Envision an effective energy transition in the production of electricity in Algeria

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Abstract:

This study is a contemporary diagnosis of the stakes in achieving an energy transition in the production of electricity in Algeria, by highlighting the most important structures and the current situation of electric energy production in Algeria.

On the other hand, a contemporary economic analysis of the level of energy efficiency in Algeria, in terms of several global indicators, all of which confirm the modest contribution of energy Renewable compared to Arab and international countries. Finally, the measures to promote Renewable Energy use for Electricity in Algeria.

Keywords: Renewable energy, indicators, energy transition, promote, Electricity.

JEL Classification: A11, O13, P17, P28, Q01, K12, O55

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1. Introduction:

Economic, political, biological and climatic changes, such as volatile fuel prices (LAFDAL & DAHMANI, 2020), food insecurity, energy shortages, biodiversity degradation, regional conflicts and epidemics, are all phenomena affecting the world economy today, and support the need to expand the use of renewable energy solutions, which have the criteria and results to achieve the desired economic goals, reducing expenses, creating new financial resources to the achievement of sustainable development (CHERIFI & HADDAD, 2020).

It is undeniable that the development of future plans or programs to ensure an efficient energy transition is difficult to achieve in the near future, but not impossible; The modern economic vision of the Algerian state shows bold and logical steps in renewable energies and energy transition, the objective of which is to be free from dependence on fossil energy and achieve energy diversification. As economists, it is our role to arm the technical and technological aspects of these programs with the necessary economic and legal instructions, to support them with realistic and logical ideas, to foresee the results and to try to reduce the risks, in order to obtain results that are both profitable and reassuring. Therefore, on the basis of the betting principle on the subject of energy transition in Algeria, we have done this work according to the following question:

What is the extent of the contribution of renewable energy in the production of electrical energy in Algeria?

To answer this problem, we formulated the following hypothesis: "Currently, Algeria explicitly places the energy transition and renewable energies in its economic programs through its institutions and organizations, due to the positive economic effects of this energy trend."

The theme of renewable energies and its relation to sustainable development has been addressed by several previous studies, such as: Dolf Gielena, Francisco Boshella, Deger Sayginb, Morgan D. Bazilianc, Nicholas Wagnera, Ricardo Gorinia Sara: *"THE ROLE OF RENEWABLE ENERGY IN THE GLOBAL ENERGY TRANSFORMATION"*, the article explores the technical and economic characteristics of an accelerated energy transition until 2050, using new datasets for renewable energies (Dolf, et al., 2019).

CHERIFI and Mohamed HADDAD; "SOLAR ENERGY: AN ENGINE OF SUSTAINABLE DEVELOPMENT IN ALGERIA", a study consists of evaluating the contribution of solar energy to sustainable development in Algeria.

The Renewable Energy Development Center (CDER): "AN AMBITIOUS THREE-YEAR RESEARCH PROGRAM TO SUPPORT THE ENERGY TRANSITION IN ALGERIA", contains research projects validated by the Scientific Council of EPST CDER, whose objectives are to conduct applied research in priority areas having a real impact on the economic sector.

It should be noted, that this article cites many articles and economic research, national and international journals, conferences and official global publications. Our work would not have been possible without the previous efforts of the studies and articles of our fellow researchers.

In order to achieve the best conclusions and results in our subject, with a scientific, economic, logical and objective methodology, we had to learn and acquire new knowledge, especially in the technical aspect of renewable energies, all this in order to create harmony between the economic and technological argument, and to invest its results in this article. Based on this, we decided that the main themes of this scientific paper should be:

- First: Renewable energy status in Algeria,
- Second: Electrical energy in Algeria,
- Third: Evaluation of the energy transition in Algeria,
- Fourth: Measures to Promote Renewable Energy Use for Electricity.

2. Renewable energy status in Algeria:

The fact that fossil energy is considered, par excellence, the dominant basis for Algeria's economy, due to its huge revenues, as according to the statistics of the Bank of Algeria, fuels of all kinds represent more than half of the gross domestic product, more than 90% of the state's financial revenues, in addition to its contribution to the added value. Disbursement worth more than \$ 60 billion. But with the beginning of the year 2020, and with the inauguration of the new government, contemporary features and trends were evident, placing renewable energy at the core of the goals, based on a realistic diagnosis of economic conditions and changes, crises, regional conflicts and even epidemics that emphasize the inevitability of an effective energy transition and encourage the policy of energy diversification to support Sustainable development solutions in the economy.

2.1. Concept of energy transition:

The energy transition is a set of processes that radically change the principle of energy production and consumption, and by this we do not mean technical developments, prices and availability of renewable energy sources. only, but even the will of authority. The original concept of energy transition emerged in Germany and Austria, where it began as a set of scientific expectations and proposals developed by the German Öko institute in 1980, with the aim of finding an alternative to oil and the atom (BOULANGER, 2017).

