Energy transition strategies and their role in achieving sustainable economic growth: A comparative applied study on four African countries

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Abstract:

The study aimed to analyze energy transition strategies and their role in achieving sustainable economic growth in four major African countries by comparing their experiences and policies in the field of renewable energy. The research focuses on examining the installed capacities of renewable energy, as capacity in Egypt reached 11.8 GW in 2024, targeting 25.1 GW by 2030 to represent 30-42% of the energy mix, while Algeria plans to reach 4 GW by 2025 and 16 GW by 2035 after achieving more than 600 MW currently. Morocco has achieved 5.6 gigawatts of renewable energy and aims to exceed 15 gigawatts by 2030, constituting 52% of installed electricity capacity, with investments estimated at 110 billion dirhams ($10.6 billion), while Nigeria plans to raise the share of renewable electricity from 13% in 2015 to 23% by 2025 and 36% by 2030, with an expected capacity of 1.7 gigawatts by 2035. The study found that the clear disparity in the pace of energy transition between the four countries reflects fundamental differences in political will, financing capabilities and development strategies, as Egypt and Morocco lead the African scene with higher installed capabilities and more ambitious goals compared to Algeria and Nigeria, with expectations that this transition will contribute to promoting sustainable economic growth by saving energy, creating job opportunities, and reducing dependence on fossil fuels.

Keywords: energy transition, renewable energies, energy projects, sustainable growth.

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I- Introduction:

The African continent is witnessing a radical shift in its energy model, as many of its countries seek to move from traditional reliance on fossil fuels towards renewable energy sources as a basic pillar for achieving sustainable development and long-term economic growth. Although Africa has the largest renewable energy reserves in the world, it accounts for only 2% of global investments in clean energy, with this percentage expected to rise to 2.7% by 2030. The continent invested about $34 billion in clean energy technologies between 2020 and 2025, including 52% for solar energy and 25% for onshore wind energy, while Africa saw a 3.7% growth in electricity consumption in 2024. The continent faces a major challenge, with 42% of its population lacking electricity and 70% lacking clean cooking fuel, making energy transition an urgent necessity to close the energy gap and achieve social justice.

Egypt leads North African countries in the field of renewable energy thanks to its strategic geographical location and ambitious policies. Egypt's installed renewable energy capacity reached 6.8 GW in 2022, rising to 11.8 GW by 2024, with 10.5 TWh of renewable electricity generated in 2021. As part of its integrated sustainable energy strategy 2035, Egypt aims to generate 42% of electricity from renewable sources

Morocco is a leading model of energy transition on the African continent thanks to its proactive policies. Morocco achieved a cumulative renewable capacity of 5.6 gigawatts, including 774 megawatts of solar energy, in 2021. Morocco aims to produce 52% of its electricity from renewable sources by 2030, with plans to install 15 gigawatts of total renewable capacity.

Algeria is accelerating its renewable energy program after years of systematic delays. Algeria has currently achieved more than 600 MW of installed renewable energy capacity, and aims to reach 4 GW by 2025 and 16 GW by 2035. The country plans to produce 3,000 megawatts of solar energy by 2025, with a particular focus on solar photovoltaic projects. Algeria has witnessed a boom in importing solar panels from China,

Imports increased 70-fold during the period from January to September 2025. Algeria is looking to become a global competitor in renewable energy with a plan to deploy 22 gigawatts of clean energy by 2030. The Algerian economy is expected to grow by 4.5% in 2025, driven in part by energy transition initiatives.

Nigeria, Africa's largest economy, is seeking to diversify its energy mix and reduce dependence on fossil fuels. Nigeria aims to raise the share of renewable electricity from 13% in 2015 to 23% by 2025 and 36% by 2030. Renewable capacity in Nigeria is expected to reach 1.7 GW by 2035, despite financing and infrastructure challenges.

Africa's energy transition is expected to create about 14 million jobs by 2030, with the potential to save $150 billion annually by 2050 that can be reinvested in climate action and other development goals. The Mission 300 initiative, led by the World Bank and the African Development Bank, has launched an ambitious goal to provide electricity to 300 million people in Africa by 2030, mobilizing more than $500 million in commitments to expand access to electricity and deploy clean energy. Africa requires 23% annual growth in renewable energy to achieve the Nairobi Declaration's ambition to generate 300 GW of renewable capacity by 2030.

1.1 Study Problem :

African countries face a complex development dilemma: the urgent need to meet the growing demand for energy to support economic growth, at a time when 42% of the continent's population lacks electricity and 70% suffers from a lack of clean cooking fuel. Although Africa has the largest renewable energy reserves in the world, it accounts for only 2% of global investments in clean energy, reflecting a large gap between potential and actual exploitation. African countries differ markedly in the speed and scale of energy transition, with Egypt and Morocco leading with installed capacities of 11.8 and 5.6 gigawatts, respectively, while Algeria and Nigeria lag behind with capacities below 1 gigawatt, despite their enormous potential. This disparity raises fundamental questions about the effectiveness of energy policies and their impact on sustainable development paths, especially given the need to mobilize $500 billion annually to achieve the continent's sustainable energy goals by 2030.

To what extent do the energy transition strategies adopted in Algeria, Morocco, Egypt and Nigeria contribute to achieving sustainable economic growth, and what are the decisive factors that explain the disparity in the pace of transition and its development results between these countries?

1.2 Study assignements :

This study is based on the basic premise that energy transition strategies based on clear and ambitious goals contribute positively and directly to achieving sustainable economic growth. International experience indicates that energy transition is capable of creating 14 million jobs by 2030 and saving $150 billion annually by 2050 in Africa. The study assumes that countries with legislative and regulatory frameworks that encourage investment in renewable energy, such as Morocco and Egypt, which target 52% and 42% of the energy mix, respectively, achieve higher growth rates and better economic diversification compared to countries with less ambitious policies. The study also assumes a direct relationship between the volume of investments allocated to renewable energy and actual installed capacities, as evidenced by the fact that Morocco has allocated 110 billion dirhams ($10.6 billion) to achieve the goal of 15 gigawatts by 2030. The study also posits that systematic delays in implementing renewable energy programs, such as in Algeria, which has achieved less than 600 MW despite its potential, hinder these countries' ability to bridge the energy gap and achieve the Sustainable Development Goals. Finally, the study assumes that regional and international cooperation and access to climate finance are crucial factors in accelerating the pace of energy transition, especially in light of the continent's need to achieve 23% annual growth in renewable energy to achieve the Nairobi Declaration's ambition to generate 300 gigawatts by 2030.

1.3 Research Objective :

This research seeks to achieve a set of scientific and applied objectives centered around understanding the dynamics of energy transition and its relationship to sustainable growth in the African context. The research aims first to analyze and evaluate the energy transformation strategies adopted in Algeria, Morocco, Egypt and Nigeria, by studying the legislative and regulatory frameworks and policies followed to enhance the share of renewable energy in the national energy mix, especially in light of Egypt targeting 42% and Morocco targeting 52% of renewable electricity by 2030. Second, the research aims to measure and analyze the actual installed capacities and future renewable energy targets in

the four countries, enabling an understanding of the gap between potential and actual achievements. Egypt achieved 11.8 gigawatts, while Algeria did not exceed 600 megawatts, despite targeting 16 gigawatts by 2035. Third, the research seeks to identify the critical factors that explain the disparity in the pace of energy transition among the countries studied, including the volume of investments, political will, technical capabilities, and international cooperation, given that Africa accounts for only 2% of global investments in clean energy. Fourth, the research aims to explore the causal relationship between energy transition and sustainable economic growth indicators, by analyzing the direct and indirect impacts on job creation, economic diversification, and achieving the Sustainable Development Goals, particularly in the context of expectations of creating 14 million jobs by 2030. Fifth, the research seeks to extract lessons learned from comparative experiences and provide practical recommendations to policy makers in the four countries, which contributes to accelerating the pace of energy transformation and enhancing its effectiveness in achieving comprehensive and sustainable development at the national and regional levels.

