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EXPLOITATION OF SOLAR ENERGY BETWEEN THE GERMAN LEADERSHIP AND THE REALITY OF THE ALGERIAN EXPERIENCE: ANALYTICAL STUDY DURING THE PERIOD (2000-2017)

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ABSTRACT

This study aims to reveal the reality of the Algerian experience in the exploitation of solar energy, considering that Algeria is a large country in terms of space and climate capabilities that allow it to attract this kind of renewable energies. The study also observes the German experience in this field in order to benefit from it; thus, it relied upon the analytical descriptive approach. The results of the study showed the limited exploitation of this type of energy in Algeria. Despite the gradual improvement in the use of solar energy, mainly since 2015, this improvement is not as expected as it recorded an output of 244.1 MW in 2016, and the output did not exceed 400 MW until the end of 2017. This is despite the tendency of Algeria in activating and assimilating solar energy and developing its exploitation as an alternative energy for fossil energy, which comes as a priority within the National Renewable Energy Program 2015-2030. The results of the study also showed the high level achieved by Germany in the exploitation of solar energy despite the obstacles encountered where the country is cloudy. Germany's solar power capacity reached 40988 MW in 2016 after it was within 114 MW in 2000. This would not have been achieved in Germany in the absence of the promotion of investment in renewable solar energy and consumption, where the growth rate of solar energy consumption reached about 9% in 2016, but in Algeria remains very modest, as less than 0.05%.

Contribution/Originality: The paper's primary contribution is giving a clear vision about the possibility of strengthening the partnership between Germany's technical development as the largest generator of electric energy from sunlight in the world, and Algeria's abundant potential as the largest solar energy reservoir in the world.

1. INTRODUCTION

Against the backdrop of the serious and scientifically justifiable consequences of climate change (temperature rise, floods, droughts, Arctic ice melting and the extinction of species), and in light of the increasing global consumption of conventional energy sources, renewable and environmental alternatives energy are becoming increasingly important. For instance, air, water, sun, biomass and geothermal heat, are all available energy sources without limits, and do not cause any harmful gases to the environment. One of the most important types of renewable energy is the solar energy. The energy that the sun provides for earth in just one hour exceeds that of the energy used in the entire year all around the world. Furthermore, the use of the sun as an energy source is not

modern, but today it is among the alternative sources of oil, on which future hopes are held, since it is a clean and inexhaustible energy.

Renewable energies have been increasing in the world since 2009, with an annual growth rate of 8-9% recorded at record levels by the end of 2016, with a growth rate of 8.7% in 2016. The renewable energy installation capacity reached a record level of 2006 GW according to the International Renewable Energy Agency (IRENA), which is derived mainly from solar energy by 32% and 12% of wind power. According to the International Energy Agency (IEA) forecasts published in 2017, renewable energies will grow by 43% in 2022 thanks to new solar PV installations in China and India. Moreover, according to the same report, in the five coming years, solar PV will enter a new era of lower prices, vibrant markets especially in China, improvement of the preferred policies for widespread solar energy deployment (International Energy Agency (IEA), 2018).

In this context, we find many countries that are interested in developing this source, setting it up as a goal to achieve (Sami and Marin, 2019). One of these countries is Germany, which is one of the leading countries in this field. Algeria is also one of the world's most abundant of natural and energy resources, with a huge potential of renewable energies as solar energy. Although, statistics indicate a significant difference between the two countries despite the varying possibilities. In 2016, Germany's growth rate of energy consumption from renewable solar energies was estimated at 9%, while in Algeria it was less than 0.05% (BP Statistical Review of World Energy, 2017). The key role played by German solar panel factories in employment cannot be ignored; they have contributed to the creation of 38000 jobs in 2015 (Renewables Global Futures Report, 2017). On the other hand, solar power centres in the Algerian desert are often projects and hopes (Atmania, 2015). In particular, Algeria has not given the necessary importance to renewable energies as a ministry for the environment and renewable energies was established only in 2017, with a solar energy group of 15 entities, including economic enterprises and entities in the research and development sector.

Through this research paper, we will try to highlight the potential of solar energy of both countries, and the reality of exploiting this energy source in each of them. In addition to the challenges faced by Algeria in this field; as well as, the lessons learned from the German experience through a comparative study between the two countries.

Thus, the present study aims to identify:

- The potential of solar energy in both Algeria and Germany by comparison.
- The relative importance of solar energy compared to other renewable energy sources in Algeria and Germany.
- Solar energy efficiency in Algeria and Germany.
- To illustrate the reality of solar energy exploitation in Algeria and Germany by comparison.
- Highlighting the factors of Germany's success in exploiting solar energy, and making the latter the key to its success in generating renewable energies.
- The search for obstacles to the optimal exploitation of solar energy in Algeria.
- Explore ways of German-Algerian bilateral cooperation to ensure increased and directed efforts to strengthen the global standing of the two countries.

2. METHODS

The exploitation of solar energy in Algeria is a very recent topic, considering that Algeria has the largest solar fields on one hand, and on the other, it is dependant on depleted oil, which is threatened by prices falling on the world market.

The present study aims to highlight the advantages of solar energy, and to crystallize the reality in Algeria, as well as showing the experience of solar energy in Germany, which is a leader in this field; therefore, Algeria can benefit from it.

In order to achieve the objectives of this study, we used the comparative approach to compare the possibilities of the two countries of Germany and Algeria in terms of solar energy and exploitation, using the descriptive and analytical approach to describe these possibilities and analyze the results of the study.

