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Energy Transition and Sustainable Development Practices in Algeria: Challenges and Opportunities

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ABSTRACT:
This paper explores Algeria's efforts to transition to renewable energy, improve energy efficiency, and achieve sustainable development. It highlights the country's ambitious goals, such as generating 22 gigawatts of renewable energy by 2030, and examines the challenges it faces, including economic constraints, technological gaps, and policy implementation. The paper also discusses opportunities for Algeria, such as leveraging international partnerships, fostering innovation, and creating jobs in the renewable energy sector. By adopting a comprehensive approach that combines economic diversification, environmental protection, and social development, Algeria can achieve a sustainable and resilient future, contribute to global efforts to combat climate change while ensuring long-term prosperity for its citizens and its significant renewable energy potential, particularly in solar energy, which puts it well positioned to diversify its energy mix and reduce its carbon footprint.

Keywords: Energy Transition, Sustainable Development, Renewable Energy, Environment.

JEL Classifications Codes: Q2, Q4, Q56, O1

1. INTRODUCTION

The global energy landscape is undergoing a profound transformation as countries worldwide strive to address the dual challenges of climate change and sustainable development. This shift is driven by the urgent need to reduce greenhouse gas emissions, mitigate environmental degradation, and ensure access to affordable, reliable, and clean energy for all. For resource-rich countries like Algeria, this transition presents both opportunities and challenges. As one of the largest exporters of natural gas and a significant producer of oil, Algeria's economy has long been dependent on fossil fuels. However, the global push toward renewable energy and sustainable practices necessitates a reevaluation of its energy strategy and economic model.

Algeria is uniquely positioned to leverage its abundant natural resources, particularly its vast solar energy potential, to drive its energy transition. With over 3,000 hours of sunlight annually, the country has the capacity to become a regional leader in renewable energy production. At the same time, Algeria faces pressing domestic challenges, including rising energy demand, economic diversification, and the need to create jobs for its growing population. These factors underscore the importance of aligning its energy transition with broader sustainable development goals.

This paper examines Algeria's efforts to transition from a fossil fuel-based economy to one that embraces renewable energy and sustainable development. It explores the country's current energy landscape, its renewable energy potential, and the policies and initiatives being implemented to achieve its energy transition goals. The paper also highlights the challenges Algeria faces, such as economic constraints, technological gaps, and the need for effective policy

implementation. Finally, it discusses the opportunities for Algeria to leverage international partnerships, foster innovation, and create a sustainable and resilient future.

Problem Statement: Based on the above, we pose the following question: How does the energy transition contribute to achieving sustainable development in Algeria?

To address this problem, we propose the following hypotheses:
Hypothesis 1: Algeria's renewable energy potential places it in a favorable position for energy transition .
Hypothesis 2: Renewable energy in Algeria acts as a catalyst for energy diversification and environmental sustainability.

Study Objectives: The study aims to:
- The primary aim of this study is to analyze Algeria's energy transition and its efforts to achieve sustainable development, identifying key challenges, opportunities, and strategies for success. Specifically, the study seeks to achieve the following objectives:

- Evaluate the country's dependence on fossil fuels and its implications for economic stability and environmental sustainability.
- Examine the current state of renewable energy development and energy efficiency initiatives.
- Explore Algeria's Renewable Energy Potential:
- Examine the social and environmental challenges associated with achieving sustainable development.
- **Importance of the Study**: this study is crucial for guiding Algeria toward a sustainable and resilient future, ensuring that its energy transition efforts contribute to economic growth, social development, and environmental preservation. It also provides valuable insights for the global community in addressing the interconnected challenges of energy security, climate change, and sustainable development.

Methodology: Our study is based on the descriptive and analytical approach, which includes a theoretical presentation of renewable energies and energy transition in Algeria, in addition to studying the environmental dimensions and the impact of renewable energies. The analytical aspect deals with the potential of renewable energy in Algeria and the relationship between energy transition and the environment.

Previous studies:

1. **PhD thesis entitled: "Modern and renewable energies and their role in achieving the dimensions of sustainable development in Algeria in the horizon of the year 2030",** prepared by: 'Cherifi Sarah', University of Algiers 03, academic year 2020-2021, where the study found that despite the huge energy potential that Algeria possesses from renewable energies, they remain weak.

2. **Article : The Role of the Energy Transition in Achieving Sustainable Development in Algeria -Requirements, Potential and Exploitation**, prepared by: Guecherou Fatiha, REVIEW: OF "ECO RESEARCH,2024, The study concludes that energy transition plays a crucial role in achieving sustainable development in its various dimensions, contributing to economic growth, social justice, and environmental protection. However, the study also finds that Algeria's renewable energy diversification efforts are modest, as renewable sources contribute less than 1% to the energy mix. Despite the many national efforts and programs, this contribution remains small, though it is steadily increasing, offering hope for an independent energy transition in Algeria.

3. **Article : Sustainable Energy Transition in Algeria: Factors Influencing Investment, prepared by: Safaa** BOUZIANI , Nacera BELGHAOUTI, REVIEW: Economic Sciences, Management and Commercial Sciences Review - University of M'sila ,2024, the state of renewable energy in Algeria, finding that the country is seeking to invest in solar photovoltaic energy due to its significant solar potential, favorable legal framework, and encouraging economic and financial factors.

