Algeria's Future Energy Mix: The Challenges to Transit to Renewable Energy

مزيج الطاقة المستقبلي في الجزائر: تحديات التحول نحو الطاقات المتجددة

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Abstract:

This study aims to show the importance of Algeria transformation to renewable energies, taking into account the economic reality of the country, where fossil energies, especially gas, are still of the utmost importance. In our study, we will focus on the optimal and potential energy combination of the Algerian economy.

The results of study show the important place of the "gas" and "renewable energies" elements in a successful energy transformation process in Algeria.

Keyword: Energy; Algeria; Energy transformation; Renewable energies; Gas.
JEL classification code : Q4 , Q3

ملخص:

تهدف هذه الدراسة إلى إظهار أهمية لجوء الجزائر بشكل أكبر إلى الطاقات المتجددة، مع مراعاة الواقع الاقتصادي للبلاد، حيث لا تزال الطاقات الأحفورية، ولاسيما الغاز، ذات أهمية قصوى. سنركز في دراستنا على التوليفة الطاقوية المثلى والممكنة للاقتصاد الجزائري.

توصلت نتائج الدراسة إلى أهمية مكانة عنصري "الغاز" و"الطاقات المتجددة" في إطار أي عملية تحول طاقوي ناجحة في الجزائر.

الكلمـات المفتاحيـة : الكلمـات المفتاحيـة : الطاقـة ؛ التحـول الطـاقوي ؛ الجزائـر، الطاقـات المتجددة ؛ الغاز

تصنيف JEL : Q4 , Q3

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1. Introduction :

Energy is an important factor for every economy. Fossil resources and primary energy (coal, natural gas, oil, and uranium) in Algeria, as elsewhere in the world, are limited and not renewable. The fluctuations in the prices of these energies are an additional element of fragility, which further complicates the economic choices of countries in which the hydrocarbon sector is an important part of the structure of GDP and the formation of export earnings.

The energy transformation in Algeria imposes itself as a necessity for economic reasons linked to the scarcity of fossil energy resources and the problems associated with their exploitation, and environmental reasons mainly related to the international commitments of Algeria. On the other hand, the domestic model of energy consumption and the position of the energy sector in the balance of payments (97% of exports) and within the country's revenues (about 60%) and in the structure of GDP (about 35%) are factors that cannot be overlooked in any economic policy in Algeria.

With regard to traditional fossil energies, Algeria, which is one of the most important producers at the continental level, remains in the face of a dual challenge represented in the difficulty of raising production from gas and oil for several reasons that led to a decrease in investments in the hydrocarbon sector more than fifteen years ago, this is on the one hand and On the other hand, an accelerating rise in domestic energy consumption.

In addition to the aforementioned, the repercussions of Algeria's international commitments in the field of the environment. Here, energy transformation becomes an inevitable option in the long and possibly medium term. This energy transition should be based, inter alia, on the rationalization of energy consumption at the internal level, the rationalization of the exploitation of fossil energy sources

And the gradual use of renewable energies (hydro, wind, solar, biomass and geothermal).

This study will attempt to address the following problematic:

- What place can renewable energies occupy as part of the energy mix in Algeria in the framework of a successful energy transformation?

Through this paper we will try to answer the following sub-questions:

What are the limits of options based on fossil energies in Algeria?

- What are the obstacles that prevent a real start in the field of renewable energies in Algeria?

- Will the decline in traditional hydrocarbon production in Algeria be compensated for by investing in renewable energies?

To answer these questions, the paper was divided into two main sections:

The first section discusses the energy situation in Algeria with all its components, fossil and renewable, in the context of the general directions of energy policies in Algeria, as well as in the context of the challenges of global energy markets.

While the second section will be devoted to analyzing the potential and limits of renewable energies in Algeria. The analysis will be conducted on the basis of the national renewable energy development program, as a national reference in this area, but also in light of alternative opportunities that have not been sufficiently taken into account in this program.

2. The general principles and orientations of energy policies in Algeria:

The energy and oil sector in Algeria plays an important and major role in economic development, and it is considered the driving tool for the rest of the branches of the national economy , And considering the important resources of hydrocarbons and natural resources found in Algeria.Where the fuel represents, on average, about:

- 35% of GDP.
- 97% of export revenues.
- More than 60% of the state's budget revenues.

