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# Measures to Promote Renewable Energy for Electricity Generation in Algeria

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**Abstract:** Algeria has enormous renewable energy potential. However, fossil fuels remain the main electricity generation source, and the country is the third largest CO<sub>2</sub> emitter in Africa. Algeria is also particularly vulnerable to climate change. Therefore, a set of actions related to energy, forests, industry and waste sectors have been programmed, over the period 2015–2030, and the government action program has given priority to promote renewable energy. In this sense, Algeria is committed to significantly promote investment in renewable energy, during the period 2020–2030. Thus by 2030, renewable electricity production capacity will achieve 22,000 MW, representing 27% of total electricity generation. This paper analyzes the electricity generation measures implemented in Algeria to reach the required energy mix, the legislative framework, financial aid, the feed-in tariff system, the tax incentives, and the tender and auctions undertaken. The analyses reveal that, although the electricity price premium policy has not been revoked, the newly enacted tender scheme is designed to become the standard procedure for launching renewable energy projects in Algeria in the coming years.

**Keywords:** renewable energy; electricity generation; Algeria; renewable energy action programs; financial aid; tax incentives; feed-in tariff system; energy mix

## 1. Introduction

Algeria has enormous renewable energy (RE) potential. It possesses high solar potential, with more than 3000 hours of sunshine per year [1,2]. 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 CO<sub>2</sub> emission growth [3–6]. The use of gas and fossil fuels in economic activities leads to the emission of an important amount of CO<sub>2</sub> (carbon dioxide) into the air, which contributes to the greenhouse effect [7]. Consequently, Algeria is the third highest CO<sub>2</sub> emitter country in Africa, and one of the most important among developing countries. It emitted 147 MtCO<sub>2</sub> in 2014, and was 34th in the list of countries with fossil fuel emissions from gas flaring [8].

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 [1]. For those reasons, Algeria is interested in developing the COP21 (Conference of the Parties) agreement. In fact, it was one of the developing countries which first submitted the Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change.

In that context, the Algerian strategy to mitigate global climate change was built on the balance between sustainable development and international climate commitments. The government action program has given priority to promote RE in the electricity sector, with a view of reaching an adequate energy mix. The aim of this paper is to present and analyze the measures which have been implemented, with a view to reaching the required energy mix, and achieving sustainable development in Algeria.

Some previous research has focused on the energy situation in Algeria. Some of them refer to specific technologies, such as the studies by Kaid et al. [9] and Sahouane et al. [10] related to photovoltaic, Nacer et al. [11] related to wind energy, and Akbi et al. [12] referring to bioenergy. Some others analyze the Algerian RE development or its potential. In this respect, it is worth noting the studies by Himri et al. [13], Stambouli et al. [14] and Bouraiou et al. [15]. Others, such as Mourad and Avery [16], focused on the sustainability situation from an historical point of view. Finally, others have also analyzed energy policy and the promotion of RE. Among these could be mentioned the studies by Stambouli [17], Ghezloun et al. [18], and Sahnoune et al. [19]. However, these papers are outdated and do not include the policies and data of recent years, when the most important RE increases have occurred. Finally, it is also worth noting the recent study by Haddoum et al. [20] which includes energy policy questions, but does not review the RE policy measures adopted in the country. Based on previous research, the present study focuses on giving a detailed review of the measures applied in Algeria, to promote the use of RE in the electricity sector, and on assessing the extent to which the objectives set in the programs, approved by the government, are being met.

This paper is structured as follows. After the introduction, Section 2 gives an overview of the RE targets established in the INDC of Algeria and the Algerian national program to develop REs and energy efficiency. Section 3 analyzes the measures to promote RE use for electricity generation in Algeria. An analysis and discussion of the effectiveness of the measures adopted are presented in Section 4. Finally, Section 5 concludes.

