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Future of the Renewable Energy in Algeria: A Review

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Abstract:

In Algeria the energy consumption is based almost exclusively on fossil energy sources, hydrocarbons and especially natural gas. In recent years, Algerian government has shown an ambition to start a new renewable energy (RE) development plan.

Algeria intends to be an important player in the production of electricity from the photovoltaic and wind sectors by integrating biomass, cogeneration, geothermal and eventually thermal solar, under its renewable energy program.

These energy sectors will be the driving force for a sustainable economic development model. This is a real investment opportunity.

Keywords: Algeria; renewable energies; Renewable energy transition.

مستقبل الطاقات المتجددة في الجزائر

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الملخص:

يعتمد استهلاك الطاقة في الجزائر بشكل شبه حصري على مصادر الطاقة الأحفورية والهيدروكربونات وخاصة الغاز الطبيعي. أظهرت الحكومة الجزائرية في السنوات الأخيرة طموحًا لبدء خطة تنمية جديدة للطاقة المتجددة.

تعتزم الجزائر أن تكون لاعباً هاماً في إنتاج الكهرباء من قطاعي الطاقة الكهروضوئية وطاقة الرياح من خلال دمج الكتلة الحيوية ، والتوليد المشترك للطاقة ، والطاقة الحرارية الأرضية ، ثم الطاقة الشمسية الحرارية ، في إطار برنامجها للطاقة المتجددة.

ستكون قطاعات الطاقة هذه القوة الدافعة لنموذج التنمية الاقتصادية المستدامة في الجزائر.

الكلمات المفتاحية: الطاقات المتجددة –الجزائر - الانتقال الى الطاقة المتجددة

1. INTRODUCTION

The energy is one of the sensitive issues in the modern economies of the world, where it is relying in all life areas, due to the offered benefits for the human kind because of exploitation

and of all without excellence .

Although it is drawn energetic policies in various countries around the world, whether producing energy or consume it, as a result of this global attention to the importance of taking power far beyond its means, in which to direct their economies and cast its future and the development of their sources, especially in countries that growing importance industrial.

Algeria has enormous renewable energy (RE) potential. It possesses high solar potential, with more than 3000 hours of sunshine per year.
However, fossil fuels remain the main source of electricity generation in Algeria. In fact, Algeria is considered to be one of the most energy-consuming countries, with the contribution of fossil fuels in electricity generation at more than 98.75% in 2016. Moreover, energy consumption and its evolution over time are the principal factors explaining the global CO2 emission growth[1].

The use of gas and fossil fuels in economic activities leads to the emission of an important amount of CO2 (carbon dioxide) into the air, which contributes to the greenhouse effect[2].

Consequently, Algeria is the third highest CO2 emitter country in Africa, and one of the most important among developing countries. It emitted 147 MtCO2 in 2014, and was 34th in the list of countries with fossil fuel emissions from gas flaring.[3]

Furthermore, Algeria is particularly vulnerable to climate change. On the one hand, Algeria has low—and decreasing—yearly average rainfall (having declined 30% over the past decades). On the other, its land characteristics reduce the carbon capture possibilities.

2. Global Energy Status in Algeria :

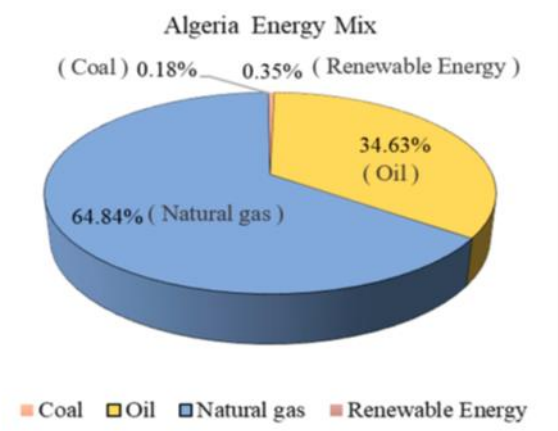
Energy has two main types renewable and non-renewable sources, and each type has certain characteristics that distinguish it from others.
Recent statistics show that most of the industrial countries stopped using the traditional energy resources due to the negative effects to the environment,

Algeria is one of those countries, which have a huge potential in the two kinds, which Allow acquiring an important place on the international level in the field of energy.[4]

Figure 01: Algeria fossil fuel generation mix in 2019

[1] Mohammed Bouznit and al (2020).
[2] . Sahnoune, F and al (2013).