This study is divided into the following axes:
- **Overview of Algeria's energy situation**
- **Algeria's Energy Transformation Strategy**
- **Energy Transition and Sustainable Development in Algeria**

1. Overview of Algeria's energy situation

Algeria's energy landscape is characterized by its abundant natural resources, particularly hydrocarbons, and its growing interest in renewable energy. As one of the largest producers of natural gas and a significant oil exporter, Algeria plays a crucial role in the global energy market. However, the country faces challenges related to economic diversification, energy security, and environmental sustainability. (**Derradji,2024,P28).**

Algeria has a significant energy profile, driven primarily by its vast reserves of hydrocarbons, particularly natural gas and oil. Below are key figures and data regarding Algeria's energy situation:

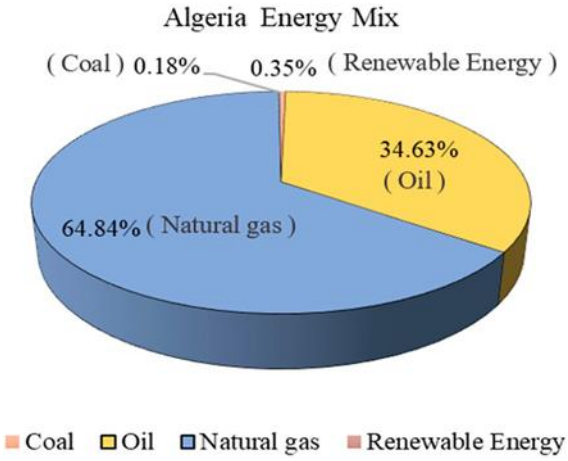


Figure 01

Source: (Sahraouian; Khan; AlHamrouni; Mekhilef; Ahmed, **2021,P7)**

1.1 Natural Gas Reserves and Production

- **Reserves**: As of 2023, Algeria holds approximately **4.5 trillion cubic meters** (Tcm) of proven natural gas reserves, making it the **10th largest natural gas reserve** holder globally.
- **Production**: Algeria produces about **90 billion cubic meters (Bcm)** of natural gas annually. This production is mainly for export, with **approximately 55 Bcm** being exported, primarily to Europe.
- **Exports**: The country is a significant exporter of natural gas, ranking **4th in the world** for LNG exports and **5th** in pipeline exports. Key export markets include Spain, Italy, and France.

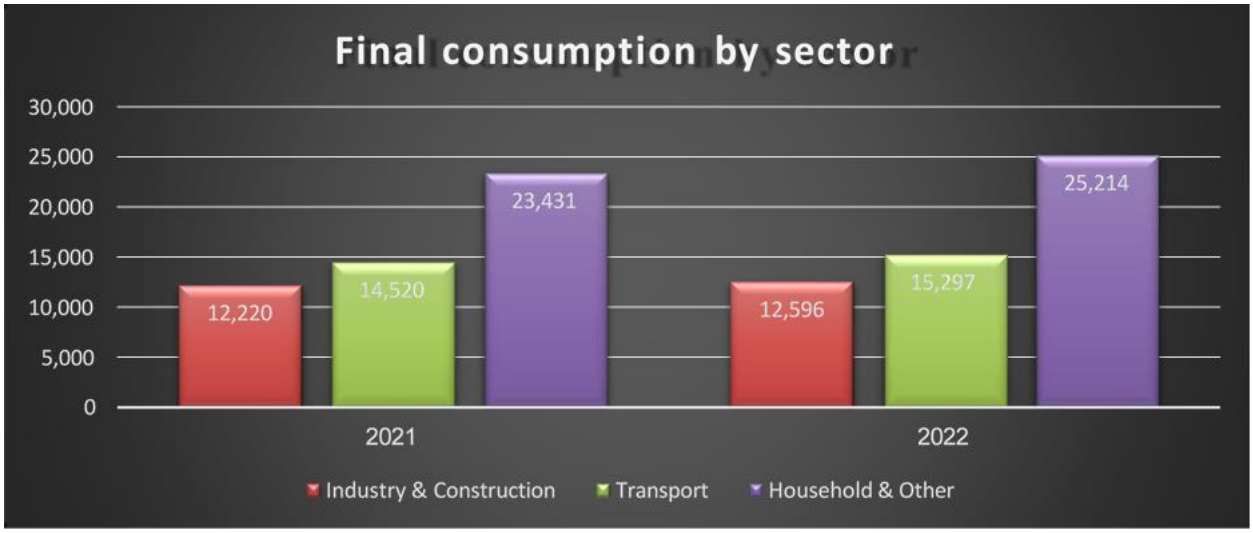
1.2. Oil Reserves and Production

- **Reserves**: Algeria holds **12.2 billion barrels** of proven oil reserves as of 2023, making it one of Africa's top oil producers.
- **Production**: Algeria's oil production averages around **1 million barrels per day (bpd)**. However, production has been on a declining trend due to aging oil fields and lower investments in exploration and technology.
- **Exports**: The country exports about **600,000–700,000 bpd** of crude oil, mainly to Europe.

(BOUZIANI, BELGHAOUTI,2024,P174)

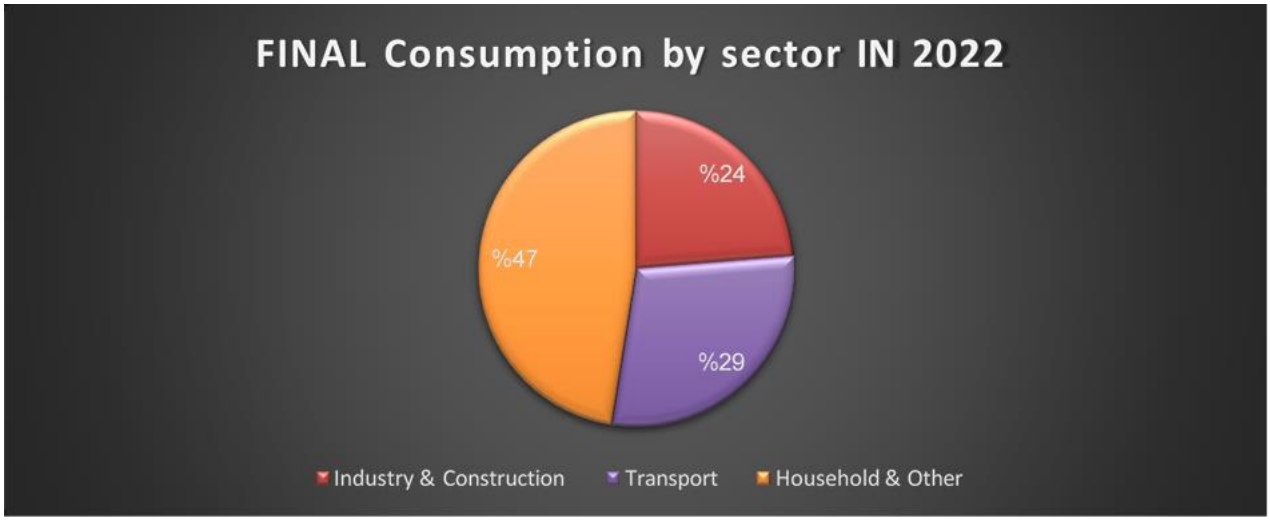
1.3. Electricity Generation and Consumption