## 2. Electricity Targets in the Algerian INDC and National Program to Develop REs and Energy Efficiency

Before starting to report the main targets related to the electricity sector in Algeria, it seems important to give an idea on the structure of the Algerian electricity market. Despite the suitable legislative framework, and the incentive measures granted to the private sector, electricity generation and distribution are guaranteed completely by the government company, Sonelgaz. According to the legislation in force, the Algerian electricity market is divided into four segments (see Figure 1). Electricity production is open to private and government companies. However, the private power producers are subject to the feed-in tariff agreement. Transmission and distribution are controlled completely by the subsidiaries of the government company, Sonelgaz.

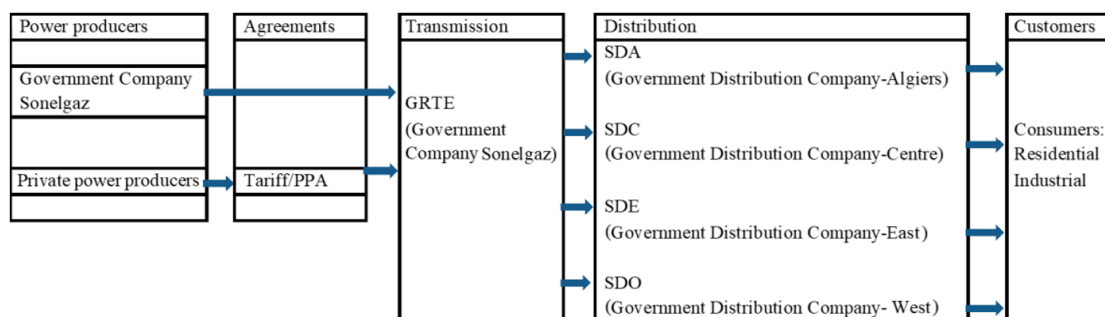


Figure 1. Structure of the Algerian electricity market. Source: Enerray [21].

### 2.1. The Intended Nationally Determined Contribution of Algeria

After a wide consultation, Algeria adopted a reviewed version of its INDC in 2015. As the fossil fuels are the main sources of electricity generation, Algeria has not hesitated to adopt a global strategy

to mitigate climate change, with a view to achieving sustainable development. In that context, Algeria's INDC reports the regulatory framework, government actions and incentive measures that should be implemented over the period 2021–2030, to fight against climate warming. Indeed, the proposed strategy is ambitious and aimed at significantly reducing greenhouse gas (GHG) emissions. Algeria's INDC concerns itself with three kinds of GHG emissions: CO<sub>2</sub>, Methane (CH<sub>4</sub>), and Nitrous dioxide (N<sub>2</sub>O). To approach the strategy, a set of investment projects will be reached in several activity sectors, such as energy, industry, agriculture and forestry, transport, construction and the environment. In fact, the cornerstone of this strategy is the energy sector, by adopting the program to promote RE and energy efficiency, in 2011.

Using endogenous efforts, Algeria has pledged to reduce GHG emissions by 7%, by 2030. However, with international support, especially financial aid in terms of technology and capacity building, the reduction of GHG emissions can increase from 7% to 22%, by 2030 [1]. The targets of Algeria's INDC, and the main actions which should be implemented in the different sectors, are summarized in Table 1.

**Table 1.** Targets of Algeria's Intended Nationally Determined Contribution (INDC) and the main intended actions (2021–2030).