Indeed, if we analyze these concepts, we conclude that this is a "democratization" of energy supplies; Considering that the traditional model of fossil energy being controlled by a small number of influential groups in its market, which materializes in a monopoly at the political and competitive level. Therefore, efficient energy transition emerges through: decentralization of production, wide availability of renewable energy sources and diffusion of energy conversion technologies; which leads to direct participation of the individual in the production and supply of energy, through participatory models such as wind farms and solar complexes for institutions and residents.

2.2. Renewable energies in the Algerian government:

After the 1986 world oil crisis, Algeria pursued several economic programs aimed at supporting economic growth and improving living conditions. In the new growth program (2015-2019), an economic growth model was adopted in 2016, and the energy horizons of which extend until 2030 (2020 (العالية و مزريق)).

Unfortunately, according to the current reality, the embodiment of investment projects in this area was neglected, and the planned results were not achieved according to the previous calendar. The accomplishment of the efficient energy transition towards renewable energies takes place within the framework of economic development policies, and this is really only possible with an explicit political and legal translation of it which reflects the will of the state today:

2.2.1 National Agency for the Promotion and Rationalization of the Use of Energy (APRUE):

APRUE is a public industrial and commercial establishment created by presidential decree in 1985, placed under the supervision of the Ministry of Energy and Mines. Its main mission is to implement the national energy management policy, through the promotion of energy efficiency. Within the framework of Law No. 99-09 of July 28, 1999 on energy management, the agency has several missions generally to promote energy savings and improve and strengthen energy efficiency capacities (Journal, 1985).

2.2.2 The Renewable Energy Development Center (CDER):

CDER is a Research Center, resulting from the restructuring of the High Commission for Research, created on March 22, 1988. It is a Public Establishment of a Scientific and Technological nature (EPST) responsible for developing and implementing programs research and development, scientific and technological, of energy systems exploiting solar, wind, geothermal and biomass energy. The Center is active in the implementation of this strategy through the deployment and integration of several achievements at the national level (Journal, Décret n°88-61, 1988).

2.2.3 The Renewable Energies and Energy Efficiency Commission (CEREFE):

CEREFE is a public establishment with legal personality and financial autonomy. It was created with the Prime Minister by executive decree n° 19-280 of October 20, 2019. CEREFE is a design body for the national strategy for the development of renewable energies and energy efficiency. It is also an instrument to assist in the implementation and evaluation of national policy in the field of renewable energies and energy efficiency. It has a board of directors and an advisory board (Journal, Décret exécutif n° 19-280, 2019).

2.2.4 Ministry of Energy Transition and Renewable Energies:

Contemporary Algeria has reserved an explicit position for renewable energies and energy transition in the composition of the members of the current government, where under the presidential decree n° 20-163 of June 23, 2020 appointing members of the Government, the Ministry of Energy Transition and Renewable Energies has been created. Indeed, any future energy strategy will be considered as a national economic strategy, marked by a legal character, which will give a faster temporal and spatial impetus to implement energy transition and renewable energy programs and achieve one of the sustainable development goals (Journal, Décret présidentiel n°20-163, 2020).

2.2.5 International Solar Alliance (ISA):

According to the presidential decree n° 20-146 of June 8, 2020 ratifying the framework agreement establishing the international solar alliance (ISA, 2020), signed in New Delhi (India) on March 7, 2018. Algeria opens the way to all cooperation in the service of all possible uses of solar energy as an alternative to fossil and polluting energies in the intertropical belt (Journal, Décret présidentiel n°20-146, 2020).

2.2.6 National School of Renewable Energies, Environment and Sustainable Development:

According to Executive Decree No. 20-152 of June 08, 2020, the National School of Renewable Energies, the Environment and Sustainable Development was created. This school assumes the mission of ensuring higher education, scientific research and technological development in the fields and divisions of renewable energies, the environment and sustainable development, in particular electrical engineering, the network of intelligence and metrology, new and renewable energies, the environment, public health and the green economy (Journal, Décret exécutif n° 20-152, 2020).

3. Electrical energy in Algeria:

Electricity represents about a third (1/3) of the energy consumed in the world (Centre for Energy Economics Research and Policy, 2020). Technically, the most common method of producing large amounts of electricity is to use a generator that converts mechanical energy into alternating voltage. This energy of mechanical origin is most of the time obtained from primary energy (fossils) or renewable energy.

3.1. Production of electrical energy in Algeria:

In 2019, Algeria ranked forty-second (42) in the world, third (03) in Africa and second (02) in the Arab world (after Egypt), with an electricity production capacity of 67 billion of kilowatts (Index, 2020).



