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Energy Transition Pathways in Algeria (2000–2024): Structural Constraints, Institutional Dynamics, and Strategic Perspectives

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Abstract:

Algeria's energy transition remains a paradox of vast potential versus stagnant implementation. Despite boasting over 3,500 annual sunshine hours, the nation remains heavily tethered to hydrocarbons, with renewables accounting for less than 3% of electricity generation as of 2024. This study utilizes a descriptive–analytical framework to highlight a significant "implementation gap" caused by structural and institutional barriers, reflected in a negative governance index of approximately –0.50 and rising carbon emissions of 198 million tons.

To bridge this gap, the research proposes a 2025–2035 roadmap focused on reforming subsidies to realign economic incentives, strengthening institutional governance and regulatory frameworks, and diversifying the energy mix by scaling green hydrogen and renewable infrastructure.

Keywords: Energy Transition; Renewable Energy; Energy Policy; Green Hydrogen; Sustainable Development.

JEL Classification: Q42; Q43; Q48; O55.

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1. Introduction :

Over the past two decades, the global energy system has undergone profound structural transformations driven by climate concerns, technological innovation, and increasing geopolitical uncertainty in energy markets. As a result, the transition toward low carbon energy systems has become a central component of contemporary development strategies. Governments are increasingly adopting policies aimed at reducing greenhouse gas emissions, improving energy efficiency, and diversifying national energy mixes in order to enhance long-term energy security and environmental sustainability (IPCC, 2022, p. 4).

These transformations pose particular challenges for fossil fuel exporting countries. For several decades, hydrocarbon revenues have constituted the principal source of fiscal income and foreign exchange in many resource-dependent economies. The global shift toward cleaner energy systems therefore raises important questions regarding economic diversification and the long-term sustainability of these development models (Cherif, Hasanov, & Pande, 2017, p. 6)

Algeria represents a relevant case within this context. The national economy remains highly dependent on hydrocarbons, which account for the majority of export revenues and a large share of public budget resources. At the same time, the country possesses substantial renewable energy potential, particularly solar energy, due to its vast desert territory and high solar irradiation levels. These structural characteristics place Algeria at the intersection of two contrasting dynamics: continued dependence on hydrocarbon revenues and the strategic need to diversify its energy system.

Despite this favorable natural potential and the adoption of several national energy strategies during the past decade, progress toward a diversified energy mix remains limited. Renewable energy still represents a marginal share of electricity generation, while natural gas continues to dominate the power sector. This situation raises important questions regarding the structural and institutional factors that slow the energy transition process.

In this context, the present study analyzes the evolution of the Algerian energy system between 2000 and 2024 and examines the economic, institutional, and environmental dynamics shaping the national energy transition. The central research question guiding this analysis is: *What structural and institutional factors explain the relatively slow progress of the energy transition in Algeria during the period 2000–2024?*

To address this question, the study pursues three main objectives. First, it examines the evolution of the Algerian energy sector and the relative roles of hydrocarbons and renewable energy over the past two decades. Second, it identifies the principal structural and institutional constraints affecting the pace of energy transition. Third, it explores potential strategic pathways capable of supporting a gradual transformation toward a more diversified and sustainable energy system.

Methodologically, the research relies on a descriptive analytical approach based on longitudinal statistical data obtained from national institutions and international energy organizations. The analysis focuses on key indicators related to hydrocarbon production, electricity generation, renewable energy capacity, carbon emissions, and governance quality

in order to provide an integrated assessment of the dynamics shaping Algeria's energy transition.

The remainder of the paper is organized as follows. Section 2 presents the theoretical foundations of energy transition. Section 3 reviews the relevant literature. Section 4 analyzes the evolution of Algeria's energy sector between 2000 and 2024. Section 5 examines the macroeconomic, environmental, and regulatory framework of the transition. The final section discusses policy implications and proposes strategic recommendations for the future development of Algeria's energy system.

2. Theoretical and Historical Foundations of Energy Transition:

2.1. Concept and Systemic Nature of Energy Transition:

Energy transition refers to the long-term structural transformation of energy systems characterized by the gradual replacement of dominant energy sources, technologies, and patterns of consumption within an economy. This process involves more than a simple substitution between energy sources; it encompasses systemic changes affecting technological innovation, institutional structures, market incentives, and industrial organization (Smil, 2017, p. 302).

Energy transitions typically occur through the progressive diffusion of emerging technologies that gradually gain market share while established energy systems decline in relative importance. However, these transformations tend to unfold slowly due to the structural characteristics of energy systems. Energy infrastructures require large capital investments, operate over long lifecycles, and are embedded in complex regulatory and institutional frameworks. These features generate strong path dependency and limit the speed of structural change (Fouquet, 2016, p. 8).

In recent decades, the concept of energy transition has become closely associated with the global shift toward low-carbon energy systems. Unlike earlier historical transitions that were primarily driven by technological and economic factors, the contemporary transition is strongly influenced by environmental imperatives, particularly the need to mitigate climate change and reduce greenhouse gas emissions (IPCC, 2022, p. 6).

2.2. Historical Dynamics of Global Energy Transitions

Historical experience shows that energy transitions are long-term processes. Before the Industrial Revolution, societies relied primarily on biomass, such as wood, with energy consumption remaining limited and tied to agriculture (Smil, 2017, p. 89).