1.4 Study Methodology :

This research relies on the comparative descriptive analytical approach to study energy transformation strategies in the four countries, where quantitative and qualitative data related to the installed capabilities of renewable energy, the volume of investments, and the strategic goals of each country are collected and analyzed. The research uses the multidimensionnel comparison method (Cross-Country Analysis) to analyze the similarities and differences between Algeria, Morocco, Egypt and Nigeria in terms of energy policies, institutional framework, and development outcomes. The research relies on diverse data sources, including official government reports, data from international organizations such as the World Bank and the African Energy Union, and peer-reviewed academic studies, ensuring the credibility and comprehensiveness of the analysis. The approach includes time series analysis to track the evolution of installed capacities and investments in renewable energy during the period 2015-2030, with a focus on critical transition phases and factors influencing the pace of transition

1.5 Divisions of study :

To comprehensively cover the various dimensions of the topic and achieve the desired research objectives, this research paper was organized according to a methodological structure consisting of two main integrated axes

2- Theoretical and conceptual foundations of energy transformation and renewable energies.

3- An in-depth applied analysis of the reality of energy transition in the four countries under study.

4- The repercussions of energy transition on sustainable growth.

2- Theoretical and conceptual foundations of energy transformation and renewable energies.

2.1 What is renewable energy :

Renewable energy is defined as energy derived from natural resources that are constantly renewed and do not run out with consumption, such as sun, wind, water, biomass and geothermal energy. These sources are always available, clean, and environmentally

friendly, as they do not produce harmful carbon emissions or greenhouse gases that contribute to global warming, unlike traditional fossil fuels such as coal, oil, and natural gas. Renewable energy includes several main types, including solar energy, which converts sunlight into electricity via photovoltaic panels, wind energy, which is exploited through turbines, hydroelectric energy resulting from the movement of water in dams and rivers, in addition to bioenergy extracted from organic materials and agricultural waste. The shift towards renewable energy is gaining increasing importance in the modern era as it represents a sustainable alternative that meets growing energy needs without harming the environment or depleting natural resources, while providing new job opportunities and raising the level of the national economy by reducing dependence on energy imports.

2.2 The concept of renewable energy :

The International Energy Agency (IEA) defines renewable energy as resources "derived from natural processes" and "that are replenished at a rate faster than they are consumed." These sources include electricity and heat derived from solar, wind, ocean, hydropower, biomass, and geothermal resources, as well as biofuels and hydrogen derived from renewable resources (IEA, 2002, p. 4). UNESCO adopts a similar definition, describing renewable energy as "energy derived from natural processes (such as sunlight and wind) that is replenished at a higher rate than it is consumed," emphasizing its critical role in preserving World Heritage sites during the transition to low-carbon energy systems. **(UNESCO, 2024)**

For its part, the International Renewable Energy Agency (IRENA) emphasizes that renewable energy represents a center of excellence and a repository of political, technical, and financial knowledge, encompassing all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean energy, solar energy, and wind energy, in its pursuit of sustainable development, energy access, energy security, and a low-carbon economy (IRENA, 2014, p. 6). IRENA notes in its analysis that doubling the share of renewable energy in the global energy mix by 2030 is not only possible, but achievable at a lower cost than traditional alternatives, with social and economic benefits including climate change mitigation, health impacts, and job creation **(IRENA, 2014)**.

The World Bank defines renewable electricity as "the share of electricity generated by renewable energy plants in the total electricity generated by all types of plants", providing a clear benchmark indicator for tracking progress in energy transition at the national and regional levels (World Bank, 2025). These international definitions agree that renewable energy is a key component of sustainable, environmentally friendly, and cost-effective electricity production. Official reports indicate that demand for fossil fuels for electricity generation has been declining since 2019, paralleling the rising use of renewable energy to meet global energy needs. **(IEA, as cited in Renewable Energy Journal, 2021).**

2.2.1 Sources and characteristics of renewable energies :

- **Solar energy :**

Solar energy is derived directly from solar radiation and can be exploited across two main technological tracks that serve multiple applications. The first path is based on solar thermal conversion (Solar Thermal) which is used in industrial, residential and commercial applications, as this sector witnessed remarkable growth by installing 120 MW of solar thermal energy for industrial processes in 2024, an increase of 28% over the previous year.

Solar heating and cooling systems currently serve at least 122 million residential, commercial and industrial customers globally, and solar central heating systems have expanded into new markets by establishing 346 stations in cities around the world, including a 34 MW station in the Netherlands that is among the largest in the world. The second path is based on photoelectric conversion (Photovoltaic), which relies on the phenomenon of the photoelectric effect to convert solar radiation directly into an electric current using solar cells, which is the fastest growing sector in the world by installing 503 gigawatts in 2024, an increase of 44% over 2023.

At the regional level, the Middle East and North Africa (MENA) region achieved a total solar capacity of 24 GW by the end of 2024, an annual increase of 25%, with more than 80% of this growth concentrated in Egypt, Morocco, the UAE and Saudi Arabia. Morocco topped the North African market with its cumulative capacity exceeding 2 gigawatts, followed by Egypt, while Tunisia and Algeria are seeking to catch up quickly. As part of its updated strategy, Egypt aimed to achieve a renewable capacity of 10,000 megawatts by 2025, with 27% of the energy mix targeting solar energy alone by 2030, compared to 2.5% currently, and was able to achieve a competitive tariff of two US cents per kilowatt hour. Algeria has launched an ambitious 3 GW program distributed across 20 projects, many of which are expected to be operational before the end of 2025. Morocco is targeting 20% of its solar energy capacity by 2030, compared to 8% currently, becoming a hub for renewable energy and green hydrogen.

- **Wind energy**

Wind energy is one of the fastest growing renewable energy sources in the world, with the sector witnessing unprecedented historical growth during 2025. Wind energy is converted into electrical energy by huge turbines that exploit the kinetic energy of the wind to rotate blades connected to electric generators. The sector recorded the addition of 72.2 gigawatts of new capacity during the first half of 2025, an increase of 64% compared to the same period in 2024. Over the twelve months from July 2024 to June 2025, the sector added 148 GW compared to 125 GW during the previous period, bringing the total globally installed capacity to 1,245 GW (1.25 TW) by the end of June 2025, with an annual growth rate of 13.5%.

Global wind energy additions in 2025 are expected to reach a record 150-170 GW, surpassing previous annual additions of 120 GW in 2024 and 121 GW in 2023. The fourth quarter of 2025 alone is expected to contribute 70 GW, a figure that exceeds the annual additions for any year before 2020

- **Hydroelectric power :**

Hydropower is derived from the exploitation of running water, waterfalls, and dam falls to generate electricity, and is considered one of the cleanest, most efficient, and most reliable sources of renewable energy for electricity production. Global installed hydropower capacity reached 1,425 GW by the end of 2024, with 31 GW of new capacity added during the year, contributing approximately 15-19% of total electricity generated globally. In North Africa, Egypt has the largest hydropower capacity at 2,832 MW, followed by Morocco at 1,770 MW and Algeria at 286 MW, while Nigeria contributes significantly to West Africa's hydropower mix. Although hydropower has a lower growth rate than solar

and wind power, it remains the largest renewable resource in terms of cumulative capacity and the most stable source of primary energy.