Fig.1. Electricity production by country in Africa (2019)

Source: Index Mundi, consulted on 09/13/2020, at 01:56. Available at: <u>https://www.indexmundi.com/map/?t=0&v=79&r=af&l=fr</u>

3.1.1 National Production Park:

The national production park is made up of power stations which are a subsidiary of SONELGAZ, as well as partnership companies.



Fig.2. Installed capacity per electricity producer (2017)

Source: MINISTRY OF ENERGY, consulted on 09/13/2020, at 02:46. Available at: <u>https://www.energy.gov.dz/?rubrique=electricite-et-gaz</u>

3.1.2 Electricity production by source:

Electricity production in Algeria comes mainly from natural gas at a rate of 99%. Namely that Algeria contains several sources that can support national and global energy needs (Export of electrical energy).

Fig.3. Electricity production by source, Algeria (1990-2018)



Source: International Energy Agency, consulted on 09/14/2020, at 01:21. Available at: https://www.iea.org/data-and-

statistics?country=ALGERIA&fuel=Electricity%20and%20heat&indicator=Electricity%20generation%20by %20source

From fig.3, we confirm the predominance of natural gas in the Algerian energy mix, and this is due to the fact that the country is a major producer of fuel. Algeria is one of the largest electricity consuming countries in the world (56 billion KWh in 2019). Therefore, breaking free from dependence on hydrocarbons and moving towards renewable energies is no longer a choice for the Algerian government, but an imperative necessity, given the fluctuations in fuel prices, and according to the results of an economic study conducted by Lazard Bank, it is evident that investing in the construction of new power plants from the source of the sun or the wind is the best in terms of financial return and profit (GOULARD, 2019).

3.2. Photovoltaic solar energy in Algeria:

Algeria is indeed one of the most important sources of solar energy in the world with an insolation duration of 2,000 to 3,900 hours per year, and a daily irradiation of 3,000 to 6,000 Wh / M^2 , the equivalent of 10 times global consumption (GRIM, 2020).

3.2.1 Situation of Photovoltaic production:

Fig.4. Solar PV electricity production, Algeria (2015-2018)



Source: International Energy Agency, consulted on 09/14/2020, at 02:21. Available at: <u>https://www.iea.org/data-and-</u>

statistics?country=ALGERIA&fuel=Electricity%20and%20heat&indicator=Solar%20PV%20electricity%20 generation

According to Fig.4, it is noted that the production of electrical energy from the solar photovoltaic energy source has experienced a gradual increase over the past three years (2016-2018). And despite this, this production of 655 GW does not at all reflect Algeria's potential in solar PV energy.

3.2.2 Photovoltaic solar energy potential:

Photovoltaic solar energy is electrical energy produced from solar radiation through solar photovoltaic panels or plants. It is said to be renewable because its source (the Sun) is considered inexhaustible on the scale of human time. Algeria is probably the African and Mediterranean country with the greatest potential for photovoltaic solar energy on a global scale.



Fig.5. Algeria's potential for solar PV energy (1990-2018)

Source: Global Solar Atlas, version 2.3, accessed 09/18/2020, 02:47. Available at: <u>https://globalsolaratlas.info/download/algeria</u>

Fig.5 is a solar resource map that shows a summary of solar photovoltaic (PV) power generation potential and average daily / annual power generation totals from a grid-connected solar photovoltaic power plant 1 kW, calculated for a period of the last 25 years

(1998-2018). The calculation takes into account solar radiation, air temperature and terrain, to simulate energy conversion and losses in photovoltaic modules and other components of a photovoltaic power plant. The underlying solar resource database is calculated from atmospheric and satellite data with a time step of 15 minutes and 30 minutes and a spatial resolution of 1000 m. In the simulation, the electricity production capacity varies between 1500 and more than 2100 KWh / m^2 .

3.3. Wind energy in Algeria:

Wind energy is the energy of the wind (renewable energy). According to data on wind farms in Algeria, very significant potential can be exploited by economic operators (GUERRI, 2018).

3.3.1 Wind power generation situation:





Source: International Energy Agency, consulted on 09/18/2020, at 02:58. Available at:

https://www.iea.org/data-and-

statistics?country=ALGERIA&fuel=Electricity%20and%20heat&indicator=Wind%20electricity%20generati on

From Fig.6, we notice a continuous decrease in electricity production from wind source over the last three years (2016-2018). This clearly shows the low investment in wind power. Namely, Algeria has enormous wind potential (especially in the south), and the reasonable costs related to the construction of wind farms.