Targets	Main Intended Actions (2021–2030)
Unconditional goal: <ul style="list-style-type: none"> <li>• With national efforts, the greenhouse gas (GHG) will be reduced by 7% by 2030.</li> </ul> Conditional goal: <ul style="list-style-type: none"> <li>• With international support in terms of financial aid, high technology transfer, and capacity building, the amount of GHG should be reduced from 7% to 22%, by 2030.</li> </ul>	Energy sector: <ul style="list-style-type: none"> <li>• Electricity generated from renewable sources reaching 27% by 2030.</li> <li>• Generalize high-performance lighting.</li> <li>• Thermal insulation of buildings between 2021 and 2030.</li> <li>• Increasing the share of liquefied petroleum and natural gas in the total energy consumption, between 2021 and 2030.</li> <li>• Reducing the volume of gas flaring to less than 1%, by 2030.</li> </ul> Waste: <ul style="list-style-type: none"> <li>• Waste valorization.</li> <li>• Organic and green waste.</li> <li>• Energy from landfill sites and waste water treatment plants.</li> </ul> Forestry sector: <ul style="list-style-type: none"> <li>• Forestation, reforestation and forest fires prevention.</li> <li>• Improving means and provide equipment to fight forest fires.</li> </ul>

Source: Own elaboration from Algeria's INDC submitted to United Nations Framework Convention on Climate Change (UNFCCC) [1].

## 2.2. The National Program to Develop Renewable Energies and Energy Efficiency

In 2011, Algeria adopted the Algerian Renewable Energy and Energy Efficiency Development Plan. The main objective of this national plan was to expand the usage of REs and to diversify the energy sources in the country. Initially, the plan was going to be developed in three stages. The deployment of the renewable electricity production program (12,000 MW), dedicated to the national market, was also going to be conducted in three stages. During 2011–2013, several pilot projects were to be undertaken in order to test different technologies. During 2014 to 2015, the program development was to begin. Finally, from 2016 to 2020, the large-scale deployment was to be developed.

Nevertheless, in 2015, the Algerian government updated the 2011–2020 program, envisioning the installation of 22,000 MW of RE by 2030. In this program, two sets of objectives were established. The first is related to RE promotion, and the second to energy efficiency [22,23]. The main aim of the RE program is to reach a share of about 27% RE in total electricity production by 2030.

The established RE targets are programmed to be achieved in two periods (2015–20 and 2021–30), by significantly promoting investment in all RE sources (photovoltaic, concentrated solar power (CSP), geothermal, wind, biomass and cogeneration). Table 2 shows the main RE targets for the electricity production in both periods. By 2030, it is expected to produce a total of 22,000 MW by using RE, with 12,000 MW devoted to the national market, and 10,000 MW to exports [22,24]. The production of this amount of RE implies that more than 300 billion m<sup>3</sup> of natural gas will be saved (this quantity represents eight times the national consumption of 2014) [25]. Additionally, this implies that 348 MtCO<sub>2</sub> equivalents of CO<sub>2</sub> emission could be reduced [26].

**Table 2.** RE targets for the electricity production of the Algerian national program of RE and energy efficiency (2015–30).

Energy Source	Electric Power					
	1st Period (2015–20)		2nd Period (2021–30)		Total (MW)	
	MW	%	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	

Source: Algerian Ministry of Energy-Program of renewable energy and energy efficiency and cogeneration [22].

To achieve the first stage targets, the Algerian government has already established a list of power plant projects, which should be built during the period 2011 to 2020. In total, 60 power plant projects were programmed, including 27 photovoltaic, to connect the north network, six solar thermal and seven wind generation plants [24,27]. In addition to these plants, Algeria has also included targets related to CSP, for the second period.

In addition to these RE targets, some energy efficiency targets are also included in the National Program in order to reduce GHG emission and energy consumption by 7% and 9%, respectively. These targets mainly refer to three sectors: the building, transport and industry sectors.

In the building sector, more than 30 Mtoe are supposed to be saved by 2030. This will be achieved through innovative technologies and thermal insulation of constructions. The thermal insulation of 100,000 homes per year, and the development of solar water heating, are programmed. In addition, the distribution of 10 million energy efficiency lamps and switching to light-emitting diodes (LEDs) will lead to savings of 7.2 and 20 Mtoe, respectively.

Finally, the industry sector is meant to contribute to saving 34 Mtoe by 2030. Basically, the industry sector will benefit from helping to realize the energy audits, which help organizations better manage their energy use, leading to improved productivity and therefore to achieving the energy management system (ISO 50001).