- **Biomass energy :**

Biomass energy is derived from organic plant and animal resources that can be converted into energy, including timber, forest waste, agricultural waste, and organic matter resulting from photosynthesis. The biofuel sector added 11 gigawatts of new capacity in 2024, bringing the global total to 164 gigawatts, an annual growth rate of 7.3%. Biomass is widely used in thermal and electrical applications and plays an increasing role in the production of sustainable biofuels for transportation and industry. In the African context, biomass represents an important source of energy, especially in rural areas, where 70% of the continent's population still lacks clean cooking fuel, making the development of sustainable biomass technologies a development priority.

- **Earth's interior heat energy :**

Geothermal heat energy (GEO) exploits the enormous heat latent beneath the Earth's crust, ranging from 200-1000 degrees Celsius, and is manifested through geological phenomena such as volcanoes, hot springs, and thermal eruptions. The global installed capacity of geothermal energy reached 17 GW by the end of 2024, with the addition of 1.4 GW of new capacity, making it contribute about 0.3-0.5% of the total global electricity generation. Although its current contribution is limited, geothermal energy is a reliable and continuous source of 24-hour primary energy, especially in areas with high volcanic activity such as East Africa.

- **Nuclear energy :**

Nuclear energy represents an important source of low-carbon electricity generation, providing about 9-17% of the electricity generated globally and contributing about 7% of total global energy consumption. Uranium is used as the main fuel for nuclear power reactors, with the potential energy of one kilogram of enriched uranium equivalent to the energy of 2,700 tons of coal, making it highly energy dense. In the African context, South Africa has the only operating nuclear plant on the continent with a capacity of 1,860 megawatts, while Egypt, Algeria and Morocco are exploring the possibility of introducing nuclear energy into their energy mix to achieve energy security and diversify sources.

- **Ocean energy :**

Ocean energy encompasses a variety of forms, including tidal energy resulting from the gravitational pull between the Earth, Moon, and Sun, wave energy derived from the movement of sea waves, ocean temperature gradient energy that exploits the temperature difference between surface and deep water layers, and salt gradient energy resulting from differences in salt concentrations. Despite the enormous theoretical potential of ocean energy estimated at thousands of gigawatts, global installed capacity does not exceed 535 megawatts by the end of 2024, due to high capital costs and technical challenges associated with the harsh marine environment. This technology has not received sufficient attention in Africa, despite the continent's extensive coastline, due to the cost of the technologies used and the priority of investing in more economically mature solar and wind energy technologies

2.2.2 Motivations for the transition towards renewable energy to achieve dimensions of sustainable development.

The shift towards renewable energy is an inevitable necessity to achieve sustainable and balanced development at the environmental, economic and social levels, as a set of intertwined factors push countries to accelerate this transformation. The main motivations revolve around three strategic axes :

- **Protecting the environment and confronting climate change.**

Relying on renewable energy sources represents an effective, dual-benefit strategy for achieving energy security and environmental conservation at the same time. Renewable energy directly contributes to reducing greenhouse gas emissions, especially carbon dioxide resulting from the combustion of fossil fuels (coal, oil, and natural gas), which is considered the main cause of global warming, environmental pollution, and climate change. In the African context, the energy transition could save $150 billion annually by 2050 that could be reinvested in climate action and other development goals, as well as improving air quality and reducing negative health impacts associated with fossil fuels. Data indicate that Morocco has succeeded in significantly reducing carbon dioxide emissions while enhancing the share of renewable energy in its energy mix, despite the slight increase in total emissions associated with the growth of energy supplies.

- **Economic feasibility and low costs.**

Renewable energy technologies have undergone a radical transformation in their efficiency and cost over the past decade, becoming the most viable economic option in many global markets. The decline in renewable energy costs is due to ongoing technological improvements and economies of scale resulting from production expansion. The cost of solar PV has fallen by more than 85% since 2010, and onshore wind costs have fallen by 50% over the same period. In the Middle East and North Africa region, Egypt has achieved a competitive solar energy tariff of just two US cents per kilowatt-hour, a price far lower than the cost of generating electricity from fossil fuels. IRENA analyses indicate that doubling the share of renewable energy in the global mix could be achieved at a lower cost than conventional alternatives, with additional economic benefits including creating 14 million jobs in Africa by 2030.

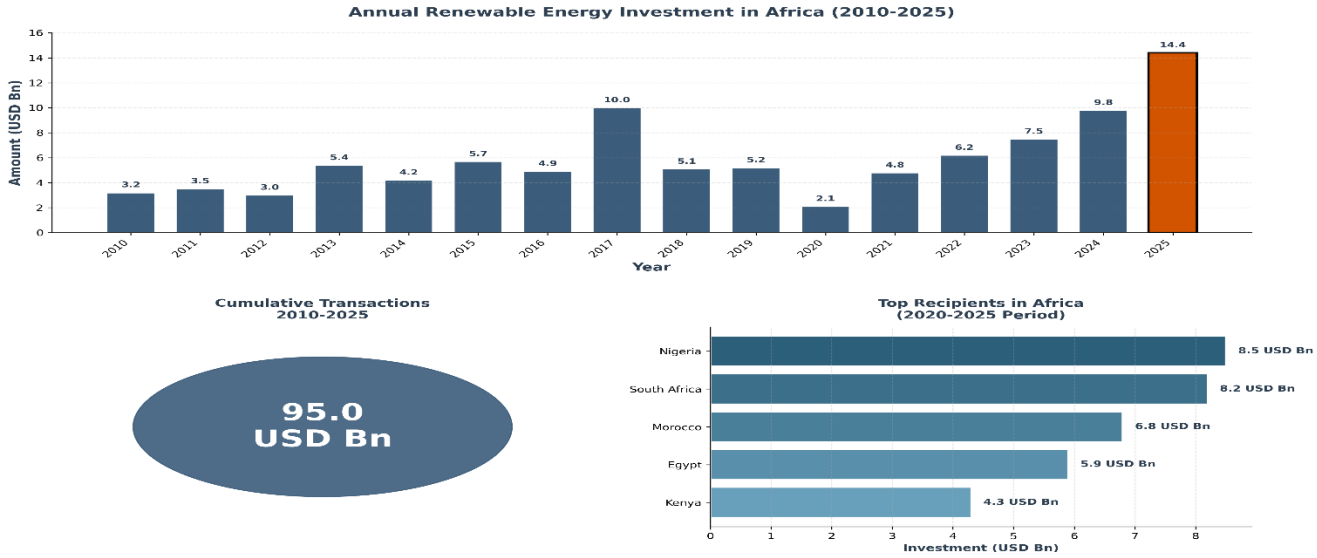
- **Achieving energy security and sustainability.**

Given that fossil fuels are a limited, depleted and non-renewable resource, and with increasing rates of global energy consumption, over-reliance on them will inevitably lead to the depletion of this vital source and threaten future energy security. The shift towards renewable energy provides a strategic solution to achieve sustainability of the energy sector and reduce dependence on fossil fuel imports that drain hard currencies, especially in energy importing countries. In the African context, 42% of the population faces a lack of access to electricity, and 70% lack clean cooking fuel, making the development of local renewable energy sources an urgent necessity to achieve energy security and social justice. Africa has the world's largest renewable energy reserves, enough to meet its growing energy needs without the need for imports, provided the necessary investments estimated at $500 billion annually are provided to achieve the sustainable energy goals by 2030.

