

The impact of natural resources on environmental development in Algeria

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Abstract:

This study aims to shed light on the available opportunities and challenges facing Algeria towards moving forward in adopting natural resources as a main source of renewable energies in the first place and its impact on environmental development in Algeria in order to achieve sustainable development in light of the current situation that calls for the necessity of finding ways to get out of oil dependency and achieve economic diversification. The study concluded that although Algeria possesses enormous natural resources that enhance renewable energies, especially solar energy, its experience in this field is still in its infancy, and that the success of the program to develop these energies in the future depends on finding the appropriate financial structure through openness to the private and foreign sectors. Focusing on the human and technological factor to achieve comprehensive and sustainable development.

Keywords: Natural resources; Renewable energies; Sustainable development; Solar energy; Hydropower; Environmental development.

Jel Classification Codes : Q2, Q3, Q4

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1. INTRODUCTION

The trend towards exploiting renewable energies has recently become the focus of attention of many economic policies in countries of the world as a top priority alternative, in order to ensure the achievement of energy security, especially for countries that possess significant resources of these energies, such as solar energy, wind energy, hydroelectric energy, and others. Recently, interest in the environment and development in general and energy in particular has increased, and it has become certain that traditional energy sources, or what are known as fossil fuels, are vulnerable to depletion sooner or later, as they are non-renewable sources, not to mention the excessive exploitation of these energy sources, in order to secure the growing demand. On the energy level at the global level, which caused the depletion of these sources, which led to the emergence of environmental problems and which accelerated the search for energy other than the mechanical energy of depletion, which led to theories and studies heading towards energy that is not depleted, renewable, and does not pollute the environment on the one hand, and to achieve The use of traditional sources on the other hand, and therefore renewable energies today have become an essential means for achieving sustainable development, at a time when many problems are increasing in severity, as well as environmental pressures that have affected the absorptive capacity and environmental balance in general, in addition to many The negative factors that led to the spread of epidemics and the destruction of nature, among others, are why resorting to these energies has become necessary in accordance with the achievement of development goals for sustainable development, given that

development has an integrated relationship with renewable energies to achieve this. (Abbasi, 2021)

Algeria is one of the countries that have been interested in renewable energy, especially solar energy and wind energy. Algeria took the initiative to experiment in investing in renewable energy as an alternative energy to depleted fossil energy in order to achieve sustainable development and the right of future generations to natural resources, which puts it in front of Betting on how to make effective use of renewable energy sources in Algeria. All of this lead us to ask the following question:

What role do renewable energies play in achieving sustainable development in Algeria?

2.The theoretical framework for renewable energies and sustainable development

2.1 What are renewable energies?

Renewable energy means all energy whose source is solar, geophysical or biological, and which is renewed in nature, such as biomass energy, solar energy, underground energy, water movement, tidal energy in the oceans, and wind energy. There are also many mechanisms that allow the conversion of this energy sources are transformed into primary energy, such as heat and electrical energy, into kinetic energy using advanced technology that allows the provision of energy services from fuel and electricity. (Hafezi, 2021). This means that renewable energy is an energy resource that is automatically renewed in nature at a rate equal to or greater than the rate of its consumption. The most important reasons that led to the development of renewable energy are: (Santosh, 2024)

- Increasing concern about the depletion of oil or the exhaustion of its reserves due to its use at a faster pace
- Eliminating the burden of the significant rise in oil prices, as well as the turmoil in their prices and the resulting negative economic, social and security impacts.
- Getting rid of the environmental problems resulting from the extraction and burning of fossil fuels to generate energy, such as environmental pollution, the rise in Earth's temperature, and the extinction of many animals.)

2.2 The most important sources of renewable energy

There are many sources of renewable energy that can be used in energy supplies, which include:

2.2.1. Solar energy

Solar energy is the main source of energy on Earth, and it is the source of light and heat necessary for life. The sun contains energy amounting to 665 million tons of hydrogen, of which 660 million tons are converted into helium energy, and the remaining difference of 5 million tons is converted into energy every day. (Haldorai, 2022).