The nineteenth century marked the first major transformation with the large-scale adoption of coal. The diffusion of steam-engine technology enabled industrial mechanization and the expansion of railway transportation networks, which significantly increased industrial productivity and accelerated urbanization (Allen, 2009, p. 214).

During the twentieth century, oil progressively replaced coal as the primary energy source in several sectors, particularly transportation. The widespread adoption of internal combustion engines and the rapid growth of the automobile industry dramatically increased global demand for petroleum products (Yergin, 1991, p. 412).

The expansion of electricity generation during the same period further diversified the global energy system. Electrification transformed industrial production and household

consumption patterns, while nuclear energy emerged as an alternative large-scale source of electricity generation in several industrialized economies (IEA, 2023) .

Since the late twentieth century, a new phase of transformation has emerged, driven by climate concerns and international commitments to reduce greenhouse gas emissions. Technological progress in renewable energy—especially solar photovoltaic and wind power—has substantially reduced the cost of electricity generation, improving the competitiveness of low-carbon energy technologies (Gielen, et al., 2019, p. 40).

Despite these developments, historical evidence shows that energy transitions remain gradual processes shaped by technological diffusion, infrastructure constraints, and institutional dynamics (Fouquet, 2016, p. 10)

2.3. Structural Dimensions of the Contemporary Energy Transition

The contemporary energy transition is driven by the interaction of several structural factors that influence the transformation of energy systems.

Technological innovation constitutes a central driver of this process. Rapid progress in renewable energy technologies, electricity storage systems, and digitalized power networks has significantly improved the efficiency and reliability of low-carbon energy systems. In particular, the cost of solar photovoltaic electricity has declined sharply over the past decade, making solar power one of the most competitive sources of electricity generation in many regions (IRENA, 2023).

Global investments in energy transition reached $1.7 trillion in 2023, reflecting a massive financial shift toward renewable infrastructure and low-carbon development as the economic dimension of the global energy transition expands. (BloombergNEF, 2024).

Energy transition also involves important social transformations. Decentralized energy systems increasingly allow households, local communities, and small producers to participate in electricity generation. The concept of the prosumer, referring to consumers who also produce electricity, illustrates the growing importance of distributed energy systems in modern electricity markets.

Finally, institutional and political frameworks play a decisive role in shaping energy transition pathways. Governments influence energy markets through regulatory instruments such as renewable energy subsidies, feed-in tariffs, carbon pricing mechanisms, and long-term strategic planning. Carbon pricing policies currently cover approximately 23% of global greenhouse gas emissions, reflecting the increasing importance of policy frameworks in guiding investment decisions within the energy sector (World Bank, 2023).

2.4. Implications for Resource-Dependent Economies

Energy transition presents particular challenges for economies that rely heavily on fossil fuel resources. In these contexts, hydrocarbons frequently constitute a major source of fiscal revenues, export earnings, and employment, creating strong structural dependencies within national economic systems.

Consequently, the transition toward low-carbon energy systems involves complex trade-offs between economic stability, energy security, and environmental sustainability. The speed and effectiveness of transition processes depend not only on technological

potential but also on institutional capacity, economic diversification strategies, and the coherence of national energy policies.

This analytical perspective is especially relevant in the Algerian case. Algeria combines two structural characteristics that strongly influence its transition trajectory: a high level of economic dependence on hydrocarbon exports and substantial renewable energy potential, particularly in solar power. Understanding the interaction between these structural factors is therefore essential for analyzing the opportunities and constraints shaping the country's transition toward a more diversified and sustainable energy system.

3. Literature Review:

Research on energy transition has expanded considerably in recent years, reflecting the growing importance of decarbonization in global economic and environmental policy. The academic literature generally addresses three interconnected debates: the economic drivers of renewable energy expansion, the geopolitical implications of energy transition, and the structural challenges faced by fossil fuel–exporting economies.

3.1. Economic Drivers of Renewable Energy Expansion

A first strand of the literature focuses on the economic determinants of renewable energy development. Early studies emphasize the role of technological progress, learning curves, and economies of scale in reducing the costs of renewable energy technologies, particularly solar photovoltaic and wind power (Gielen, et al., 2019, p. 40). Rapid cost declines have significantly improved the competitiveness of these technologies relative to fossil-fuel-based electricity generation.

Public policy instruments represent another central factor shaping renewable energy diffusion. Mechanisms such as feed-in tariffs, renewable energy auctions, tax incentives, and carbon pricing have been widely implemented to reduce investment risk and stimulate private-sector participation in clean energy markets (IRENA, 2023). Empirical evidence suggests that stable regulatory frameworks and long-term policy commitments are critical conditions for attracting investment in renewable infrastructure (IEA, 2023).

While some studies suggest renewables coexist with fossil fuels rather than immediate replacement, investment remains tethered to hydrocarbons. Consequently, oil price fluctuations indirectly dictate renewable expansion by impacting fiscal revenues and government investment capacity. (Sorokin, Balashova, & Gomonov, 2023, p. 4).