Likewise, it is worth noting that the national RE program also aims to promote technology and to adopt measures to help rationalize the endogenous consumption of electricity, increase the energy savings, and consequently decrease the energy losses, because the latter are estimated at 20% [28].

### 3. 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.

### 3.1. 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 main 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.

Table 3 summarizes the main regulatory laws adopted by Algeria to promote RE.

**Table 3.** Legislative framework to promote renewable energy (RE) in Algeria.

Law References	In Force	Main Objectives
Law No. 99-09 (28-6-1999)	Yes	<ul style="list-style-type: none"> <li>Define the contours of energy management policy, namely:               <ul style="list-style-type: none"> <li>Rationalizing the endogenous use of energy.</li> <li>Developing RE (solar energy, geothermal, biomass, hydroelectricity and wind energy).</li> <li>Reducing the impact of the energy system on the environment (reduction of greenhouse gas and urban exhaust gas).</li> </ul> </li> </ul>
Law No. 99-11 (2000 Finance Bill)	No	<ul style="list-style-type: none"> <li>Creating the National Fund for Energy Management (NFEM) and determining its functions (finance actions and projects included in the energy management and energy efficiency program).</li> </ul>

Table 3. Cont.

Law References	In Force	Main Objectives
Executive Decree No. 2000-116 (29-5-2000)	No	<ul style="list-style-type: none"> <li>Official implementation of the National Fund for Energy Management (NFEM).</li> </ul>
Law No. 02-01 (5-2-2002)	Yes	<ul style="list-style-type: none"> <li>Provides the legal basis which organizes electricity activities and gas by pipeline (production, transport, distribution and marketing).</li> <li>Defines the regulatory framework to:               <ul style="list-style-type: none"> <li>Promote RE and generalize its uses.</li> <li>Protect the environment.</li> <li>Fight against climate warming by limiting greenhouse gas emissions.</li> <li>Preserve and conserve fossil fuels.</li> </ul> </li> </ul>
Law No. 04-09 (14-8-2004)	Yes	<ul style="list-style-type: none"> <li>Promote RE and generalize its uses.</li> <li>Protect the environment.</li> <li>Fight against climate warming by limiting greenhouse gas emissions.</li> <li>Preserve and conserve fossil fuels.</li> </ul>
Law No. 09-09 on the Finance Bill 2010	No	<ul style="list-style-type: none"> <li>Provides the regulatory basis to create the National Fund for Renewable Energy and its functions.</li> <li>Determines financial resources (0.5% of oil royalties).</li> </ul>
Law No. 11-11 on the complementary Finance Bill 2011	Yes	<ul style="list-style-type: none"> <li>Provides the regulatory basis to create the National Fund for Renewable Energies and Cogeneration and its functions.</li> <li>Determines financial resources (1% of oil royalties).</li> </ul>
Executive Decree No. 11-423 (8-12 December 2011)	Yes	<ul style="list-style-type: none"> <li>Official implementation of establishing the operational modalities related to the National Fund for Renewable Energies and Cogeneration.</li> </ul>
Executive Decree No. 13-218 (18-6-2013) & Executive Decree No. 17-166 (22-5-2017)	Yes	<ul style="list-style-type: none"> <li>Determine the incentive measures to promote investment in RE (premiums for the costs of diversification of electricity production from RE).</li> </ul>
Law No. 14-10 2015 Finance Bill	Yes	<ul style="list-style-type: none"> <li>Closing the National Fund for Energy Management and transferring of its operations to the National Fund for Renewable Energies and Cogeneration.</li> </ul>
Ministerial decision (2-2-2014)	Yes	<ul style="list-style-type: none"> <li>Determines the guaranteed purchase rates related to electricity generation from solar photovoltaic.</li> </ul>
Executive Decree No. 17-98 (26-2-2017) & Executive Decree No. 17-204 (22-6-2017)	Yes	<ul style="list-style-type: none"> <li>Define the legal procedures for tendering to produce RE and cogeneration, and their integration into the national electricity system.</li> </ul>

Source: Official Journal of Algeria [29].