2.2.2. Wind energy

It is the energy derived from the movement of air and wind. Man has known it since ancient times and used it to travel by sailing ships and for various industrial and agricultural purposes. Today, this type of energy is linked to its use in generating electricity through windmills and generating stations established in a specific place and the needy areas are connected via electrical wires, as the use of wind energy began at the beginning of the twentieth century because of the high prices of non-renewable energy. (Herzog, 2001)

2.2.3. Hydropower

Hydropower is considered one of the most important sources of renewable energy as it is used in most countries, and constitutes about 20% of the total global production of electrical energy, by converting the kinetic energy of running or falling water, i.e. large mechanical energy capable of rotating turbines and generators that rotate at a rate of 1500 revolutions per minute and produce this is electrical energy with an efficiency of up to 90% . (Killingtveit, 2019)

2.2.4. Biomass energy

Biomass has been, historically, the main source of global energy, primarily for cooking, heating, and small cottage industries. It is witnessing a strong revival and is currently used in a multitude of applications. It provides between 10 and 14% of world energy, with the potential to provide 30–40 + % and is an integral component of all energy scenarios. Biomass energy is providing multiple energy, environmental, and socio-economic benefits, both modern and traditional, ranging from electricity, heat, to transportation fuels. (Rosillo-Calle, 2016)

2.2.5. Hydrogen energy

It represents an important type of fuel, and it is likely to play a major role in providing energy in the future. (Le, 2024)

✓ Nuclear fusion:

Current nuclear reactors operate and depend on uranium as their primary fuel, and nuclear energy is derived from nuclear fission, so it is considered depleted energy, because its reserve base is a depleted resource that will run out eventually. (Sadik-Zada, 2024)

2.3. Reasons for moving towards renewable energies

There are many reasons that push for a move towards renewable and sustainable energies, including:

2.3.1. Environmental imbalance

The massive and irrational use of fossil energy and its burning causes the emission of large quantities of greenhouse gases, which has led to the emergence of the phenomenon of global warming that threatens the world with serious environmental disasters and climate changes that may affect the Earth negatively in a significant way. (Shan, 2021)

2.3.2. Depletion of traditional energy sources

The depletion of fossil energy sources is considered one of the most important factors that led to the search for other sources of energy, as it was noted that the discovery of oil fields tends to follow a downward sloping curve, and this is because the amount of oil underground is limited in any area. (Wang, 2024)

2.3.3. Instability of global energy markets

Financial forecasts for global energy consumption show the continued rise of this demand, which depends largely on meeting traditional energy sources, especially oil and natural gas. (Kreps, 2020)

2.4. The concept of sustainable development and its dimensions

2.4.1. What is sustainable development?

Sustainable development is a comprehensive concept to meet the needs of people at the present time and improve their living conditions without compromising the ability of future generations to achieve their goals through economic development, social development and environmental protection. (Ruggerio, 2021)

2.4.2. Dimensions of sustainable development

In order for the theoretical study of the concept of sustainable development to be complete, it is necessary to study all its dimensions, which are: (Martín-Blanco, 2022)

- ✓ The economic dimension: It is the principle that requires increasing the welfare of society to the maximum extent and eliminating poverty through optimal exploitation of natural resources.
- ✓ The administrative and technical dimension: It expresses the dimension that concerns the transition to cleaner technology. Society must move to an era that uses standards that limit the flow of waste and work with and support natural systems.
- ✓ The environmental dimension: Sustainable development, with its emphasis on the principle of human needs, raises the issue of industrial sufficiency, that is, the needs that the economic system is responsible for meeting, but nature must be taken into account when starting industrialization, and the goal behind all of this is the better management and employment of natural capital and working to prevent Extravagance.
- ✓ The social and political dimension: Sustainable development is characterized in particular by this third dimension, so the human dimension makes growth a means of social cohesion and the process of development in the political choice, and this choice must be a choice of fairness between generations as much as it is between countries.