- **Total Installed Capacity**: Algeria's total installed electricity generation capacity is **20,000 MW** (megawatts). The country generates the majority of its electricity from **natural gas**, with a small portion coming from oil and hydroelectric power.
- **Electricity Consumption**: Domestic electricity consumption has been increasing steadily, and as of 2023, **Algeria's total electricity consumption** is approximately **70–75 terawatt-hours (TWh)** annually.
- **Generation Mix**:
  - **Natural Gas**: Around **98%** of Algeria's electricity comes from natural gas-fired power plants.
  - **Hydropower**: About **1-2%** comes from hydroelectric power.
  - **Renewables**: Around **1%** of the electricity is generated from renewable energy sources, including solar and wind, but this share is expected to rise.
  - Figure.2. Final consumption by sector in 2021



Source: **(BOUZIANI, BELGHAOUTI,2024,P176)**

- **Figure.2. Final consumption by sector in 2022**



Source: (BOUZIANI, BELGHAOUTI,2024,P176)

1.4. Renewable Energy Goals

- **Solar Energy**: Algeria has high potential for solar energy due to its vast deserts, with the country receiving more than **3,000 hours of sunshine** per year. The government aims to deploy **22,000 MW** of solar capacity by 2030.
- **Wind Energy**: Wind energy is also part of the renewable energy strategy, with plans to install **2,000 MW** of wind power by 2030.
- **Renewable Energy Target**: The government aims for **27%** of its electricity to come from renewable sources by 2030, which includes both solar and wind.
- **The reality and prospects of solar energy in Algeria:**
- In order to learn about the various programs and projects related to solar energy in Algeria, we begin our work by presenting an overview of the Algerian capabilities regarding this type of energy.
- **Solar energy potential in Algeria:**
- The Algerian government seeks to find alternative ways to exploit energy after the oil era. It has revealed an ambitious plan to produce (10%) of electricity from renewable resources by 2020, especially since Algeria has enormous potential for solar energy due to its vast area and geographical location. The German Space Agency announced after a study it conducted that the Algerian desert is the largest reservoir of solar energy in the world, as solar radiation in the Algerian desert lasts 3000 hours of radiation per year (Issani Maamer, 2017, p. 392). It is considered one of the richest solar fields in the world due to the amount of energy received per square meter in most parts of the national territory, sometimes reaching 7) kilowatts/hour/m2. These enormous potentials allow covering

60 times the needs of

- Western Europe, and four times the global consumption, according to the Algerian Ministry of Energy and Mines. It also allows covering 5000 times the national consumption of electricity (MENIAI,2022,P197/198).

1.5. Energy Subsidies

- **Subsidies**: The Algerian government heavily subsidizes energy prices, particularly for electricity, natural gas, and gasoline. This leads to lower costs for domestic consumers but puts pressure on the state's finances. Energy subsidies cost the government approximately **$10 billion annually**.

1.6. Energy Export Pipelines

- **Maghreb-Europe Gas Pipeline**: This pipeline transports natural gas from Algeria through Morocco and into Spain. It has a capacity of about **8 Bcm/year**.
- **Transmed Pipeline**: Transports natural gas from Algeria to Tunisia and then to Italy via the Mediterranean. Its capacity is about **30 Bcm/year**.
- **LNG**: Algeria exports around **20 Bcm** of natural gas annually as liquefied natural gas (LNG), primarily to European countries. **(BOUZIANI, BELGHAOUTI,2024,P175/P177)**

1.7. Investment and Future Prospects

- **Hydrocarbon Investment**: The government has been working to attract foreign investment into the oil and gas sectors to maintain and increase production. Investment in exploration and field development has been a focus, as older fields show declining production.
- **Diversification**: The country is looking to diversify its energy mix, reduce dependency on hydrocarbons, and increase renewable energy capacity, as part of its long-term economic and energy transition strategy.

1.8. Climate and Energy Policy

- **Paris Agreement**: Algeria has committed to reducing its greenhouse gas emissions under the **Paris Climate Agreement**. The country's energy policy aims to shift towards cleaner sources, including solar, wind, and improving energy efficiency across various sectors.