[3] Olivier, J.G.J and al (2015).
[4] Mohamed ALLAOUI and al (2017).



2.1. Non Renewable-Energies in Algeria :

Non-renewable resources are energy sources that we use and consume faster than nature produces them. Fossil fuels such as coal and natural gas, take centuries to form naturally, and crude oil takes millions of years to form.

These resources are not infinite and over time, most experts believe they will cease to exist.

Non-renewable energy sources come out of the ground as liquids, gases, and solids. Crude oil (petroleum) is the only commercial non-renewable fuel that is naturally in liquid form. The main types of this classical energy are Coal, Oil, Natural gaz and electricity.

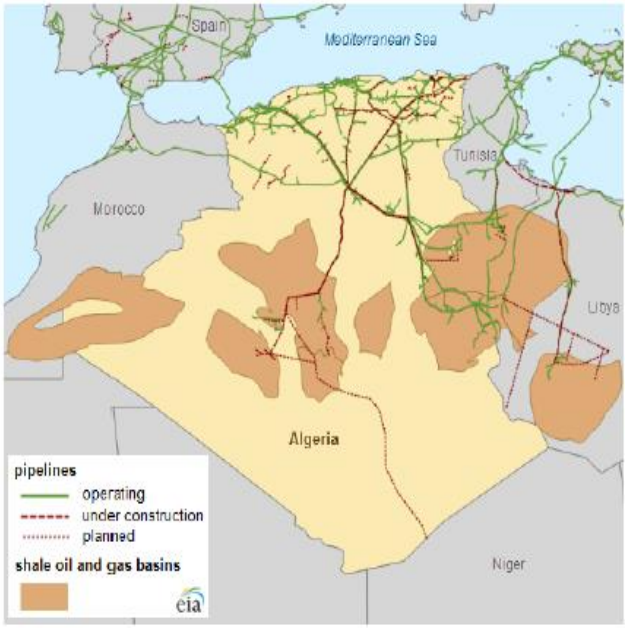
2.1.1. Oil:

Algeria's indigenous oil reserves are the third largest in Africa, after Libya and Nigeria.[5] In 2014, Algeria was the world's seventh top oil products exporter and ranked 17th globally in 2014 with a total of 1.721 million barrels a day. Much of its crude oil is exported to Western Europe and North America.[6]

The principal oil provinces are located in the central and southeastern parts of the country. Hassi Messaoud, discovered in 1956, is the largest oil field. Others include Ourhoud oil field and Rhourde El Baguel oil field.

[5] (WEC, 2013).
[6] (IEA 2014).

Figure 02: Algeria's oil and gas fields

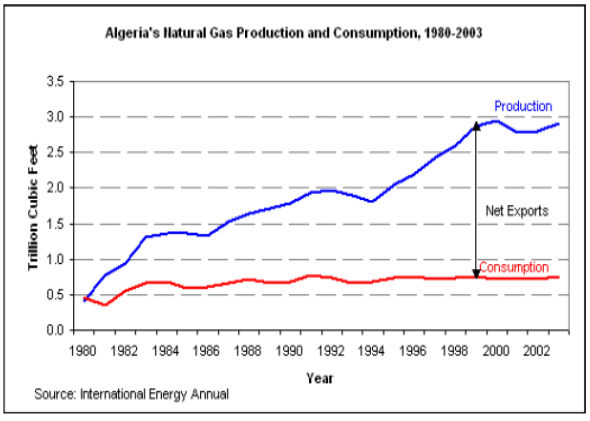


Algerian crudes are of high quality, with low sulphur content. Algeria is estimated to have oil reserves of 12.2 billion barrels.[7]