3. LITERATURE REVIEW

The sun is the origin of all sources of energy, it can also provide energy directly. It is understood that at the time when the search for solutions to the energy crisis arose, environmentalists believed that this energy must be exploited directly (Ozuomba *et al*., 2019). This is just as it did at the end of the 1970s because of the two oil shocks; however, the petroleum counter-shock of the 1980s led to a slowdown in research and the use of solar energy was confined to domestic heating only. However, technical development and rising oil prices in recent years have led to the resurgence of solar energy. This energy is used to generate heat and electric power (Merlin, 2008).

Solar energy, radiation from the Sun, is capable of producing heat, causing chemical reactions, or generating electricity. The total amount of solar energy incident on Earth is vastly in excess of the world's current and anticipated energy requirements. If suitably harnessed, this highly diffused source has the potential to satisfy all future energy needs. In the 21st century, solar energy is expected to become increasingly attractive as a renewable energy source because of its inexhaustible supply and its nonpolluting character in stark contrast to the finite fossil fuels, coal, petroleum, and natural gas.

In the industrial countries, Solar energy contributes more and more in heating houses and providing sanitary hot water, yet it is the production of electricity sold to the network that develops rapidly. In developping countries, solar energy may be the main vector of electrification out of large cities (Bonal and Rossetti, 2011).

3.1. Types of Solar Energy

The basis of solar energy means the transformation of sunlight into thermal energy or electrical energy; therefore, we can draw the following two types (Planete Energies, 2014).

- Photovoltaic solar technology, which directly converts sunlight into electricity using panels made of semiconductor cells.
- Solar thermal technology, which captures the sun's heat. This heat is used directly (low temperature solar thermal) or converted into mechanical energy and in turn electricity, known as concentrated solar power (CSP).

3.2. Solar Energy Uses

The potential for solar energy is enormous, since earth receives about 200000 times the world's total daily electric-generating capacity every day in the form of solar energy. Unfortunately, though solar energy itself is free, the high cost of its collection, conversion, and storage still limits its exploitation in many places. Solar radiation can be converted either into thermal energy (heat) or into electrical energy, although the former is easier to accomplish.

3.3. The Importance of Solar Energy

The solar energy is one of the most important alternative sources of oil on which future hopes are held. "Bradford" finds that most alternatives to fossil fuels have their own problems. For instance, electricity generated by water has its own hidden environmental and social costs; for example, it usually leads to the displacement of large communities. Another example is nuclear energy that includes well-known safety and security issues. In addition, the widespread use of wind power has its limits, biomass energy requires a lot of water and soil, and hydrogen fuel cells are very costly.

Solar energy, on the contrary, is relatively simple and uncomplicated compared to the technology used in other energy sources. It provides the environmental safety factor since solar energy is clean and does not pollute the

atmosphere, thereby gaining a status in this area. In addition to the foregoing, solar energy has important advantages that cannot be ignored or overlooked:

- Its material and environmental requirements are highly available in the Arab world (Salami *et al.*, 2017).
- It probably needs a big capital at first, but it does not need raw materials due to their availability in nature.

Considering the advantages of solar energy that we have already mentioned, we find many countries, including Germany, which are interested in developing this source and setting it up as a goal to achieve.

4. RESULTS AND DISCUSSION

4.1. The Experience of Solar Energy in Germany

Despite its late entry into the field, Germany today is one of the leading countries in renewable energies, covering 15% of its electricity needs from a variety of energy sources, including wind, sun, and biomass. However, only solar energy will be addressed through the following points:

In Germany it rains throughout the year and clouds cover the sky about two-thirds of daylight hours; However, Germany has been able to become the largest generator of electricity from sunlight in the world. A promising new industrial sector for the future has emerged in Germany, which is called the solar energy industry sector. Thanks to the law of renewable energy sources (EEG), this sector has been achieving tremendous growth rates for a few years. The size of German solar technologies has increased in a few years from about 450 million euro to nearly 4.9 billion euro. Moreover, the number of workers directly or indirectly in this sector has reached more than 50000. The number of jobs will reach 200000 by the year 2020 (World Nuclear Association, 2019).

The number of German households seeking to secure their energy needs through solar compounds and photovoltaic cellsis is constantly increasing, as confirmed by a recent study on the consumption of private houses, prepared by the institute "the Rynenfestivalia" for RWI economics research in Essen and the institute of opinion reconnaissances commissioned by the German Ministry of Economy. In 2006, there were 800000 solar complexes ready-made in Germany in which water is heated and the required heating is provided for about 5% of inhabited German houses. The German government's earnest desire to achieve energy transition with a focus on solar energy as well as wind energy, and to work towards achieving its goals through the provision of all possibilities. Thus, Germany has been placed at the forefront of the European Union (EU):

- It was the first place for two years (2011 /2012) in terms of photovoltaic solar additive with a capacity of 7490 and 7604 (MW). Germany dominated the solar energy market in Europe by 33.3% and 45, 55%;
- It was the first for two consecutive years (2011/2012) in terms of accumulated solar photovoltaic power. Germany was able to reach 25094 (MW) in 2011 and 32698 (MW) in the year after.
- It was the first for two consecutive years (2011/2012) in terms of the amount of electricity generated from solar energy. The total power generated from this source in all EU countries estimated as 45341.5 (GWh) in 2011 while its 2012 realized counterpart reached 67084.3 (GWh). Germany accounted for 42.65% and 39.32% respectively.
- It was the first for two years (2011/2012) in terms of accumulated concentrated thermal solar energy of 10644 (MWth), 11416 (MWth).