Summary of Key Figures:

- Proven Natural Gas Reserves: 4.5 Tcm
- Natural Gas Production: 90 Bcm/year
- Oil Reserves: 12.2 billion barrels
- Oil Production: 1 million bpd
- Electricity Generation Capacity: 20,000 MW
- Electricity Consumption: 70–75 TWh annually
- Renewable Energy Target (2030): 27% of electricity from renewables
- Solar Energy Target (2030): 22,000 MW
- Wind Energy Target (2030): 2,000 MW
- LNG Exports: 20 Bcm/year
- Energy Subsidy Cost: $10 billion/year (BOUZIANI, BELGHAOUTI,2024,P177)

Algeria's energy situation is heavily reliant on oil and gas, with ongoing efforts to diversify through renewable energy projects. However, challenges related to aging infrastructure, energy subsidies, and the need for economic diversification remain key hurdles for the country's energy future. development.(***Aidouni, Aiouadj, 2023,P61)***

1.9- The Concept of Energy Transition:

The concept of energy transition refers to the global shift from fossil fuel-based energy systems to cleaner, more sustainable energy sources, such as renewables (solar, wind, hydro, geothermal, and biomass). This transition is driven by the need to address climate change, reduce greenhouse gas emissions, enhance energy security, and promote sustainable (**Derradji,2024,P27).**

Renewable Energies as a Strategy for Energy Transition:

Renewable energies play a central role in the global energy transition, offering a sustainable alternative to fossil fuels and helping to address climate change, energy security, and economic development. For countries like Algeria, which are heavily dependent on fossil fuels, renewable energies provide a pathway to diversify energy sources, reduce greenhouse gas emissions, and achieve long-term sustainability.(*Aidouni,2023,P64)***.**

Renewable Energies, Their Characteristics, and Sources:
Renewable energies are derived from natural sources that are replenished on a human timescale, making them sustainable and environmentally friendly alternatives to fossil fuels. Below is an overview of the main types of renewable energies, their characteristics, and sources.

Renewable energies are essential for energy transition because they:

Reduce Greenhouse Gas Emissions:
Unlike fossil fuels, renewables produce little to no carbon dioxide (CO_2) or other pollutants during operation, helping to mitigate climate change.

Enhance Energy Security:
By diversifying energy sources, countries can reduce dependence on imported fossil fuels and minimize vulnerability to price fluctuations and supply disruptions.

Promote Sustainable Development:
Renewable energy projects create jobs, stimulate local economies, and improve access to energy in remote and underserved areas.

Leverage Abundant Natural Resources:
Many regions, including Algeria, have vast renewable energy potential (e.g., solar, wind) that remains underutilized.

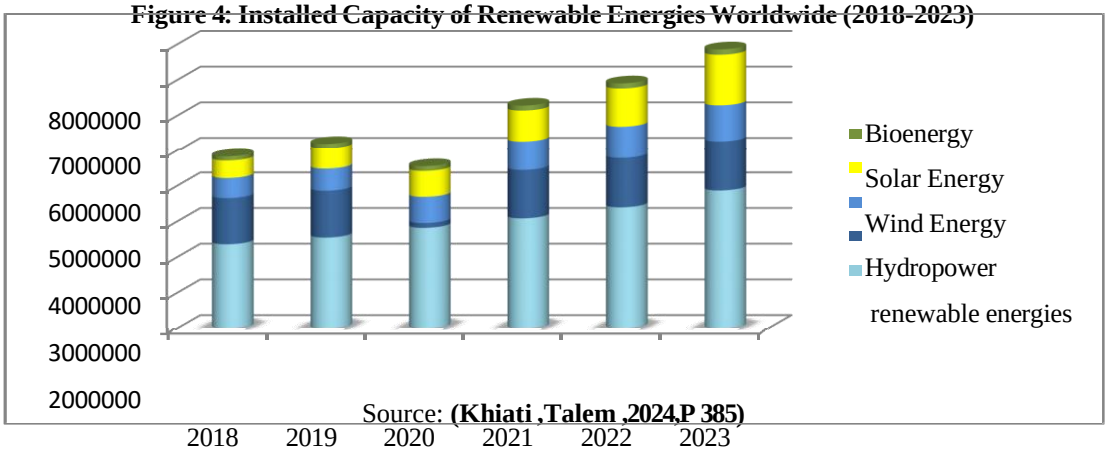
Support Technological Innovation:
The renewable energy sector drives advancements in energy storage, smart grids, and energy efficiency technologies. *(Yousfi,2023,P65)*

Sources of Renewable Energies
The sources of renewable energies are diverse, including solar energy, wind energy, in addition to hydropower and biomass energy. Below is an explanation of these:

Renewable energies are derived from natural sources that are replenished on timescale.
These include:
Solar Energy: Harnessing sunlight using photovoltaic (PV) panels or concentrated solar power (CSP).
Wind Energy: Using wind turbines to convert kinetic energy into electricity.
Hydropower: Generating electricity from flowing or falling water.
Geothermal Energy: Tapping into heat from the Earth's interior.

Biomass: Using organic materials (e.g., wood, agricultural waste) for energy production.
(Khiati ,Talem ,2024,P 385).

Figure 4: Installed Capacity of Renewable Energies Worldwide (2018-2023)



Source: **(Khiati ,Talem ,2024,P 385)**

Algeria has been making strides in developing its renewable energy sector, particularly in solar energy, as part of its broader strategy to diversify its energy mix and reduce reliance on fossil fuels. Below is an overview of the installed capacity of renewable energies in Algeria from 2018 to 2023, based on available data and estimates.

1.10 - The Role of Renewable Energies in Enhancing Energy Security and Efficiency

Renewable energies play a critical role in enhancing energy security and energy efficiency, which are essential for sustainable development and economic stability. For countries like Algeria, which are heavily dependent on fossil fuels, transitioning to renewable energy sources offers numerous benefits, including reduced vulnerability to external shocks, improved resource management, and long-term sustainability. Below is an in-depth analysis of how renewable energies contribute to energy security and efficiency.

Energy Security in Algeria:

Energy security in Algeria is a critical concern for both domestic stability and its role as a major energy exporter. As one of the largest producers of oil and natural gas in Africa, Algeria's energy security is deeply intertwined with its ability to manage natural resources effectively, ensure infrastructure reliability, and balance domestic energy needs with export commitments. Here's an overview of Algeria's energy security landscape. (Gueddiri , Chemani ,2024,P168)

switching to renewable and new energy seems necessary owing to the oncoming depletion of non-renewables. Ergo, the daunting challenge for Algeria is to adopt a relevant strategy that might ensure meeting the increasing energy needs. This can be achieved via exploiting non-costing, non-depleting, and environmentally friendly alternatives other than the hazardous shale gas that has negative impacts at environmental and financial levelsand nuclear energy, which advanced countries are seeking to get rid of.