2.1.2. Natural Gas:

Natural gas can be considered the main source of power that Algeria depends on and it is the most efficient among all the fossil fuels. A total of 98% of all the power generated in Algeria, is through natural gas resources. This means that Algeria ranks the eleventh most country with natural gas reserves and the third for the amount of recoverable shale gas resources.[8]

Figure 03: Algeria's Natural gas Production and Consumption, 1980-2003.

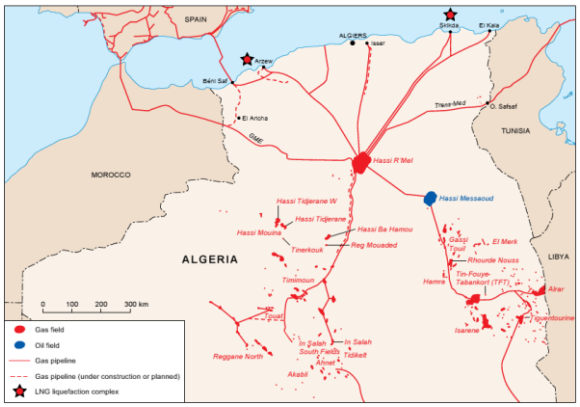


In 1980, Algeria's gas production was at the same rate as the country's consumption. Later on, steady increase in the consumption is reflected by increased difference with the production

[7] (WEC, 2013).
[8] "U.S. Energy Information Administration - EIA –(2016)

through time thus creating a huge gap between production and consumption calls for an increased exports rate.

Figure 03: Simplified Natural Gas Map of Algeria[9]

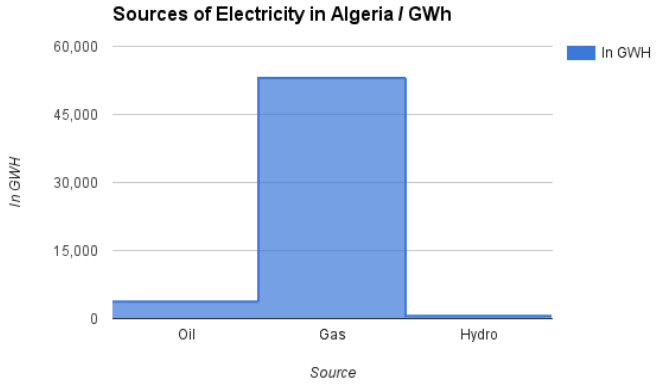


2.1.3. Electricity :

According to Sonelgaz, the energy demand has been increasing on an average of 8 % annually in Algeria. Between 2001 and 2013, electricity production rose from 26,250 GWh to 57,397 GWh.

The powering sources varied for generation processes, like Oil represents 6.49 % of the total, Gas represents 92.42 % and lastly Hydro means generate just 1.08 % of the total. Natural Gas isn't just needed to improve the economy but to provide full electricity access to citizens and transport it to them. This increase in demand has to be responded with an increased rate in the production amount, and this likely would require billions of dollars' worth of investments in new generating capacity, plus transmission and distribution infrastructure.[10]

Figure 04: Algeria's sources of power, for Electric generation.



2.1.4. Nuclear Energy:

Algeria doesn't have any nuclear weapons, biological or chemical, but it was one of the first African countries to sign the "Treaty of Pelindaba".

[9] adapted from Sonatrach's Oil and Gas Map of Algeria, 2018.
[10] Temmam Asma (2017).

In the 1960's, France was experimenting it's nuclear weaponry on Algerian lands, as they carried out seventeen nuclear weapons tests in the Algerian desert (4 atmospheric tests and 13 underground tests). However, Algeria was interested in developing a nuclear power civilian project.