4.2. Factors of Solar Energy Boom in Germany

There is no doubt that the prosperity of solar energy in Germany has not come from a vacuum, as it was not by chance, but by the availability of many factors. Perhaps the most important of which are:

- *The Renewable Energy Sources Act in Germany*: In an effort to encourage the expansion of renewable energy, the Renewable Energy Sources Act (EEG) was introduced in April 2000. In the wake of this legislation, Germany experienced an accelerated growth in the generation of power from renewables. The most impressive area of growth has been in wind power. Between the adoption of the 1991 Electricity Feed Act that required utilities to purchase electricity generated from renewables at a subsidized rate (introduced by the previous government) and the implementation of the EEG in April 2000, Germany had achieved an installed capacity of 4,500 MW. By the end of 2001, capacity had almost doubled to approximately 8,750 MW (BMU 2002: 14). At the beginning of 2003, over 12,000 MW of electricity was being generated by wind power, representing 3.5 per cent of all electricity consumption in Germany (Paul, 2007). The law aims to address climate change, reduce dependence on fossil fuels, and give monetary incentives to those who provide renewable energy sources.

This law, which many consider to be the new model of European and global energy policy, has laid the foundation for the development of the renewable energy industry with guaranteed investments (Googasian, 2006) The law helped Germany, which has rainfall and clouds during the year, in becoming the giant of solar chips industry in the world. The President of the company Solar Wolnike "Frank Asppec" considered that the law was the most important factor in supporting the solar energy market in Germany.

- *Interest in scientific research in the field of renewable energy*: Higher education institutions today have 144 specializations on wind power, solar and bioenergy technologies. Many masters programs are especially geared towards foreign learners to meet their demands and expectations.

4.3. The Algerian Experience's Reality in the Field of Solar Energy

Algeria first introduced solar energy in 1988 into the Southern project. It started preparing larger cities like Skikda and Oran with the adequate equipment to improve the potential of solar energy, which can be generated through either the installation of CSP (Concentrated Solar power Plant) system, or the PV (PhotoVoltaic) system (Hadji, 2016).

- *Solar energy fundamentals in Algeria:*Algeria has a fundamental advantage due to its location and its energy potential; it is a strong producer country of energy sources. As it will move into a new phase characterized by the exploitation of renewable energy and the initiation of export to Europe after few years; thus, Algeria proves itself once again as a stronger country that renews its productive and export capacities sustainably. It benefits through its privileged location of the sun, which represents a huge energy mine that exceeds five billion MW per year.

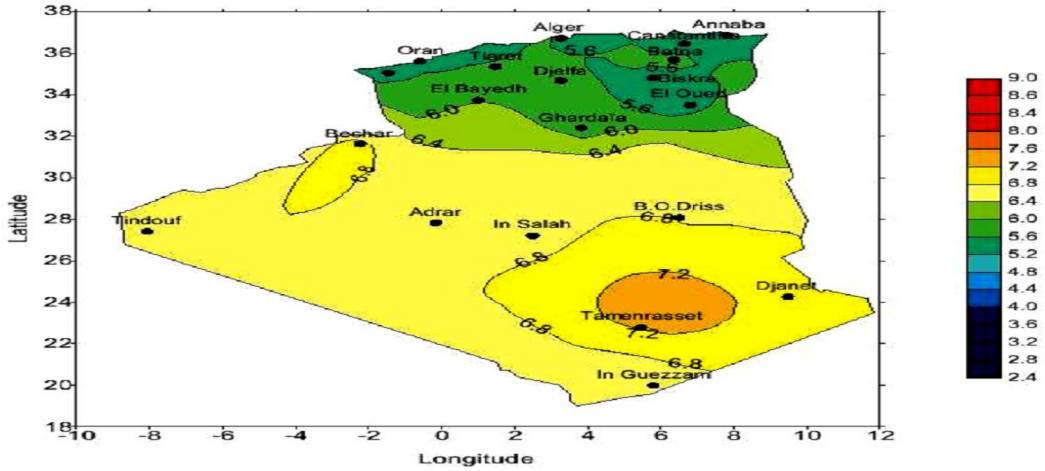

Figure-1. Annual average intensity of daily solar radiation in various regions of Algeria (KW/hrs/m² per day).
Source: Ministry of Energy - Algeria.

The potential of each area of solar energy can be extracted by multiplying the total energy available on average and the capacity of the sun on average; as well as, the area of the region. By collecting the three products, we find that Algeria receives a solar energy estimated at 169440 TW/hour, i.e. 5000 times of annual national consumption of electric power Figure 1.

After a recent study, the German space agency announced that the Algerian desert is the largest solar reservoir in the world. The solar radiation in the Algerian desert lasting 3900 hours a year, which is the highest level of sunshine on a global scale, as shown in Figure 2.