The absence of a developmental policy based on an energy strategy brought about an insignificant investment in renewables regardless of the existing laws and regulations. This situation led to the belief that, on the one hand, legal security shall be of central importance in that it contributes to bringing investments in renewables as a future alternative, a guarantee to investors and capital providers. On the other hand, economic feasibility must be taken into account when developing policies to achieve energy security.Notwithstanding, legal security remains an insufficient guarantee to achieve alternatives other than traditional energy because of the absence of political will and the need to adopt wise decision-making such as the nationalisation of fossil fuels to align with the post-oil world policy as of 2040**.(** Boubechiche , MANSOURI,2024,P418).

4 Strategies for the exploitation of solar energy in Algeria to promote environmental sustainability:

Algeria, with its vast solar energy potential, is uniquely positioned to leverage solar power as a key driver of environmental sustainability. The country receives over 3,000 hours of sunlight annually, particularly in the Sahara Desert, making it one of the most solar-rich regions in the world. By strategically exploiting solar energy, Algeria can reduce its reliance on fossil fuels, lower greenhouse gas emissions, and promote sustainable development.

2- Algeria's Energy Transformation Strategy:

Algeria, a country rich in fossil fuel resources, has recognized the need to diversify its energy mix and transition toward renewable energy and sustainable development. This shift is driven by the global push to combat climate change, reduce greenhouse gas emissions, and enhance energy security. Below is an overview of Algeria's energy transformation strategy, including its goals, initiatives, challenges, and opportunities.

2.1. **Goals of Algeria's Energy Transformation Strategy**

Algeria's energy transformation strategy aims to:

Diversify Energy Sources: Reduce dependence on fossil fuels by increasing the share of renewable energy in the energy mix.

Enhance Energy Security: Ensure a stable and reliable energy supply by leveraging domestic renewable resources.
Reduce Greenhouse Gas Emissions: Contribute to global climate goals by transitioning to cleaner energy sources.
Promote Sustainable Development: Support economic growth, job creation, and social equity through renewable energy projects.

Improve Energy Efficiency: Optimize energy use in industries, buildings, and transportation to reduce waste and lower costs.(**kaouane,2023,P120).**

2.2 **Key Initiatives and Programs**

a. National Renewable Energy and Energy Efficiency Program (2015)

Target: Install 22 GW of renewable energy capacity by 2030, including:

- 13.5 GW of solar energy
- 5 GW of wind energy
- 2 GW of hydropower
- 1 GW of biomass

- 0.5 GW of geothermal energy

Focus Areas: Large-scale solar and wind projects, energy efficiency measures, and research and development.
b. Solar Energy Development
Hassi R'Mel Solar Power Plant: A hybrid power plant combining natural gas and solar energy, with a capacity of 150 MW (solar component).

Large-Scale Solar Farms: Projects in the Sahara Desert to harness Algeria's vast solar potential.

Rooftop Solar Programs: Initiatives to promote small-scale solar installations in residential and commercial buildings.

c. Wind Energy Development Skikda Wind Farm: A pilot project with a capacity of 10 MW.

New Wind Farms: Plans to develop additional wind farms in coastal and southern regions with favorable wind conditions.

d. Energy Efficiency Measures Building Standards: Introduction of energy efficiency standards for new constructions and renovations.

Industrial Efficiency: Programs to reduce energy consumption in industries through modern technologies and best practices.

Public Awareness Campaigns: Efforts to educate citizens and businesses about the benefits of energy efficiency.

e. International Cooperation Partnerships: Collaboration with international organizations, such as the International Renewable Energy Agency (IRENA), and foreign investors to secure funding and technology transfer.

Regional Projects: Participation in regional energy initiatives, such as the Desertec project, which aims to supply Europe with renewable energy from North Africa.

2.3. **Challenges to Energy Transformation**
Dependence on Fossil Fuels:
Algeria's economy is heavily reliant on oil and gas revenues, which has slowed investment in renewables.

Policy and Regulatory Barriers:
Inconsistent policies and bureaucratic hurdles have hindered the grooth of renewable energy projects.

Financing Constraints:
High upfront costs for renewable energy infrastructure and limited access to financing.

Technological Gaps:
Limited local expertise and reliance on imported technologies.

Grid Infrastructure:
The existing grid may not be equipped to handle large-scale renewable energy integration.
.(**kaouane,2023,P122/P123).**

2.4. **Opportunities for Energy Transformation**
Solar Energy Leadership:
Algeria has the potential to become a regional leader in solar energy production and export.

Economic Diversification:
Developing the renewable energy sector can create jobs and reduce dependence on hydrocarbons.

Energy Access:
Renewable energy can provide electricity to remote and rural areas that are not connected to the national grid.
International Support:
Partnerships with international organizations and foreign investors can provide funding, technology transfer, and expertise.

2.5. **Progress and Future Outlook**
Current Capacity (2023): Algeria's renewable energy capacity is estimated at 630 MW, primarily from solar energy.

2030 Target: The country aims to reach 22 GW of renewable energy capacity, with solar energy accounting for the majority.