### 3.2. 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, which are summarized in Table 4.

**Table 4.** The National Fund for Renewable Energy and Cogeneration (financial resources and aid).

<b>The National Fund for Renewable Energies and Cogeneration</b>	
Financial resources	<ul style="list-style-type: none"> <li>• 1% of oil royalties each year.</li> <li>• The balance of the Account related to the National Fund for Energy Management.</li> <li>• Government subsidies.</li> <li>• Tax revenues from energy consumption.</li> <li>• Revenues from taxes on energy inefficient appliances.</li> <li>• The proceeds from fines provided in the Energy Efficiency Law.</li> <li>• The repayment proceeds related to unpaid interest-free credits.</li> <li>• Any other resources or contributions.</li> </ul>
Kinds of aid to finance RE related activities 1st set of financial aid: REs and cogeneration	<ul style="list-style-type: none"> <li>• Financing actions and projects included in the promotion of REs and cogeneration program:               <ul style="list-style-type: none"> <li>• Electricity generation projects from RE sources and/or cogeneration.</li> <li>• Purchase of equipment for electricity production from RE sources and/or cogeneration.</li> <li>• Over-costs compensation, arising from electricity generation from RE sources, and/or the cogeneration systems.</li> <li>• Pilot projects and demonstration operations relating to REs and/or cogeneration.</li> <li>• Actions to upgrade/maintain RE electricity installations generation.</li> <li>• Training actions related to REs and/or cogeneration systems.</li> </ul> </li> <li>• The allocations for the pre-financing of actions related to the promotion of REs and cogeneration.</li> </ul>
2nd set of financial aid: Energy management	<ul style="list-style-type: none"> <li>• Financing actions and projects included in the energy management program.</li> </ul> <p>Actions included in the Energy management program:</p> <ul style="list-style-type: none"> <li>• Requirements conformity, norms and energy efficiency labels.</li> <li>• Awareness, communication, information, education, promotion, co-ordination and training in the field of energy management.</li> <li>• R&amp;D in the field of energy management.</li> <li>• Accompaniment of industrialists in order to improve the energy efficiency of equipment.</li> <li>• Actions and works to evaluate energy efficiency potentials in the different activity sectors.</li> <li>• Animation and co-ordination of energy management.</li> <li>• Production and monitoring of the energy management program.</li> <li>• Management and monitoring of energy audits.</li> <li>• Instruction, monitoring and control of projects financed by the resources of the National Fund for Energy Efficiency.</li> <li>• Evaluating the impact of projects on energy consumption.</li> <li>• Production, publication and diffusion of the energy efficiency indicators.</li> </ul> <p>Projects included in the Energy management program:</p> <ul style="list-style-type: none"> <li>• Thermal insulation of buildings.</li> <li>• Use and diffusion of high-performance lamps.</li> <li>• Efficient public lighting.</li> <li>• Diffusion of individual and collective solar water heating.</li> <li>• Conversion of vehicles to Liquefied Petroleum Gas and Natural Gas.</li> <li>• Acquisition and conversion of buses to Natural Gas.</li> <li>• Introduction of efficient equipment in all activity sectors. Assistance for the decision on energy audits and project feasibility.</li> <li>• Pilot operations and demonstrations.</li> <li>• The Banks grant interest-free credits to investors in energy efficiency, which are not included in the energy management program.</li> <li>• The government is the guarantor of Bank credits.</li> </ul>

Source: Official Journal of Algeria [29] (O.J. No. 69, 27 December 2015; and O.J. No. 31, 28 May 2017).

### 3.3. 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 5.

**Table 5.** Financial aid granted to producers of solar thermal energy. with the solar-gas hybrid 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%

Source: Official Journal of Algeria [20] (O.J. No. 33, 23 June 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 6 summarizes the feed-in tariff associated with the different duration of exploitation and amount of electricity production.