3.3.2 Wind energy potential:

Fig.7. Algeria's wind energy potential (2008-2017)



Source: Global Wind Atlas, version 3.0, accessed 09/19/2020, at 21:44. Available at: <u>https://globalwindatlas.info/en/area/Algeria?print=true</u>

Fig.7 shows the map of Algeria's wind fields in the World Atlas Wind database. According to a study published by CDER in 2019 (2020), the Atlas of the Winds of Algeria saw data recorded for 10 consecutive years (from 2004 to 2014) at 74 national meteorological stations of the National Meteorological Observatory and 21 additional stations in neighboring countries, reflects the estimated potentials of the wind source, especially in the desert. For example: Ein Saleh's average speed location 06.4 meters / s, the center near Aderar, which recorded 06.3 meters / s, Ilizi state which has dozens of stations showing speeds above 05 meters / s, Hassi-Raml station, is at medium speed, considering it up to 06.5 meters / s.

3. Evaluation of the energy transition in Algeria:

The global energy transition has progressed slowly and steadily over the past five years, but the COVID-19 crisis and falling fuel prices risk either accelerating the pace of the energy transition, or derailing progress in the long run term. However, the resumption and evolution of global energy order is inevitable. Therefore, and as economists, our role is to choose the best match, so in this point we will present an assessment of the energy transition strategy applied in Algeria, according to reports from recognized and credible organizations on a global scale.

3.1. Regional Center for Renewable Energies and Energy Efficiency (RCREEE):

About: The Regional Center for Renewable Energies and Energy Efficiency (RCREEE) is an independent regional non-profit organization that aims to facilitate and promote the adoption of renewable energy and energy efficiency practices in the Arab World. RCREEE works with governments in the region and international organizations to initiate dialogues on sustainable policies, strategies, technologies and capacity development in clean energy to affirm the importance of Arab States in the field of the energies of the future. The index issued by this center is: The Arab Future Energy Index (RCREEE, 2020).

3.2. Arab Future Energy Index (AFEX):

AFEX is the first Arab index dedicated to monitoring and analyzing sustainable energy competitiveness in the Arab region. AFEX offers quantitative and qualitative analyzes on the main renewable energy and energy efficiency markets in 20 Arab countries. AFEX data has been collected and obtained locally and internationally to ensure accuracy and transparency.

In its 2019 edition, AFEX Renewable Energies ranks 20 Arab States and provides personalized recommendations to countries to help them improve their sustainable energy markets. The countries assessed are: Algeria, Bahrain, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, State of Palestine, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates and Yemen. AFEX ER 2019 is produced in collaboration with the United Nations Development Program. AFEX provides an assessment of countries progress in renewable energy according to four assessment categories: market structure, policy framework, institutional capacity, finance and investment (AFEX, 2020).

Table 1. AFEX renewable energy index in Algeria, 2019 edition					
Country:	Market Structure:	Policy Framework:	Institutional Capacity:	Finance and Investment:	Final Score:
Algeria	78%	33%	66%	78%	64%

Source: Arab Future Energy Index (AFEX), renewable energy, version 2019, page 21.

Fig.8. Categories Scores for Algeria (2019)



Source: Arab Future Energy Index (AFEX), renewable energy, version 2019, page 21.



Source: Arab Future Energy Index (AFEX), renewable energy, version 2019, page 19.

Fig.10. Diagram illustrating the total scores of Algeria



Source: Arab Future Energy Index (AFEX), renewable energy, version 2019, page 23.

Evaluation of the AFEX index: (final score: 64, ranking: 6). Algeria presents an attractive market for the development of renewable energies because of its market size and its strong resource potential. Algeria's main achievement has been the completion of projects approved under the feed-in tariff system. Algeria has published the network code for connecting RE systems to the network. Algeria's RE projects now have guaranteed access to the network, and under the FiT scheme are subject to a specific regime offering preferential prices based on a 20-year electricity PPA with one of the four operators.

distribution network, which are all State subsidiaries (owned by the SONELGAZ Group). Algeria has stopped the FiT system and is now adopting tendering and auction systems to attract private investment, where several projects are either in the tender phase or under development. In addition, Algerian oil and gas companies have been encouraged to invest in renewable energy projects.

AFEX index recommendation: The Algerian investment framework can be improved to allow the participation of a greater number of foreign investors and to allow the establishment of decentralized small-scale RE systems in the residential sectors, commercial and industrial.

3.3. Mediterranean Association of National Energy Management Agencies (MEDENER):

About: (MEDENER) is the Mediterranean association of national energy management agencies. Convinced of the need for enhanced cooperation for the promotion of energy efficiency and renewable energies in the Mediterranean region. MEDENER was created in 1997 in Tunis, in the form of an international non-profit association. Today, it brings together 12 national organizations from both northern and southern shores of the Mediterranean: ADEME (France), ADENE (Portugal), IDAE (Spain), CRES (Greece), ENEA (Italy), AMEE (Morocco), ANME (Tunisia), APRUE (Algeria), ALMEE (Lebanon), NERC (Syria), NERC (Jordan), PEC (Palestinian Authority). In the perspective of enlargement, the association aims to extend to other countries such as Turkey or Egypt. It is open to any national organization, implementing energy and environmental policies. The association is registered in Madrid at the headquarters of the IDAE agency (Spain). The presidency of the network (currently) ENEA-Italy (October 2017) (MEDENER, 2020).