Long-Term Vision: By 2035, Algeria plans to further expand its renewable energy capacity to 27 GW, including significant contributions from wind, hydropower, and biomass. .(**kaouane,2023,P124).**

Energy Transition Program in Algeria 2011-2030:
The **Energy Transition Program (2011-2030)** in Algeria is part of the country's broader efforts to reduce its dependence on fossil fuels, increase energy efficiency, and develop renewable energy sources. The program outlines strategies to meet Algeria's growing energy demand, ensure sustainable energy security, and contribute to global climate goals, such as reducing greenhouse gas emissions and diversifying the economy. Below is an overview of Algeria's Energy Transition Program and its key objectives. (**Ghandir, Siagh ,2020,P124).**

Goals and Vision of the Energy Transition Program (2011-2030):
The overarching goal of the Energy Transition Program is to shift Algeria's energy sector toward sustainability by diversifying energy sources, improving energy efficiency, and reducing carbon emissions. Some of the key objectives include:

- **Diversify the Energy Mix**: Decrease reliance on fossil fuels (oil and natural gas) by increasing the share of **renewable energy** in Algeria's energy mix.
- **Achieve Energy Security**: Ensure reliable energy supply while reducing the strain on natural gas resources, which are heavily used for domestic consumption and electricity generation.
- **Sustainable Development**: Promote environmentally-friendly energy solutions that align with global climate change targets.
- **Economic Diversification**: Support Algeria's transition to a less oil-dependent economy, creating new industries and job opportunities in renewable energy sectors.
- **Increase Energy Access**: Ensure affordable and equitable access to energy for all Algerians, particularly in remote or underserved regions.

Renewable Energy Development:
The Energy Transition Program places significant emphasis on the development of **renewable energy**. Algeria's renewable energy potential is vast, particularly in solar and wind energy. The program sets ambitious targets for the share of renewables in Algeria's energy mix.

- **Renewable Energy Capacity**:
  - The program aims for **27%** of Algeria's total electricity production to come from renewable energy sources by **2030**.
  - This includes a focus on **solar power** and **wind energy**, given the country's natural advantages (more than 3,000 hours of sunshine per year in the southern desert areas).
  - The government has set a target of **22,000 MW** of solar capacity by 2030 and **2,000 MW** of wind energy.

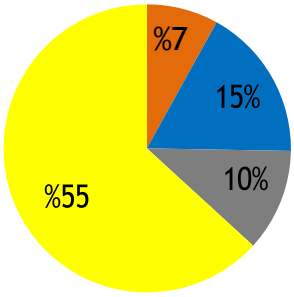
- **Solar Energy**:
  - Algeria is targeting **13,000 MW** of installed solar power by 2030. This is driven by
  - the country's immense potential for solar energy, especially in its desert regions, which receive high levels of sunlight.
  - Large-scale solar projects have been launched in the south of the country, including the **Noor Solar Complex**, which is expected to become one of the largest solar power plants in the world.

- **Wind Energy**:
  - The program outlines the goal of installing **2,000 MW** of wind power by 2030. Algeria's northern coast, which benefits from strong winds, is ideal for wind power generation. (**Ghandir, Siagh ,2020,P125/P127)**

Figure 05: Algeria's energy mix (scenario 2050)

Energy mix in Algeria 2050

Nuclear Energy Natural gaz
Oil
solar energy



Source (Khiati, Talem ,2024, P 391)

Algeria's energy mix in 2050 is expected to undergo a significant transformation as the country transitions from a fossil fuel-dependent economy to one that embraces renewable energy and sustainable development. This shift is driven by global climate goals, the need to diversify the economy, and the desire to enhance energy security. Below is a projected vision of Algeria's energy mix in 2050, based on current trends, policies, and technological advancements.

3- Energy Transition and Sustainable Development in Algeria:
Algeria, a country rich in natural resources, is at a critical juncture in its energy and economic development. With a heavy reliance on fossil fuels, particularly natural gas and oil, Algeria faces the dual challenge of transitioning to cleaner energy sources while ensuring sustainable development. This transition is essential for reducing greenhouse gas emissions, enhancing energy security, and promoting economic diversification. Below is an in-depth analysis of energy transition and sustainable development in Algeria, including current efforts, challenges, opportunities, and future outlook.(**Ait Bara , Baar ,2024,P6)**

Sustainable Development: Linking Energy Transition to Broader Goals Sustainable development in Algeria is closely linked to its energy transition efforts. Key areas of focus include:(**Ait Bara , Baar ,2024,P7)**

a. **Economic Diversification**
Reducing dependence on hydrocarbon revenues by developing new industries in renewable energy, technology, and manufacturing.

Creating jobs in the renewable energy sector, particularly for youth and women.

b. **Environmental Protection**
Reducing greenhouse gas emissions and air pollution by transitioning to cleaner energy sources.
Protecting natural ecosystems and biodiversity through sustainable energy practices.

c. **Social Equity**
Improving energy access for rural and marginalized communities through decentralized renewable energy systems.
Addressing energy poverty and improving quality of life.

d. **Climate Resilience**
Building resilience to climate change impacts, such as extreme weather events and water scarcity, through sustainable energy solutions.

3.1- Challenges to Energy Transition and Sustainable Development:
Dependence on Fossil Fuels:
Heavy reliance on oil and gas revenues makes the economy vulnerable to global market fluctuations.

Policy and Regulatory Barriers:
Inconsistent policies and bureaucratic hurdles hinder the growth of renewable energy projects.

Financing Constraints:
High upfront costs for renewable energy infrastructure and limited access to financing.

Technological Gaps:
Limited local expertise and reliance on imported technologies.

Grid Infrastructure:
The existing grid may not be equipped to handle large-scale renewable energy integration (**Ait Bara , Baar ,2024,P8/P9).**

3.2- The Role of the Energy Transition in Achieving Sustainable Development Dimensions
The energy transition is a critical component of sustainable development. In the context of Algeria, this transition involves shifting from an energy system dominated by fossil fuels (mainly oil and natural gas) to one that incorporates renewable energy, enhances energy efficiency, and prioritizes environmental sustainability. The energy transition has the potential to impact several dimensions of sustainable development, including economic growth, social equity, environmental protection, and institutional capacity. Below, we explore how the energy transition in Algeria contributes to each of these dimensions.

Economic Dimension:
The energy transition plays a significant role in reshaping Algeria's economy, ensuring that it moves beyond its heavy dependence on fossil fuels and becomes more diversified and resilient.