Other than that, Algeria is still in the process of exploiting its Uranium sources, as it was predicted that about 26,000 tons of uranium are reserved in the Southern Sahara desert.

Draria Nuclear Complex (CRND) :

- **NUR reactor:** 1 MW used for training and research purposes for reactor engineering.
- **UDEC**(nuclear fuel development unit)

Birine Nuclear Complex (CRBD):

- **Es-salem reactor:** 15 MW used for isotope production and materials testing.[11]

Figure 05 : Birine nuclear research site.[12]

2.2. Renewable energies :

Algeria has an important potential for power generation from renewable sources, for the domestic market as well as for export to the European market. The current share of renewables is not very significant in the total energy balance, but an ambitious development program was set up, with a specific law in 2004, including incentives for electricity production from renewable, and the creation of a support fund and a renewable energy institute (IAER: Institut Algérien des Energies Renouvelables). Through a March 2004 decree, the government also introduced incentives for electricity production from renewable energy plants, including a feed-in tariff .

Pilot projects implemented in recent years justify the possibility to accelerate the use of indigenous energy resources, particularly for electricity supply.

Algeria generated 25.8x109 KWh of electricity in 2002 and 30.06x109 KWh in 2005. The consumption of the country amounted to a value between 25 and 30 TWh/year. Conventional

[11] Lokman Hadji (2016).
[12] International Atomic Energy Agency.

thermal sources of which natural gas accounted for 94.5%, contributed almost all of Algeria's electricity, supplemented by a small amount of hydroelectricity (5%) and solar photovoltaic/wind (0.5%).

2.2.1. Hydropower

Both the kinetic energy and the potential energy from flowing water can be converted into mechanical power by a turbine wheel, which in turn can drive machines or generators.
Hydropower is a mature technology which, worldwide, generates the second largest share of energy from renewable sources, after the traditional use of biomass. 17% of the electricity consumed in the world today is generated by hydroelectric power stations.

The overall flows falling over the Algerian territory are important and estimated to 65 billions m^3 but of little benefit to the country:

- restrained rainfall days.
- concentration on limited areas,
- high evaporation and quick evacuation to the sea.

Schematically, the surface resources decrease from the North to the South. Currently the evaluation of useful and renewable energies is about 25 billion m^3, of which the 2/3 approximately is for the surface resources.

103 dam sites have been recorded. More than 50 dams are currently operational. The share of these small-sized production parks is about 5 % which supplements the natural gas production of electricity. The total capacity of 13 of them is 269.208 MW as shown in table 01.[13]

Table 02: Hydroelectric production park[14]

Plant	Installed power (MW)	Plant	Installed power (MW)
Darguina	71.5	Ighzernchebel	2.712
Ighil Emda	24	Gouriet	6.425
Mansouria	100	Bouhanifia	5.700
Erraguene	16	Oued Fodda	15.600
Souk El Djemaa	8.085	Beni Behde	3.500
Tizi Meden	4.458	Tessala	4.228
Ghrib	7.000	Total	269.208

2.2.2. Wind Energy Potential:

The resources in wind energy in Algeria vary
widely from one place to another **(Figure 06)**. This is mainly due to a diversified topography and climate. In fact, our vast country is divided in two large distinct geographical zones.