3.3.1. Energy efficiency in the countries of the Mediterranean basin:

MEDENER has set up an energy efficiency observatory based on energy and climate indicators common to all the countries of the North and South of the Mediterranean.

Fig.11. Renewable energy in the energy mix in the North and South of the Mediterranean



Source: Renewable Energies in the Mediterranean, 2018 version, page 9.



Fig.12. Capacities and Objectives in non-hydro

Source: Renewable Energies in the Mediterranean, 2018 version, page 16.

Fig.13. Production of Renewable Electricity in the SEMCs in 2040



Source: Renewable Energies in the Mediterranean, 2018 version, page 16.

Conclusion of the index: The development of renewable technologies is accompanied by promotional measures. Almost all of the countries in the southern and eastern Mediterranean have included awareness campaigns in their renewable's programs. In total, almost 1.8 million US dollars in funds have been mobilized and allocated for awarenessraising actions, with a particular focus on the younger generations and the public sector. In addition, annual or biannual conferences are held in several countries.

The Regional Center for Renewable Energies and Energy Efficiency (RCREEE) and the Mediterranean Association of National Energy Management Agencies (MEDENER) have developed a two-year project, funded by the European Union called Mitigation enabling energy transition in the Mediterranean region (The Mitigation Enabling Energy Transition in the Mediterranean region - meetMED).

3.4. World Economic Forum (WEF):

About: The World Economic Forum is the international organization for publicprivate cooperation. The Forum engages key political, business, cultural and other leaders in society to shape global, regional and industry agendas. The forum was established in 1971 as a non-profit foundation and is headquartered in Geneva, Switzerland. He is independent, impartial and not tied to any particular interest. The Forum strives in all its efforts to demonstrate entrepreneurship in the global public interest while upholding the highest standards of governance. The institution carefully combines and balances the best of many types of organizations, from the public and private sectors, international organizations and academic institutions (WEF, 2020). (ETI); (against 48% in 2019).

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3.4.1. Energy transition index (ETI):

The "Fostering an Efficient Energy Transition" initiative, assisted by the World Economic Forum, aims to accelerate the pace of the global energy transition by encouraging the adoption of effective policies, business decisions and public-private collaboration for the transition to a safe, sustainable, affordable environment and future inclusive energy system. The Energy Transition Index (ETI), which is part of this initiative, establishes and disseminates an evidence-based framework to foster a better understanding of the state and readiness of energy systems across countries for this transition. It is a comparative analysis of the performance of energy systems in 115 countries around the world, as well as their preparation for transition (WEF, from crisis to rebound, 2020).

Constant	Performance	Preparation	2020 ETI	Derel-in e
Country	of the system	at the transition	score	Kanking
Algeria	61%	37%	49.1%	83
Source: WEF, Fostering an efficient energy transition, 2020 edition, page 13				

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Algeria came in 83rd place. (89th in 2019). Thus, Algeria reached a score of 49.1% in

Regarding sub-indicators, Algeria posted a rate of 61% in terms of performance of the energy system (Score identical to that of 2019). Regarding the score relating to the readiness index for a safe and sustainable energy transformation; it fell from 36% in 2019 to 37% in 2020.

In terms of ETI, Algeria ranked 5th in Africa, and 6th in the Arab world (as the index AFEX also indicates).

4. Measures to Promote Renewable Energy Use for Electricity in Algeria:

It should be noted that promoting the investment in RE electricity generation requires a favorable legislative framework and attractive incentive measures. In that sense, Algeria has adopted a set of laws which clearly define the guarantees, financial aid and tax incentives, granted to both public and private enterprises, to raise interest in investing in the RE sector (Bouznit, Pablo-Romero, & Sánchez-Braza, 2020).

4.1. Regulation (Legislative Framework):

The legislative framework is designed to encourage investment in RE and energy efficiency, and to protect the environment. Law No. 99-09 of 2009, still in force, was the first to define the regulatory framework and the mean objectives of energy management policy. This Law aims to rationalize endogenous energy consumption, promote electricity generation from RE sources (solar energy, geothermal and wind energy, and hydroelectricity), and fight against greenhouse gas emission in residential areas, with a view to preserving the environment and public health. Indeed, it is the first time Algeria has clearly defined the outlines of the new energy consumption model, within the framework of sustainable development, by giving priority, especially in the electricity generating sector, to the use of clean energy sources (natural gas and liquefied petroleum gas). Additionally, two years later, the National Fund for Energy Management was funded, to promote the RE

sector, either by granting financial aid or interest-free credits, to all actions and investment projects recorded in that strategic sector (Law No. 99-11).