2.4.3. Characteristics and goals of sustainable development

2.4.3.1. Characteristics of sustainable development

Sustainable development is characterized by several characteristics, including:

Continuity: This requires generating high income, part of which can be reinvested, enabling replacement, identification and formulation of resources

Regulating the use of natural resources: non-renewable resources, whether exhaustible, depleted or renewable, in a way that ensures the interest of future generations

Achieving environmental balance: It is the criterion for sustainable development and means preserving the environment.

Sustainable development relies on environmental foundations and considerations: since its goal is to transfer natural capital to subsequent generations and give a new social image of nature.

Stimulating general popular participation: coordinating different visions of creativity and working towards achieving common goals for the future and supporting an integrated methodology for communication.

Education: Learning from others and transferring best applications and practices to improve the environment

2.4.3.2. Sustainable development goals

Sustainable development aims to achieve: (Mio, 2020)

- ☐ Increasing raw national income
- ☐ Raising the standard of living
- ☐ Achieving rational exploitation of resources
- ☐ Enhancing the population's awareness of existing environmental problems
- ☐ Creating continuous and appropriate change in the needs and priorities of society in a way that suits its capabilities

3. Future prospects for the development program for investment in renewable energies in Algeria

3.1 Solar energy

Solar energy represents the most effective alternative due to its importance as it is enormous energy that can be exploited anywhere and constitutes a free, inexhaustible source of fuel. It is considered clean energy, does not produce any type of environmental pollution and can be used in many fields of agricultural activity, heating and cooling. Water, water desalination, sewage treatment, and electricity generation as well.

Solar energy in Algeria has witnessed development over the past years, as it is expected that this industry will continue to grow at relatively high rates in the future. It is also expected that solar energy will contribute to the generation of total electricity. However, the most important obstacles standing in the way of achieving these expectations are the high costs of its exploitation, which exceed the costs of generation. Electricity is another technology. (Ben Lakhdar, 2020)

Table 1. Costs of generating electricity from various energy sources during the year 2030

Electrical power source	Photovoltaic cells	Natural gas	Coal
Electricity generation costs (\$/MWh)	70-325 dollars / MWh	35-45 dollars/MWh	40-45 dollars /MWh

Source: Ben Lakhdar, I., & Iftikhar, Y. (2020). *The reality of renewable energy in Algeria and its prospects*, p. 230.

The table displays the costs of generating electricity from various energy sources during the year 2030, where we note:

Photovoltaic cells: The varying costs of generating electricity using photovoltaic cells appear, with the range ranging from \$70 to \$325/MWh. The difference in cost can be due to factors such as the efficiency of the photovoltaic cells and the location of the project.

Natural gas: The cost of generating electricity using natural gas appears to be the cheapest among all the energy sources mentioned in the table, as the cost ranges between \$35 and \$45/MWh.

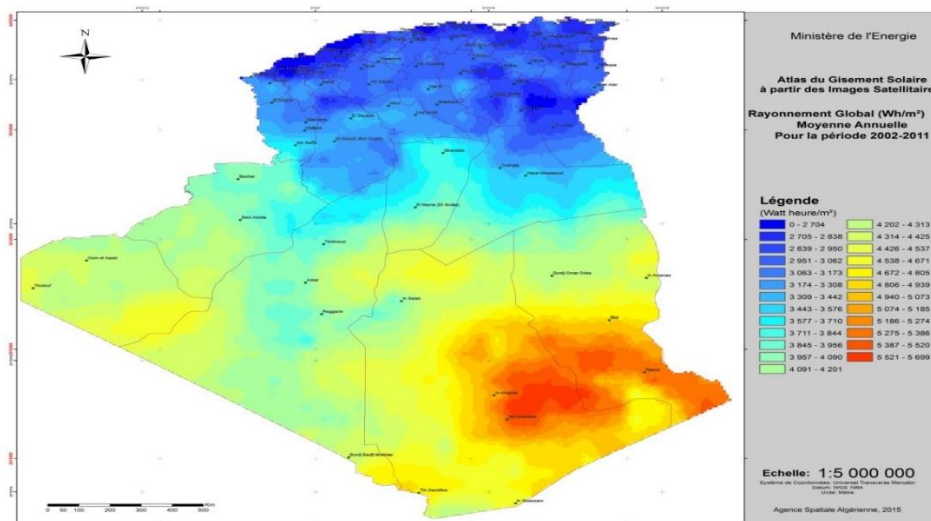
Coal: The cost of generating electricity using coal ranges between \$40 and \$45/MWh, which is slightly less than the cost of generating electricity using natural gas.

