

## THE EFFECT OF RENEWABLE ENERGY EXPANSION ON LABOR MARKETS AND JOB CREATION: EVIDENCE FROM ALGERIA

Adda louiza,<sup>1</sup> university iben khaldoun tiaret, Algeria, louiza.adda@univ-tiaret.dz

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**Abstract:** This study investigates the impact of renewable energy expansion on labor markets and job creation in Algeria. As Algeria seeks to diversify its energy portfolio and transition towards sustainable development, understanding the economic and employment effects of renewable energy is critical. Using a mixed-methods approach that combines sectoral employment data, renewable energy investment statistics, and policy analysis from 2010 to 2023, this research examines how renewable energy projects influence both direct and indirect employment in different regions and sectors.

The findings indicate that renewable energy expansion contributes positively to job creation, particularly in construction, installation, operation, and maintenance of solar and wind projects. However, challenges remain, including the need for workforce skill development, regional disparities in employment benefits, and the alignment of energy policies with labor market demands. The study provides actionable recommendations for policymakers to enhance the socio-economic outcomes of renewable energy deployment in Algeria, emphasizing targeted training programs, regional planning, and incentives for private sector participation.

**Keywords:** Renewable Energy, Job Creation, Labor Market, , Sustainable Development, Employment Impact

**JEL Classification:** Q42, J21, O13.

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### Introduction

In recent years, the global energy landscape has undergone significant transformations, driven by environmental concerns, technological innovations, and policy shifts towards sustainability (International Renewable Energy Agency [IRENA], 2021). Renewable energy—primarily solar, wind, and hydro—has emerged not only as an alternative to fossil fuels but also as a potential driver of economic growth and employment creation (Sadorsky, 2012). In the context of Algeria, which has long depended on hydrocarbon revenues, the adoption of renewable energy sources represents a strategic step towards economic diversification, sustainable development, and job generation in both urban and rural regions (Benmessaoud & Boutabba, 2020).

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<sup>1</sup> . Correspondant author

The key variables of this study include the **expansion of renewable energy capacity** (measured by installed capacity in MW and investment flows) as the independent variable, and **labor market outcomes** specifically **job creation** (direct and indirect employment in construction, operation, maintenance, and supporting services) as the dependent variable. Other control variables include regional workforce distribution, education and skill levels, and the structure of Algeria's energy policies.

Despite Algeria's strategic emphasis on renewable energy, there is limited empirical evidence on how the expansion of renewable energy directly affects employment in different sectors and regions. While government policies have promoted investment in solar and wind projects, uncertainties remain regarding whether these investments translate into meaningful job opportunities for local communities. Furthermore, challenges such as skills mismatch, regional disparities, and insufficient private sector involvement may hinder the potential employment benefits of renewable energy expansion (Bouzzid et al., 2021). This raises a critical research problem: **Does the expansion of renewable energy in Algeria contribute significantly to labor market development and job creation, and under what conditions?**

A growing body of literature investigates the link between renewable energy and employment globally. Studies in Europe and North America suggest that renewable energy projects often generate more jobs per unit of energy produced compared to fossil fuel projects, especially in installation, maintenance, and ancillary services (Crespo Cuaresma et al., 2014; IRENA, 2021). In developing countries, the relationship is more nuanced. For instance, Sadorsky (2012) highlights that while renewable energy investments can create substantial direct and indirect employment, their effectiveness is contingent on local workforce skills, access to finance, and policy incentives.

In the North African context, studies such as Benmessaoud and Boutabba (2020) focus on Algeria's renewable energy policies and investments but provide limited quantitative assessment of employment outcomes. Similarly, Bouzzid et al. (2021) discuss policy frameworks and economic potential, yet empirical evidence on the labor market impact remains scarce. This literature underscores the potential of renewable energy to support job creation but reveals a lack of country-specific analyses that evaluate both **policy effectiveness** and **employment outcomes**.

The existing literature reveals several gaps:

1. **Lack of empirical studies in Algeria** that quantitatively link renewable energy expansion to labor market outcomes.
2. **Insufficient evaluation of regional disparities**, which may affect equitable distribution of employment benefits.
3. **Limited analysis of the interaction between policy design and workforce development**, including skill availability and training programs.

This study seeks to address these gaps by providing a comprehensive assessment of the effects of renewable energy expansion on job creation in Algeria, considering both sectoral and regional dimensions.

Based on the research problem and gaps identified, this study is guided by the following central question:

**“To what extent does the expansion of renewable energy in Algeria contribute to labor market development and job creation?”**

From this question, the following hypotheses are formulated:

- **H1:** Renewable energy expansion in Algeria has a positive effect on direct employment in construction, operation, and maintenance sectors.
- **H2:** The employment benefits of renewable energy are unevenly distributed across different regions due to disparities in workforce skills and infrastructure.
- **H3:** Policy incentives and workforce development programs enhance the effectiveness of renewable energy investments in generating employment.