3.2. Geopolitical Dimensions of Energy Transition

A second debate examines the geopolitical implications of the global transition toward low-carbon energy systems. The diffusion of renewable energy technologies is expected to reshape patterns of economic and political influence within the international energy system (IRENA, 2019).

Countries that have invested heavily in renewable technologies and clean-energy manufacturing (such as China, Germany, and the United States) have emerged as key actors in global value chains. Their technological leadership provides important strategic advantages in the evolving energy landscape.

Global shifts toward diversified, decentralized energy systems may diminish the geopolitical influence of hydrocarbon exporters. Consequently, the strategic value of oil and

gas resources will likely decline, outweighed by advanced technological and industrial capabilities (Goldthau & Sovacool., 2018, p. 45).

This transformation is also generating new forms of international cooperation focused on renewable energy development, technological transfer, and green hydrogen markets. Multilateral initiatives aimed at accelerating the diffusion of clean technologies increasingly shape international energy governance structures (IRENA, 2019).

3.3. Structural Constraints in Fossil Fuel–Exporting Economies

A growing body of literature examines the specific challenges that energy transition poses for fossil fuel–dependent economies. Unlike energy-importing countries, resource-dependent states must simultaneously transform their energy systems while diversifying broader economic structures.

Several studies highlight the concept of the carbon lock-in effect, whereby existing infrastructure, fiscal dependence on hydrocarbon revenues, and established institutional arrangements create structural barriers to energy transition (Unruh, 2000, p. 819) . These constraints often slow the diffusion of renewable energy technologies and reinforce reliance on fossil fuels.

Energy subsidy systems represent another critical obstacle. In many hydrocarbon-exporting countries, subsidized domestic energy prices reduce incentives for energy efficiency and undermine the competitiveness of renewable electricity. As a result, subsidy reform is frequently identified as a necessary component of energy transition strategies (Fattouh, Poudineh, & West, 2018, p. 6) .

Recent research also emphasizes the broader political economy of transition in rentier states. In such economies, hydrocarbon revenues play a central role in sustaining public spending and social welfare systems. Consequently, the transition toward low-carbon energy sources may threaten established fiscal and political arrangements unless accompanied by comprehensive economic diversification strategies (Overland, 2019, p. 4).

Empirical studies further suggest that institutional quality and governance capacity significantly influence the success of energy transition policies in resource-dependent economies. Countries with stronger regulatory institutions and diversified economic structures tend to achieve faster progress in renewable energy deployment (Stevens, Lahn, & Kooroshy, 2018, p. 21)

3.4. Research Gap

Despite the rapid expansion of the global literature on energy transition, relatively limited attention has been devoted to hydrocarbon-dependent economies in North Africa, particularly Algeria. Existing research often focuses either on the technological potential of renewable energy resources or on macroeconomic aspects of resource dependence.

Few studies integrate structural energy indicators, institutional dynamics, and macroeconomic variables within a unified analytical framework capable of explaining the slow pace of energy transition in rentier economies.

This study addresses this gap by examining the evolution of Algeria’s energy system (2000–2024) through a multidimensional analytical approach combining sectoral energy

data, institutional analysis, and macroeconomic indicators. By doing so, it aims to provide a more comprehensive understanding of the structural constraints and strategic opportunities shaping the country's transition toward a diversified and sustainable energy system.

4. Methodology

4.1. Research Approach

This study adopts a descriptive–analytical research design to examine Algeria's energy sector evolution (2000–2024) and the structural factors shaping its transition. The descriptive component quantifies trends in production, consumption, and energy mix composition. Concurrently, the analytical dimension evaluates the interaction between institutional frameworks, regulatory policies, and sectoral performance. This dual approach facilitates a comprehensive assessment of the "implementation gap" between policy targets and actual renewable deployment. By integrating statistical data with institutional analysis, the study provides a holistic understanding of the structural constraints and governance challenges hindering the transition from hydrocarbon dependence toward a sustainable energy system.

4.2. Data Sources

Data is triangulated from reputable international and national sources to ensure reliability. Primary statistical data is drawn from the International Energy Agency for energy balances and production figures; the World Bank for macroeconomic indicators; and the International Renewable Energy Agency for renewable capacity statistics. Hydrocarbon production data is cross-referenced with the BP Statistical Review of World Energy. National data is sourced from the Ministry of Energy and Mines, Algeria and annual reports from Sonelgaz, the state electricity utility.

4.3. Indicators and Variables

The study tracks several key indicators: (1) Oil and natural gas production volumes (Mbpd and bcm); (2) Installed renewable energy capacity (MW); (3) Carbon dioxide emissions (Million tons); (4) Energy subsidy expenditure (billion DZD); and (5) International oil prices ($/bbl). These quantitative variables are analyzed in conjunction with qualitative assessments of regulatory frameworks, specifically Laws 02-01, 04-09, 19-13, and 22-18.

4.4. Analytical Framework

The analytical framework of this study links three interrelated dimensions of the energy transition: structural energy indicators, macroeconomic dynamics, and institutional governance variables. Structural indicators capture the evolution of hydrocarbon production, renewable energy capacity, and electricity generation patterns. Macroeconomic variables reflect the influence of oil price fluctuations, fiscal capacity, and economic growth on investment dynamics within the energy sector. Institutional factors refer to the regulatory framework, governance quality, and policy mechanisms shaping energy transition strategies. By integrating these dimensions, the framework enables the identification of structural constraints affecting the pace of energy transition in Algeria.