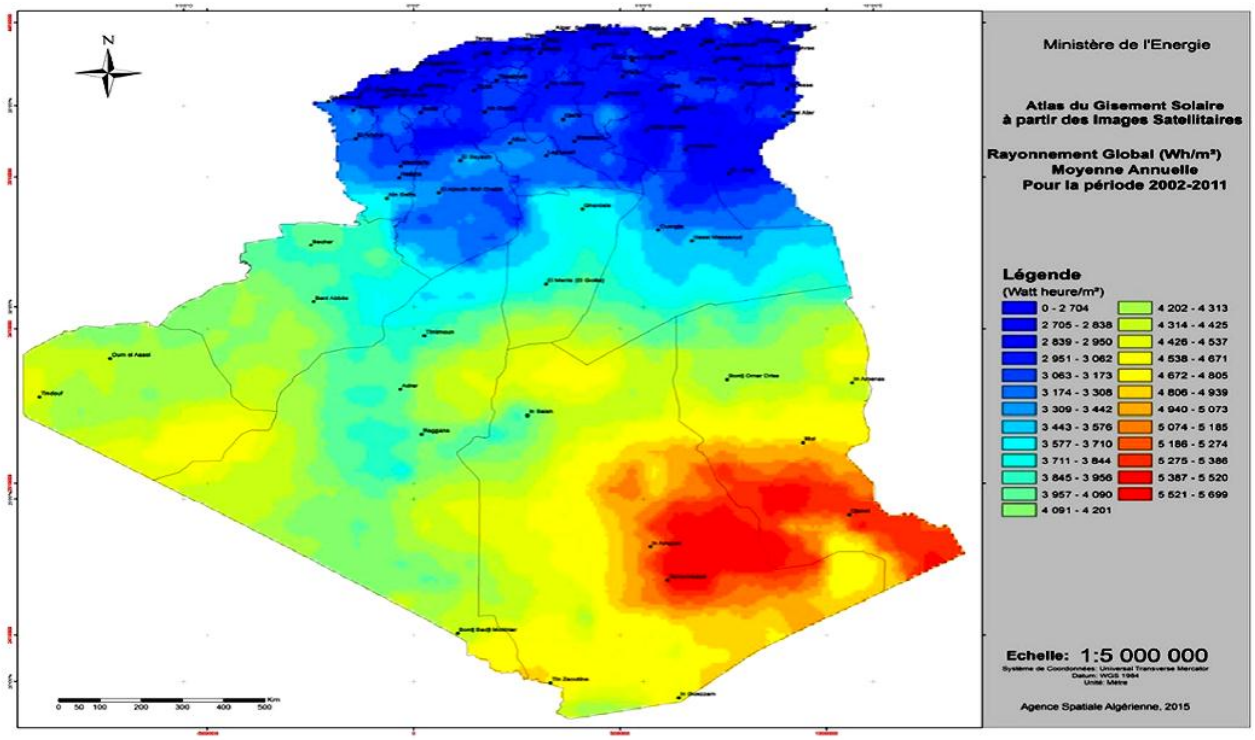

Figure-2. Annual average of solar energy received in Algeria for the period (2002-2011).
Source: Ministry of Energy - Algeria (2019).

In brief, Through Figure 1 and Figure 2, the importance of geographical location of Algeria, which has one of the highest solar potentials in the world, is evident. Solar radiation on the entire national territory is more than 2000 hours a year and can reach 3900 hours (in the highlands and desert). The energy received annually on a horizontal surface of approximately 1 square meter is almost 3 kw/m² in the north and exceeds 5.6 kw/m² in the south.

This prompted the agency to submit a proposal to the German Government on the establishment of investment projects in southern Algeria. On that basis, the two governments agreed in December 2007 to produce about 5% of the electricity from solar energy and transport it to Germany through a naval electric carrier via Spain. In addition to the project on the construction of solar panels in the Rouiba area, which came into production in 2012, with a capacity of between 50 and 120 MW per year. This trend is moving towards export with another local plan to produce 20% by 2020.

Algeria has the largest share of solar energy in the Mediterranean Basin, estimated at 4 times the world's total energy consumption, and 60 times the European countries' need for electric power. Therefore, Algeria has embarked on the establishment of a hybrid power plant, which is the first of its kind in the world; it works by combining gas and solar energy. Algeria also started the construction of three hybrid power plants of 400 MW, which will be intended for local consumption only; thus, activating energy will protect Algeria's gas stocks because its use in electricity production has drained about 48% of the reserves of gaseous energy. Therefore, reliance on

solar energy has become the solution, especially after the increase of the cost of electricity produced by natural gas, knowing that the amount of consumption in Algeria ranges from 25 to 30,000 MW per year, while 9130 MW per year can be used as solar cell energy (The Ministry of Environment and Renewable Energy, 2019).

- *Exploitation of solar energy in Algeria:* No less than 18 villages of the Great South and 3000 households of the steppic region benefited from solar electricity within the framework of the 1995/99 national electrification programme. A second operation of the same kind will be carried out within the framework of the 2005/2009 growth support programme, and will also concern the solar electrification of 16 villages in the wilayas of the High Plateaus and of the south of the country. Furthermore, another important programme has been realised on behalf of the steppic region of the High Plateaus, where more than 3000 households have been electrified with solar energy and benefit from solar and wind power-based irrigation equipment (The Ministry of Energy and Mines, 2008).

Despite the challenges, major works have already begun in more than 12 countries especially Germany, quickly putting the first electric-solar current in North Africa, which includes Algeria, to provide Europe with 15% of its sustainable needs. They more than 12 solar centers with an estimated production volume of 5 MW per centre in North Africa and the Middle East. The production of solar energy in Algeria stagnated during the period 2010-2014, where the production capacity reached only 25 MW, becoming 74.1 MW in 2015; however, 2016 saw a significant leap exceeding the barrier of 244 MW, with an annual growth rate estimated at 229.41%. As shown in Figure 3.