**Table 6.** Feed-in tariff associated with renewable electricity generation in Algeria.

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

Source: MEDENER/OME [31].

### 3.4. 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.

### 3.5. 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 proposals 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.

## 4. Effectiveness of the Energy Policies

### 4.1. Methodological Framework

Recently, several researchers have been focusing not only on the study of the measures applied to encourage the use of REs in different countries, but also of the effectiveness of these measures. Most of the studies carried out are qualitative. For example, the early study by Gan et al. [32] referred to Europe and the USA. Nevertheless, others have tried to measure the effect of these policies in some way. In some studies, the evolution of the weight of REs in total energy generation has been analyzed since the energy policies were launched. For example, Cansino et al. [33] analyze the effect of tax incentives to promote renewable electricity generation in the European Union countries. Likewise, Pablo-Romero et al. [34] analyze the effect of feed-in-tariffs, premiums and tenders to promote the use of biogas to generate electricity in Europe. These studies, in addition to analyzing the growth of electrical energy generated from RE since the implementation of RE promotion measures, also analyze the degree of compliance with the initially set objectives.

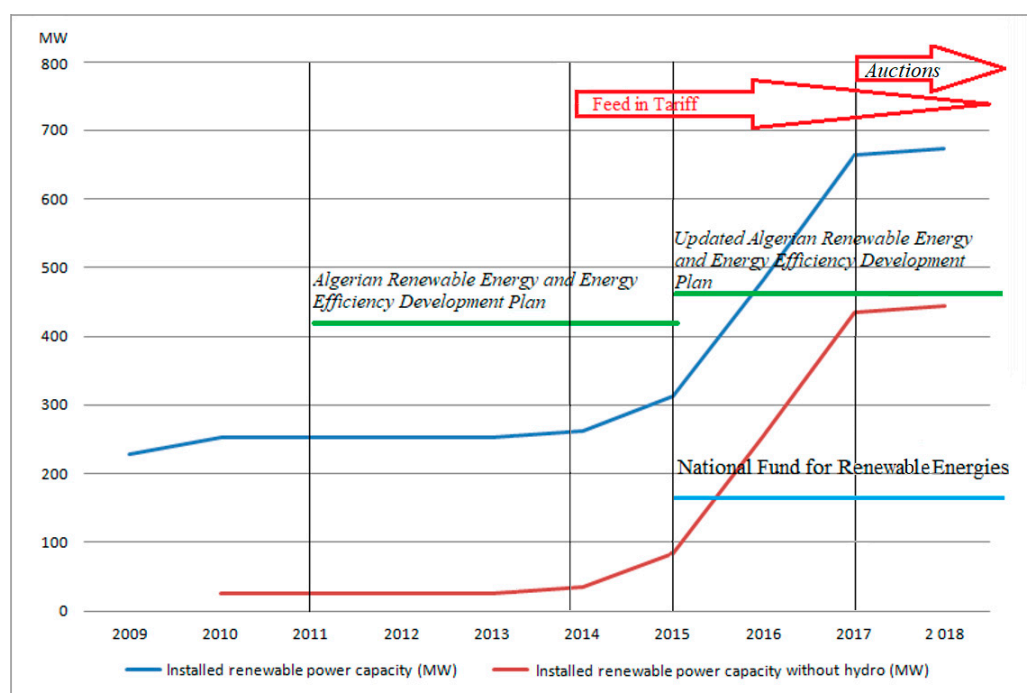
Finally, some studies have gone further and have analyzed the effect of RE policies by using regression analysis. In this regard, it is worth highlighting, for example, the studies by Dong [35], Zhao and Wang [36], Liu et al. [37], and Schmidt and Sewerin [38]. All these studies use panel data referring to countries that have been applying measures to promote the use of RE for years, having increased the scale of RE use in a stable manner. However, the regression methodology is not applicable when analyzing the effect of recent policies in countries that are starting their promotion of REs, such as the case of Algeria. However, some questions related to the methodology used in these studies are of interest in the case of Algeria. Firstly, it is worth noting that, in these studies, the dependent variable used to measure the impact of the energy policy is related to RE capacity, more than the electricity generated by using REs. Secondly, these studies take into account that, not only the specific policies employed can affect the evolution of REs, but also other economic or political variables. Thus, in their regressions, they take into account the effect of production and the international commitments acquired, such as the signing of the Kyoto protocol.