For Algeria, promoting RE is the key factor to achieving sustainable development. In that context, Law No. 04-09 clearly defined the objectives which should be reached, to adopt the overall strategy to promote RE and energy efficiency. To achieve this, a set of practical measures was established in Law No. 09-09 of 2009, such as the creation of the National Fund for Renewable Energy (NFRE), and devoting 0.5% of oil royalties to its funding. Therefore, the investors engaged in all actions and projects, included in the government RE program, will benefit from different financial aid. Furthermore, Law No. 11-11 of 2011 has extended the NFRE to cover cogeneration activities, which will lead to the creation of the National Fund for Renewable Energies and Cogeneration (NFREC). The government increased its financial participation to 1% of oil royalties. Likewise, Law No. 14-10 announced closure of the National Fund for Energy Management, with the transfer of its functions to the NFREC.

Later, the adopted Executive Decree No. 13-218 of 2013 identified the incentive measures to be taken to boost the production of renewable electricity generation. Thereby, the government had committed to grant bonuses for the costs of diversification of electricity production from RE sources on the one hand, and, on the other, to buy all renewable electricity, produced by both public and private enterprises, at a price above the whole production cost. Finally, in 2017, Executive Decree No. 17-98 and Executive Decree No. 17-204 were approved. Consequently, all new investment projects in renewable electricity generation have to be allocated through tenders, or auctions.

4.2. Financial Aid:

The Algerian government contributes to the development of new capacities through the NFREC. By suppressing the National Fund for Energy Management (Special Account No. 302-101), the Finance Bill of 2015 had created the NFREC, defined as Special Account No. 302-131, which is funded by the public purse, and authorized by the Energy Minister.

The NFREC aims to promote electricity generation from RE and cogeneration systems, and also to improve energy management. This fund provides greater financial capacities, mainly from a tax levy of 1% on oil revenues, and taxes on energy consumption, paid by energy users. Its purpose is not only dedicated to financing the feed-in tariff under the Power Purchase Agreements (PPAs), but is

also notably designed for financing different RE project costs. Thus, the government aid takes several forms and should be used, either to realize power station projects, purchase of production equipment, financing additional production costs and the maintenance of production installations, or, to finance training and research and development (R&D).

Executive Decree No. 17-168 (22 May 2017), amending and supplementing the Executive Decree No. 15-319 (13 December 2015), set the financial resources allocated to the NFREC and their uses to finance RE activities.

4.3. Feed-In Tariff:

In 2004, the Algerian government introduced a feed-in tariff mechanism to speed up RE development, in order to diversify its national energy mix, and achieve established RE

targets. This was created on the basis of setting up a legal framework for a feed-in tariff scheme, incorporating elevated tariffs for renewable power production, in order to promote the production of solar electricity in integrated solar combined cycles. The Executive Decree No. 13-218 of 2013 specified the administrative process and conditions for benefiting from the feed-in tariff mechanism. Likewise, it established the technologies eligible to receive these benefits: photovoltaic, CSP, solar thermal, hydropower, wind, cogeneration and waste to energy and hybrid plants.

These government financial aids are used to cover the additional costs arising from the production of electricity, produced from REs, and from the costs of diversification. In this sense, this feed-in tariff scheme is designed as a premium paid per kWh above a base tariff (average annual electricity price in Algeria), expressed as a percentage of the base electricity tariff. Therefore, the producer of REs benefits from a bonus for each kWh produced, marketed, or consumed. The bonus value is related to the type and the percentage of the RE sources used in the electricity generation [30]. Therefore, feed-in tariff levels vary between technologies.

According to Executive Decree No. 13-218 of 2013, the government bonuses are in the percentage range of 100%, 200% and 300% of price per kWh, if the electricity is produced from hydroelectricity, biomass, and waste and wind, respectively. Moreover, the government bonus reaches 300% of price per kWh, when the electricity is produced exclusively from radiant or thermal solar energy. However, the government bonuses linked to the REs generated from solar thermal energy with the solar-gas hybrid system, are presented below in Table 3.

ng ond system.		
Contribution of Solar Energies	Granted Bonus (% of price per kWh)	
25% and more	200%	
20-25%	180%	
15-20%	160%	
10-15%	140%	
5-10%	100%	
0-5%	0%	

Table 3. Financial aid granted to producers of solar thermal energy. with the solar-gas hybrid system.

Source: Executive Decree No. 13-218 of 2013

Regarding the electricity produced from the cogeneration of steam and/or hot water, the government bonuses will be calculated proportionally to the usable energy. In that field, producers could benefit from a government bonus of 160% of price per kWh, if their production capacity does not exceed 50 MW, where at least 20% is usable energy. However, the government bonus will be 120%, 80% and 0%, if the usable energy is 15-19%, 10-15% and less than 10%, respectively.