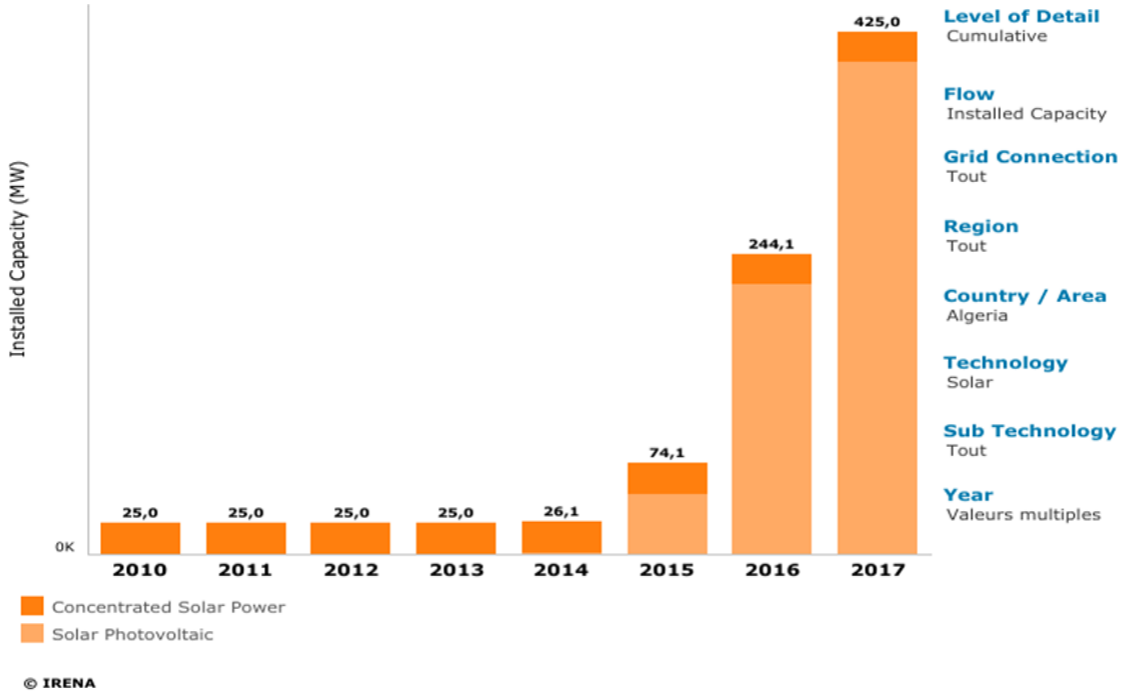

Figure-3. The development of solar energy production in Algeria (2010-2017).

Source: IRENA (2018).

When we do a simple comparison between Algeria and Germany in the field of solar energy exploitation, we find that German solar production capacity was 40988 MW in 2016, after being 114 MW in 2000. It experienced a strong growth at an average annual rate in 16 years (2000-2016) of more than 44.45%. This can be observed in Figure 4.

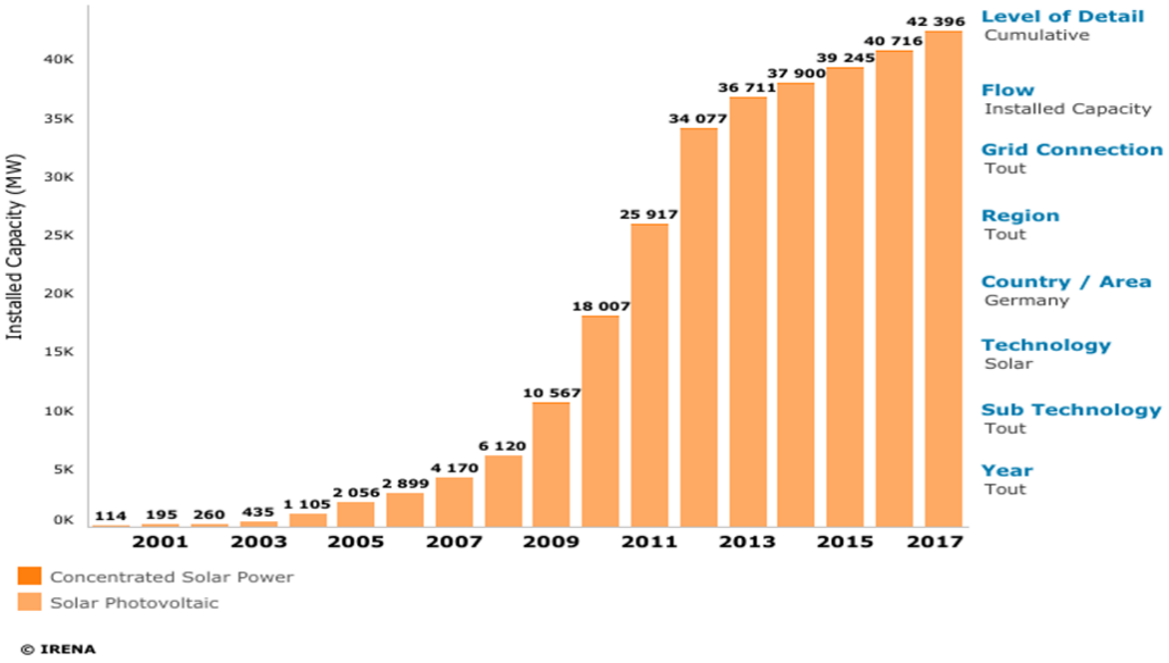

Figure-4. The development of solar energy production in Germany (2010-2016).

Source: IRENA (2016).

This is probably due to the significantly lower cost of manufacturing solar panels in the last decade, what made her find reasonable prices. As the prices of solar PV units in Germany have gradually declined from 3.129 dollars/W in January 2010 to 0.643 dollars/W in December 2015, noting that solar panels are almost 30 years old. As shown in Figure 5 (IRENA, 2016).