3.1.1. Solar potential

Based on experts' warnings of the depletion of Algerian oil reserves within 50 years, the government sought to find alternative ways to exploit energy beyond the oil era. It revealed an ambitious plan to produce (10%) of electricity from renewable resources by 2020. (Zahraoui, 2021) It has enormous potential for renewable energies, especially solar energy, due to its vast area on the one hand and its geographical location on the other hand. (Eddine Boukelia, 2013).

It is considered one of the richest solar fields in the world due to the amount of energy received per square meter, estimated at (kilowatts/hour/m) in most parts of the national territory and sometimes reaching (7 kilowatts/hour/m), which allows annual radiation exceeding (3000 kilowatts/hour/m²) over an area estimated at 2,381,745 km². The energy available daily over a transverse area of (1 m²) reaches (5 kilowatts/hour) in most parts of the national territory, i.e. about (1,700 kilowatts/hour/m²) per year in the north of the country and (2,263 kilowatts/hour/m²) in the north of the country. /m²) per year in the south of the country. (Himri, 2022)

Fig1: Map of Average Annual Direct Global Irradiation (Period 2002-2011)



Source: <https://www.energy.gov.dz/?rubrique=energies-nouvelles-renouvelables-et-maitrise-de-lrenergie>. Accessed on 30/09/2024.

Algeria is among the Arab countries which are part of the Sunbelt, and it benefits from high solar insolation intensities. Algeria has one of the highest solar potentials in the world, estimated at 13.9 TWh/year. The average annual sunshine is evaluated at 2650 h/year in the coastal region, 3000 h/year in the high plateau, and 3500 h/year in Sahara. The corresponding average annual direct normal irradiance (DNI) in the above three regions is estimated to be 1700, 1900, and 2650 kWh/m²/year, respectively. (Himri, 2022)

Table2: Solar potential In Algeria

Regions	Country			Unit
	Coast	High Plateaus	Sahara	
Area	4	10	86	%
Average sun duration	2650	3000	3500	hours/year
Average annual energy received	1700	1900	2650	KWh / m ²
Average GHI	2100	2100	2400	KWh / m ² /year

Source: Himri, Y., Rehman, S., Mostafaeipour, A., Himri, S., Mellit, A., Merzouk, M., & Merzouk, N. K. (2022). Overview of the role of energy resources in Algeria's energy transition, p.16.

The Algerian government seeks to expand the use of solar energy in several areas by implementing huge programs and projects to generate solar energy, including solar power plants that use solar concentration technology and large solar power plants that use efficient solar cell panels. It works to encourage the use of solar energy in buildings, industrial and commercial areas, by providing facilities to finance projects and encourage investments in this field.

3.1.1 . Algerian solar energy program

At present, the solar power generation in the country is insignificant but the deployment of CSP plants is due to start in the 2020s in the south, high plateau and coastal regions. These power projects include the following:

- 150 MW parabolic trough CSP plant with gas solar combined cycle installed in 2011 in HassiR'mel.
- A platform with 1.1 MW PV capacity with multi-technology installed in Ghardaïa and in operation since 2014.

Furthermore, about 20 solar PV power plants with capacity of around 225 MW were commissioned in 2016 in the south and high plateau regions.