Finally, concerning the feed-in tariff scheme, the Algerian government committed to buying all quantities of renewable electricity generated from photovoltaic and wind, for 20 years, at a price above the whole production costs. In that sense, Algeria established an appropriate scale of purchase prices for electricity generated from RE sources. This scale is based on the electricity power and the duration of investment exploitation (the first 5 years and the remaining 15 years). Table 4 summarizes the feed-in tariff associated with the different duration of exploitation and amount of electricity production.

Power		Feed-In Tariff (DZD/kWh)	
		5 Initial Years	15 Remaining Years
Wind	1 to 5 MW	13.10	9.55-16.66
w ma	More than 5 MW	10.48	7.64-13.33
Solar DV	1 to 5 MW	15.94	11.80-20.08
	More than 5 MW	12.75	9.44-16.06

Table 4. Feed-in tariff associated with renewable electricity génération in Algeria.

Source: Executive Decree No. 13-218 of 2013

4.4. Tax Incentives:

It should be noted that the investment code of Algeria is based on three pillars: the freedom of investment, equity, and the protection of existing rights. Thereby, Algerians and foreigners could invest freely in any field, and they can benefit from the same treatment, in terms of incentive supports. In fact, like several other countries in the world, Algeria established specific varieties of support measures to promote renewable electricity generation.

According to Ordinance No. 01-03 of 20-8-2001 (modified and completed by Ordinance No. 06-08 of 15-7-2006), the main incentive supports to promote national and foreign investment in renewable electricity generation are defined below:

- Investment projects at the achievement phase (incentive supports are granted for 5 years at most):
- The equipment, machinery, materials and services imported, or purchased from the local market, are exempt from customs duties and Value Added Tax (VAT).
- Exemption from all fees due for the registration and transfer of real estate property necessary to achieve the investment project.
- For 10 years, the investors are exempt from the land tax related to the real estate used in the production process.
- The investors do not pay any fees on the registration of the Articles of Incorporation and the increase of capital.
- Investment exploitation phase (the incentive supports are granted for 10 years):
- Exemption from tax on company profits (IBS) and the tax on turnover (TAP).
- The investors could benefit from other sets of advantages granted by the National Investment Council (CNI).
- The investors benefit from a reduction of 50% on the annual rental fee set by the state property department.
- Goods and equipment included in the production process are exempt from customs tax and VAT.

4.5. Tender and Auctions:

The implementation of the solar program was clarified through Executive Decree No. 17-98 of 26 February 2017. This Executive Decree provides the legal basis for tendering of renewable and cogeneration energies, and their integration into the national electricity supply system. It is worth noting that, although the electricity price premium policy has not been revoked, the newly enacted tender scheme is designed to become the standard procedure for launching RE projects in Algeria in the coming years.

The Decree sets out two types of requests for proposals for the development of renewable photovoltaic energy projects: requests for proposals to investors (appels d'offres à investisseurs) and requests for proposals by auction (appels d'offres aux enchères).

The first, the requests for proposais to investors (RPI), should be conducted at the initiative of the Minister of Energy (although they may delegate the process to a public body or a State-owned company), and it would be applied only to large projects, for previously determined quantities of REs. Likewise, the sites of projects are previously determined by the Minister of Energy, based on a proposal by the Gas and Electricity Regulatory Commission. The RPI must cover two components: the energy component and the industrial component.

The energy component includes the design, supply of equipment, construction, operation of facilities generating electricity from RE sources, and the marketing of the electricity produced. This component is divided into three batches of 1350 MW, each to be developed and financed through a Special Purpose Vehicle held by private investors (49%), and state-owned companies and/or Private Algerian Companies (51%).

The industrial component (also called industrial project) is defined as "an investment project for manufacturing equipment, used in the generation of RE sourced electricity and/or the supply of services". In this case, the bidder must submit an offer for the development of an Industrial Project that includes the establishment of one, or several, Algerian companies. The Algerian company (or companies) will be in charge of the construction, exploitation, and maintenance of manufacturing facilities (photovoltaic cell, modules, and inverter), including the marketing and sale of these industrial products. If bidders do not wish to personally invest in the Industrial Project, the Decree allows for their bid to be accompanied by a bid from a third party industrial investor, selected by the bidder. However, the Decree provides for the possibility of granting an exemption, by a joint decision of the Ministry of Energy and the Ministry of Industry, from the obligation to implement the Industrial Project requirement. The Ministers of Energy and Industry will be responsible for the selection of any public entities participating in the Industrial Project.