4.5. Analytical Approach

The analysis proceeds through time-series trend analysis to identify correlations

between oil prices and renewable energy investments. Comparative scenario modeling is used in the discussion section to project future pathways. Policy documents are analyzed to identify regulatory bottlenecks.

4.6. Limitations

This study acknowledges limitations in data availability, noting fragmented national statistics and restricted access to Sonatrach's internal documents. Relying on secondary sources and policy declarations, the analysis lacks primary survey data for deeper validation.

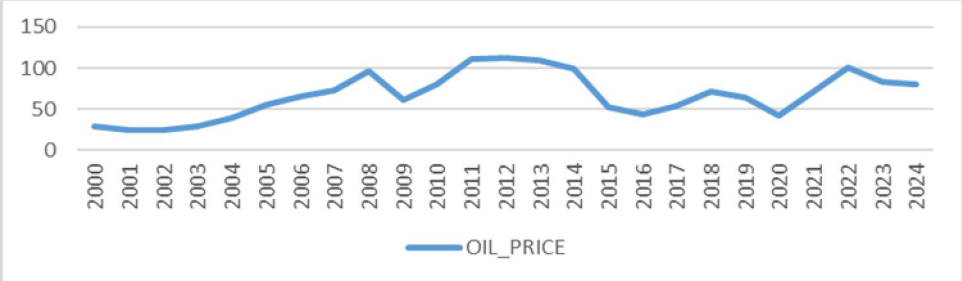
5. Evolution of the Energy Sector in Algeria (2000–2024)

Algeria's 2000–2024 energy evolution reveals persistent hydrocarbon dominance despite emerging renewable initiatives. This trajectory is defined by fluctuating global oil prices, national production dynamics, and strategic, albeit early, shifts toward sustainable energy diversification.

5.1. Oil Price Dynamics

International oil price fluctuations represent a critical external determinant of Algeria's energy sector performance. Given the country's strong dependence on hydrocarbon revenues, variations in global oil prices exert a significant influence on national fiscal stability and investment capacity.

Figure N° 1. Oil Prices ($/barrel)



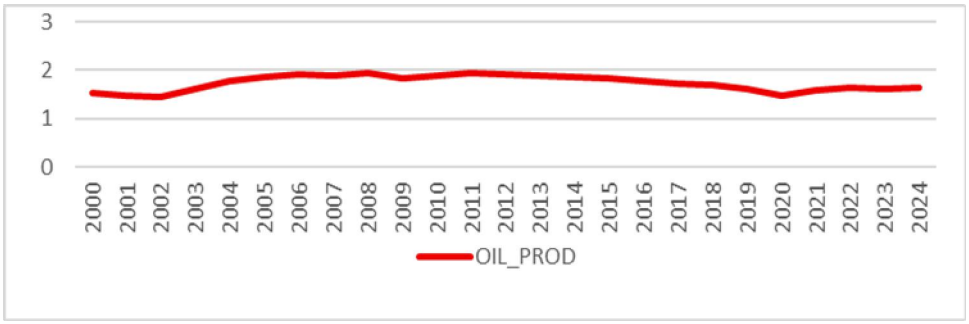
Source: Prepared by the researcher based on BP Statistical Review.

As illustrated in Figure 1, oil prices increased significantly from approximately 29 USD per barrel in 2000 to reach a peak of nearly 99 USD in 2008. Following the global financial crisis, prices declined sharply in 2009, before recovering during the period 2011–2013, when they exceeded 110 USD per barrel. However, the global oil market experienced another major shock during the COVID-19 pandemic in 2020, when prices dropped to around 40 USD per barrel. By 2024, prices stabilized at approximately 80 USD per barrel, reflecting continued volatility in global energy markets (BP Statistical Review of World Energy).

5.2. Oil Production Trends

Alongside price fluctuations, Algeria has experienced a gradual decline in oil production over the past two decades. This trend reflects both structural and market-related factors, including the maturation of several oil fields, limited exploration activities, and production adjustments associated with international agreements aimed at stabilizing oil markets.

Figure N° 2. Oil Production in Algeria (million barrels/day)



Source: Prepared by the researcher based on BP Statistical Review.

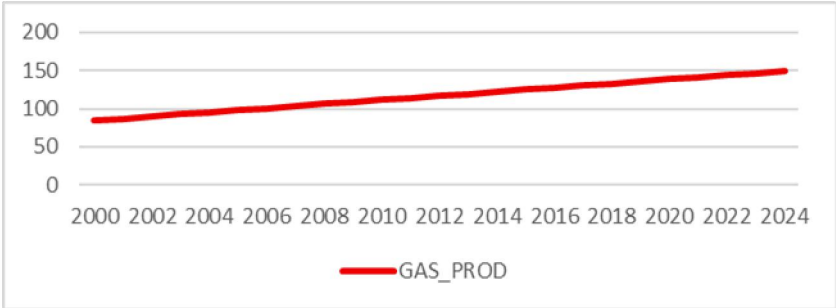
As shown in Figure 2, Algeria's oil production reached its highest level in the mid-2000s, approaching 2 million barrels per day. However, production progressively declined in subsequent years, falling to approximately 1.4 million barrels per day in 2020. Although a moderate recovery has been observed in recent years, with production reaching around 1.65 million barrels per day in 2024, the current levels remain below historical peaks.