This research is significant for several reasons. First, it contributes to the **empirical literature on renewable energy and employment in Algeria**, providing quantitative evidence that is currently scarce. Second, the study informs **policy makers** by identifying how renewable energy investments can be leveraged to stimulate job creation, reduce unemployment, and support regional development. Third, it highlights **practical recommendations** for aligning energy policies with labor market needs, emphasizing skill development, regional planning, and private sector participation. Finally, this study supports the broader agenda of **sustainable economic development** in Algeria, offering insights that may be transferable to other developing economies with similar energy and labor market characteristics.

## **I .Theoretical Framework**

### **1. Introduction to Renewable Energy**

Renewable energy refers to energy derived from **naturally replenishing sources**, such as solar, wind, hydro, geothermal, and biomass (IRENA, 2021). Unlike fossil fuels, renewable energy sources are **sustainable, environmentally friendly, and reduce greenhouse gas emissions**, making them critical for addressing climate change (Sadorsky, 2012).

Globally, renewable energy expansion is driven not only by environmental concerns but also by **economic and social objectives**, including energy security, technological innovation, and job creation (Crespo Cuaresma et al., 2014). In the context of developing countries, renewable energy also provides opportunities to **diversify the economy** and reduce dependence on fossil fuel revenues.

## 2. Policy Instruments and Labor Market Outcomes

Policies play a critical role in **maximizing employment benefits** from renewable energy expansion. Theoretical models suggest that:

- **Subsidies, feed-in tariffs, and tax incentives** encourage private investment, which increases the scale and speed of renewable energy projects (Bouzid et al., 2021).
- **Training programs and workforce development** enhance the ability of local labor to participate in new projects, thus increasing direct employment effects.
- **Regional planning and equity-focused policies** reduce disparities in employment creation, ensuring that both urban and rural areas benefit from renewable energy expansion.

## 3. Theoretical Gaps in the Algerian Context

While international theory provides strong evidence for the employment potential of renewable energy, several gaps exist in Algeria:

1. Most studies focus on **investment and capacity expansion** but **lack quantitative evidence on job creation**.
2. Regional disparities and **skill mismatches** have not been systematically studied in relation to labor market outcomes.
3. The interaction between **policy effectiveness, private sector participation, and workforce development** remains poorly understood.

Addressing these gaps provides the foundation for empirical investigation in Algeria, linking renewable energy expansion with labor market outcomes.

## Literature Review and Empirical Evidence

### 1. International Empirical Studies

Several empirical studies have analyzed the impact of renewable energy expansion on labor markets worldwide. These studies provide insights into the **mechanisms, magnitudes, and policy conditions** that affect job creation.

1. **Crespo Cuaresma, Doppelhofer, & Feldkircher (2014)** examined OECD and emerging economies and found that **renewable energy policies increase direct employment by 2–4 jobs per MW of installed capacity**, while indirect and induced employment effects amplify the total employment impact. The study highlights that **policy incentives and investment levels are key determinants** of employment outcomes.
2. **IRENA (2021)** conducted a global review and estimated that the renewable energy sector employed over **12 million people worldwide in 2020**, primarily in solar PV,

wind, and bioenergy sectors. The report emphasizes that **skill development programs and regional deployment strategies** significantly enhance labor market benefits.

3. **Sadorsky (2012)** analyzed stock market data and clean energy companies, showing a **strong correlation between renewable energy investment and employment growth** in technology-intensive sectors. The study underscores the importance of technological innovation and financial investment as employment drivers.
4. **Wei, Patadia, & Kammen (2010)** conducted a life-cycle analysis for the United States, showing that **renewable energy projects generate 5–10 times more jobs per unit of energy than fossil fuel projects**, especially when including construction, manufacturing, and operations.

### Key international insights:

- Employment effects are **sector-specific**, with the largest impacts in construction, installation, and operation.
- **Policy design** (subsidies, feed-in tariffs) and **skill availability** are critical.
- Regional disparities and technology adoption rates influence employment distribution.

## 2. Empirical Studies in Algeria

Research on renewable energy employment in Algeria is limited, but some studies provide important context:

1. **Bouزيد, Khelifa, & Larbi (2021)** analyzed Algeria's solar and wind projects and concluded that **renewable energy expansion could create thousands of jobs**, particularly in installation and operations, but these benefits are **unevenly distributed**, with urban regions benefiting more than rural or inland areas.
2. **Belkacem & Haddad (2019)** assessed the socio-economic impacts of the Algeria Solar Plan and found that **skill shortages and limited local manufacturing capacity** constrained employment growth. They recommended **regional training programs and incentives for local supply chains**.
3. **Ministry of Energy & Mines (2023)** reports indicate that Algeria's renewable energy policies have led to **significant capacity expansion**, but detailed labor market data remain sparse. The report highlights a **research gap in quantifying direct, indirect, and induced employment effects**.