Taking into account these previous studies, to analyze the effect of the policies used in Algeria, the evolution of both electricity generated by REs and installed capacity, both in absolute and relative terms, is analyzed. Likewise, the evolution of the degree of fulfillment of the objectives set until 2020 is analyzed. The data obtained are related to the effective dates of the different measures approved by the Algerian government.

### 4.2. Analysis Results and Discussion

Figure 2 shows the evolution of installed renewable power capacity related to the start dates of the main programs and measures adopted to promote REs in the electricity sector. The first renewable project was initiated in 2010. It was a hybrid solar power plant which combined 25 MW CSP with a 130 MW turbine plant. Since 2014, there has been a growth in capacity that coincides with the implementation of the feed-in tariffs scheme. However, it can be observed that the greatest growth in installed electrical capacity is from 2015, when the Algerian energy plan was renewed. It also coincides with the implementation of the RE fund. It is also worth noting that growth of installed capacity, since 2015, is related to the photovoltaic solar source, which accounts for higher feed-in tariff prices. The growth of installed capacity continues until the end of the period for which there is available data. However, since 2017, it seems that there is a certain stagnation, which in turn coincides with the entry into force of the auction system. It is worth noting that although the Decree that provides the legal basis for tendering was published in February 2017, it was not until 2019 when the first call for tender took place, the results being also lower than expected. Therefore, the establishment of this new system may have produced some uncertainty or disincentive that has slowed the growth of renewable facilities. Some authors have pointed out that poor auction design can be responsible for inefficient

outcomes. In this regard, for example, Del Río and Linares [39] and Keay and Robinson [40], have considered that bad designs can occasion low effectiveness, as in Algeria.



**Figure 2.** Evolution of installed renewable power capacity related to main programs and measures adopted to promote REs in the electricity sector. Source: Own elaboration from International Renewable Energy Agency (IRENA) database [41].

The growth of installed capacity can be considered insufficient if we relate it to the national program of RE target for 2020. With available data from 2018, installed renewable capacity in the power sector is much lower than the established targets. Table 7 shows both values for each energy source. As can be observed, in 2018 the targets are far from being met, especially those related to wind energy and other technologies apart from photovoltaic. Therefore, the result of the measures put into operation by the Algerian government can be considered very inadequate if they want to reach the commitments of their own program and, therefore, the targets of Algeria's INDC.

**Table 7.** Installed RE capacity and RE targets for the electricity production of the Algerian national RE and energy efficiency program (2015–2030).

Power Sector			
Energy Source	Targets for 2020 in MW	2018 Installed Capacity in MW	% of Target
Photovoltaic	3000	410	13.7%
Wind power	1010	10	0.99%
CSP in hybrid solar power		25	
Others	515	0	
Total	4525	445	9.83%

Source: Algerian Ministry of Energy-RE and energy efficiency and cogeneration program [22] and International Renewable Energy Agency (IRENA) [41].

The effectiveness of the measures established in Algeria can also be assessed, based on the growth of electrical energy generated from RE. Table 8 shows that the percentage of electricity production from RE in 2017 (the last year for which data is available) was clearly below the target set for 2030,

which is set in the INDC at 27%. This low value is obtained when the RE from hydraulic energy is not taken into account. It can be seen that, in the best of cases, in six years, only the percentage of 2011 has increased by 1.05 percentage points. That is, 0.175 points annually. This means that, if the same rate is maintained until 2030, the percentage reached would be only 3.25%, very far from the target.