The sector also contributes to meeting the full national energy needs, as consumption for the year 2017 amounted to 52 million oil equivalent tons (OAPEC, 2018, p. 64)

The various development programs adopted by Algeria led to the preparation of an energy policy framework that defines the role assigned For the energy sector in achieving economic and social development in the country, especially determining the basic options regarding the internal and external use of energy at all levels of the energy chain.

The increasing demand from the national energy needs has led to the necessity of setting a policy that guarantees the national energy supply in the medium and long term on the one hand, and the continuous guarantee of financing needs in order to perpetuate the concept of sustainable development. Within this framework, a national energy strategy for 2040 prospects has been developed, based on (Ministry of Energy, 2014, p. 3):

- Using gas by stimulating the use of LPG and CNG in the transportation sector.
- Appraising the use of energy resources through developing the manufacturing industry, such as petrochemistry, refining, etc.
- Developing the use of renewable energies on a large scale by raising the percentage of electricity generation from renewable sources to 30 %.
- Begin studying the possibility of developing the exploitation of non-conventional fuel resources.
- Relying on the principles of prudence, prevention and environmental protection in the context of sustainable development.
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1.2 Energy capabilities and options in Algeria

The energy sector in Algeria has experienced several fluctuations in recent years in an attempt to adapt to the global energy scene, whether in terms of investment, production, export and domestic consumption. It can be said that the hydrocarbon sector remains the dominant option

among other energy options that Algeria has and can be developed such as renewable energies or nuclear energy.

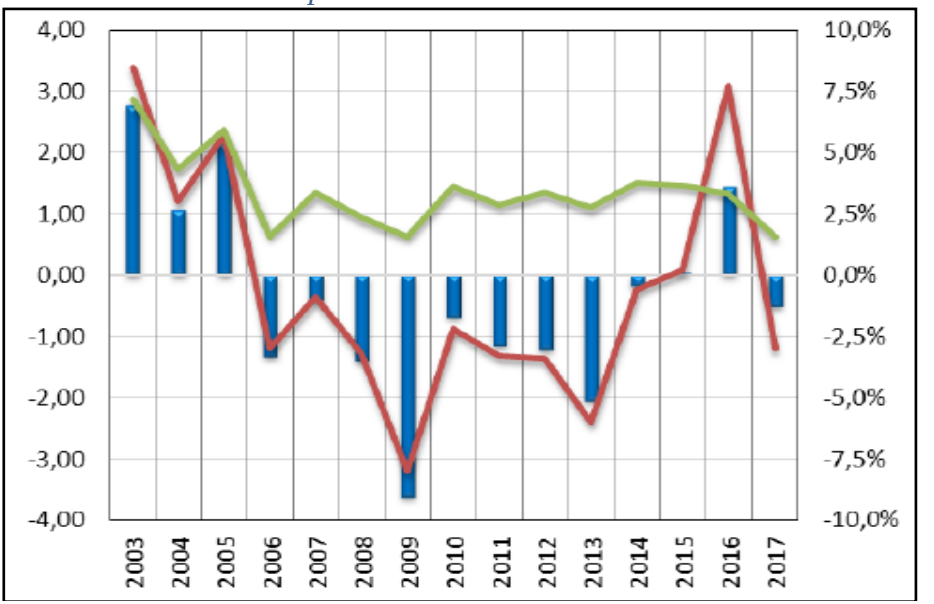
a. The hydrocarbon sector in Algeria between dominance and volatility

Algeria has modest proven reserves of crude oil, which by the end of 2017 amounted to 12.2 billion barrels, which is almost constant and has not changed throughout the period 2013-2018, which represents 0.95 % of the world total. On the other hand, proven reserves of natural gas from traditional sources are of greater importance, although they have not changed also during the period 2013-2018, reaching 4504 billion cubic meters, which represents 2.3 % of the world total (OAPEC, 2018, p. 67)

While the production of commercial primary energy from hydrocarbons in Algeria increased by 2 % in the period between 2000-2013, as it moved from 152 million oil equivalent tons from the year 2000 to reach 156 million oil equivalent tons from the year 2013 and both oil and condensate represented a percentage 43 % of total production, while natural gas recorded 52 % in 2012. However, the situation tended to change during the period 2014-2018, as it was characterized mostly by the trend towards fluctuation and decline; it is an average oil production of 1.2 million barrels per day in 2012 Production decreased to 1.01 million per day in 2018. The Gas production declined in 2017 to 92.3 billion cubic meters, compared of 96.6 billion cubic meters in 2014, to decrease again by -4.5 % in 2018, to 83.3 billion cubic meters, which is a level less than 11 billion cubic meters before 5 years (OAPEC, 2018, p. 68)

