but relatively little permanent labor after the construction phase. Thus, the jobs created remain limited compared to the needs of the labor market.

Secondly, a significant portion of the equipment and technologies used in solar and wind projects are imported from abroad. Consequently, the industrial benefits and multiplier effects on local employment may remain relatively limited.

Third, the evolution of unemployment depends on numerous structural factors such as population growth, the mismatch between available skills and labor market needs, and the performance of other economic sectors. Therefore, increasing renewable energy production capacity may not be sufficient to offset job losses or the influx of new job seekers.

Finally, the positive effects of renewable energy on employment can appear with a significant time lag. Investments made today can generate long-term economic benefits and job creation, without these effects being immediately observable in the period studied.

#### D. Model 4: Impact of renewable energies on energy dependence “Hypothesis H4”

##### Model results:

- $DEPt = \beta_0 + \beta_1(ENR_t) + \epsilon_T$
- $DEPt = 0.980862 - 0.0000112(ENR_t)$

Table 9: Impact of renewable energies on energy dependence

Dependent Variable: DEPENDENCE RATE	
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Method: Least Squares				
Sample: 2007-2024				
Included observations: 18				
Variable	Coefficient	Standard Error	t - Statistics	Prob.
C	0.980862	0.006579	149.0985	0.0000
ENT	-1.12E-05	1.27E-06	-8.852385	0.0000
R-squared	0.830445	Mean dependent var		0.929361
Adjusted R-squared	0.819848	S.D. dependent var		0.030699
S.E. of regression	0.013030	Akaike info criterion		-5.738690
Sum squared resid	0.002716	Schwarz criterion		-5.639759
Log likelihood	53.64821	Hannan-Quinn criter.		-5.725048
F-statistic	78.36472	Durbin-Watson stat		1.029646
Prob(F-statistic)	0.000000			

The estimation results show that the coefficient associated with renewable energy is negative (-0.0000112), indicating that an increase in renewable energy production contributes to reducing Morocco's energy dependency rate. From an economic perspective, a 1,000 GWh increase in renewable energy production leads to an average decrease of approximately 1.12 percentage points in energy dependency. This result confirms the role of renewable energy in strengthening national energy independence and reducing reliance on fossil fuel imports.

Statistically, the coefficient is highly significant, as indicated by the Student's t-test value ( $t = -8.852$ ) associated with a near-zero probability ( $p\text{-value} = 0.0000$ ). This significance allows us to reject the null hypothesis of no effect of renewable energies on energy dependence and to conclude that there is a statistically robust relationship between the two variables.

The coefficient of determination ( $R^2 = 0.8304$ ) reveals that 83.04% of the observed variations in the energy dependency rate are explained by variations in renewable energy production. This high  $R^2$  value reflects the strong explanatory power of the model and underscores the importance of renewable energies among the factors determining the evolution of energy dependency in Morocco.

Furthermore, Fisher's exact test ( $F = 78.365$ ;  $p\text{-value} = 0.0000$ ) shows that the model is globally significant. This means that the chosen explanatory variable contributes significantly to explaining the phenomenon under study and that the model demonstrates a good fit.

Finally, the Durbin-Watson statistic ( $DW = 1.03$ ) suggests the existence of a positive autocorrelation of the residuals. Although this does not invalidate the results, it indicates that some temporal information may not be fully captured by the model. Further diagnostic tests could be considered to verify the robustness of the estimates.

Overall, the results confirm that the development of renewable energies is a key lever for reducing Morocco's energy dependence. The observed effect is consistent with theoretical predictions and the objectives of the

national energy strategy. **Hypothesis H4 is thus fully validated, confirming the strategic role of renewable energies in strengthening the country's energy security and economic resilience.**

**E. Model 5: Impact of renewable energies on CO<sub>2</sub> emissions. “Hypothesis H5”**

**Model results**

- $ECO2t = \beta_0 + \beta_1(ENR_t) + \epsilon_T$
- $ECO2t = 798.1185 - 0.014955(ENR_t)$

Table No. 10: Impact of renewable energies on CO<sub>2</sub> emissions

Dependent Variable: EMISSION_CO2_G_KWH				
Method: Least Squares				
Sample: 2007 2024				
Included observations: 18				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	798.1185	16.97773	47.00974	0.0000
ENT	-0.014955	0.003270	-4.573719	0.0003
R-squared	0.566618	Mean dependent var		729.4483
Adjusted R-squared	0.539531	S.D. dependent var		49.55511
S.E. of regression	33.62703	Akaike info criterion		9.972977
Sum squared resid	18092.44	Schwarz criterion		10.07191
Log likelihood	-87.75679	Hannan-Quinn criter.		9.986618
F-statistic	20.91890	Durbin-Watson stat		1.110998
Prob(F- statistic )	0.000312			

This equation demonstrates a negative relationship between renewable energy (RE) and CO<sub>2</sub> emissions per kWh. Specifically, the coefficient associated with the RE variable is -0.014955, meaning that a one-unit increase in renewable energy leads, on average, to a 0.014955-unit decrease in CO<sub>2</sub> emissions per kWh, all other things being equal. This result aligns with the economic and environmental logic that developing renewable energy reduces reliance on fossil fuels and thus contributes to lower pollution levels.

Statistically, the coefficient of the ENT variable is significant. The Student's t-statistic is -4.5737, and the associated probability is 0.0003, a value well below the 5% threshold. This means that we reject the hypothesis that renewable energies have no effect on CO<sub>2</sub> emissions. We can therefore conclude that the observed negative impact is real and not due to chance.