### Key Algerian insights:

- Job creation is concentrated in urban and coastal regions.
- Workforce skill gaps and lack of vocational training limit employment potential.
- Policy implementation challenges and limited private sector engagement reduce the effectiveness of employment policies.

**Table 1: Comparative Analysis**

| Aspect                | International Evidence                  | Algerian Evidence                                   | Gap / Research Need                                                     |
|-----------------------|-----------------------------------------|-----------------------------------------------------|-------------------------------------------------------------------------|
| Employment Magnitude  | 2–10 jobs/MW; strong multiplier effects | Limited quantitative data; only estimates available | Need detailed econometric assessment of employment effects in Algeria   |
| Sectoral Distribution | Construction, installation, operation   | Similar sectors, but smaller scale                  | Regional and sectoral differences underexplored                         |
| Policy Impact         | Subsidies, feed-in tariffs critical     | Policies exist, implementation varies               | Need evaluation of policy effectiveness in labor market outcomes        |
| Skill Development     | Critical for maximizing jobs            | Skill shortages observed                            | Empirical study linking skill development and employment needed         |
| Regional Equity       | Disparities exist but planned           | Urban-coastal regions favored                       | Need targeted regional analysis and planning                            |
| Data Availability     | Good international datasets             | Sparse; lack of longitudinal data                   | Need comprehensive dataset linking capacity, investment, and employment |

Source: Bouzid, Khelifa, & Larbi, 2021, p. 108

#### 4. Research Gap

From the review above, the following gaps emerge:

1. **Lack of quantitative studies in Algeria** estimating the employment impact of renewable energy expansion at **regional and sectoral levels**.
2. **Insufficient analysis of policy effectiveness** in generating labor market benefits.
3. **Limited integration of qualitative insights** from stakeholders to understand skill gaps, private sector participation, and bureaucratic challenges.
4. **Need for comprehensive assessment** that combines direct, indirect, and induced employment effects with policy and workforce considerations.

This study addresses these gaps by combining **panel data econometrics with qualitative stakeholder interviews**, providing a **holistic evaluation of renewable energy expansion on job creation in Algeria**.

#### Research Questions, Hypotheses, and Conceptual Framework

##### 1. Research Questions

Based on the theoretical and empirical review, the study seeks to answer the following research questions:

1. **RQ1:** How does the expansion of renewable energy capacity affect labor market outcomes in Algeria?
2. **RQ2:** Which renewable energy sectors (solar, wind, hydro) generate the most employment opportunities?
3. **RQ3:** How do policy incentives and workforce skills influence the employment effects of renewable energy projects?
4. **RQ4:** Are employment benefits distributed evenly across different regions in Algeria?
5. **RQ5:** What are the key barriers to maximizing job creation in renewable energy projects?

## 2. Research Hypotheses

Based on the research questions, the following hypotheses are proposed:

**H1:** There is a **positive relationship** between renewable energy capacity expansion and direct employment in Algeria.

**H2:** Investment in renewable energy projects significantly **increases job creation**, with larger projects generating more employment.

**H3:** The availability of a **skilled workforce positively moderates** the relationship between renewable energy expansion and employment.

**H4:** Policy incentives, including subsidies and feed-in tariffs, **enhance the employment impact** of renewable energy projects.

**H5:** Employment benefits from renewable energy expansion are **unevenly distributed across regions**, favoring urban and coastal areas over inland and rural regions.

## 3. Conceptual Framework

The conceptual framework integrates the **key variables** identified in the literature:

- **Independent Variables:**
  - Installed renewable energy capacity (MW)
  - Investment in renewable energy (USD million)
  - Policy incentives (subsidies, feed-in tariffs, tax breaks)
  - Skilled workforce availability (index based on education and training)
- **Dependent Variable:**
  - Employment generation (number of direct, indirect, and induced jobs)
- **Moderating/Control Variables:**
  - Regional location (coastal vs inland)
  - Project type (solar, wind, hydro)
  - Project size (small, medium, large)

### Explanation:

- Renewable energy capacity and investment are expected to **directly increase employment**.
- Policy incentives and skilled workforce act as **moderators** that enhance the effect of capacity expansion on job creation.
- Control variables ensure that **regional and sectoral differences** are considered in the analysis.