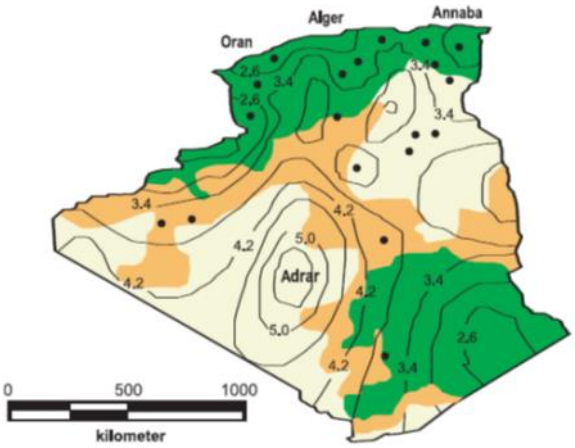
[13] Amine Boudghene Stambouli
[14] Energy & Mines Book 2007.www.mem-algeria.org

The Northern Mediterranean area is distinguished by a coastline of 1.200km and mountainous terrain represented by the two chains, the Tellian Atlas and the Saharan Atlas. Between these re plains and highlands with a continental climate.

The South is characterized by a Saharan climate. The map below shows that the South is marked by higher wind velocities than the North; this is particularly true in the South-West where velocities are more than 4m/s and exceed 6m/s in the Adrar region.

Regarding the North, it appears that the average velocity is not very high. However, we notice micro climates in the coastal areas of Oran, Béjaïa and Annaba, on the highlands of Tiaret and Kheiter, as well as in the region bounded by Béjaïa in the North and Biskra in the South.

Figure 06: Wind chart of Algeria



Wind energy can be feasible where the average wind velocity is higher than 5–6 m/s. Algeria has a huge plan to develop wind energy. Studies of indigenous wind resources, performed by the CDER during recent years, show that the climatic conditions in Algeria are favourable for wind energy utilisation.

This energy potential is ideal for the water pumping especially in the high plains. The wind resource has also been assessed by the developer, Sonelgaz, and at present, there are six pilot projects for electrification and telecommunication which are identified and quantified. These are Adrar, Tindouf, bordj Badji Mokhtar, Bechar, Tamanrassat and Djanet.

Table 03: The annual average wind velocities in the six identified places

Sites	Adrar	Tindouf	Bordj Badji Mokhtar	Bechar	Tamanrassat	Djanet
Annual average speed (m/s)	6.3	5.1	4.6	4.4	3.7	3.3

The region of Adrar receives the most wind in the country judging from the results of the preliminary survey. Evaluations of powers recoverable at heights from 10 to 50 m could conclude in registering this region as a favourable site for the establishment of a windy farm.

Other sites (North, High Plateaux) hide non-negligible energetic potentials. The installation, by Sonelgaz, of a 30 MW wind farm in Adrar region and the nine assessment stations in different regions of Algeria is seen as a second step in stimulating much faster the use of the wind power. The topography and terrain roughness of these prospective wind sites are also measured and quantified to better simulate and understand the wind flow.[15]

2.2.3. Solar:

According to its geographical location, Ageria holds one of the highest solar potential. Indeed , following an assessment by the satellites, the German Aerospace Center (DLR) concluded that Algeria has the largest solar potential in the Mediterranean basin: 169,440 TWh / year.Sunshine duration on almost all the country over 2000hours per year and can reach 3900 hours in the Highlands and the Sahara. The daily energy obtained on a horizontal surface is about 5 kWh on most of the national territory, about 1700 kWh / m² year for the North and 2263 KWh / m² / year for the South.[16]

The climatic conditions in Algeria are favorable for the development of solar energy due to the abundant sunshine throughout.

Pilot projects for the construction of two solar power plants with storage of a total capacity of about 150 MW each, are launched during the 2011-2013 period. These became in addition to the hybrid power plant project of Hassi R'Mel with a total power capacity of 150 MW, including 25 MW in solar. Four solar thermal power plants with a total capacity of about 1,200 MW are to be constructed over the period of 2016 to 2020.

Figure 07: One of the world's first hybrid solar power plant is located at Hassi R'Mel

The Hassi R'Mel integrated solar combined cycle power station is one of world's first hybrid power stations. The plant combines a 25 MW parabolic trough concentrating solar power array, covering an area of over 180,000 m2, in conjunction with a 130 MW combined cycle gas turbine plant, so cutting carbon emissions compared to a traditional power station. The gas turbine and steam cycle are fired by natural gas, with the steam turbine receiving additional solar-generated steam during the day. The plant began electricity production in June 2011.[17]

[15] Amine Boudghene Stambouli.