Referring to the national renewable energy development program 2015–2030, SKTM has recently signed an agreement with a Chinese company for the construction of a 9 PV plant with an installed capacity of 50 MW for the benefit of the regions of the great south, namely, Guezzem (6 MW), Tinzaouatine (3 MW), Djanet (4 MW) and Bordj Omar Dris (3 MW), Bordj Badji Mokhtar (10 MW), Timiaouine (2 MW), Talmine (8 MW), Tabelbala (3 MW), and Tindouf (11 MW). Completion of these projects will allow SKTM to annually save 20,600 tons of gasoline and generate a revenue of USD 14 million annually .

The PV park is situated at the exit of Adra. It is composed of twenty subfields of 1 MW power capacity; each consists of 186 strings (4092 modules YL245P-29P PV). A total of 81,840 polycrystalline silicon PV occupies an area of 0.4 km² and is oriented to the south at an inclination angle of 27°. This park was commissioned in October 2015 and connected to electrical grid through 4 × SG500MX inverters (500 kW) and then to 2 × 0.315/30 kV step-up power transformers (1.25 MVA). The capacity factor depend on weather parameters, particularly solar radiation, temperature, and wind speed, as shown in Table3. (Himri, 2022)

Table3: Weather data and energy data measured and collected from the PV station during one year (January–December 2018).

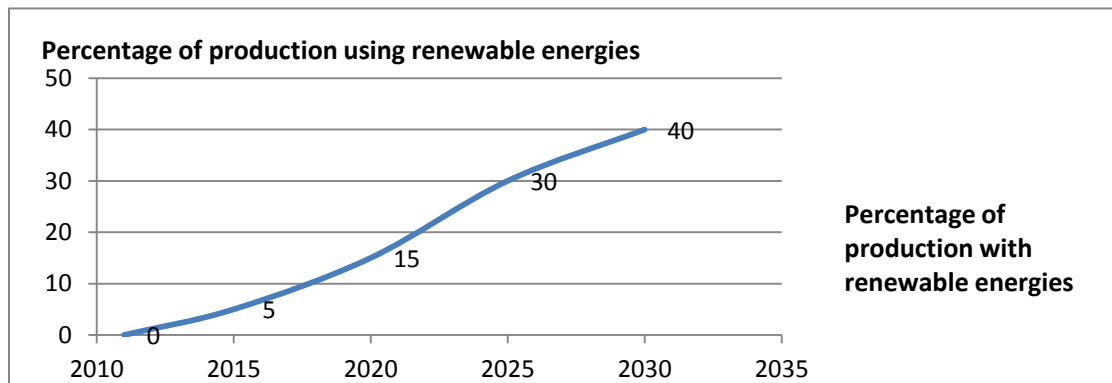
Month	Temperature (°C)	Solar Radiation (kWh/m ²)	Wind Speed (m/s)	Energy Output (MWh)	Performance Ratio (%)	Capacity Factor (%)
January	15.3	172.3	4.6	2813.2	82.4	20.3
February	16	180.5	4.3	2813.2	78.9	21
March	21.6	232.4	4.4	3450.6	74.7	23.2
April	26.2	224.2	5.1	3252.8	73.1	22.7
May	29.5	251.4	4.1	3230.8	64.8	21.8
June	35	243.1	4.8	2945.1	61	20.4
July	40.8	246.4	4.3	2725.3	55.8	18.4
August	33.9	225	4.7	2967	66.2	19.9
September	32.7	194.5	4.6	2813.2	72.5	19.6
October	25.7	181.3	3.6	2736.3	75.8	20.3
November	19.2	185.4	3.7	2945.1	79.7	20.4
December	14	202.8	4.7	3274.7	80.8	22

Source: Himri, Y., Rehman, S., Mostafaiepour, A., Himri, S., Mellit, A., Merzouk, M., & Merzouk, N. K. (2022). Overview of the role of energy resources in Algeria's energy transition, p.18.

The ambitious Algerian solar energy program will allow, within twenty years, the production of electricity from renewable energies with the same quantities of electricity currently produced from natural gas. It is divided into three stages:

- ✓ (2011-2014): A first pilot phase extending over three years related to sponsorship and framing of the program.
- ✓ (2014-2020): The second phase: Improving management in the field of research and development.
- ✓ (2020-2030): The final stage concerns the economic applications of research and the initiation of development projects.