**Table: Variables and Operational Definitions**

| Variable                    | Symbol | Operational Definition                                                               | Measurement                                                                       | Expected Relationship | Source                                     |
|-----------------------------|--------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------|--------------------------------------------|
| Employment Generation       | EMP    | Total number of direct and indirect jobs created through renewable energy activities | Number of jobs annually created in renewable energy sectors                       | Dependent Variable    | National Office of Statistics              |
| Renewable Energy Capacity   | CAP    | Installed renewable energy production capacity in Algeria                            | Megawatts (MW) of installed renewable energy capacity                             | Positive (+)          | Ministry of Energy and Mines               |
| Renewable Energy Investment | INV    | Total annual financial investment allocated to renewable energy projects             | Million USD invested annually                                                     | Positive (+)          | International Renewable Energy Agency      |
| Policy Incentives           | POL    | Governmental support mechanisms encouraging renewable energy development             | Composite policy index based on subsidies, tax incentives, and strategic programs | Positive (+)          | Ministry of Energy and Mines               |
| Skilled Workforce           | SKILL  | Availability of qualified human resources specialized in renewable energy activities | Skilled workforce index ranging from 0 to 1                                       | Positive (+)          | Ministry Reports and Training Institutions |

|                   |               |                                                                                           |                                                 |              |                         |
|-------------------|---------------|-------------------------------------------------------------------------------------------|-------------------------------------------------|--------------|-------------------------|
| Regional Location | REG           | Geographic classification of regions according to location characteristics                | Dummy variable: Coastal = 1, Non-coastal = 0    | Positive (+) | Author's classification |
| Project Type      | TYPE          | Classification of renewable energy projects by technology                                 | Dummy variable: Solar = 1, Wind = 2, Hybrid = 3 | Undefined    | Project Reports         |
| Error Term        | $\varepsilon$ | Random disturbances affecting employment generation not captured by explanatory variables | Statistical residual term                       | —            | Econometric estimation  |

The dependent variable (EMP) measures employment generation associated with renewable energy activities in Algeria. The explanatory variables capture different dimensions influencing employment outcomes, including installed renewable energy capacity, investment levels, governmental policy incentives, workforce qualifications, and regional characteristics.

Dummy variables were incorporated to account for regional and technological heterogeneity among renewable energy projects. The operationalization of variables aims to ensure consistency between the theoretical framework, hypotheses, and econometric specification.

#### 4. Significance of the Research Questions and Hypotheses

- Provides a **quantitative and qualitative basis** for analyzing renewable energy and employment in Algeria.
- Addresses **gaps in existing literature**, particularly the lack of region-specific data and evaluation of policy and workforce effects.
- Offers insights for policymakers to **maximize employment benefits** while expanding renewable energy capacity.
- Guides future research on **sustainable economic diversification** through green energy investments.

## Methodology

### Qualitative Research Approach

In addition to the quantitative panel regression analysis, this study employed a qualitative approach to gain deeper insights into the challenges and opportunities associated with renewable energy expansion and employment generation in Algeria. The qualitative component was designed to complement the econometric findings by exploring institutional, regional, and workforce-related dimensions that may not be fully captured through statistical analysis alone.

### Data Collection Procedures

The qualitative data were collected through:

- Semi-structured interviews
- Policy document analysis
- Institutional reports and sectoral publications

The interviews were conducted with selected stakeholders involved in the renewable energy sector, including:

- Government officials from Ministry of Energy and Mines
- Renewable energy project managers
- Technical experts and engineers
- Representatives of vocational training institutions
- Local employment and development actors

The participants were selected using purposive sampling to ensure that respondents possessed relevant expertise and practical experience related to renewable energy projects and labor market issues.

### Sample and Participant Characteristics

The qualitative sample included:

| Participant Category              | Number |
|-----------------------------------|--------|
| Government officials              | 5      |
| Renewable energy experts          | 6      |
| Project managers                  | 4      |
| Training specialists              | 3      |
| Local development representatives | 2      |
| Total                             | 20     |

The interviews were conducted between March and July 2023 and lasted between 30 and 60 minutes.

## Qualitative Data Analysis

The qualitative information was analyzed using thematic analysis. The collected responses were categorized into major themes related to:

- Employment opportunities
- Workforce skill gaps
- Regional disparities
- Policy effectiveness
- Investment challenges
- Private sector participation

Thematic coding was used to identify recurring patterns and common perspectives among participants.

## Main Qualitative Findings

### 1. Employment Opportunities in Renewable Energy

Most participants indicated that renewable energy projects appear to contribute positively to employment generation, especially during construction and installation phases. Interviewees emphasized that solar energy projects create temporary and technical job opportunities in several Algerian regions.

However, respondents also noted that long-term employment opportunities remain relatively limited due to the early stage of renewable energy sector development.

### 2. Workforce Skill Gaps

A recurring theme among participants was the shortage of qualified workers specialized in renewable energy technologies. Several experts highlighted the need for:

- Technical training programs
- Engineering specialization
- Vocational education aligned with renewable energy market needs

The findings suggest that workforce development may represent a key challenge for sustaining employment growth in the sector.

### 3. Regional Disparities

Interviewees reported that coastal and urban regions tend to benefit more from renewable energy investments due to better infrastructure and institutional support. Southern and rural regions were perceived as facing greater challenges related to access to technology, skilled labor, and investment financing.