[16]

[17] https://www.ecomena.org/renewables-algeria

2.2.4. Bio-Power :

There are many investigations highlighted how important and diversify is the bioenergy potential in Algeria ranging from different waste origins and sectors.

(Table 05) summarized the investigated bioenergy resources and their energy power generation potential. Considering only the resources studied here, an electricity potential of more than 1700 GWh can be reached from waste recovery. Given that the annual average electricity consumption per capita in Algeria is about 1236 kWh, the projected potential could cover the electricity needs for more than a million of inhabitants.[18]

Table 04: Summary of bioenergy resources.

Biomass resources	Annual biogas potential	Power generation potential (GWh)
Urban wastes		
Organic fraction of household wastes	974 million of m^3	1646
Sewage from wastewater treatment plants	22.91 million of m^3	38.72
Industrial and agribusiness wastes		
Amurca from olive oil industry	10.5 million of m^3	17.74
Pomace from olive oil industry	–	215.5
Whey from dairy industry	2.35 million m^3	3.97
Total	**1009.76 million m^3**	**1706.43**

2.2.5. Geothermal :

The compilation of the geological, geochemical and geophysical data contributed to layout a preliminary geothermal chart. More than two hundred (200) hot springs have been recorded in the Northern part of the country.[19]

Approximately a third of these hot spring (33%) show temperatures exceeding 45° C. High temperature springs exist in Biskra region reaching 118°C.

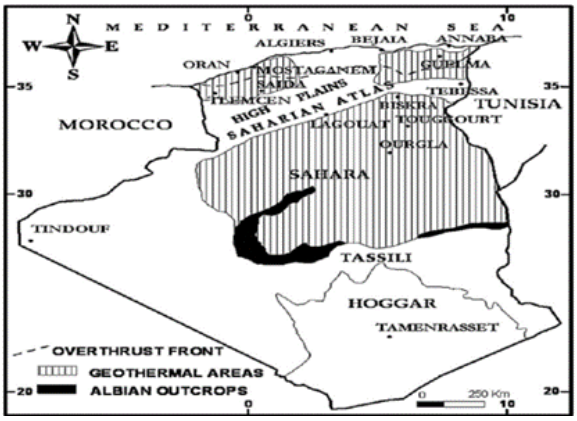
These natural outflows which are generally leakages from existing reservoirs have a flow of more than 2m3/s of hot water. This represents only a very small part of the production possibilities of the reservoirs.[20]

Deeper in the South, the continental rock formation constitutes a great geothermal reservoir extending over several thousand km2. This reservoir commonly called the ‘‘albian platform’’ is

[18] Amine Akbi (2017).
[19] CDER, Algeria.2012. http://www.cder.dz.
[20] Saibi H. (2009)..

exploited through drilling, at a flow rate of over 4m3/s. This water has an average temperature of 57 °C (Fig. 3) .[21]

Figure 08: Main geothermal areas



3. Difficulties and Barriers in use of renewable energies*:*

Like the most developing countries, the use of renewable energies in Algeria was encountered many problems and difficulties, some of them as the fellowings :[22]

- Cost and pricing:

A lot of interested peoples argues that renewable energies costs more than other energy sources, resulting in the cost driving decisions and policies that avoid renewable energy. The determination of real cost and appropriate price assessment are facing:

- Subsidies for capital cost.
- Difficulties of fuel price risk assessment
- Unfavorable power pricing rules
- Transaction costs.
- Environmental externalities.