Fig.2. The rate of penetration of renewable energies into the expected national production



Source: The Commission for the Regulation of Electricity and Gas (CREG)2011-2030, 2011, p9

The Algerian Ministry of Energy and Mining expects that about 40% of the electrical energy produced by the project for local consumption will be from renewable energy sources by 2030 (37% solar energy and 3% wind energy).

Recent forecasts in this field highlight the goal of reaching (30%) by the year 2025, which represents the share of renewable energies in the country's energy plan, and in the medium term, that is, on the horizon. 2015 Reaching 5% of the share of renewable energy in the nation's energy plan. (Senouci Ben Alou., 2018)

3.2 Wind energy

Algeria has fields suitable for establishing wind farms to produce electrical energy, especially in the southern regions where the average wind speed exceeds 6 m/s, such as the Adrar, Timimoun and Ain Salah regions.

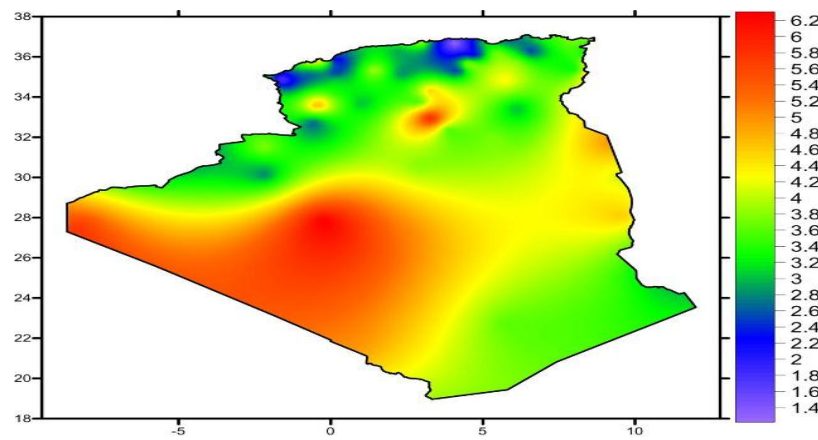
Table4: Areas associated with different wind turbine CF

	Wind Potential (TWh/Year)	
All areas with wind turbine	All areas with wind turbine	All areas with wind turbine
CF greater than 20%	CF greater than 30%	CF greater than 40%
30.155	2535.9	153.4

Source: Himri, Y., Rehman, S., Mostafaeipour, A., Himri, S., Mellit, A., Merzouk, M., & Merzouk, N. K. (2022). Overview of the role of energy resources in Algeria's energy transition, p.21.

The importance of using wind energy lies in its being economical (5 to 6 dinars per kilowatt per year hour), which makes it less compared to solar energy, and it also has simple and uncomplicated technology compared to other energy sources.