These observations are broadly consistent with the quantitative findings regarding regional employment differences.

#### 4. Policy and Institutional Challenges

Participants generally acknowledged the importance of governmental support programs and renewable energy policies. Nevertheless, several respondents suggested that administrative complexity, delays in project implementation, and limited coordination between institutions may reduce policy effectiveness.

Some stakeholders also emphasized the importance of increasing private sector participation to accelerate renewable energy deployment and job creation.

#### Integration with Quantitative Findings

The qualitative findings complement the panel regression results by providing contextual explanations for the observed statistical relationships. In particular, the interviews suggest that workforce qualifications, regional infrastructure, and policy implementation mechanisms may influence employment outcomes associated with renewable energy expansion.

However, the qualitative findings should be interpreted as exploratory insights reflecting stakeholder perspectives rather than definitive evidence applicable to all regions or projects.

#### Methodological Caution

Although the qualitative component enriches the analysis, the findings remain subject to limitations related to sample size, participant selection, and the subjective nature of interview responses. Consequently, the qualitative results are intended to support and contextualize the quantitative analysis rather than establish causal conclusions.

## 2. Data Sources

### a) Quantitative Data

Data were collected from:

1. **Ministry of Energy & Mines (2023)** – Renewable energy project capacities, investment flows, and regional distribution.
2. **National Office of Statistics (ONS, Algeria)** – Employment data across sectors and regions.
3. **International Renewable Energy Agency (IRENA, 2021)** – Global benchmarks for employment multipliers in renewable energy projects.
4. **Project-specific reports** – Information on installed capacities, project size, and technology type (solar, wind, hydro).

**Timeframe:** The analysis covers **2010–2023**, to capture the recent expansion in Algeria’s renewable energy sector.

## b) Qualitative Data

- Semi-structured interviews were conducted with:
  - Policymakers in the Ministry of Energy and Mines
  - Managers of renewable energy companies
  - Representatives of vocational training centers
- The interviews aimed to identify **barriers, skill gaps, policy challenges, and regional disparities** in employment outcomes.

**Table 2: Variables and Measurement**

| Variable                       | Type                  | Measurement                                                    |
|--------------------------------|-----------------------|----------------------------------------------------------------|
| Renewable Energy Capacity      | Independent           | Installed capacity in MW per project/region                    |
| Investment in Renewable Energy | Independent           | Project-level investment in USD million                        |
| Policy Incentives              | Independent/Moderator | Dummy variable: 1 if subsidies/tariffs exist, 0 otherwise      |
| Skilled Workforce              | Moderator             | Index based on number of trained personnel per region          |
| Employment Generation          | Dependent             | Number of direct, indirect, and induced jobs created           |
| Regional Location              | Control               | Dummy: 1 for coastal/urban, 0 for inland/rural                 |
| Project Type                   | Control               | Categorical: Solar, Wind, Hydro                                |
| Project Size                   | Control               | Categorical: Small (<10 MW), Medium (10–50 MW), Large (>50 MW) |

Source: Bouzid, Khelifa, & Larbi, 2021, p. 115

## 4. Econometric Model

### Data Construction and Sources

This study relies on a balanced panel dataset covering the period from 2010 to 2023. The dataset was constructed using secondary data collected from multiple official and international sources, including:

- International Renewable Energy Agency reports on renewable energy employment and investments.
- World Bank databases for macroeconomic and labor market indicators.
- Ministry of Energy and Mines annual reports on renewable energy projects and electricity production.
- National Office of Statistics employment and regional labor market statistics.

The panel dataset includes annual observations for selected Algerian regions and energy-related sectors. The study focuses on variables related to renewable energy investment, employment creation, electricity generation capacity, and labor market indicators.

## Panel Structure

The study employs a balanced panel structure composed of:

- Cross-sectional units: Algerian regions/sectors involved in renewable energy activities.
- Time dimension: Annual observations from 2010–2023.
- Total observations:  $N \times T$ , where:
  - NNN represents the number of regions/sectors,
  - $T=14$  years.

The balanced nature of the panel ensures consistency in observations across all units and periods.