3- An in-depth applied analysis of the reality of energy transition in the four countries under study.

3.1 Location of the countries studied within the African context of energy transition.

Figure (01) : Trends in public investment in renewable energies for the African continent 2010-2025.



)Africa Climate Insights. 2025(Surce:

Investments in renewable energy in Africa have seen remarkable growth, reaching $14.4 billion in 2025, a record number that far exceeds previous investments. The cumulative total of investments during the period 2010-2025 was approximately $99.2 billion, with only $34 billion invested between 2020-2025, of which 52% was directed to solar energy and 25% to onshore wind energy.

Nigeria topped the list of beneficiaries with about $8.5 billion, followed by South Africa with $8.2 billion, then Morocco with $6.8 billion, Egypt with $5.9 billion, and Kenya with $4.3 billion. Nigeria and South Africa ranked among the top five countries globally benefiting from international public financing for clean energy in 2023, with South Africa receiving $935 million and Nigeria receiving $829 million.

Investment in clean energy rose from less than $17 billion in 2019 to about $40 billion by 2024

Africa's solar panel imports saw a record 60% increase to 15,032 MW in the 12 months to June 2025

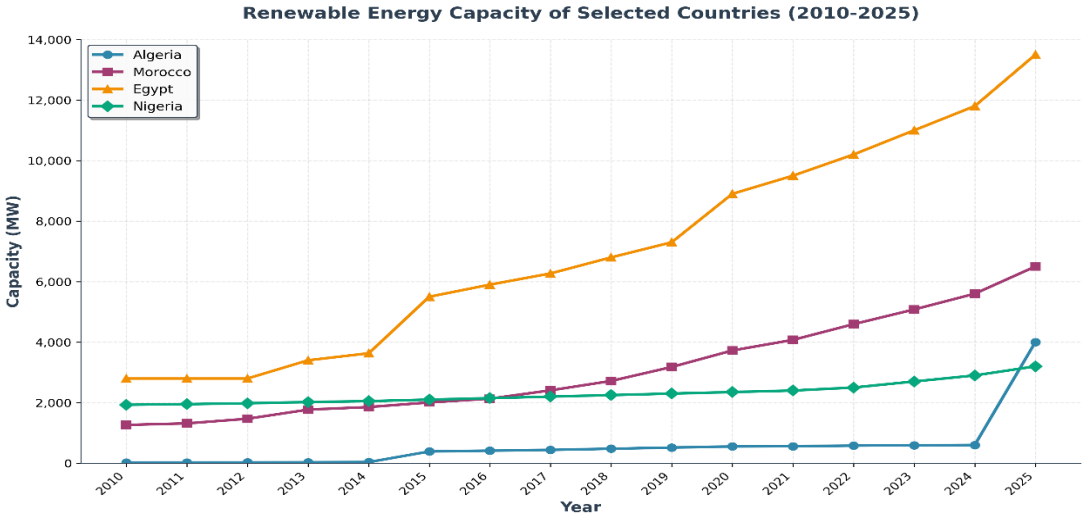
Energy investments in Africa are expected to reach $54 billion annually by 2030

This chart reflects the remarkable acceleration in energy transition on the African continent, with a particular focus on solar and wind energy and decentralized solutions to expand access to electricity.

3-2 Energy transformation indicators in countries, sample study.

3-2-1Size of completed private energy projects:

Figure : 2 Evolution of the volume of private energy projects completed in the countries under study during the period 2010-2025



Surce :(World Economic Forum. 2025).

Algeria witnessed an unprecedented boom in 2025, adding more than 3,400 megawatts in one year, implementing its updated strategy of approximately 15 gigawatts by 2035.

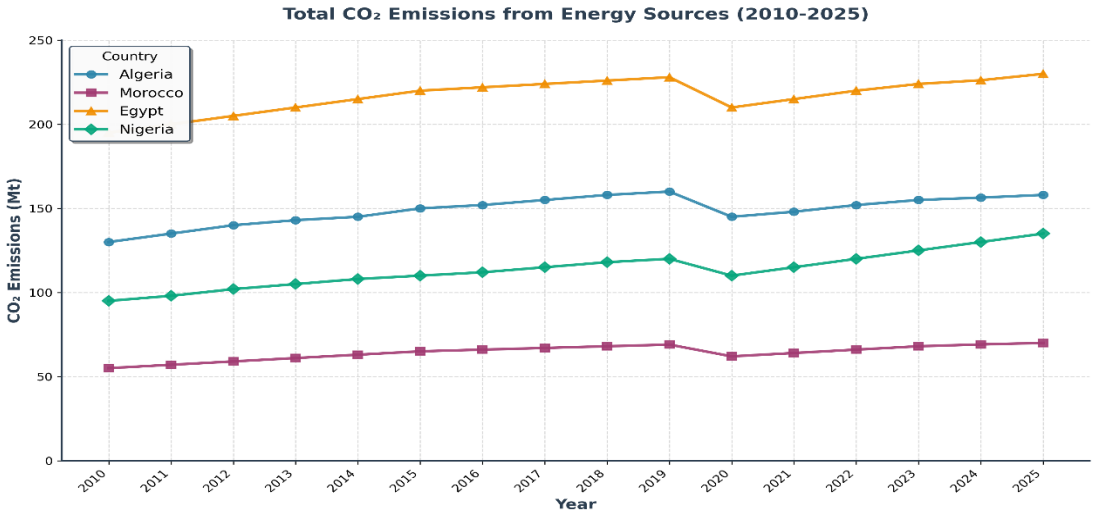
Morocco maintains stable growth and approaches its target of 52% renewable installed capacity by 2030

Egypt continues its regional lead with the largest installed capacity of 11.8 GW in 2024 and is expected to reach 13.5 GW in 2025.

Nigeria is experiencing rapid growth in decentralized solar energy after the removal of fuel subsidies.

3 -2-2 Totales productions capacity of renewable energies:

Figure (03) Development of total production capacity in the study sample countries In the period 2010-2025



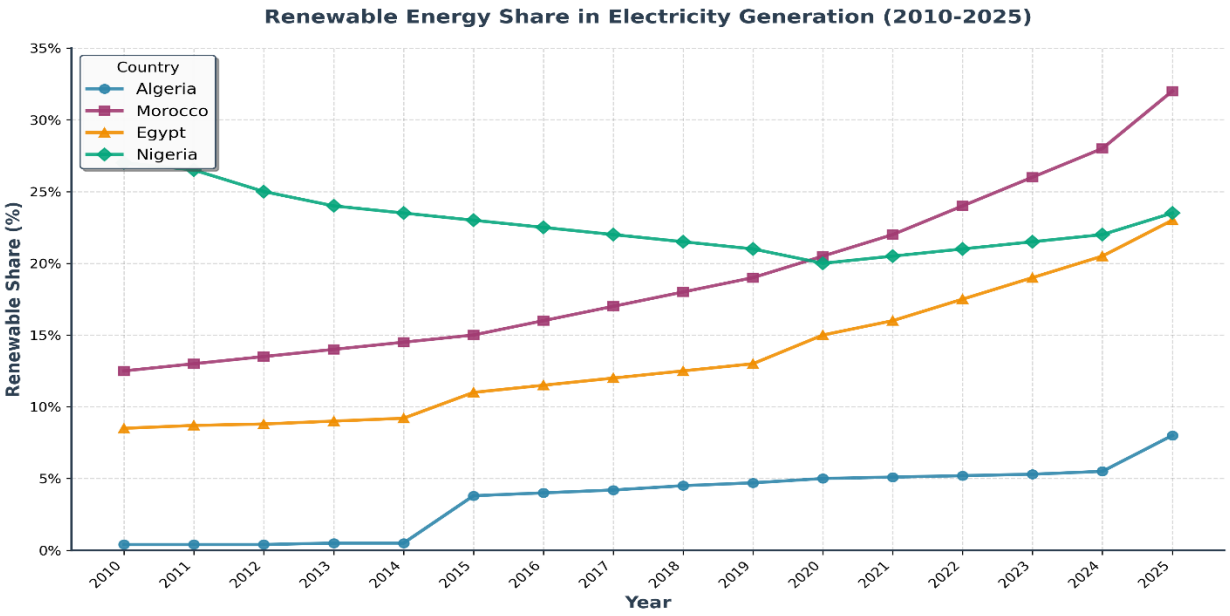
Zhang, Q(2025). Surce :