The following figure summarizes the developments witnessed in the hydrocarbon sector during the period 2003-2017, which show negative real growth rates during the period 2006-2015, except for the year 2016, which witnessed an increase in production, to decline again in 2017, with a negative growth in added value reached -3% on average during the period 2006-2014. Combined with a negative contribution to the overall growth of -32.4%.

Fig. 1: *The growth of the hydrocarbon sector in Algeria during the period 2003-2017*



Source: (Bank of Algeria, 2017, p. 20)

And in terms of production capacities, the capacities of refineries in Algeria increased from 583 thousand barrels per day in 2013 to 657 thousand barrels per day in 2016, with these capabilities being stable on 2017.

As for the production of energy derivatives, they are distributed as follows (OAPEC, 2017, p. 61):

- Petroleum products (which include various fuels, such as fuel for cars and airplanes): Production increased in 2016 to about 612.1 million barrels, an increase of 8 % compared to 2013, when 488.5 million barrels were registered. However, production decreased in 2017 to 597.9 million barrels.
- liquefied natural gas (liquefied): production decreased from 26.5 million tons in 2000 to 14.3 million oil equivalent tons in 2012 due to the failure of Skikda unit and the decrease in demand due to the economic crisis, especially in the Europe region.

- liquefied petroleum gas (LPG): Refineries' production of LPG decreased from 1.5 million oil equivalent tons in 2000 to 0.9 million oil equivalent tons in 2012, an average of 4 % / year. However, production increased during the period 2013-2016 from 16.4 million barrels to 24.4 million oil equivalent tons, and decreased again to the level of 23.7 million oil equivalent tons in 2017.

b. Energy production potential outside the hydrocarbon sector in Algeria

The other energy sources include,coal production, hydroelectric power, nuclear energy, wind power, solar energy, and thermal energy, remains very marginal in the case of Algeria, it opens up broad prospects for the development of many sources, especially solar and wind energy. As the total production of electric energy from various renewable sources in 2016 reached about 536 MW, which represents 4.18% of the total energy production in Algeria.

Energy production is distributed outside of hydrocarbons in Algeria as follows (Ministry of Energy, 2014, pp. 7-8):

- The production of Electricity from solar and wind energy increased by 21 % / year to 157,000 oil equivalent tons from 2012, with the receipt of the hybrid terminal of Hassi EL-Rm l.
- The total electric power generated by solar and wind sources in Algeria in 2017 was 344 and 10 MW, respectively.
- Hydroelectric Energy: The production of electrical energy from hydraulic sources remains marginal in Algeria, as it did not exceed 100 barrels of oil equivalent per day in 2017, and it represents an electric generating capacity of 228 megawatts during the same year. It is lower than the production recorded in 2013, which amounts to 400 barrels of oil equivalent per day. It should be noted that the production of hydroelectric energy is directly related to rainfall, and reflects the effects of the drought that characterized Algeria in recent years, as this type of electricity in 1985 represented about 6%, but today it represents only less than 1%.

- With regard to the use of nuclear energy, which will contribute to strengthening the provision of electricity at the national level, it remains very limited to the challenges and difficulties it faces, especially the technological dependency with regard to reprocessing radioactive materials, as well as providing enriched fuel. Where the capabilities of generating electricity from nuclear energy have not exceeded 150 MW in 2017.

1.2. The energy consumption mix in Algeria

In terms of consumption, the national consumption of energy in 2012 was about 36.4 million oil equivalent tons, after the year 2000 was estimated at 18.3 million oil equivalent tons. The final energy consumption increased by 8.6 % / year during the period 2013-2017, meaning that it increased from 37 million tons in 2013 to more than 41.87 million oil equivalent tons in 2017 (OAPEC, 2019, p. 94)

The consumption of electricity, petroleum derivatives and natural gas also witnessed a continuous acceleration in consumption due to the improvement in the living conditions of the citizen through (Ministry of Energy, 2014, p. 11):

- Electrification of most of the country's regions, which necessitated the development of electricity production methods by accomplishing more than 7,000 MW from 2000 to 2017.