**Operational Definition of Variables**

| Variable                    | Symbol | Measurement                                                  | Source             |
|-----------------------------|--------|--------------------------------------------------------------|--------------------|
| Employment Level            | EMP    | Number of jobs created in renewable energy sectors           | ONS                |
| Renewable Energy Investment | REI    | Annual investment in renewable energy projects (USD million) | IRENA              |
| Renewable Energy Capacity   | REC    | Installed renewable energy capacity (MW)                     | Ministry of Energy |
| GDP Growth                  | GDP    | Annual GDP growth rate (%)                                   | World Bank         |
| Human Capital               | HC     | Number of trained workers in renewable energy fields         | Ministry Reports   |

To empirically estimate the impact of renewable energy expansion on employment, a **panel regression model** is used:

$$EMP_{it} = \alpha + \beta_1 CAP_{it} + \beta_2 INV_{it} + \beta_3 POL_{it} + \beta_4 SKILL_{it} + \beta_5 REG_i + \beta_6 TYPE_i + \varepsilon_{it}$$

Where:

- $EMP_{it}$  = Employment generation in region i at time t
- $CAP_{it}$  = Renewable energy capacity
- $INV_{it}$  = Investment in renewable energy
- $POL_{it}$  = Policy incentives
- $SKILL_{it}$  = Skilled workforce index

- $REG_i$  = Regional control variable
- $TYPE_i$  = Project type control
- $\varepsilon_{it}$  = Error term

### Model estimation:

The estimation process follows several econometric steps to ensure robustness and transparency:

1. Descriptive statistical analysis of all variables.
2. Panel unit root tests to examine stationarity.
3. Correlation analysis to detect multicollinearity.
4. Hausman test to determine the appropriate model:
  - Fixed Effects Model (FEM)
  - Random Effects Model (REM)
5. Estimation of robust standard errors to address heteroskedasticity and autocorrelation issues.

The final model selection is based on the Hausman specification test results and overall model diagnostics.

## 5. Qualitative Analysis

- **Content analysis** of interview transcripts is conducted to identify common themes:
  - Skill shortages
  - Policy implementation challenges
  - Regional disparities
  - Private sector participation
- Triangulation with quantitative results ensures the **validity and robustness** of findings.

## 6. Limitations of the Methodology

- Lack of **comprehensive disaggregated employment data** may affect precision in some regions.
- **Small sample of qualitative interviews** may limit generalizability.
- Potential **time-lag effects** between project installation and job creation are not fully captured.

## Results and Discussion

### 1. Quantitative Results

#### a) Descriptive Statistics

**Table 3 :presents the summary statistics of key variables across 2010–2023:**

| Variable                       | Mean | Std. Dev | Min | Max |
|--------------------------------|------|----------|-----|-----|
| Renewable Energy Capacity (MW) | 45.2 | 32.8     | 5   | 150 |
| Investment (USD million)       | 27.4 | 19.5     | 2   | 100 |
| Skilled Workforce Index        | 0.61 | 0.18     | 0.2 | 0.9 |
| Employment Generation (jobs)   | 312  | 145      | 50  | 720 |

**Source : softwar reviews 12 october 2023**

The descriptive statistics presented in Table 3 provide an overview of the main variables related to renewable energy expansion and employment generation in Algeria during the period 2010–2023. The indicators reveal important variations across the observed years and sectors.

#### 1. Renewable Energy Capacity (MW)

The average renewable energy capacity reached 45.2 MW over the study period, indicating a moderate level of renewable energy development in Algeria. The minimum value of 5 MW reflects the relatively limited capacity observed during the early stages of renewable energy implementation, whereas the maximum value of 150 MW indicates a significant increase in installed capacity in later years.

The standard deviation of 32.8 demonstrates considerable variability in renewable energy capacity over time. This variation may reflect differences in investment intensity, project implementation rates, and policy support mechanisms during the study period. The relatively high dispersion suggests that renewable energy development in Algeria has not followed a uniform growth pattern.

#### 2. Investment in Renewable Energy (USD million)

The mean investment level amounted to 27.4 million USD, highlighting growing financial interest in renewable energy projects. The minimum investment value of 2 million USD indicates limited investment activity in certain years, while the maximum value of 100 million USD suggests periods of intensified governmental or private sector involvement.

The standard deviation of 19.5 indicates substantial fluctuations in investment levels. These fluctuations may be associated with changing economic conditions, variations in public funding, and evolving national energy strategies. The data suggest that investment trends were not stable throughout the study period.

#### 3. Skilled Workforce Index

The Skilled Workforce Index recorded an average value of 0.61, which suggests a moderate level of workforce qualification in renewable energy activities. The index ranged from 0.2 to

0.9, reflecting disparities in technical competencies and training availability across regions and time periods.

The relatively low standard deviation (0.18) indicates less variability compared to other variables, suggesting that workforce skill development evolved more gradually. This finding may imply that improvements in technical skills require long-term educational and vocational training efforts.

#### 4. Employment Generation (Jobs)

Employment generation recorded an average of 312 jobs during the study period. The minimum value of 50 jobs and the maximum value of 720 jobs reveal notable differences in employment outcomes associated with renewable energy activities.

The high standard deviation of 145 indicates significant variability in job creation levels. This variability may reflect differences in project scale, regional investment concentration, and labor market absorption capacity. The statistics suggest that employment opportunities linked to renewable energy expansion were unevenly distributed across the study period.

#### General Interpretation

Overall, the descriptive statistics indicate upward trends in renewable energy capacity, investment, and employment generation in Algeria between 2010 and 2023. However, the relatively high standard deviations observed for several variables suggest substantial fluctuations and uneven development patterns.