An analysis of the carbon dioxide emissions trajectory of the four countries over the period 2010–2025 reveals a close relationship between economic growth and emissions intensity, with upward trends in emissions in Egypt, Algeria, Nigeria, and Morocco reflecting the expansion of industrial activities and energy consumption linked to economic

development. Egypt tops the list with emissions of 230 million tons in 2025 compared to 195 million tons in 2010, reflecting a strong economic growth rate averaging 4-5% annually, driven by industrial and urban expansion and continued reliance on natural gas, which constitutes 59% of the energy mix, despite efforts to shift towards renewable energy, the capacity of which has reached 11.8 gigawatts. Nigeria recorded the highest relative growth rate in emissions at 42.1% during the same period, which is in line with GDP growth and attempts to meet the growing demand for energy in Africa's largest economy with a population exceeding 220 million people, although 42% of them still lack electricity. Algeria shows a similar pattern with a 21.5% increase in emissions to 158 million tons, driven by a dense energy sector that consumes 50.5 billion cubic meters of gas annually, with a marked delay in implementing renewable energy strategies until 2024. In contrast, Morocco shows the best relative performance despite increasing its emissions by 27.3% to 70 million tons, as it succeeded in achieving a better balance between economic growth and environmental sustainability by raising the share of renewable energy to 40% of installed capacity, which qualified it to rank 19th globally in the 2026 Climate Change Performance Index as the best African country. The temporary decline in emissions in 2020 across all countries indicates the impact of the COVID-19 pandemic on economic activity, followed by a gradual recovery that reflects a recovery in economies and a return in production and consumption levels. These data confirm that an effective energy transition represents a dual economic challenge that requires a careful balance between meeting the needs of economic growth and job creation on the one hand, and committing to reducing emissions and achieving the sustainable development goals on the other hand, especially in light of Africa's need for investments estimated at $500 billion annually to achieve the sustainable energy goals by 2030.

3-2-3 Percentage of electricity produced from total renewable energy :

Figure (04) : Percentage of renewable electricity production out of the total electricity of the study sample countries during the period 2010-2025



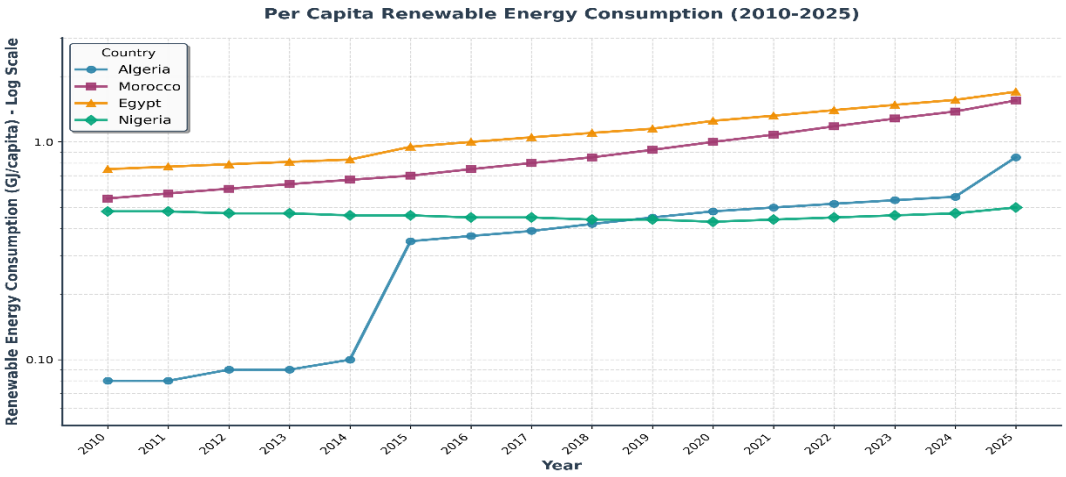
Zhang, Q(2025). Surce :

An analysis of the trajectories of renewable energy's share of electricity generation across the four countries over the period 2010-2025 reveals a fundamental divergence in energy transition strategies and their economic implications. The upward trend for Morocco and Egypt reflects a strategic commitment to diversifying the energy mix and reducing dependence on fossil fuels, while the trajectories of Algeria and Nigeria present profound structural challenges. Morocco has achieved its most ambitious path by raising the share of renewable energy from 12.5% in 2010 to 32% in 2025. This achievement reflects strong political will and cumulative investments exceeding $10 billion in mega projects such as the Noor Ouarzazate Solar Complex (580 MW) and wind turbines with a capacity of 2.37 GW, which qualified it for 19th place globally in the 2026 Climate Change Performance Index and established a local renewable energy industry that has created thousands of direct and indirect job opportunities. Egypt recorded similar growth from 8.5% to 23% over the same period, driven by mega projects such as the Benban Solar Power Plant (1.8 GW), one of the largest solar power plants in the world, and wind projects in the Gulf of Suez. This contributed to reducing the oil import bill and providing clean energy at a competitive cost of up to 2 US cents per kilowatt hour, a price approximately 70% lower than the cost of generating from fossil fuels

In contrast, Nigeria's downward trajectory from 27% to 23.5% reveals a dramatic economic paradox : the relative share of renewable energy has declined despite the growth in absolute hydropower and solar power capacity. This is due to the faster expansion of natural gas plants to meet the explosive demand for electricity in a country where 42% of its 220 million people lack electricity, reflecting the fundamental challenge of balancing the speed of expanding access to electricity with a commitment to environmental sustainability. Algeria presents the most worrying case, as the share of renewable energy remained below 1% until 2014. Despite the recent jump to 8% in 2025 thanks to the 4 GW program, this percentage remains the lowest among the four countries, reflecting the systematic delay in implementing energy transition strategies despite the country having the third largest natural gas reserves in Africa and consuming 50.5 billion cubic meters annually This represents a huge alternative opportunity cost that could have been directed towards building a sustainable energy economy. From a macroeconomic perspective, these trajectories indicate that countries that invested early and intensively in renewable energy (Morocco and Egypt) are now reaping multiple benefits, including diversifying sources of income, reducing dependence on imports, improving the trade balance, creating quality jobs, and enhancing competitiveness in attracting green foreign investment exceeding $40 billion annually in Africa. On the other hand, Algeria and Nigeria face increasing economic risks, including the erosion of competitiveness in the global low-carbon energy market, rising costs of complying with international environmental standards, and the loss of domestic value-added creation opportunities in the renewable energy industry, which is expected to create 14 million jobs in Africa by 2030

3-2-4 The percentage of renewable energy consumption out of the total energy of the sample countries during the period -2010-2025.