This downward trend highlights the structural vulnerability of an energy model heavily reliant on conventional hydrocarbon resources.

5.3. Natural Gas Production

In contrast to oil production, natural gas has played an increasingly important role within Algeria's hydrocarbon sector. The country possesses substantial gas reserves and has significantly expanded its production capacity over the past two decades.

Figure N° 3. Gas Production (bcm)



Source: Prepared by the researcher based on BP Statistical Review.

As indicated in Figure 3, natural gas production increased from approximately 84 billion cubic meters (bcm) in 2000 to nearly 132 bcm in 2024. This expansion has been driven by sustained investments in gas field development and the strategic importance of Algerian gas exports to European markets, particularly through pipeline infrastructure.

Consequently, natural gas has become a central pillar of Algeria's energy system, both for domestic electricity generation and for export revenues.

5.4. Renewable Energy Potential

Beyond hydrocarbons, Algeria possesses considerable natural potential for renewable energy development, particularly in the field of solar energy. The country's geographical location within the global solar belt, combined with vast desert territories and high solar irradiation levels, provides favorable conditions for large-scale solar energy projects.

The technical potential of renewable energy resources in Algeria is summarized in Table 1, which highlights the significant opportunities for developing solar and wind energy

systems capable of contributing to national energy diversification.

Table N°1. Natural Potential for Renewable Energy in Algeria

Energy Type	Key Indicator	Estimated Value
Solar Energy	Annual Solar Radiation	2,000–3,000 kWh/m²
Solar Energy	Annual Sunshine Hours	Over 3,500 hours
Solar Energy	Exploitable Desert Area	~ 2 million km²
Wind Energy	Average Wind Speed	6–7 m/s
Hydropower	Main Dams	Over 80 dams

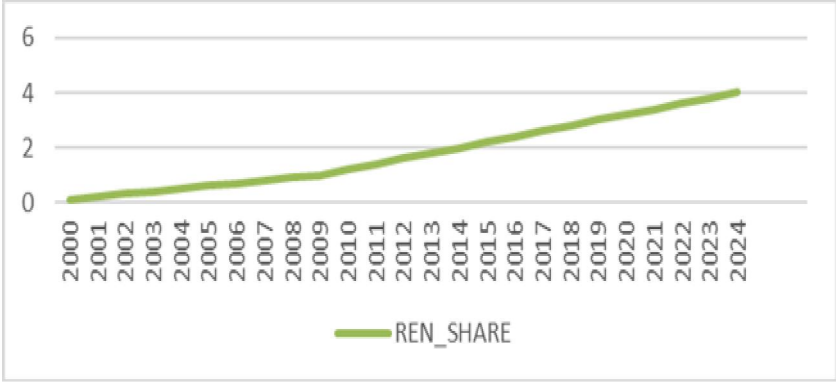
Source: Compiled from the Ministry of Energy Transition and IRENA.

Nevertheless, transforming this natural potential into effective production capacity requires substantial investments in infrastructure, regulatory reforms, and stronger institutional frameworks to support renewable energy deployment (IRENA).

5.5. Renewable Energy Development

Despite its significant potential, the actual contribution of renewable energy to Algeria's energy mix remains limited. Progress in this area has been relatively gradual, reflecting structural and institutional constraints.

Figure N° 4. Renewable Energy Share (%)



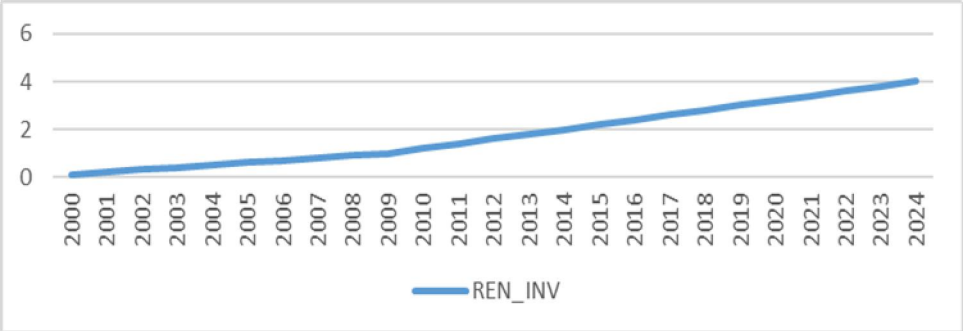
Source: Prepared by the researcher based on BP Statistical Review.

As illustrated in Figure 4, the share of renewable energy in total energy production increased from almost zero in 2000 to approximately 2% in 2024. Although this evolution indicates the beginning of an energy transition process, hydrocarbons—particularly natural gas—continue to dominate the national electricity system.

5.6. Investment in Renewable Energy

Investment trends provide additional insight into the pace of Algeria's energy transition. The level of financial resources allocated to renewable energy projects has increased progressively, although it remains modest relative to the country's potential.