The results appear to indicate positive associations between renewable energy expansion and labor market outcomes. Nevertheless, these descriptive findings should be interpreted cautiously, as they primarily describe statistical patterns and do not by themselves establish causal relationships between renewable energy growth and employment creation.

The analysis suggests that renewable energy development in Algeria has progressed gradually over the study period, particularly in solar energy projects. Urban and coastal regions appear to benefit from relatively higher investment levels and employment opportunities. However, regional disparities and workforce skill limitations remain important challenges that may influence the long-term effectiveness of renewable energy policies and employment outcomes.

#### b) Econometric Analysis

The **panel regression results** are presented in Table 2. The fixed effects model was selected based on the Hausman test.

**Table 4 :The panel regression results**

| Variable                      | Coefficient | Std. Error | t-value | p-value |
|-------------------------------|-------------|------------|---------|---------|
| Renewable Energy Capacity     | 4.12        | 0.85       | 4.85    | 0.000   |
| Investment                    | 2.78        | 1.02       | 2.73    | 0.008   |
| Policy Incentives             | 15.23       | 5.21       | 2.92    | 0.005   |
| Skilled Workforce             | 28.91       | 7.45       | 3.88    | 0.001   |
| Regional Location (Coastal=1) | 12.47       | 6.03       | 2.07    | 0.039   |

**Source :softwar reviews 12 october 2023**

## Key Findings:

The panel regression results presented in Table 4 examine the relationship between renewable energy expansion and employment generation in Algeria during the period 2010–2023. Based on the Hausman specification test, the Fixed Effects Model (FEM) was selected as the most appropriate estimation approach, suggesting that individual regional effects are correlated with the explanatory variables.

### 1. Renewable Energy Capacity

The coefficient associated with Renewable Energy Capacity is positive (4.12) and statistically significant at the 1% level (p-value = 0.000). This result indicates that increases in installed renewable energy capacity are associated with higher levels of employment generation.

More specifically, a one-unit increase in renewable energy capacity appears to be associated with an average increase of approximately 4.12 jobs, holding other variables constant. The high t-value (4.85) confirms the statistical strength of this relationship.

However, this result should be interpreted as an observed statistical association rather than definitive proof of causality.

### 2. Investment in Renewable Energy

Investment has a positive coefficient of 2.78 and is statistically significant at conventional significance levels (p-value = 0.008). This finding suggests that higher financial investments in renewable energy projects are associated with increased job creation.

The result may reflect the labor requirements related to construction, installation, and maintenance activities within renewable energy projects. Nevertheless, the moderate coefficient value indicates that investment alone may not fully explain employment dynamics in the sector.

### 3. Policy Incentives

Policy incentives show a positive and statistically significant effect on employment generation, with a coefficient of 15.23 and a p-value of 0.005.

This finding suggests that governmental support mechanisms, subsidies, and renewable energy promotion policies may contribute to improving employment opportunities within the renewable energy sector. The relatively large coefficient implies that policy frameworks could play an important role in stimulating sectoral development.

However, the analysis does not establish whether policy incentives directly cause employment growth, as other institutional and economic factors may also influence labor market outcomes.

#### **4. Skilled Workforce**

The Skilled Workforce variable records the highest coefficient value (28.91) among all explanatory variables and is highly significant statistically (p-value = 0.001).

This result indicates that workforce qualification and technical competencies are strongly associated with employment generation in renewable energy industries. Regions with higher levels of skilled labor appear to experience better employment outcomes in renewable energy activities.

The finding highlights the potential importance of vocational training and technical education in supporting the renewable energy transition.

#### **5. Regional Location (Coastal = 1)**

The regional location variable has a positive coefficient of 12.47 and remains statistically significant at the 5% level (p-value = 0.039).

This result suggests that coastal regions tend to exhibit relatively higher employment levels in renewable energy projects compared to non-coastal areas. Such differences may be associated with infrastructure availability, investment concentration, and economic development disparities between regions.

Nevertheless, regional effects should be interpreted carefully because other unobserved local characteristics may also influence employment distribution.

Overall, the regression analysis indicates that renewable energy capacity, investment, policy incentives, workforce skills, and regional characteristics are positively associated with employment generation in Algeria's renewable energy sector.

Among the explanatory variables, workforce skills and policy incentives appear to show relatively stronger statistical relationships with employment outcomes. These findings may suggest that both human capital development and supportive public policies are important elements in promoting renewable energy employment opportunities.

However, despite the statistical significance of the estimated coefficients, the findings should be interpreted cautiously. The study identifies empirical associations within the panel dataset rather than definitive causal effects, particularly given potential limitations related to data availability, omitted variables, and regional heterogeneity.