Figure (05) :Evolution of the percentage of renewable energy consumption out of the total energy of the sample countries during the period 2010-2025.



Surce :(World Economic Forum, 2025)

An analysis of per capita renewable energy consumption trajectories across the four countries over the period 2010–2025 reveals complex economic and social dynamics that reflect different levels of development and divergent strategic priorities in managing the energy transition. The logarithmic scale shows a deep development gap between countries, with Egyptians consuming 1.70 gigajoules of renewable energy annually in 2025, compared to 1.55 for Moroccans, 0.85 for Algerians, and only 0.50 for Nigerians, reflecting the stark disparity in access to clean energy as a key determinant of quality of life and economic productivity. The steady upward trend for Egypt and Morocco reflects a conscious development strategy that links increased per capita renewable energy consumption with sustainable economic growth. Egypt invested more than $5 billion in renewable energy projects between 2020 and 2025, while Morocco allocated $10.6 billion to achieve its ambitious target of 52% installed capacity by 2030. These investments translate into tangible improvements in per capita consumption of 127% and 182%, respectively, over 15 years.

From a macroeconomic perspective, the Algerian case reveals the cost of strategic lag. Per capita renewable energy consumption remained below 0.1 gigajoules until 2014, before witnessing a dramatic jump of 963%. However, it remains the lowest among the four countries at 0.85 gigajoules in 2025, which means the loss of huge development opportunities that could have contributed to diversifying the Algerian economy, which is 95% dependent on oil and gas exports This is a reality that has led to the accumulation of alternative opportunity costs estimated at billions of dollars in lost revenues and uncreated jobs. In contrast, the Nigerian case represents the most pressing challenge, as the semi-horizontal line reveals the dilemma of African development par excellence: despite the absolute increase in renewable capacities, explosive population growth at a rate of 2.5% annually (adding 5.5 million people annually) is eating up all the gains.

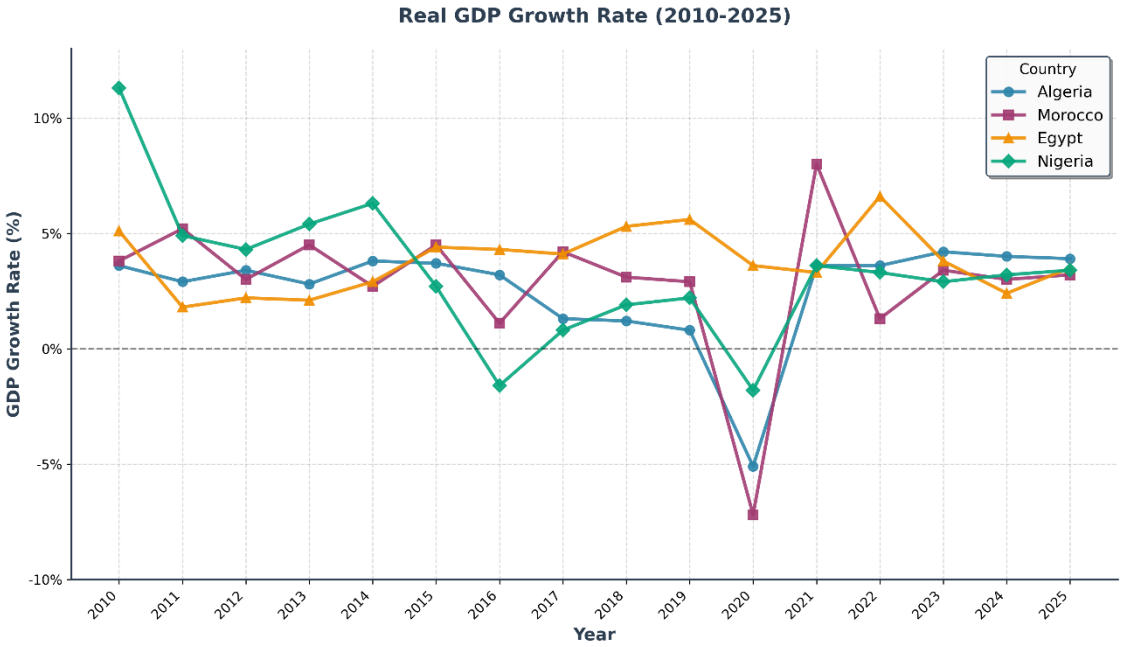
This keeps per capita consumption stagnant at 0.50 gigajoules, a level that reflects a structural failure to achieve energy justice in a country where 42% of its 220 million population lacks electricity, and millions are forced to spend 20-40% of their income on polluting and expensive diesel generators.

Economic literature indicates that per capita energy consumption is strongly positively correlated with human development indicators, with every one gigajoule increase in per capita renewable energy consumption being associated with an average $1,200 increase in per capita GDP, which partly explains the disparity in living standards between Egypt and Morocco on the one hand, and Algeria and Nigeria on the other. From a financial sustainability perspective, the data reveals that countries that have successfully increased per capita renewable energy consumption (Egypt and Morocco) have achieved huge financial savings from reducing their fossil fuel import bills. Morocco saved approximately $1.2 billion annually from reducing oil imports, while Egypt reduced energy subsidies from 7% to 3% of GDP by relying on renewable energy, which has a competitive cost of 2 cents per kilowatt-hour. On the social level, the increase in per capita renewable energy consumption is linked to the creation of quality job opportunities. The renewable energy industry in Morocco has created more than 40,000 direct and indirect jobs, while renewable energy is expected to create 14 million jobs in Africa by 2030, provided that investments are accelerated, which require $500 billion annually to bridge the gap. This analysis confirms that per capita renewable energy consumption is not just a technical indicator, but a direct reflection of the effectiveness of development policies and the ability to transform abundant natural resources (2,000-3,600 kWh/m2 per year of solar radiation in North Africa) into tangible economic and social well-being for citizens.

4- The repercussions of energy transition on sustainable growth.

4-1 GDP growth rate of the sample countries during the period 2025-2010.

Figure (06) : GDP growth rate of the sample countries during the period 2025-2010.



(surce :Africa Climate Insights. 2025)

An analysis of the economic growth trajectories of the four countries over the period 2010–2025 reveals complex dynamics that reflect the structural fragility of African economies and their severe vulnerability to external shocks and divergent domestic policies. The figure shows sharp fluctuations in growth rates, with Nigeria emerging as the most volatile performer, starting with exceptional growth of 11.3% in 2010 (driven by the oil

price boom) before collapsing to -1.6% in 2016 when oil prices fell from $100 to less than $40 per barrel, revealing over-reliance on oil exports, which constitute 90% of exports and 60% of government revenues This is a structural weakness that prevented sustainable growth, despite Nigeria being the largest African economy with a GDP of $477 billion.