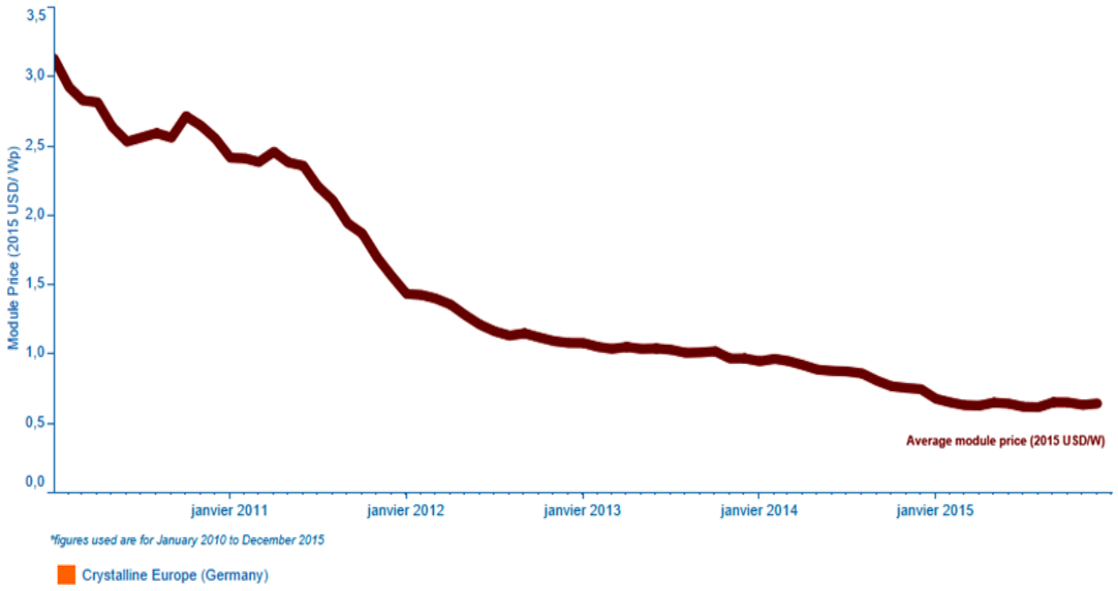

Figure-5. The evolution of the prices of solar PV units in Germany for the period 2010-2015.

The following is the huge program that Algeria is adopting in the 2030 horizon for the production of renewable energies.

- *Program of renewable energies in Algeria (2015-2020-2030):* Algeria has created a green momentum by launching an ambitious program to develop renewable energies (REn) and promote energy efficiency. This program leans on a strategy focussed on developing and expanding the use of inexhaustible resources, such as solar energy in order to diversify energy sources and prepare Algeria for tomorrow. Through

combining initiatives and the acquisition of knowledge, Algeria is engaged in a new age of sustainable energy use.

The program consists of installing up to 22000 MW of power generating capacity from renewable sources between 2011 and 2030, of which 12000 MW will be intended to meet the domestic electricity demand while 10000 MW is destined for export (MEM, 2011).

The program is distributed on the completion of 13575 MW photovoltaic solar energy, 2000 MW solar thermal energy, 5010 MW wind energy, 1000 MW biomass energy, 400 MW steam pressure and 15 MW geothermal energy. The distribution of this program by technology is as follows in Table 1.

Table-1. Algeria's renewable energies programme targets 2030.

Type of energy	Production
Solaire photovoltaïque	13575 MW
Eolien	5010 MW
Solaire thermique	2000 MW
Biomasse	1000 MW
Cogénération	400 MW
Géothermie	15 MW

Source: The Ministry of Energy and Mines.

The renewable energy program consistency to be achieved for the national market needs over the period 2015-2030 is 22000 MW, of which more than 4500 MW will be achieved by 2020 Figure 6.

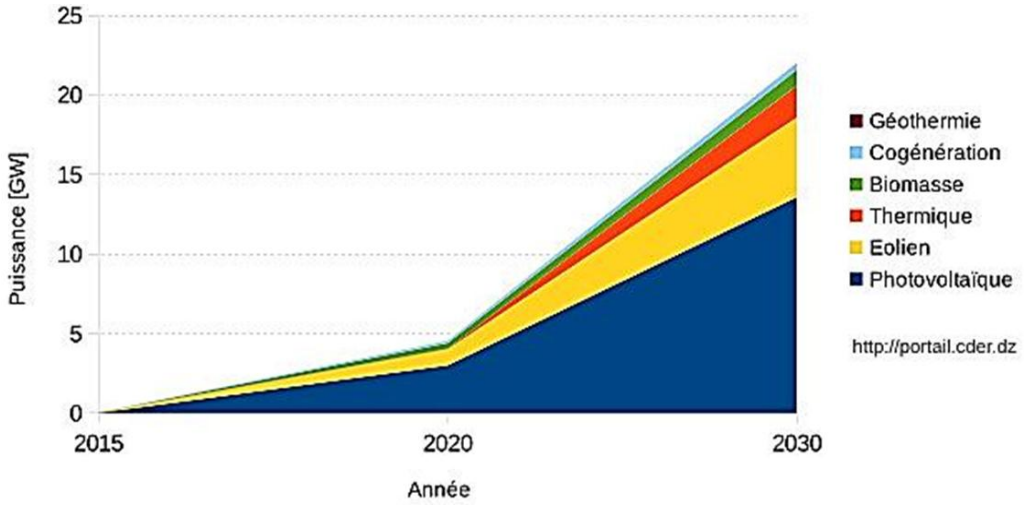

Figure-6. The phases of completion of the renewable energies programme in Algeria.
Source: IRENA (2018).

The implementation of the program will make it possible to achieve by 2030 a share of renewable energy of nearly 27%in the national balance sheet of electricity production.

The volume of natural gas saved by the 22000 MW in renewable energy, will reach approximately 300 billion m^3, representing a volume equivalent to 8 times the national consumption of 2014 (National Agency of Investment Development, 2017).

In addition, Algeria benefits from Germany through the implementation of cooperation between the two countries, where a declaration of energy partnership between them was signed in Berlin on March 26, 2015. This declaration aims to strengthen bilateral energy relations by establishing dialogue on various energy policy topics, such as diversifying the energy mix, developing renewable energies, improving energy efficiency (EE) and environmental protection.