**Table 8.** Electricity production, consumption, and socio-economic factors.

Electricity Generation and Consumption (GWh)	2011	2015	2017	Growth Rate 2011–2017
Total electricity production (GWh)	51,397	68,798	76,018	47.9
Electricity production from RE (GWh)	481.3	340.2	1008.7	109.6
Electricity production from RE (% total)	0.94	0.49	1.33	
Electricity production from RE without hydro (GWh)	103.1	194.9	952.7	824.1
Electricity production from RE without hydro (% total)	0.20	0.28	1.25	
Installed electricity capacity (MW)	11,389	17,200	20,963 *	84.06 **
Installed electricity capacity from RE (MW)	253	317	673 *	166
Installed electricity capacity from RE (% total)	2.22	1.84	3.20	
Installed electricity capacity from RE without hydro (MW)	25	84	445 *	1680 **
Installed electricity capacity from RE without hydro (% total)	0.20	0.48	2.12	
Electricity consumption (GWh)	35,867	50,153	56,377	57.2
Electricity consumption in the residential sector (GWh)	12,915	19,672	21,776	68.6
Electricity consumption in the industrial sector (GWh)	13,138	17,441	20,182	53.6
GDPpc	4524.6	4777.3	4793.9	6.0
Population	36,661,444	39,728,025	41,389,198	12.9

\* value for 2018 \*\* growth rate 2011–18 Source: International Renewable Energy Agency (IRENA) [41] and World Bank database [42].

Part of the difficulty in reaching the target can be explained by the growth in non-renewable power generation, which in turn can be explained by the need to meet a growing electricity demand. In fact, electricity consumption in Algeria has experienced a large increase, higher than that observed worldwide. This growth in demand could be related to the growth in economic activity, and the high population growth rate [28]. Nevertheless, as can be observed in Table 8, the growth rates of these socio-economic indicators are much lower than those for electricity generation and consumption. Therefore, the growth in electricity consumption, and consequently the need for growth in generation, also reflects a change in the way of producing industrial goods and a change in consumer behavior that drives electricity demand, which could also be explained by the highly subsidized low electricity prices [43,44]. All of this in turn leads to the inefficient use of electricity. Thus, RE promotion measures must in turn be accompanied by rationalization in the use of electricity if it is desired to achieve the proposed objectives. This is especially the case, as the electricity demand is expected to more than double by 2030 [45]. As stated in Haddoum et al. [20], it becomes necessary to promote REs accompanied by energy efficiency measures, for which price signals are necessary. In short, the growth in electricity demand may be making it difficult to achieve the renewable targets set by the Algerian government, so greater effort, both in renewable promotion and energy efficiency, will be necessary if the proposed objectives are to be achieved.

The growing demand for electricity has necessitated the growth of electricity generation and the increase in installed capacity. As shown in Table 8, between 2011 and 2018, installed capacity grew by 84.06%, increasing by more than 9500 MW throughout the period. Thus, although the renewable power capacity has higher growth rates (increasing 420 MW), the percentage values are still very low, little more than 3% of total capacity when including hydroelectricity. This signifies that only around 4.5% of the increased capacity has come from renewable technologies. Therefore, and taking into account that the electricity market is controlled by the national Sonelgaz group, it seems that the Algerian government continues to focus on an energy model based on fossil fuels, due to the important endowment in this resource. In this sense, and according to Bouraiou et al. [15], it is recommendable that the national authorities improve the conditions for implementing the renewable program, including means to facilitate private investment, especially in the calls for tender. In short,



as stated in Sun and Kim [46], it is necessary to adopt a more proactive attitude in order to achieve the proposed objectives of energy sustainability.

## 5. Conclusions

Algeria has enormous RE potential. However, fossil fuels remain the main electricity generation source, with the country being the third highest CO<sub>2</sub> 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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