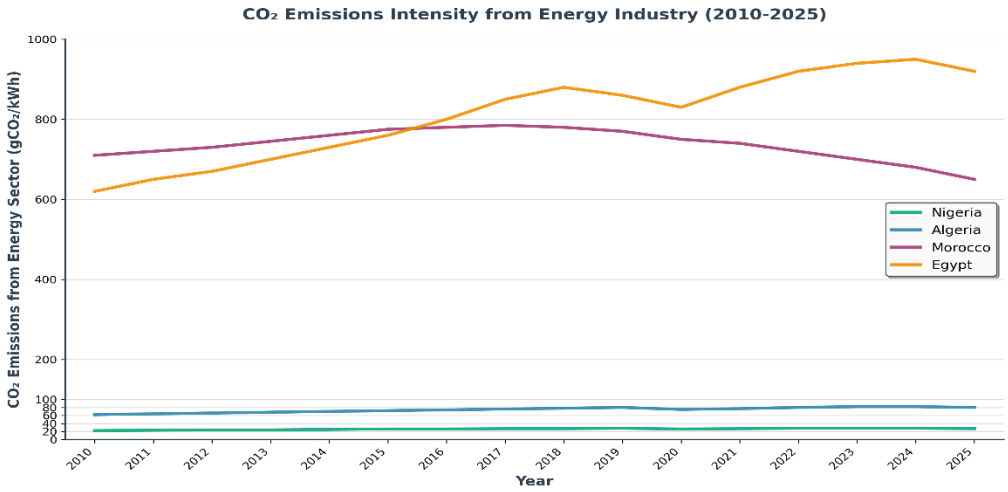
Egypt represents the most flexible and relatively stable model, maintaining positive growth rates throughout almost the entire period except for the Arab Spring of 2011-2013 (1.8-2.2%), achieving the most sustainable recovery in the region between 2017-2019 (4.1-5.6%), which is partly attributed to the economic reform program that included floating the pound and reducing energy subsidies from 7% to 3% of GDP In addition to intensive investment in infrastructure and renewable energy (11.8 GW). What distinguishes the Egyptian case is that it is almost the only African economy that maintained positive growth (3.6%) during the Covid-19 pandemic in 2020, while Algeria contracted by -5.1%, Morocco by -7.2%, and Nigeria by -1.8%, an achievement that reflects relative strength in economic diversification and the effectiveness of health and financial policies.

Morocco's trajectory reveals a climate-sensitive economy, with sharp fluctuations between years of drought (1.1% in 2016, 1.3% in 2022) and years of abundant water, given that the agricultural sector contributes 12-15% of the GDP and employs 40% of the workforce. However, Morocco achieved a record recovery of 8.0% in 2021 thanks to an exceptional agricultural season and a rapid tourism recovery, with a strategic focus on renewable energy (32% From electricity) and export industries directed towards Europe. Algeria presents the most worrying case, as the Blue Line shows a continued decline in growth dynamics from 3.6% in 2010 to 0.8% in 2019, before a catastrophic collapse to -5.1% in 2020. This reflects a structural failure to diversify an economy that relies 95% on hydrocarbon exports. Although growth regained some strength, reaching 3.9% in 2025, it was driven by the non-oil sector, which grew by 5.7% and a record quarterly boom of 18.6% In the first quarter of 2025, but this improvement remains fragile unless supported by profound reforms.

From a standard perspective, the economic literature confirms a two-way causal relationship between renewable energy and economic growth in sub-Saharan Africa, where every 1% increase in renewable energy consumption contributes to a 0.11-0.15% increase in economic growth over the long term. However, this effect is compounded in countries with high institutional quality and good governance. This partly explains why, despite the challenges, Morocco and Egypt have performed relatively better than Algeria and Nigeria in sustaining growth. Morocco invested $10.6 billion and Egypt $5 billion in renewable energy, generating jobs (40,000 jobs in Morocco), reducing the import bill ($1.2 billion annually in Morocco), and enhancing competitiveness in attracting clean, energy-intensive industries. On the contrary, the data shows that Algeria and Nigeria lost a decade of development opportunities due to delays in the energy transition, as renewable energy could have added an additional percentage point to annual growth, cumulatively equivalent to $50 billion in lost GDP during 2010-2025.

4-2 Volume of carbon dioxide emissions from the energy industry:

Figure (07) : Evolution of the volume of carbon dioxide emissions from the energy industry during 2025-2010



(Surce :Africa Climate Insights. 2025)

An analysis of the energy sector CO2 emission intensity of the four countries over the period 2010–2025 reveals divergent development paths that reflect strategic choices in energy infrastructure construction and their long-term economic and environmental impacts. The figure shows a huge gap of up to 34 times between Egypt (920 g CO_2/kWh) and Nigeria (27 g), a gap that reflects more than just technical differences, but rather reveals contradictory development models in natural resource management and strategic priorities. Egypt's sharply rising red path represents the classic development dilemma: Although Egypt has succeeded in raising electricity capacity from 30 gigawatts in 2010 to more than 60 gigawatts in 2025 to meet the needs of 105 million people, the increasing reliance on combined-cycle natural gas plants (59.8 billion cubic meters annually) and imported coal plants has raised emissions by 48.4% This means that every additional kilowatt-hour generated in Egypt produces emissions three times higher than the global average of 475 grams, a reality that translates into huge future environmental and economic costs, including the risks of a European border carbon tax that could cost the Egyptian economy billions of dollars in export losses.

In contrast, Morocco's gradually sloping purple path provides a model of relative separation (Relative Decoupling) between economic growth and emissions, as Morocco succeeded in reducing emissions intensity from 785 grams in 2017 to 650 grams in 2025 (a decrease of 17%) thanks to Intensive investment in renewable energy has reached 32% of electricity generation With a plan to stop coal plants (which currently represent 30% of the mix) by 2040 It is a strategy that has achieved dual benefits: reducing the coal import bill by about $800 million annually and qualifying the Moroccan economy to rank 19th globally in the 2026 Climate Change Performance Index as the best African country, which enhances its attractiveness for European green investments. Algeria's fixed horizontal blue line reveals a wasted competitive advantage, as its low density of 80 grams (a slight increase of only 29% since 2010) reflects its almost complete dependence on natural gas, which produces half of coal's emissions. But Algeria has failed to translate this environmental advantage into economic added value by exporting clean electricity to Europe or attracting energy-intensive industries seeking a low carbon footprint Which means a potential loss of revenue estimated at billions of dollars annually.

Nigeria's stable Green Line at 27 grams is an exception globally, as Nigeria has the lowest emissions intensity of the four countries thanks to a unique combination of hydropower (accounting for about 20% of generation) and natural gas. However, this environmental achievement masks a catastrophic development failure: Nigeria, with its electricity capacity of only 13 gigawatts for 220 million people (59 watts per capita), has the lowest electricity access rate on the continent (58%), forcing millions to use polluting diesel generators that produce additional emissions not counted in official statistics, a reality that costs the Nigerian economy $14 billion annually in spending on polluting fuels and hampers industrial productivity. From a macroeconomic perspective, the literature confirms that emissions intensity is a pivotal indicator of future competitiveness in the low-carbon global economy. High-density countries (Egypt and Morocco) face increased risks from the European border carbon tax that will come into full effect in 2026, while low-density countries (Algeria and Nigeria) have a competitive advantage provided they invest in expanding clean electricity capacities With estimates suggesting that each 100-gram reduction in density could save $50-100 million annually in carbon compliance costs for exporting countries.

4-3 Sustainable growth in the countries studied:

Based on GDP growth indicators and carbon dioxide emissions, a comparison between the four countries reveals divergent paths toward balancing economic growth and environmental sustainability over the period 2010–2025.

A comparative analysis of countries' performance in achieving sustainable growth within the framework of energy transition Based on GDP growth indicators and carbon dioxide emissions, a comparison between the four countries reveals divergent paths toward balancing economic growth and environmental sustainability over the period 2010–2025. Morocco: Regional leadership with emissions challenges.