As part of the implementation of this declaration, a steering committee and two objective working groups (RES and EE), represented by the governments and economic sectors of both countries, have been formed. The first session of the steering committee was held in Berlin on May 20, 2015, during which priority topics were discussed to be implemented. The second session of the steering committee of the Algerian-German Energy Partnership was held on the sidelines of the Fourth Berlin Energy Transfer Dialogue (BETD), which took place from 17 to 18 April 2018.

The first Algerian-German planning workshop was held in Algiers on 25 May 2016; however, the second meeting of the working groups "Renewable Energy" and "Energy Efficiency" took place on April 25, 2018, in Algiers, on the sidelines of the Algerian-German Day held on April 24, 2018 in Algiers.

To implement this partnership, an action plan for 2017/2018, jointly developed by the parties, with a timetable for implementation focuses on four objective priorities below in the areas of renewable energies and energy efficiency (Energy Ministry, 2018).

- Bilateral exchanges on energy policies.
- Developing and integrating renewable energy into the grid.
- Energy efficiency in industry.
- Energy scenario.

All in all, through these efforts, Algeria is seeking to position itself as a key player in the production of electricity from the photovoltaic and wind sector through the integration of biomass and cogeneration. Then, after 2021, it seeks to experiment with the exploitation of geothermal energy, not to mention the exploitation of solar energy, where these energy sectors become engines of sustainable economic development that can stimulate a new model of economic growth. The authorities' goal is to achieve 37% of installed capacity by 2030 and 27% of electricity production for domestic consumption will have a renewable origin.

The national potential of renewable energies is strongly dominated by solar energy, which Algeria sees as an opportunity and a means of economic and social development, particularly through the creation of industries that offer wealth and jobs. This does not rule out the launch of several wind farm projects and the implementation of pilot projects in biomass, geothermal and cogeneration.

Although Algeria has almost the largest solar field in the world, the use of solar energy remains limited. The main constraints and obstacles are the following.

- *Obstacles of Solar Energy Exploitation in Algeria*: The limited exploitation of solar energy in Algeria is due to a number of constraints, including the following:

- *Legislative and Institutional Constraints*:
- The inadequacy of legislation to support the diffusion of renewable energy (the availability of state land to investors at nominal prices, the obligation to purchase productive energy, and the reduction/exemption of equipments for the application of renewables from customs).
- Insufficient legislation to protect scientific creativity and encourage innovation.
- *Financial Constraints:*
- The exploitation of solar energy is financially costly because it is a new technology.
- The private sector is not motivated to invest (e.g. temporarily exempt from tax on profits for a certain period, provide state land to industrial enterprises at nominal prices, and facilitate administrative and banking procedures).
- The weakness of the banking system leading investors, whether foreign or local, to refrain from investing in the industrial sector.
- Weak budgets for scientific research activities in the field of renewable energy, where we find that Algeria registered only 70 patents as a cumulative total in the field of solar energy in 2016 (representing 0.002% of the total global patents in the field of solar energy that reached 317224 in 2016), after it was 40 in 2001.

From 2002 to 2016, Algeria recorded only one patent, unfortunately, according to the international agency for renewable energies, as shown in Figure 7.

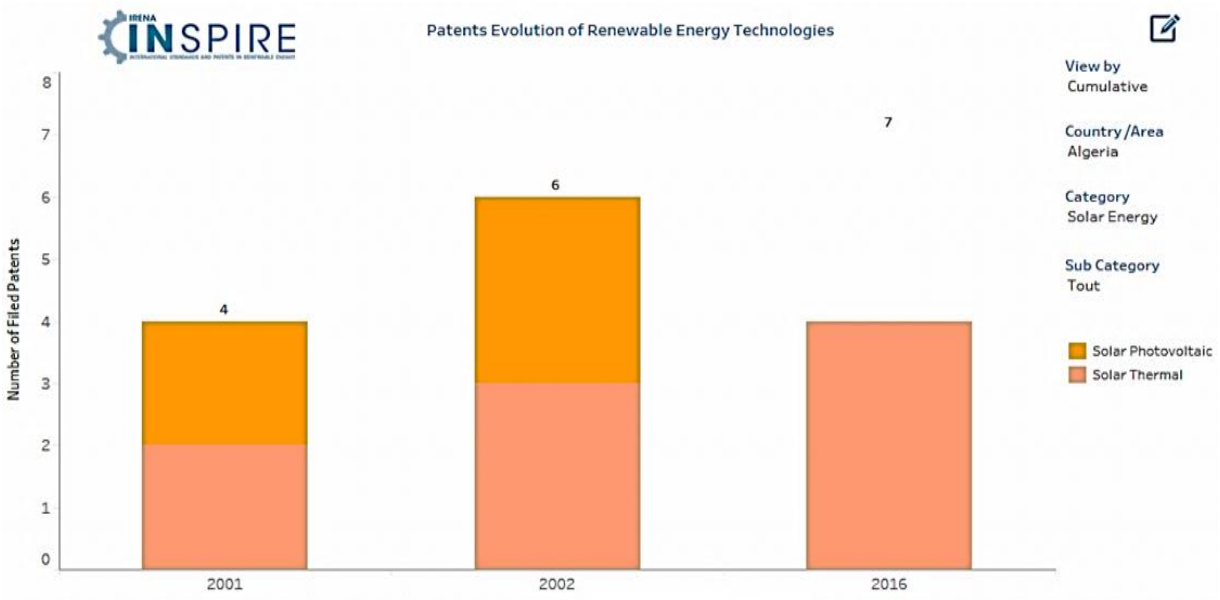

Figure-7. The development of patents registered in solar energy – in Algeria.