Regarding the model's quality, the coefficient of determination R<sup>2</sup> is 0.5666. This means that 56.66% of the variations in CO<sub>2</sub> emissions per kWh are explained by variations in renewable energy. This level is considered satisfactory and shows that the variable studied plays a significant role in explaining CO<sub>2</sub> emissions. However,

nearly 43% of the variations remain explained by other factors not included in the model, such as energy consumption, the energy mix structure, and economic activity.

The overall significance of the model is confirmed by Fisher's exact test. The F-statistic is equal to 20.9189 with a probability of 0.000312. Since this value is less than 5%, the model is globally significant. In other words, the selected variables adequately explain the variations in CO<sub>2</sub> emissions.

Analysis of the Durbin-Watson statistic yields a value of 1.1110. Since this value is less than 2, it suggests the existence of a positive autocorrelation of the residuals. This means that some information related to the temporal evolution of the data is likely not fully captured by the model. While this situation does not invalidate the results obtained, it indicates that it would be beneficial to perform further tests or incorporate additional explanatory variables to improve the quality of the estimation.

In summary, the results show that the development of renewable energies contributes significantly to reducing CO<sub>2</sub> emissions per kWh in Morocco. The observed effect is negative, statistically significant, and consistent with theoretical expectations. The model is generally valid and has satisfactory explanatory power . **These results thus confirm that renewable energies constitute an important lever for reducing the carbon intensity of the Moroccan energy sector and supporting the country's energy transition and sustainable development objectives.**

Table No. 11: Summary Table of Assumptions

Assumption	Expected relationship	RES Coefficient	p -value	Significant at 5%?	Direction observed	Decision
<b>H1: Renewable energies promote economic growth</b>	Positive (+)	-0.00000153	0.6490	No	Negative	<b>Hypothesis rejected (not validated)</b>
<b>H2: Renewable energies reduce inflation</b>	Negative (-)	+0.00000254	0.1546	No	Positive	<b>Hypothesis rejected (not validated)</b>
<b>H3: Renewable energies reduce unemployment</b>	Negative (-)	+0.00000464	0.0001	Yes	Positive	<b>Hypothesis rejected (opposite effect observed)</b>
<b>H4: Renewable energies reduce energy dependence</b>	Negative (-)	-0.0000112	0.0000	Yes	Negative	<b>Hypothesis confirmed</b>
<b>H5: Renewable energies reduce CO<sub>2</sub> emissions</b>	Negative (-)	-0.014955	0.0003	Yes	Negative	<b>Hypothesis confirmed</b>

The results show that the development of renewable energies in Morocco primarily produces **energy and environmental** rather than economic effects in the short term. Indeed, the hypotheses relating to the reduction of energy dependence ( **H4** ) and CO<sub>2</sub> emissions ( **H5** ) are validated, confirming the strategic role of renewable energies in the country's energy transition.

However, the hypotheses concerning economic growth ( **H1** ) and inflation ( **H2** ) are not validated, as the observed effects are not statistically significant. Regarding unemployment ( **H3** ), the results reveal a significant relationship, but one contrary to theoretical expectations: increased renewable energy production is associated with a rise in the unemployment rate. Thus, over the period 2007-2024, the benefits of renewable

energy appear to be more evident in terms of energy security and environmental performance than in terms of economic growth and employment.

## GENERAL CONCLUSION

This study aimed to analyze the interactions between the development of renewable energies and the economic performance of Morocco over the period 2007-2024. Through an econometric approach based on five regression models, the analysis made it possible to assess the impact of renewable energies on economic growth, inflation, unemployment, energy dependence and CO<sub>2</sub> emissions.

The results obtained show that renewable energies play a crucial role in Morocco's energy transition. Indeed, their development contributes significantly to reducing energy dependence and decreasing CO<sub>2</sub> emissions. These results confirm the relevance of the national energy strategy aimed at strengthening the country's energy security while meeting the imperatives of sustainable development and combating climate change.

However, the effects of renewable energy on economic growth and inflation appear to be statistically insignificant over the period studied. These results suggest that the macroeconomic benefits of the energy transition require more time to materialize and also depend on other structural factors such as investment, innovation, industrial competitiveness, and the quality of human capital.

Furthermore, the study highlights a positive and significant relationship between renewable energy and unemployment, contrary to theoretical expectations. This result can be explained by the highly capital-intensive nature of renewable energy projects, the significant reliance on imported equipment, and the limited immediate impact on local employment. It thus underscores the need to support the energy transition with industrial, training, and skills development policies to maximize its positive effects on the labor market.

Overall, the findings of this research show that the main benefits of renewable energy in Morocco are currently observed in both energy and environmental terms. Developing renewable energy capacity is a strategic lever for strengthening the resilience of the Moroccan economy to external shocks, reducing its energy vulnerability, and supporting its international climate commitments.

However, this study has some limitations, notably the small sample size, the use of simple regression models, and the absence of certain explanatory variables that could influence the results. Future research could utilize more advanced econometric models (ARDL, VECM, or VAR), incorporate more macroeconomic variables, and examine the long-term effects of renewable energy on the growth, employment, and competitiveness of the Moroccan economy.

Ultimately, renewable energies appear as an essential pillar of Morocco's new development model. Beyond their contribution to environmental protection, they represent a strategic instrument for energy sovereignty and sustainable development, capable of supporting the structural transformation of the Moroccan economy towards more resilient, inclusive growth that respects the climate requirements of the 21st century.

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