Fig.3. Wind farms map in Algeria



Source: <https://www.cder.dz/spip.php?article1446>

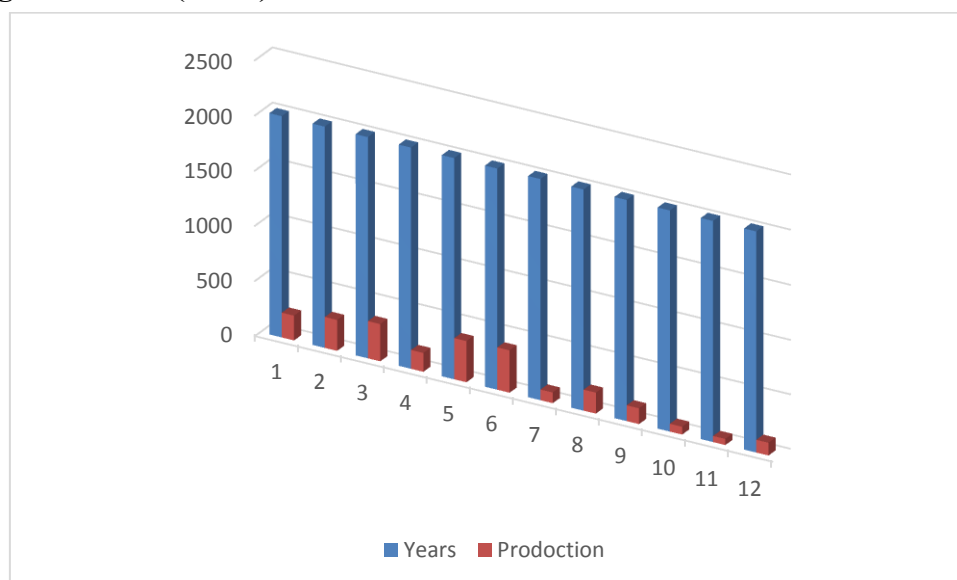
The Algerian government expects wind energy to play an important role in achieving its renewable energy strategy. The government aims to generate 22 000 megawatts of renewable energy, including Wind energy.

In addition it expects wind energy to account for about 10% of the country's total electricity production by 2030.

3.3 Hydropower: Although Algeria possesses enormous water resources, its characterized by the scarcity of surface water.

Fig.3. Hydropower Production in Algeria for the period 2007-2018

Unit: Gigawatt-hour (GWh)



Source : Aidouni, L., Aiouadj, M. (2023). Algeria and the transition to renewable energy: the path to achieving energy security, p. 67.

The overall financial potential in Algeria is estimated at less than 20 billion m3, of which only 75% is renewable, while the non-renewable financial resources are

estimated at 12.4 billion m³, which includes water resources in the northern Sahara. (Aidouni, 2023)

The Algerian government supports the development of hydropower projects, and seeks to increase the proportion of renewable energy in the electrical energy mix. In 2020, Algeria launched a hydropower development plan aiming to generate 4,500 megawatts of hydropower by 2030. Algeria is working to develop the technology of converting water energy into electrical energy using horizontal turbines, which is a technology that allows electricity to be generated more efficiently.

3.4. Geothermal energy (Ministry of Energy and Mining)

La compilation des données géologiques, géochimiques et géophysique a permis d'identifier plus de deux cent (200) sources chaudes qui ont été inventoriées dans la partie Nord du Pays. Un tiers environ (33%) d'entre elles ont des températures supérieures à 45°C. Il existe des sources à hautes températures pouvant atteindre 118°C à Biskra.

Des études sur le gradient thermique ont permis d'identifier trois zones dont le gradient dépasse les 5°C/100m

- Zone de Relizane et Mascara
- Zone de Aïne Boucif et Sidi Aïssa
- Zone de Guelma et Djebel El Onk.

4. CONCLUSION

This analytical study aimed to highlight the importance of moving towards renewable energies in achieving sustainable development goals, and this by projecting the case of Algeria. The study reached the following results:

Algeria has developed long-term policies and programs in the field of renewable energy, in addition to allocating significant sums of money to encourage investment in this field. Some of them have been accomplished on the ground, and some have been prevented by several obstacles.

Algeria has abundant sources of renewable energy, due to its natural and climatic characteristics, especially solar energy. Where it has the largest annual insolation rates in the world, followed by wind energy and other sources in a small way.

Achieving sustainable development requires Algeria to search for permanent sources of energy. This is evident in renewable energy, which guarantees life even for future generations.

The energy transition mechanism in North African countries remains one of the most important priorities and opportunities that cannot be missed to achieve energy security. However, judging its success in undertaking this experience remains hostage to the challenges and exploiting the capabilities in a rational, scientific manner.

The proportions of renewable energy consumption out of total energy consumption in North African countries are modest, compared to the renewable energy potential that these countries harness, and the strategies they have developed.

The success of the Algerian national program for the development of renewable energies for the 2030 horizons is linked to the activation of the parallel program to improve energy efficiency.

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