Source: IRENA (2018).

While Germany has seen a significant boom in solar energy, which is a result of the great motivation and interest in scientific research and the valorization of its output. The cumulative total of solar energy patents alone reached 17633 patents in 2016 (representing 5.55% of the total global patents on solar energy that reached 317224 in 2016), after registering almost 829 patents in 2000 according to the international agency for renewable energies, as shown in Figure 8.

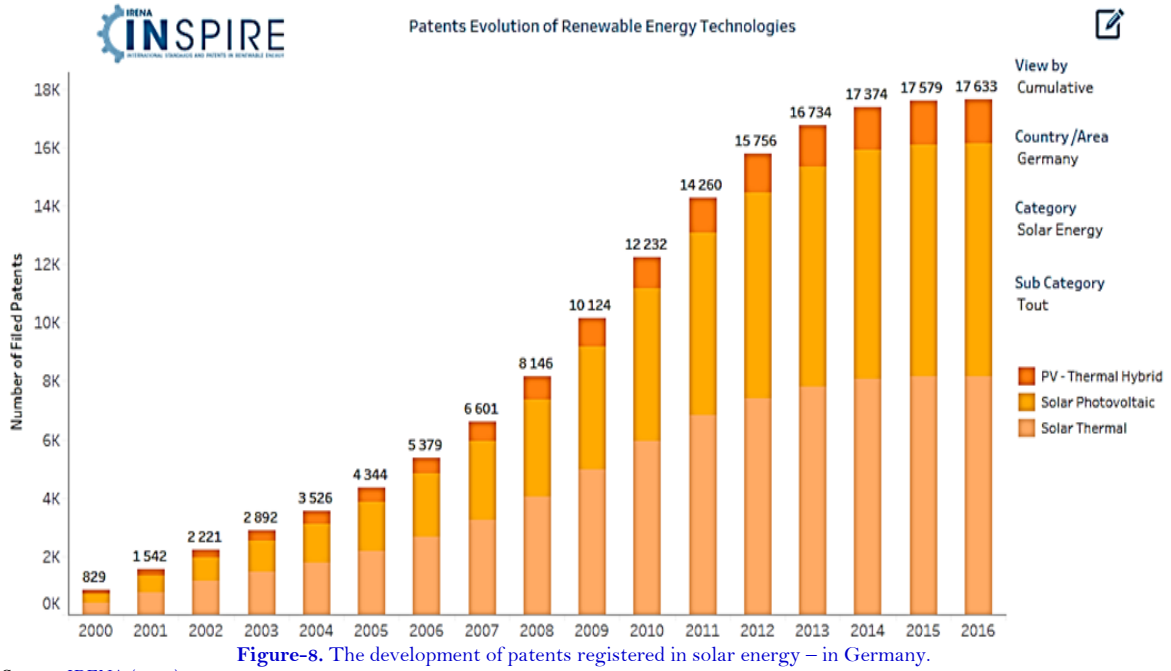

Figure-8. The development of patents registered in solar energy – in Germany.

Source: IRENA (2018).

- *Technical constraints*:

- Algeria possesses enormous oil wealth, which prevents attention to renewable energies, including solar energy.
- Lack of interest in the development of universities and academic and research institutions, the lack of connectivity to similar global networks, and the lack of keeping pace with the educational curricula for global scientific developments, taking into account the requirements of the industry.

5. CONCLUSION

Through what was presented in this study, concerning the reality and prospects of solar energy exploitation in Algeria compared to the German experience, as Germany is considered a leader in this field, in addition to the lessons learned from the German experience. Thus, the results of the present paper can be summarized as follow:

- Germany is witnessing a major boom in renewable energy and solar energy due to the renewable energy resources Act, which is conducive to its development. In addition to the interest in scientific research in the field of renewable energy, where the cumulative total of patents in solar energy alone in 2016 were 17633 patented and gradually arrived, after registering about 829 patents in 2000.
- Although Algeria has great potential in the field of solar energy, exploitation remains limited due to the very weak scientific research in the field of renewable energies, where we find that Algeria registered only 07 patents as a cumulative total in the field of solar energy in 2016, and 04 in 2001.
- There are legislative and institutional impediments, financial constraints and technical constraints preventing the good exploitation of solar energy in Algeria.
- Germany promotes investment and consumption of renewable solar energy while Algeria has a very modest consumption growth rate for renewable energies (the two-state consumption growth rate for renewable solar energy in 2016, respectively, was 9% and less than 0.05%).
- Despite the constraints faced by Algeria in its exploitation of solar energy, it implemented a program for renewable energy over the period 2011-2030, to position itself as a key player in producing electricity from renewable energies mainly solar. Moreover, Algeria and Germany implemented a cooperation between them to establish investment projects in the field of renewable energy.

In the light of the previous results, we can suggest the following recommendations:

- The promulgation of a special law only on renewable energy, which provides a range of incentives for those who invest in solar energy, and benefits from the German law "renewable energy sources act" (EEG).
- The optimisation of the enormous potential of Algerian solar energy.
- Encouraging small and medium-sized enterprises to invest in renewable energies.
- Interest in scientific research in the field of renewable energy through the establishment of research centres and the holding of conferences and symposia.
- Strengthening cooperation and partnership with Germany in the field of renewable energy in general and solar energy in particular by making the partnership between the two countries a real partnership embodied in the cooperation agreements concluded on May 20, 2015, 17 and 18 April 2018, to reflect a real cooperation in the form of deals to establish bilateral investment projects.

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