Figure N° 5. Renewable Energy Investment ($ millions)



Source: Prepared by the researcher based on IRENA and BloombergNEF.

According to Figure 5, renewable energy investments rose from around 0.1 million USD in the early 2000s to approximately 2.5 million USD in 2024. While this increase reflects growing policy interest in renewable energy development, investment levels remain relatively low compared with global trends in the energy transition (IRENA; BloombergNEF).

5.7. Structural Challenges of the Energy Transition

Overall, the empirical indicators suggest that Algeria's energy transition remains in an early stage of development. By 2024, the installed renewable energy capacity (excluding hydropower) remains limited to approximately 500–600 MW, representing less than 3% of the total national electricity capacity.

Moreover, electricity generation in Algeria continues to rely overwhelmingly on natural gas, which accounts for more than 95% of total electricity production, as summarized in Table 2.

Table N°2. Key Indicators of the Renewable Energy Model (2024)

Indicator	Value
Total Installed Capacity	24,000 MW
Installed Renewable Capacity (Excl. Hydro)	500–600 MW
Renewables Share of Capacity	< 3%
Natural Gas Share in Power Generation	> 95%
Strategic Target (2035)	15,000 MW

Source: Compiled from Sonelgaz and International Energy Agency data.

Although the government has adopted an ambitious strategy aiming to install 15,000 MW of renewable energy capacity by 2035, the pace of implementation remains relatively slow. Key challenges include insufficient investment, regulatory barriers, and the persistence of fossil-fuel subsidies that reduce the competitiveness of renewable electricity.

Overall, the empirical trends confirm the persistence of a hydrocarbon-centered energy model. While renewable energy initiatives have gradually emerged, their contribution remains marginal compared to the dominant role of natural gas in electricity generation. These dynamics highlight the structural inertia of the Algerian energy system and explain the slow pace of diversification observed during the period 2000–2024.

6. Macroeconomic, Institutional, and Strategic Energy Transition Outlook

The trajectory of Algeria's energy transition is shaped not only by the availability of renewable resources but also by the broader macroeconomic and institutional environment in which energy policies operate. Since the early 2000s, Algeria has introduced several legislative reforms aimed at modernizing the energy sector and promoting renewable energy development. Despite these initiatives, the overall impact on the national energy mix remains limited. An examination of economic conditions, environmental indicators, and regulatory structures reveals persistent structural constraints that continue to influence the pace of the energy transition.

6.1. Legislative Framework and Institutional Constraints

Since 2002, Algeria has progressively developed a legal framework governing electricity markets, hydrocarbon investment, and renewable energy development. Although this regulatory architecture has expanded over time, the policy framework remains characterized by an imbalance between incentives supporting hydrocarbon activities and those aimed at promoting renewable energy deployment. The main legislative milestones shaping Algeria's energy sector are summarized in Table 3.

Table N°3. Key Legislative Milestones in Algeria's Energy Sector

Law / Decree	Year	Content & Key Provisions	Direct Regulatory Impact
Law 02-01	2002	Electricity & Gas Distribution	Established CREG; theoretically opened the market.
Law 04-09	2004	Promotion of Renewables	First framework; lacked detailed executive decrees.
Decree 13-218	2013	Feed-in Tariffs (FiT)	Introduced incentives; rates remained non-competitive.
Law 19-13	2019	Hydrocarbon Law Amendment	Strengthened the fiscal regime for oil/gas investment.
Law 22-18	2022	New Investment Law	Offers tax exemptions for "Green Investments" and simplifies land access.

Source: Compiled by the researcher based on the Ministry of Energy.

Algeria's regulatory framework faces three primary barriers: hydrocarbon-oriented legislation (Law 19-13), regulatory instability deterring long-term renewable projects, and delayed implementation decrees. These factors collectively create animplementation gap, preventing policy objectives from translating into effective sectoral outcomes and hindering the transition from fossil fuel reliance.

6.2. Macroeconomic Volatility and Growth Constraints

Macroeconomic stability represents a key condition for financing large-scale energy transition projects. Algeria's economic performance between 2000 and 2024 has been strongly influenced by fluctuations in hydrocarbon revenues and global oil prices.

During the early 2000s, favorable oil prices supported strong economic growth, with GDP expansion reaching approximately 7.5% in 2003 and 6.5% in 2005. However, the

growth model proved highly sensitive to external shocks. The COVID-19 crisis caused an economic contraction of around −1% in 2020, followed by a partial recovery to approximately 4.5% in 2021. In subsequent years, growth stabilized at moderate levels between 3% and 3.5%.

Figure N° 6. GDP Growth Rate (%) in Algeria (2000-2024).



Source: Prepared by the researcher based on World Bank and IMF data.

This cyclical pattern reflects Algeria's continued dependence on hydrocarbon revenues. Such volatility constrains the government's fiscal capacity to sustain large and consistent investments in renewable energy infrastructure.

6.3. The Political Economy of Energy Subsidies

Energy Energy subsidies constitute one of the most significant structural barriers to energy transition in Algeria. For several decades, low domestic energy prices have been maintained as part of a broader social policy aimed at ensuring affordable electricity and fuel for households and industry. By 2024, total energy subsidies were estimated at approximately 4,200 billion Algerian dinars ($30–32 billion USD), representing nearly 27% of total public expenditure (Ministry of Finance, 2024).