- Increase the number of cars.

The development of national consumption is distributed for the various major sectors as follows (Ministry of Energy, 2014, p. 15):

- The consumption of the sectors of industry, construction and public works increased by 5 percent / year, as it moved from 4.5 million oil equivalent tons in 2000 to 7.9 million oil equivalent tons in 2017.

The consumption of the domestic and services sectors increased by 4 %/ year, as it increased from 9.2 million oil equivalent tons in 2000 to 15.0 million oil equivalent tons in 2017.

- A significant increase in the consumption of the transport sector, where it recorded a growth rate of 9.2 %/ year to reach 13.4 million oil equivalent tons in 2012, after it was not more than 4.7 million oil equivalent tons in 2000.

This development was reflected in the rise in the final national consumption per capita, as it was estimated at 1.35 oil equivalent tons in 2017 compared to 1.0 oil equivalent tons in 2000.

The national energy consumption structure is composed of the following three components:

- Energy consumption of industrial units.
- Non-energy consumption (petrochemicals, fertilizers, asphalt, and oils).
- Final consumption, which covers the final needs of the industry, transportation and home consumption sectors.
- Lost quantities.

The rise in national energy consumption is due to the development of energy industries on the one hand (especially LNG and power stations), and the rapid development of final consumption on the other hand.

National consumption is distributed in parallel with the national energy policy options used, which are based on the most abundant materials in the balance of fossil resources, especially gaseous ones. The share of natural gas increased to 35 % compared to petroleum products that did not exceed 30 % followed by electricity by 28 % in 2017.

In this framework, according to energy sources, the mix of national energy consumption is distributed as follows (OAPEC, 2019, p. 30):

-Oil consumption decreased from 416.2 thousand bpd (barel per day) in 2013 to 412.2 thousand bpd in 2017, which constitutes a decrease of -0.96 %.

-Natural gas consumption increased by 23.3 %, from 595.2 thousand bpd d in 2013 to 734 thousand bpd in 2017.

- The consumption of oil derivatives decreased during the period 2013-2017 by -1.4 %, to reach 381.1 thousand bpd in 2017, compared to 386.7 thousand bpd in 2013.

3. The potential role of renewable energies in the future energy mix of Algeria

Recent years have witnessed the growing interest in Algeria in the importance of heading towards diversification of energy sources, as studies issued in this regard have proven that Algeria has abundant sources of renewable energy, especially solar and wind energy, and therefore the trends towards the necessity of the option to work on exploiting the available renewable energy sources.

3.1 Renewable energy sources in Algeria

The renewable energy resources in Algeria consist mainly of hydro, solar, wind and ground energy.

Due to its distinguished geographical location, Algeria possesses one of the most important solar capabilities in the world, as the duration of solar sunshine exceeds 2000 hours annually on the entire national territory, and reaches 3900 hours in the high plateaux and the desert. The average daily energy obtained on a horizontal area is 5 kWh per 1 sq.m equivalent to 1700 kWh / sq.m per year in the north, and 2263 kWh / sq.m per year in the south (Ministry of Energy, 2014, pp. 16-18).

Regarding the potential of wind power generation, Algeria is divided into two distinct large geographic regions, North and South.

The north, which is bordered by the Mediterranean Sea, is characterized by a coast that extends over 1200 km, and mountainous terrain such as the hill atlas and desert atlases, where the plains and high plateaux with a continental climate are distinguished between them, characterized by a rate of wind speeds not very high, but we find quarterly climates on the coastal sites of Oran and Annaba And the high plateaux of Tiaret, as well as the areas bordered by Bejaia in the north and Biskra in the south.

As for the south, it is characterized by a faster wind speed than the north, especially the southwest, as it exceeds 4 m / s and reaches 6 m / s in Adrar.

With regard to hydropower, the share of electricity production from hydropower in the national park is 1%,about 286 megawatts, and this weak capacity is due to the insufficient number of dams on the one hand, and the lack of utilization of available resources.

These facilities are concentrated in the northern regions, and are distributed over: Derghina, Igil Amda, Mansouria, Irgan, Souk Eljamaa, Tizi Madan, Ghrib, gouraya, Bouhnifia, Oued elfadha, Bani BaHddal, Tasala.