- Legal and regulatory: The absence of legislation and regular rules decrease the investment in renewable energies it seems that:
- Lack of legal framework for independent power producer.
- Restriction on siting and constraints.
- Utility interconnection requirements
- Liability insurance requirements

Problems of market performance:

The market of renewable energy is a new and complicated market it is a combination of many parties, that's why it constrains many challenges some of theme:

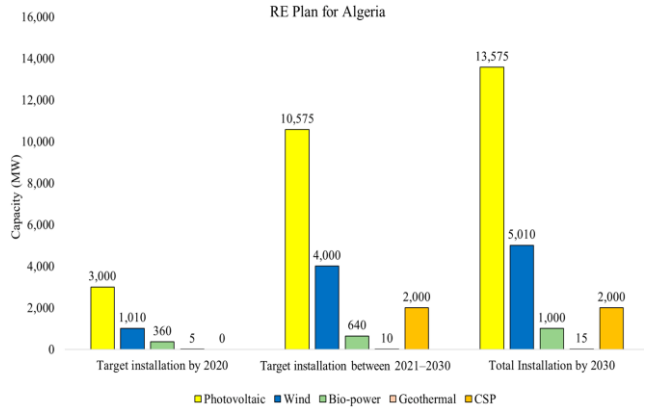
[21] Kamel Abdeladim and al (2014)
[22]Frederic Beck and al (2008).

- Lack of access to credit
- Perceived technology performance uncertainly and riskless.
- Lack of technical or commercial skills and information

4. Renewable energy transition in Algeria :

Algeria's renewable energy targets are ambitious relative to their timeframe. With approximately 450 MW of installed solar capacity today,
Algeria would need to deploy an additional 5,000 MW to meet the solar capacity target outlined in the regulator's 2028 generation capacity scenario. To meet the official 2030 targets, 22,000 MW total of renewable capacity would need to be deployed.[23]
Algeria has developed a reverse tender scheme to help drive investment in renewables, in which long-term contracts known as power purchase agreements (PPAs) are awarded to companies that offer to sell power at the lowest price. Sonelgaz, a state-owned utility, serves as the counterparty to the PPAs.
Algeria's first reverse tender took place in 2019, but it was undersubscribed: Offers were only submitted for 90 MW, while the tender process called for a total of 150 MW. The limited success was due to both the novelty of the process in Algeria and the tender rules. The opportunity limited auction participants to Algerian companies or joint-venture arrangements with a mandatory 51 percent stake for the Algerian entity. Local content requirements around solar modules and other equipment were also applied, despite relatively limited solar-related manufacturing capacity at the time. Additional requirements mandating that financing come from Algerian institutions represent a further challenge. While the 2019 tender did not meet the proposed targets, it likely proved a useful learning exercise for both the Algerian government and investors and will still result in an increase in solar capacity.[24]

Figure 09 : Algeria RE current and future generation plan



As noted above, there were a combined capacities of renewable energies program, which are shown in table below, per type and phase over 2015-2030 :

[23] Algerian Ministry of Energy.
[24] https://www.mei.edu/publications/algeria-charts-path-renewable-energy-sector-development.

Table 05: capacities of the renewable energies program (2015-2030).

Electric Power						
	1st Period (2015-20)		2nd Period (2021-30)			
Energy Source	MW	%	MW	%	Total (MW)	%
Photovoltaic	3000	66.3	10,575	60.52	13,575	61.70
Wind power	1010	22.32	4000	22.89	5010	22.77
Concentrated solar power			2000	11.44	2000	9.09
Biomass	360	7.95	640	3.66	1000	4.55
Cogeneration	150	3.31	250	1.43	400	1.82
Geothermal	5	0.11	10	0.06	15	0.07
Total	4525		17,475		22,000	

5. CONCLUSION

Despite being a hydrocarbon-rich nation, Algeria is making concerted efforts to harness its renewable energy potential. Algeria's renewable energy program is one of the most progressive in the MENA region and the government is making all-out efforts to secure investments, and reliable technology partners for ongoing and upcoming projects. It is expected that the country will emerge as a major player in international renewable energy arena in the coming years.

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