The potential implications of subsidy reform are summarized in the analytical matrix below:

Table N°4. Analytical Matrix of Subsidy Reform Dimensions

Dimension	Contextual Factor	Expected Impact of Direct Reform
Vulnerable Households	Direct reliance on cheap gas/electricity	High risk of energy poverty; requires targeted transfers.
Productive Sector (SMEs)	Energy as a primary input	Loss of industrial competitiveness in the short term.
Fiscal Health	Correlation with oil revenues	Reduced budget deficit and lower rentier dependence.
Energy Transition	Price signals for renewables	Increased competitiveness of clean energy alternatives.

Source: Compiled by the researcher based on the Finance Law (2024) and World Bank (2025).

While these subsidies contribute to social stability, they generate severe economic distortions. Artificially low prices reduce incentives for energy efficiency, accelerate domestic consumption, and undermine the competitiveness of renewable energy technologies. International experience, such as the progressive reforms in Egypt (2014–2019) and Denmark's carbon taxation models, suggests that reform is most effective when

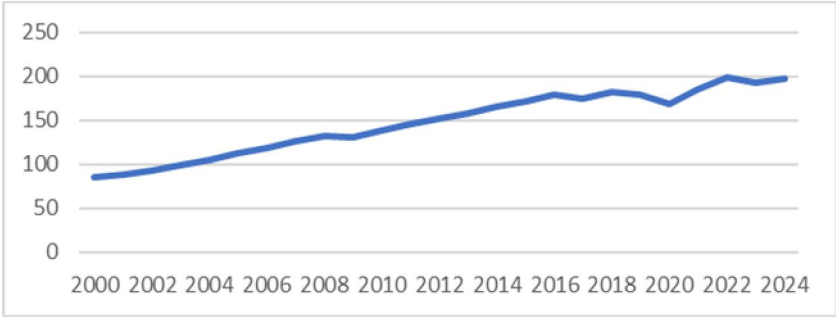
paired with targeted social protection and reinvestment in clean energy.

The current subsidy regime creates a price trap that incentivizes fossil fuel consumption while draining over a quarter of public expenditure. Transitioning from universal subsidies to a targeted compensation mechanism is essential to realign economic incentives with national sustainability goals and unlock the fiscal space needed for large-scale renewable infrastructure.

6.4. Environmental Pressures and the Carbon Transition Gap

Environmental indicators further illustrate the structural challenges facing Algeria's energy system. Despite growing international commitments to climate mitigation, carbon emissions have increased steadily during the past two decades.

Figure N° 7. CO_2 Emissions (Million Tons) in Algeria.



Source: Prepared by the researcher based on BP Statistical Review and Global Carbon Project data.

Carbon dioxide emissions increased from approximately 85 million tons in 2000 to 198 million tons in 2024. This trend reflects the continued dominance of fossil fuels (particularly natural gas) in electricity generation, transportation, and industrial activity.

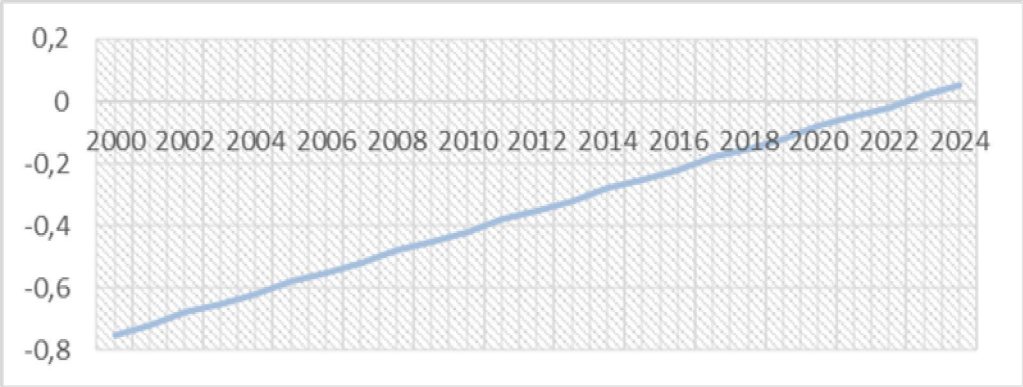
The persistence of rising emissions illustrates what may be described as a carbon transition gap, where the pace of decarbonization remains insufficient to offset the carbon intensity of economic growth.

6.5. Governance Quality and Institutional Capacity

Institutional quality represents another key determinant of energy transition performance. Effective governance structures are necessary to attract long-term investment, implement regulatory reforms, and coordinate complex energy infrastructure projects.

An examination of Algeria's Worldwide Governance Indicators (WGI) reveals moderate improvement in institutional performance over the past two decades. The composite governance index improved from approximately –0.74 in 2000 to about –0.50 in 2024. Although this trend indicates gradual progress in areas such as government effectiveness and political stability, the index remains within the negative range.

Figure N° 8. Evolution of the Governance Index in Algeria (2000-2024).



Source: Prepared by the researcher based on World Bank (WGI) data.