Algeria also has important potentials for thermal power generation, as the bell-shaped limestone in the north constitutes an important reserve of groundwater heat, resulting in more than 200 hot springs of mineral water distributed mainly in the northeast and northwest of the country. Mostly, these sources have a temperature of 40 degrees Celsius, and a maximum of a source of disgusted bath, with a temperature of 90 degrees Celsius.

These natural springs are leaks of hot internal tanks with a natural self-flow of 2 cubic meters per second, and they represent only a small part of the production capabilities of these tanks. Most of these reservoirs extend to the south, as the continent-forming formation comprises a vast reservoir of geothermal heat, extending to thousands of square kilometers. This reservoir, called the alpine, is exploited by drilling to produce a flow of up to 4 cubic meters per second. The temperature of this layer reaches 57 degrees Celsius. Exploiting the alpine and natural source flow represents a capacity of 700 MW.

With regard to bioenergy generation, Algeria's important resources are divided into two sources (Ministry of Energy, 2014, p. 26).

-Forest capabilities: Algeria is divided into two regions:

The forested forest area occupies an area of about 25 million hectares, just over 10% of the total area of the country. The desert region, which covers more than 90% of the country.

In the north, which represents 10% of the country’s area, forests cover 1.8 million hectares, while forest gradient formations in the mountains represent 1.9 million hectares. Both marine pine and chaletos are important plants for energy use, but currently consists only 5% From the Algerian forests.

-Animal waste: The valuation of organic waste, especially animal waste, to produce biogas, which can be considered an economic and ecological solution that will achieve sustainable development in rural areas in the medium term.

3.2 The National Renewable Energy Development Program

Algeria developed an ambitious program to develop renewable energies and energy efficiency. The Algerian government's vision is based on a strategy that revolves around the valuation of endless natural resources such as solar and wind resources in order to use them to diversify energy sources.

The National Renewable Energy Development Program aims to produce 22,000 megawatts by 2030, of which 10,000 megawatts are destined for export, if the appropriate conditions are met.

This program will be accomplished through three phases, (Ministry of Energy, 2014, p. 27):

-The first stage: between 2011 and 2013, and is devoted to the implementation of pilot projects to test the various technologies available.

-The second stage: between 2014 and 2015, the start of the program.

-The third stage: between 2016 and 2030, will be specific to the achievement of the large-scale solar stations.

From now until 2030, the program includes the completion of sixty (60) projects, including photovoltaic and solar thermal stations, wind farms and mixed stations. This program allows the creation of thousands of direct and indirect jobs.

With regard to solar energy projects, installed capacity is distributed according to the technology used, as follows (Ministry of Energy, 2014, p. 28):

- Solar PV systems, with a total installed capacity of 2,800 MW.

-Concentrated solar systems: a total electrical capacity of 7200 MW will be installed.

As for the wind energy, a total electrical capacity of 2000 MW will be installed.

Regarding the investment projects listed in the first phase of the National Renewable Energy Program 2011-2013, several important projects were initiated, including (Ministry of Energy, 2014, p. 28):

-Factory for the production of solar panels, with a production capacity of 140 megawatts annually.

- 1.1 MW solar PV station in Ghardaia.

-Providing 16 villages with 2554 homes in the south and the high plateaux, with solar PV.

- 5 solar photovoltaic stations with a total capacity of 19 MW in Elizi, Tindouf and Tamanrasset,

- 2 wind farms, 10 MW in Adrar and 20 MW in Khenchela and Elbeyad.

- Underground thermal station with a production capacity of 5 megawatts.

- The completion of a group of solar PV projects with a capacity of 343 MW, which fall within the framework of the 2014 emergency plan to meet the growing demand for electricity, bringing the total installed capacity of 3,200 MW of solar PV systems.