RPI will be launched in one step only. The bidders must submit technical and financial offers for the Energy Component and the Industrial Component, if relevant. Therefore, the Decree does not expressly address the possibility of a dialogue between the Algerian authorities and potential bidders before the submission of final bids. Nevertheless, although it is not clear, it seems that the negotiation (if any) of the project documents, including the PPA, would start upon selection of the preferred bidder.

The requests for proposals by auction (RPA) must be conducted at the initiative of the Gas and Electricity Regulatory Commission (Commission de Régulation de l'Electricité et du Gaz-CREG). The scope of the RPA includes the construction and operation of RE facilities generating 10 GWh to 20 GWh, and the sale of the electricity generated by these facilities. Additionally, it also includes the sale of annual quantities of energy generated by cogeneration facilities, with a nominal capacity not exceeding 1 MG. In this case, the Industrial Component is not required, and the sites are determined and acquired by the bidder. The selection of the preferred bidder is conducted by a special committee of the Gas and Electricity Regulatory Commission. Quantities of REs must be granted to the bidder with the lowest kWh price. Remaining quantities (if any), may be granted to the following-ranked bidders, until full allocation of the quantities, and provided the same kWh price applies.

In both cases, the electricity generated by the RE plants will be sold through PPAs to the state-owned utility, Sonelgaz, for a maximum period of 25 years, which is the sole utility responsible for the marketing of electricity in Algeria. In this respect, there is no model contract for the purchase of electricity.

In that context, the Algerian government launched the first solar tender in 2018. This tender aims to install electric power of 150 MW. To this end, all private investors were invited to submit their projects, in which the intended power per project should not surpass 10 to 50 MW, and to choose one of the proposal regions, located in the center and northern part of Algeria (Ghardaïa, Biskra, Ouargla, El Oued, Tendala and Nakhla) [21,22]. Nevertheless, this first tender has had limited success, as only eight technical proposals were received, with a combined capacity of 90 MW. The selected projects are to be developed on a build-own-operate basis and will be awarded 20-year PPAs.

5. conclusion:

Algeria has enormous RE potential. However, fossil fuels remain the main electricity generation source, with the country being the third highest CO₂ emitter in Africa. Likewise, Algeria is particularly vulnerable to climate change. Therefore, a set of actions related to the energy, forests, industry and waste sectors, have been programmed over the period 2015 to 2030, with the government action program giving priority to promote RE. In this sense, Algeria is committed to significantly promoting RE investment, during the period 2020 to 2030. Thus, by 2030, the production capacity of renewable electricity is projected to be 22,000 MW, representing 27% of total electricity generation. This paper analyzes the electricity consumption and the generation measures implemented in Algeria to reach the required energy mix.

In order to achieve the INDC electricity target, the Algerian government updated the Algerian Renewable Energy and Energy Efficiency Development Plan in 2015, envisioning the installation of 22,000 MW of RE by 2030, 4525 MW should be installed by 2020, with the rest during the 2021-30 period. The main RE source to generate electricity is programmed to be photovoltaic. The share of the solar photovoltaic in RE electricity production should be at least 61.70% by 2030.

Algeria has adopted a set of measures to promote the REs sector. Firstly, the Algerian government contributes to the development of new capacities, through the NFREC. Secondly, the Algerian government introduced a feed-in tariff systems (price premium) defining different bonuses from 2014, depending on the technology. Thirdly, the government also introduced several incentives to promote national and foreign investment in RE for electricity. Finally, and although the electricity price premium policy has not been revoked, a newly enacted tender scheme was designed to become the standard procedure for launching RE projects in Algeria in the coming years.

The established measures have led Algeria to start producing electricity from REs, mainly since 2015, and mostly photovoltaic energy. The greatest growth in installed capacity occurred between 2015 and 2017, before the tendering system was established. The first call has not had the expected results, mainly due to some established conditions. Therefore, it is recommended that the new calls be made taking into account some of the considerations of the bidders who finally declined on the first call.

In spite of the growth of REs in Algeria, the results of the applied measures are not sufficient to achieve the planned objectives, neither in terms of installed capacity, nor for the production of renewable electricity. In fact, the installed renewable capacity in the power sector in 2018 is much lower than the established targets. The best results are obtained for photovoltaic energy, but it does not reach 14% of the 2020 target. Likewise, the objective of producing electricity from renewable sources is also far from being achieved, since in no case does it reach 3% of total electricity generation.

Part of the difficulty in achieving this last objective may be related to the growth in electricity demand that has caused a growth in electricity generation, which, in turn, has been covered by the increased use of fossil energies. Thus, the Algerian government seems to remain committed to an energetic model based on fossil energies, due to the country's important endowment of this resource. Therefore, in order to meet the proposed targets, a more proactive attitude of the authorities in favor of RE is necessary, and at the same time, a greater impulse is needed to control the growth of demand, through energy efficiency measures and greater price liberalization.

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