- **Diversification of the Economy**: By investing in renewable energy, Algeria can diversify its economic activities beyond oil and gas, which have historically been the country's main sources of income. Expanding into renewable energy technologies, energy efficiency

- solutions, and green industries will create new sectors of economic activity, fostering sustainable economic growth.
- **Job Creation**: The renewable energy sector, particularly solar and wind energy, has the potential to generate significant employment opportunities. From the manufacturing of solar panels and wind turbines to the installation and maintenance of energy systems, the transition to renewables can create thousands of jobs across various skill levels. This would also contribute to reducing unemployment, particularly among young people, who make up a significant proportion of Algeria's population.
- **Attracting Investment**: By committing to energy transition goals, Algeria can position itself as a competitive player in the global renewable energy market. International investments in renewable energy projects and technologies can help Algeria develop the necessary infrastructure, accelerate technological innovation, and create partnerships with leading companies in the sector. This would also reduce the country's reliance on foreign oil and gas revenues.
- **Reducing Fiscal Pressure**: The transition away from subsidies for fossil fuels could reduce the financial burden on the national budget. Reducing energy subsidies would allow the government to reallocate funds to key areas such as education, healthcare, and infrastructure, helping to achieve broader development goals.

Social Dimension:
The energy transition also plays a key role in promoting social development by ensuring equitable access to energy, improving living standards, and fostering social inclusion.

- **Energy Access and Equity**: One of the most significant aspects of the energy transition is the potential to improve **energy access** for all citizens, particularly in rural and remote areas. Expanding renewable energy sources such as solar and wind can provide off-grid solutions, which are essential for rural communities in Algeria. This ensures that all Algerians, regardless of location, have access to affordable, reliable, and clean energy.
- **Improved Health and Well-being**: By shifting away from fossil fuels to renewable energy sources, Algeria can reduce harmful emissions that contribute to air pollution and climate change. This would improve public health outcomes, reducing the incidence of respiratory illnesses and other health problems associated with poor air quality. A cleaner energy system would also reduce environmental degradation and enhance the overall quality of life.
- **Social Equity**: The energy transition can foster greater social equity by ensuring that energy is affordable for all segments of society. Through targeted policies such as subsidies for renewable energy in low-income households or promoting community-based renewable energy projects, the government can reduce inequalities in energy access.
- **Education and Skills Development**: The development of the renewable energy sector will require new skills and expertise. This provides an opportunity to improve education and vocational training systems in Algeria, ensuring that the workforce is equipped with the
- necessary knowledge and skills to thrive in the green economy. Programs focused on renewable energy and energy efficiency could lead to the creation of educational pathways and research opportunities for Algerians. .(Guecherou ,lounici,2024,P108)

Environmental Dimension:
The energy transition is perhaps most directly connected to the environmental sustainability of Algeria. By reducing reliance on fossil fuels and expanding renewable energy sources, Algeria can mitigate the environmental impacts of its energy sector.

- **Reduction in Greenhouse Gas Emissions**: The shift to renewable energy sources such as solar and wind is critical

to reducing the carbon footprint of Algeria's energy sector. Reducing carbon emissions is essential for achieving national and global climate targets, particularly in light of the **Paris Agreement**. This will help Algeria play a more active role in global efforts to combat climate change.

- **Conservation of Natural Resources**: The depletion of fossil fuel resources, such as oil and natural gas, is a long-term concern for Algeria. By investing in renewable energy sources, Algeria can reduce the strain on its natural resources, which are finite. Renewables, particularly solar and wind, are inexhaustible and can help ensure long-term sustainability for the energy sector.
- **Biodiversity and Ecosystem Protection**: Moving away from fossil fuel extraction and burning can help prevent further degradation of Algeria's natural landscapes and ecosystems. Fossil fuel activities, such as drilling and mining, often lead to habitat destruction, pollution, and loss of biodiversity. By focusing on cleaner energy sources, Algeria can protect its ecosystems and promote more sustainable land and resource management practices.
- **Water Conservation**: Unlike fossil fuel power generation, which can be water-intensive (especially for cooling processes in thermal power plants), renewable energy sources such as solar and wind have minimal water requirements. This can be crucial for Algeria, which faces water scarcity in many regions, as it will reduce the strain on the country's already limited water resources.

Institutional and Governance Dimension:
The successful implementation of the energy transition requires strong governance structures, effective policymaking, and institutional capacity to manage the transition.

- **Policy and Regulatory Framework**: For the energy transition to be successful, the Algerian government must adopt clear, long-term policies that prioritize renewable energy development, energy efficiency, and sustainability. This includes implementing legal frameworks that encourage private investment, ensuring market stability, and reducing barriers to entry for renewable energy companies.
- **Governance and Institutional Capacity**: Effective governance is essential for managing the energy transition. This includes strengthening the institutional capacity of government agencies involved in energy planning, regulation, and oversight. Collaboration between various stakeholders, including local authorities, private companies, and civil society, will also be crucial to ensure the success of the transition.
- **Innovation and Research**: The energy transition will drive innovation in technology, business models, and policy frameworks. Algeria has the opportunity to become a leader in renewable energy innovation in Africa, particularly in the field of solar and wind technologies. Investing in research and development (R&D) in renewable energy technologies, energy storage, and smart grid systems can position Algeria at the forefront of
- clean energy solutions.(Guecherou ,2024,P109)

3.3- Algeria's Strategy to Shift Towards Green Energy Under the Umbrella of the Green Economy:
Algeria is increasingly aligning its energy and economic policies with the principles of the **green economy**, which emphasizes sustainable development, environmental protection, and social equity. As part of this shift, Algeria is focusing on transitioning to **green energy**—primarily renewable energy sources like solar, wind, and hydropower—while reducing its reliance on fossil fuels. This strategy is driven by the need to address climate change, enhance energy security, and promote economic diversification.