These results suggest that regulatory transparency, administrative efficiency, and institutional coordination remain important challenges. Strengthening governance capacity therefore represents a critical prerequisite for accelerating Algeria's energy transition and attracting large-scale investment in renewable energy infrastructure.

6.6. Energy Transition Scenarios

Building on the previous analysis, Algeria's energy future can be conceptualized through three possible strategic pathways that differ in terms of policy ambition and investment intensity.

6.6.1. Business-as-Usual (BAU)

The first trajectory assumes the continuation of current trends, with natural gas remaining the dominant source of electricity generation and renewable energy expanding slowly. Under this scenario, rising domestic energy demand could progressively reduce exportable hydrocarbon volumes by 2030–2035, potentially weakening fiscal revenues and external balances.

6.6.2. Gradual Energy Transition

The second scenario assumes the effective implementation of Algeria's national renewable energy strategy, particularly the objective of installing 15,000 MW of renewable capacity by 2035. Achieving this objective requires accelerating project implementation and gradually reforming domestic energy prices to create stronger incentives for private investment.

6.6.3. Deep Transition and the Hydrogen Economy

The most ambitious scenario involves transforming Algeria into a major exporter of green energy through the large-scale development of green hydrogen production and renewable electricity exports to European markets.

Recent studies suggest that Algeria possesses competitive conditions for solar-based hydrogen production, with estimated conversion yields between 539 and 589 tons of hydrogen per year for every 20 MW of installed solar capacity.

However, several technical constraints must be addressed. Hydrogen production through electrolysis requires approximately 9 liters of purified water per kilogram of hydrogen, which implies that large-scale facilities must be located near coastal regions and integrated with seawater desalination plants.

Additionally, while Algeria's 3,300 km natural gas pipeline network represents a

strategic advantage for hydrogen exports, the infrastructure must be upgraded to address technical issues such as hydrogen embrittlement, which can weaken metallic pipelines.

The main feasibility parameters of this scenario are summarized in Table 5.

Table N° 5. Key Feasibility and Performance Indicators for Scenario C

Indicator	Metric / Finding	Strategic Implication
Solar Potential	Lowest LCOE in the region	Competitive production costs ($4–$6/kg).
Water Requirement	9 L / kg H_2	Mandates coastal production & desalination.
Pipeline Network	~3,300 km total	Requires massive "Retrofitting" investment.
International Support	20M € (Initial Pilot Funds)	Critical for mitigating technical risks.

Source: Author's compilation based on IRENA (2022; 2023), IEA (2023), European Commission hydrogen cooperation reports, and Algerian energy infrastructure statistics.

7. Conclusion

7.1. The Current State: A Paradox of Potential

The study evaluates Algeria's energy trajectory through a multidimensional lens, blending economic, institutional, and environmental perspectives. The primary finding characterizes Algeria's transition as structurally incomplete. Despite the country's vast geographic advantages (specifically the Sahara's solar irradiation) the energy mix remains overwhelmingly dominated by fossil fuels, with natural gas serving as the backbone of electricity generation.

A critical "implementation gap" exists: while policy rhetoric promotes green energy, the actual contribution of renewables to the national grid remains marginal. The research identifies a cyclical dependency where renewable investment is tethered to global oil prices; high hydrocarbon revenues fuel green projects, while market downturns immediately constrain the fiscal capacity needed for energy reform.

7.2. Structural and Institutional Barriers

The slow pace of transition is not merely a technological hurdle but a systemic one. The study identifies three primary constraints:

- **Price Distortions:** Generalized energy subsidies create an artificial economic environment, removing the incentive for energy efficiency and making renewable investments appear less competitive.
- **Governance Gaps:** Limited coordination between regulatory bodies and a legal framework that, while evolving, lacks the long-term stability required to attract significant private or foreign investment.
- **Strategic Disconnect:** A lack of integration between energy policies and broader national economic diversification goals weakens the impact of individual reforms.

7.3. Strategic Roadmap: 2025–2035

To move beyond the "rentier state" model, the study proposes a phased, three-stage strategy designed to balance social stability with fiscal sustainability.

Phase I: Institutional Foundation (2025–2028)

The priority is subsidy reform. By replacing universal subsidies (estimated at $30–32 billion USD in 2024) with a targeted social registry, Algeria can alleviate its fiscal burden. This phase aims for an initial 3,000 MW of solar capacity while establishing the National Energy Transition Fund to reinvest subsidy savings into green infrastructure.

Phase II: Infrastructure & Innovation (2028–2032)

Focus shifts to modernizing the national grid to handle intermittent renewable sources. This period introduces pilot projects for green hydrogen, positioning Algeria to utilize its existing pipeline infrastructure for future clean energy exports.

Phase III: Structural Consolidation (2032–2035)

The final goal is a scaled transformation, reaching 15,000 MW of renewable capacity. By this stage, Algeria would ideally transition from a fossil-fuel exporter to a regional hub for green electricity and hydrogen, leveraging its proximity to European markets.

7.4. Future Research and Outlook

The study concludes that future inquiry should focus on the econometric relationship between oil price volatility and green investment, as well as the labor market impact of a burgeoning green economy. Ultimately, the transition is framed not just as an environmental necessity, but as a survival strategy for a resource-dependent economy seeking to decouple its growth from the fluctuations of the global hydrocarbon market.

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