4. Study Methodology :

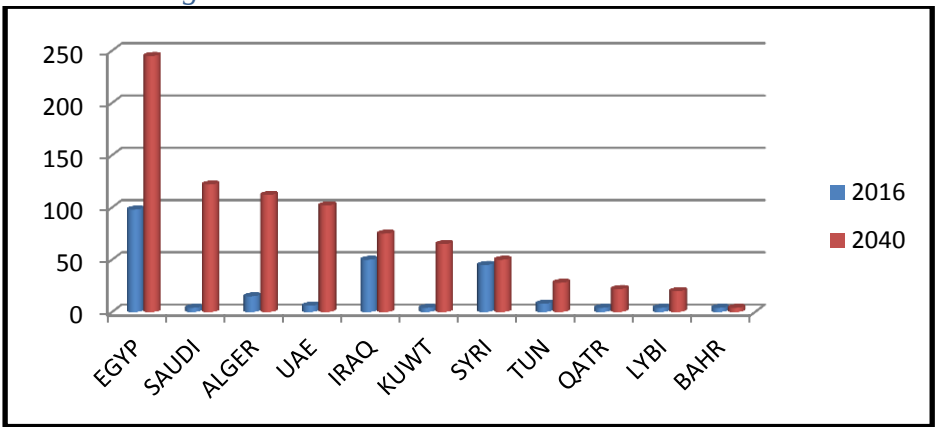
The research is based on the descriptive analytical approach, with the application of various statistical methods that allow describing, analyzing and process data.

With regard to data sources, the study relied on periodic statistical reports issued by the Organization of Arab Petroleum Exporting Countries (OAPEC) as well as various reports of the Algerian Ministry of Energy.

5. Study Results : The outlook of Algeria's renewable energy consumption 2040

In the most recent outlook studies on the development of the energy consumption in the Arab Petroleum Exporting Countries (OAPEC), it is expected that Algeria's total consumption of renewable energies will reach 114 thousand barrels of oil equivalent per day, compared to the level recorded in 2016 which recorded 11.7 thousand barrels of oil equivalent per day. This represents an increase estimated at 102 thousand barrels of oil equivalent per day, at an average annual growth rate of 9.9 % during the period 2016-2040.

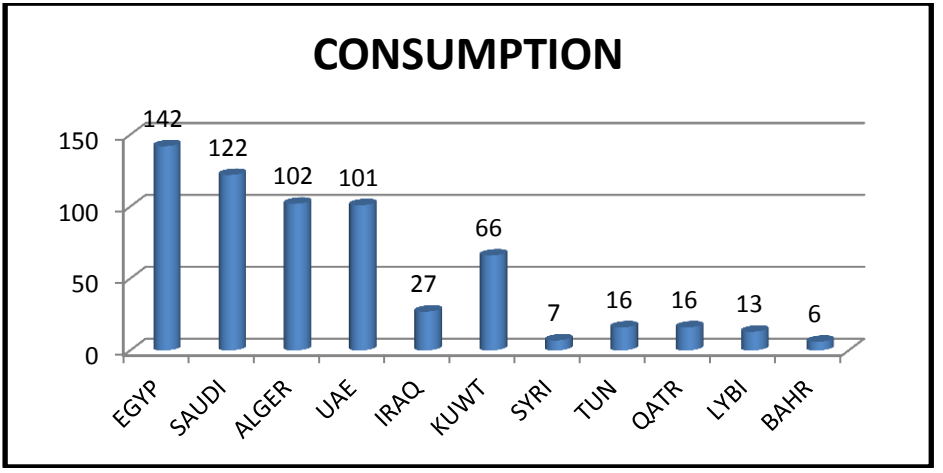
Fig.2: *Future projections for the consumption of renewable energy in Algeria and some Arab countries 2016-2040*



Source: (OAPEC, 2018, p. 102).

Algeria is expected to contribute 16.5 percent of the total renewable energy consumption in the group of Arab countries.

Fig.3: *Consumption of renewable energy consumption in Algeria and some Arab countries 2016-2040*



Source: (OAPEC, 2018, p. 102)

In Spite of the ambitious future directions of raising the contribution of renewable energies to the national energy mix, but the target percentage remains modest (10 % of the total electricity produced in 2030).