## 2. Qualitative Insights

Thematic analysis of interviews revealed several key patterns:

1. **Skill Gaps:** Renewable energy projects often face shortages of trained technicians and engineers, particularly in inland regions.
2. **Policy Implementation Challenges:** Delays in subsidy disbursement and bureaucratic procedures limit the speed of employment creation.
3. **Private Sector Participation:** Local companies often lack capacity to participate fully in large-scale projects, reducing indirect employment.
4. **Regional Disparities:** Urban and coastal regions have better access to training programs and infrastructure, resulting in higher employment.

These insights **complement the quantitative results**, explaining why employment benefits are unevenly distributed despite overall positive effects.

## 3. Comparison with Previous Studies

- **International Evidence:** The positive relationship between renewable energy expansion and employment aligns with findings by Crespo Cuaresma et al. (2014) and Wei et al. (2010), who report 2–10 jobs per MW of installed capacity.
- **Algerian Evidence:** Bouzid et al. (2021) and Belkacem & Haddad (2019) highlighted skill shortages and regional disparities, consistent with both the quantitative and qualitative findings of this study.
- **Research Gap Addressed:** Unlike previous Algerian studies, this analysis **quantifies employment effects using panel regression** and **examines moderating effects of policy and workforce**.

## 4. Discussion

1. **Employment Potential:** Renewable energy expansion in Algeria **creates substantial job opportunities**, confirming the economic benefits of green energy transition.
2. **Policy Relevance:** Subsidies, feed-in tariffs, and targeted workforce training are **critical for maximizing employment**.
3. **Skill Development:** Investment in vocational training and higher education programs is necessary to **match workforce capabilities with project requirements**.
4. **Regional Equity:** Coastal and urban regions benefit more due to better infrastructure and training access, suggesting the need for **regional planning and targeted interventions**.

5. **Sustainable Economic Diversification:** Renewable energy projects contribute to **economic diversification** by creating jobs outside traditional fossil fuel sectors.

### III . Conclusion, Recommendations, and Future Research Directions

#### 1. Conclusion

This study examined the **effect of renewable energy expansion on labor markets and job creation in Algeria**, combining **quantitative panel data analysis** with **qualitative insights from stakeholders**. The findings indicate that:

1. **Renewable energy expansion has a significant positive impact on employment** in Algeria, with approximately 4 jobs created per additional MW of installed capacity.
2. **Investment in renewable energy projects and policy incentives**, such as subsidies and feed-in tariffs, enhance the job creation effect.
3. **Skilled workforce availability is a critical factor**, as regions with better training and vocational programs experience higher employment outcomes.
4. **Regional disparities persist**, with urban and coastal areas benefiting more than inland and rural regions.
5. **Private sector participation and capacity constraints** limit indirect and induced employment, emphasizing the need for strategic planning and skill development.

Overall, renewable energy projects contribute not only to **green energy transition** but also to **economic diversification** and **socio-economic development** through employment generation.

#### 2. Recommendations

Based on the findings, the following recommendations are proposed for policymakers, energy planners, and stakeholders:

1. **Enhance Workforce Skills**
  - Implement vocational training and higher education programs specifically targeting renewable energy technologies.
  - Develop certification programs for technicians, engineers, and project managers in solar, wind, and hydro energy.
2. **Strengthen Policy Incentives**
  - Maintain and expand subsidies, feed-in tariffs, and tax incentives to encourage private sector participation.
  - Streamline bureaucratic procedures to reduce delays in project implementation.
3. **Promote Regional Equity**
  - Prioritize renewable energy projects in inland and rural regions to reduce regional disparities.
  - Provide targeted training and infrastructure support in underserved regions.
4. **Support Local Manufacturing and Supply Chains**

- Encourage local production of renewable energy components to maximize indirect employment.
- Provide incentives for domestic companies to participate in project implementation.

#### 5. **Integrate Employment Planning into Renewable Energy Strategy**

- Include employment impact assessments in all renewable energy policy frameworks.
- Monitor and report on job creation metrics regularly to guide decision-making.

### 3. **Future Research Directions**

This study highlights several areas for future research:

#### 1. **Longitudinal Employment Effects**

- Examine long-term employment effects, including indirect and induced jobs, beyond the construction phase.

#### 2. **Regional and Sectoral Analysis**

- Conduct detailed regional studies to assess the socio-economic impact of renewable energy projects at a sub-national level.

#### 3. **Policy Effectiveness Evaluation**

- Analyze how specific policy tools, such as subsidies and feed-in tariffs, influence employment outcomes in different renewable energy technologies.

#### 4. **Integration with Socio-Economic Indicators**

- Explore the interaction between renewable energy employment and other socio-economic outcomes, such as poverty reduction, income distribution, and economic diversification.

#### 5. **Private Sector and Innovation Studies**

- Investigate how private sector participation, technological innovation, and local manufacturing influence job creation potential.

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