Challenges to the Green Energy Transition

Dependence on Fossil Fuels:
Heavy reliance on oil and gas revenues makes the economy vulnerable to global market fluctuations.
Policy and Regulatory Barriers:
Inconsistent policies and bureaucratic hurdles hinder the growth of renewable energy projects.
Financing Constraints:
High upfront costs for renewable energy infrastructure and limited access to financing.

Technological Gaps:
Limited local expertise and reliance on imported technologies.

Grid Infrastructure:
The existing grid may not be equipped to handle large-scale renewable energy integration. (*BENAZZA,2023,P54).*

5. CONCLUSION:
Algeria's journey toward energy transition and sustainable development is both a necessity and an opportunity. As a country rich in fossil fuels, Algeria has long relied on oil and gas as the backbone of its economy. However, the global shift toward renewable energy, coupled with the urgent need to address climate change and promote sustainable development, has prompted Algeria to embark on a transformative path. Below is a general conclusion summarizing the

results of Algeria's efforts so far and providing recommendations for the future.

Algeria is described as a "giant" due to its renewable energy potential. Thanks to the investments made and those underway in the field of renewable energy, Algeria is heading towards achieving a production of about 4 gigawatts by early 2025, according to estimates by the Renewable Energy and Energy Efficiency Authority. Algeria has developed an energy transition strategy from fossil energy to new and renewable energy with the aim of achieving a production of 15 gigawatts by 2035 thanks to renewable energy facilities, noting that Algeria's production park for renewable energy exceeds 600 megawatts. According to the approach of the Ministry of Energy and Mines, Algeria's energy policy is based on diversifying the sources of energy used, increasing the efficiency of its consumption and rationalizing it, and preserving resources by achieving at least 30 percent of renewable energy in its energy mix by 2035, within the framework of translating the national renewable energy program with a capacity of 15,000 megawatts.

Renewable energy in Algeria is a vital element in combating climate change and environmental pollution. It contributes to: Reducing greenhouse gas emissions: The use of renewable energy reduces carbon dioxide emissions and other harmful gases. Enhancing energy security: Reducing dependence on fossil fuels, as Algeria is one of the countries seeking a real and rapid energy transition that guarantees diversification of energy sources, achieving sustainable development and preserving the environment.

Results of Algeria's Energy Transition Efforts:

1. **Progress in Renewable Energy:**
   - Algeria has made significant strides in developing its renewable energy sector, particularly in solar energy, with projects like the Hassi R'Mel Solar Power Plant and plans for large-scale solar farms in the Sahara Desert.
   - The country has set ambitious targets, including 22 GW of renewable energy capacity by 2030, with solar energy accounting for the majority.

2. **Policy Framework:**
   - The Energy Transition Law (2015) and the National Renewable Energy and Energy Efficiency Program provide a solid foundation for promoting renewable energy and energy efficiency.
   - Algeria has committed to reducing greenhouse gas emissions by 7% by 2030 (unconditional) and up to 22% (conditional on international support) under the Paris Agreement.

3. **Economic Diversification:**
   - The renewable energy sector is creating new job opportunities and attracting investment, helping to reduce Algeria's dependence on hydrocarbon revenues.
   - Initiatives to improve energy efficiency in industries, buildings, and transportation are contributing to economic diversification.

4. **Environmental Benefits:**
   - The transition to renewable energy is reducing greenhouse gas emissions and air pollution, contributing to global climate goals and improving public health.
   - Renewable energy projects are being implemented with a focus on minimizing environmental impact and protecting ecosystems.

5. **Social Equity:**
   - Renewable energy is improving energy access for remote and rural communities, reducing energy poverty, and enhancing quality of life.
   - Community engagement in renewable energy projects is ensuring that local populations benefit from job creation and economic opportunities.

Recommendations:

To build on the progress made and address the challenges ahead, Algeria should consider the following recommendations:

1. **Strengthen Policy and Regulatory Frameworks**

- Implement Clear and Consistent Policies: Ensure that renewable energy policies are stable, transparent, and aligned with long-term sustainability goals.
- Streamline Regulatory Processes: Simplify permitting and approval processes for renewable energy projects to accelerate deployment.

2. **Increase Investment in Renewable Energy**

- Attract Private Sector Investment: Provide financial incentives, such as subsidies, tax credits, and low-interest loans, to encourage private sector participation in renewable energy projects.

- Leverage International Funding: Seek funding and technical assistance from international organizations, such as the World Bank and International Renewable Energy Agency (IRENA).

3. Enhance Grid Infrastructure and Energy Storage

- Upgrade the National Grid: Invest in modernizing and expanding the grid to accommodate large-scale renewable energy integration.
- Develop Energy Storage Solutions: Invest in advanced battery storage and other energy storage technologies to manage the intermittency of renewable energy sources.

4. Build Local Capacity and Expertise

- Develop Training Programs: Establish training programs for engineers, technicians, and policymakers to build local expertise in renewable energy technologies and project management.
- Promote Research and Innovation: Invest in research and development to advance renewable energy technologies and improve efficiency.
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5. Foster International and Regional Cooperation

- Collaborate with Neighboring Countries: Participate in regional energy initiatives, such as the Desertec Project, to develop cross-border renewable energy projects.
- Share Knowledge and Technology: Partner with international organizations and foreign investors to access advanced technologies and best practices.

6. Promote Public Awareness and Engagement

- Launch Awareness Campaigns: Educate citizens and businesses about the benefits of renewable energy and energy efficiency through workshops, media campaigns, and demonstration projects.
- Engage Local Communities: Involve local communities in renewable energy projects to ensure they benefit from job creation and economic opportunities.

7. Focus on Sustainability and Environmental Protection

- Conduct Environmental Impact Assessments: Ensure that renewable energy projects are implemented in an environmentally responsible manner, with minimal impact on local ecosystems.
- Promote Sustainable Practices: Encourage the use of sustainable practices in renewable energy projects, such as recycling solar panels and minimizing land use.

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