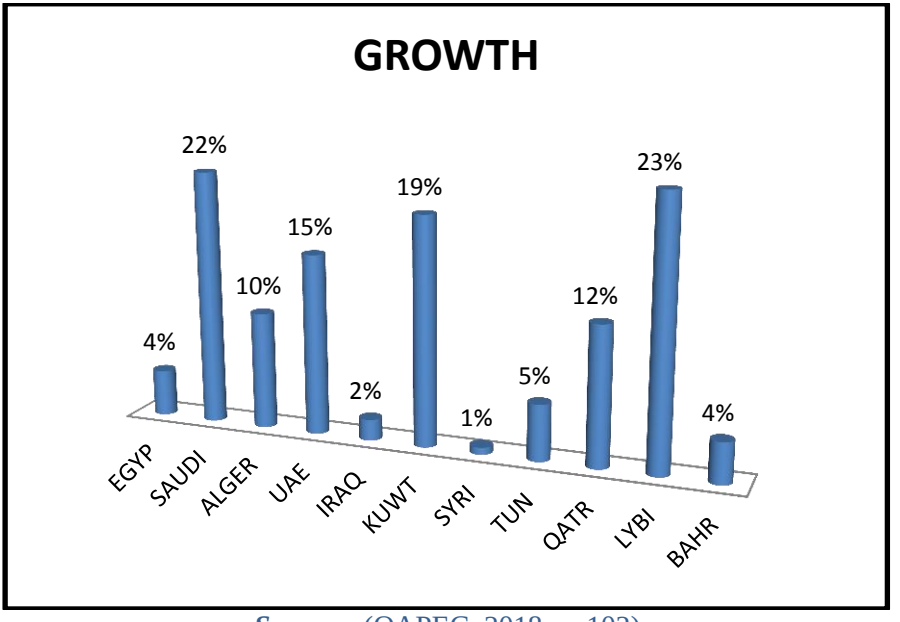
This keeps Algeria's consumption of primary energy significant in the short and medium term. However, in view of the international environmental commitments, the energy sector in Algeria should attach great importance to environmental issues, which led to the adoption of a strategy to promote sustainable development through the following programs:

-Promotion and development of clean fuels such as natural gas, liquefied petroleum gas and unleaded gasoline.

-Upgrade energy control and energy efficiency.

-Clearing and rehabilitating polluted areas.

Fig.4: *Change in renewable energy consumption in Algeria and some Arab countries 2016-2040*



Source: (OAPEC, 2018, p. 102)

It also shows clearly the importance attached to the promotion of the use of natural gas through the energy policy adopted and is based mainly on the following options:

- Maximum use of natural gas, for primary use and final consumption.
- Production of electric energy with 95 percent of natural gas and directing it to specialized uses.
- Gradually reducing the share of petroleum products in the energy balance that is directed to export.
- Limited use of firewood to preserve the forest wealth.

6. Conclusion :

Hydrocarbons (oil and natural gas) are considered to be the basics and pillars of the national economy, as they are the main financiers of development plans for the various sectoral activities of the country, in addition to providing the economy with the energy necessary to achieve growth in Algeria.

These two resources have contributed to unprecedented economic and social transformations during the past four decades, as its revenues were used to modernize infrastructure, public investment, and improve human development indicators.

On the other hand, and despite the challenges facing the energy sector in Algeria and the international oil market at the present time, from the fluctuation in oil prices, environmental challenges, Algeria seeks to keep pace with these changes, as well as expanding its economies away from oil, as well as legalizing domestic consumption of petroleum products. As Algeria is one of the countries that depend on its economy for oil, it must realize the extent of concern for the environment and the need to find effective solutions to reduce the effects of climate change.

The life of Algeria's fossil energy reserves is relatively short. The issue is related to several factors, especially the size of the reserves discovered, the profitability from the point of view of changes in the costs of exploitation and international prices, as well as the volume of exports and domestic consumption. However, renewables energies will be an unavoidable alternative in the medium and long term. Algeria has many advantages and ingredients that encourage the establishment of

an industrial base for the development of renewable energies, the most important of which is the availability of primary resources such as the sun and wind. Therefore, Algeria must make extensive efforts to develop integrated infrastructure in order to form a solid base for the development of these energies.

The energy transformation is a very important process for the Algerian economy because it is related to energy options, and it also has cross-border significance, given the interrelations and challenges in energy relations and international environmental issues. The subject of energy transformation is an issue in which it has not yet been decided on the national and even international levels. It comes in light of the prevailing ambiguity with regard to moving forward in the national program underlined for renewable energies. On the other hand, it noted that investment in fossil energies is proceeding rapidly despite doubts about the environmental risks of exploiting it.

Among the most important recommendations that can be presented in this framework:

- Continue to supply and finance the national economy with clean energy products and financial resources.
- Adopting an ambitious program for renewable energies and raising the target percentage of the contribution of renewable energies in the future energy mix to 40 %.
- Continue efforts to protect environment.

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