Morocco leads the African energy transition scene with tangible achievements, having raised the share of renewable energy from 12.5% in 2010 to 32% in 2025, an increase of 156%, driven by mega projects including the Noor Ouarzazate solar complex (580 MW) and a wind capacity of 2.37 GW, with investments exceeding 110 billion dirhams ($10.6 billion). Morocco achieved a total renewable capacity of 6,500 MW in 2025 compared to 1,265 MW in 2010, and aims for 52% of installed capacity by 2030, qualifying it for 19th place globally in the 2026 Climate Change Performance Index as the best African country. On the economic front, Morocco achieved an average growth rate of 3.3% during 2010-2025, with a record recovery of 8.0% in 2021 and stable growth of 3.2% in 2025. However, despite these achievements, the changes did not adequately reflect the reduction in absolute emissions, which rose from 55 million tons in 2010 to 70 million tons in 2025, an increase of 27.3%. This is due to the continued adoption of coal plants, which represent 30% of the energy mix, with an emission intensity of 650 grams of CO_2/kWh in 2025, despite a decrease from 785 in 2017.

Algeria: Huge potential and faltering transformation

Algeria has exceptional natural solar potential (2,000–3,600 kWh/m2 per year) and the third-largest gas reserves in Africa, but the pace of transition has remained alarmingly slow, with renewable capacity remaining below 600 MW until 2024 before jumping to 4,000 MW in 2025, a late achievement that represents a 963% increase but is still lower than Morocco

and Egypt. The share of renewable energy remained below 1% until 2014 before rising to just 8% in 2025, while the energy sector consumes 50.5 billion cubic meters of gas annually. Economically, it achieved the lowest average growth (2.6%) among the four countries, with a sharp contraction of -5.1% in 2020 and a modest growth of 3.9% in 2025, while emissions rose from 130 million tons in 2010 to 158 million tons in 2025, an increase of 21.5%, reflecting continued reliance on fossil fuels, which represent 95% of exports.

Egypt: Strong economic growth and high emissions

Egypt recorded the highest average economic growth (3.8%) during 2010-2025, and was almost the only African economy to maintain positive growth of 3.6% during the 2020 pandemic, with a peak of 6.6% in 2022 and growth of 3.5% in 2025. Egypt achieved the largest installed renewable capacity among the four countries at 13,500 MW in 2025 compared to 2,798 MW in 2010, and raised the share of renewable energy from 8.5% to 23%, an increase of 170%, with investments exceeding $5 billion, including the Benban solar station (1.8 GW). Despite this progress, carbon levels remained very high, with emissions jumping from 195 million tonnes in 2010 to 230 million tonnes in 2025, a 17.9% increase, with an emission intensity of 920 g CO_2/kWh (twice the global average). This is attributed to the continued reliance on natural gas (59.8 billion cubic metres per year) and coal plants to meet the growing demand of 105 million people.

Nigeria : Low emissions and energy crisis

Nigeria recorded the lowest emission intensity (27 g CO_2/kWh) and relatively low absolute emissions (135 million tons in 2025 compared to 95 in 2010), but this "achievement" is related to a weak production structure and not to an effective energy transition. Nigeria is suffering from a catastrophic energy crisis with an electricity capacity of only 13 gigawatts for 220 million people (59 watts per capita), with 42% of the population lacking electricity, forcing them into polluting diesel generators at a cost of $14 billion annually. Per capita renewable energy consumption has remained stagnant at 0.50 GJ (an increase of only 4.2% since 2010) due to explosive population growth of 2.5% annually that is eating up gains. Economic growth averaged 3.4%, but with sharp fluctuations from 11.3% in 2010 to -1.6% in 2016 and then 3.4% in 2025, reflecting the structural fragility of the oil-dependent economy by 90%.

Conclusion

A comparative analysis of energy transition trajectories in Algeria, Morocco, Egypt, and Nigeria over the period 2010–2025 reveals a complex reality that combines promising achievements with profound, unresolved structural challenges. These countries have made tangible progress in building renewable capacities, which rose from a combined 4,663 MW in 2010 to more than 27,000 MW in 2025, but this quantitative expansion was not sufficiently reflected in reducing total emissions, which rose from 475 million tons to 593 million tons CO_2, an increase of 24.8% This means that economic growth and growing energy demand still exceed the potential of renewable energy to fundamentally transform the carbon footprint.

Three main patterns emerge from this analysis: First, Morocco and Egypt have built massive renewable capacities (6,500 and 13,500 MW, respectively) with investments exceeding $15.6 billion, raising the share of renewable capacities to 32% and 23% and creating more than 50,000 direct jobs, but continued reliance on fossil fuels (coal in Morocco and gas in Egypt) has kept emission intensity high at 650 and 920 g CO_2/kWh. Second, Algeria wasted exceptional natural potential (solar radiation 2,000-3,600 kWh/m2) with a systematic delay that kept renewable capacity below 1% until 2014, costing the economy billions of dollars in missed opportunities to export clean electricity and attract green industries. Third, Nigeria suffers from a devastating development paradox: low emissions (27 grams CO_2/kWh) but 42% of 220 million people are deprived of electricity, forcing them into diesel generators costing $14 billion annually and emissions not officially calculated

Recommendations :

At the national policy level

Accelerating coal phase-out: Morocco should advance its coal phase-out target from 2040 to 2035, investing $3-4 billion in renewable energy and storage alternatives, which could reduce emissions intensity to 400 g CO_2/kWh and save $500 million annually in carbon compliance costs.

Deep structural reform in Algeria: Algeria needs an ambitious program targeting 22 renewable gigawatts by 2030 (as announced) with investments of $50 billion, with the launch of a national carbon pricing mechanism that stimulates transformation and directs oil and gas revenues towards building a post-hydrocarbon economy.

Expanding Nigeria's electricity grid: Solving the electricity crisis requires investing $100 billion to increase capacity from 13 to 40 GW by 2030, focusing on decentralized solar solutions (Mini-grids) that can deliver electricity to 85 million people at a cost 50% lower than the traditional grid.

Diversifying Egypt's energy mix: Despite significant renewable capacity, Egypt needs to reduce its reliance on gas from the current 75% to 50% by 2030, double renewable capacity to 27 gigawatts, and invest $10 billion in battery storage to reduce emissions to less than 600 grams.

At the level of regional cooperation

Establishing a common Maghreb electricity market: An electrical interconnection between Algeria, Morocco, and Egypt (at a cost of $5 billion) could maximize the exploitation of solar energy and save $2 billion annually in generation costs through load exchange.

Establishing a regional manufacturing center for renewable technology: The four countries can cooperate in building a local solar panel and wind turbine industry with a capacity of 10 gigawatts annually, creating 200,000 jobs and reducing the cost of projects by 30%.

At the level of financing and governance

Mobilizing blended finance: The four countries combined need $200 billion by 2030, 40% of which can be provided through green financing mechanisms (the Green Climate Fund and development banks) and the remaining 60% from the private sector by improving the investment environment and removing price distortions.

Enhancing transparency and governance: Research confirms that improving institutional quality doubles the impact of renewable energy on economic growth, so independent agencies must be established to regulate the energy sector and ensure fair competition.

Launching a fair transition strategy: 10-15% of renewable energy investments should be allocated to rehabilitating workers in the fossil fuel sector (about 500,000 workers in the four countries) and developing their skills for the green sector, which could create 1.2 million jobs by 2030.

These recommendations constitute a roadmap for achieving a real balance between economic growth and environmental sustainability, provided there is political will, financial resources, and effective regional cooperation

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