

# The Role of Solar Energy in Achieving Algeria's Sustainable Development

## Descriptive-Analytical Study

### دور الطاقة الشمسية في تحقيق التنمية المستدامة في الجزائر

#### دراسة وصفية تحليلية

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#### Abstract:

Algeria has developed various strategies to strengthen the renewable energy sector and has planned numerous development policies, with programs extending until 2040. This study employs a descriptive and analysis approach, examining the current state of solar energy systems and their applications, and identifying global obstacles to its exploitation. The analysis focuses on the contribution of solar energy to achieving sustainable development and explores solar adoption trends, along with the performance and reliability of solar energy generation facilities. The study highlights the need for continued research and exploration of renewable solar resources in Algeria to meet future sustainable energy challenges.

**Keywords:** solar energy, development programs, sustainable development, Algeria.

#### ملخص:

تسعى الجزائر إلى تحقيق هدف التنمية المستدامة توازياً مع تحقيق الأمن الطاقوي، ولهذا وضعت استراتيجيات متعددة لتطوير قطاع الطاقات المتجددة، واعتمدت سياسات تنموية متنوعة من خلال وضع برامج مسطرة إلى غاية سنة 2040. تهدف هذه الدراسة الوصفية التحليلية إلى إبراز دور الطاقة الشمسية في تحقيق التنمية المستدامة في الجزائر، والرؤية المستقبلية لمشاريع الطاقة الشمسية. وتم فيها التطرق إلى واقع استغلال الطاقة الشمسية في الجزائر، والإمكانات التي تمتلكها الجزائر للاستثمار في الطاقة الشمسية، مع تحديد معوقات استغلالها، ثم التطرق لأهم المشاريع المنجزة للطاقة الشمسية ومميزاتها. خلصت الدراسة إلى وجود مساهمة فعالة لمشاريع الطاقة الشمسية في تحقيق التنمية المستدامة في بعدها الاقتصادي، الاجتماعي والبيئي، وضرورة تطبيق البرامج التنموية المخطط لها، وتعميم إنجاز المشاريع الكبرى لمحطات للطاقة الشمسية الكهروضوئية في مختلف مناطق التراب الجزائري.

**الكلمات المفتاحية:** طاقة شمسية، تنمية مستدامة، برامج الطاقات المتجددة، مشاريع الطاقة الشمسية، الجزائر.

**JEL code :** Q13, Q55, Q56.

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## 1. Introduction:

Energy is a pivotal element in the development process, ensuring sustainability and meeting human needs. Energy security, crucial for sustainable development, poses significant challenges for countries worldwide. To achieve sustainable local development, Algeria has tapped into renewable energy sources, particularly solar energy.

Solar energy plays a crucial role in Algeria's sustainable development strategy. The country has set ambitious goals to increase the share of renewable in its energy mix to 30% by 2030.

From the above mentioned;

How does solar energy contribute to achieving sustainable development goals in Algeria?

This study assumes that solar energy plays an effective role in achieving development in Algeria by enhancing energy security, reducing dependence on fossil fuels, stimulating economic and social growth, and minimizing negative environmental impacts. The study examines the impact of solar energy projects on various aspects of sustainable development while highlighting the opportunities and challenges associated with the expansion of this sector.

Using a descriptive-analytical methodology, this study evaluates the influence of solar energy on Algeria's sustainable local development and projects future solar energy initiatives. It analyzes solar energy utilization in Algeria, exploring the nation's investment potential, identifying barriers to its use, and examining challenges within the solar energy investment sector. The study also highlights significant completed projects and the benefits of solar energy.

To address these issues, test the hypothesis, and fulfill the research objectives, we methodically examined the research's key elements across three main axes:

The first axis delves into solar energy's fundamental concepts and historical applications, followed by the evolution of solar energy technologies.

The second axis discusses solar energy's role in sustainable development.

The third axis evaluates solar energy's contribution to local development through an analysis of Algeria's renewable energy and energy efficiency programs, as well as significant completed, ongoing, and future solar energy projects.

Previous studies; Study by Saida Tayeb and Snoussi Ben Abbou (in 2018): An article in the Magazine of Economics, Management and Commercial Sciences, Volume. 11, Issue. 02, entitled "The extent to which solar energy contributes as a sustainable economic resource to Algeria's development". The objective of the study is to highlight Algeria's potential in the field of solar energy, following the attention given to the renewable energy sector, within the framework of the development policy applied, which mainly aims to diversify the economy as well as its role in achieving sustainable development. Where the researchers divided the study into six axes, the first focuses on the concepts of economic and natural resources, the second addresses the concept of energy and its classifications, the third axis focuses on depleted and renewable energy sources, and the fourth explained the possibilities of solar energy in Algeria, while the fifth axis focuses on renewable energies programmes in Algeria And the sixth and final axis shows the importance of energy in achieving sustainable development.

Study by Ouassila Ouaere and Ikram Maraouche (in 2021): An article in the Journal of Industrial Economics (khezzartech), Volume 11, Issue 01, entitled "Solar and wind energy: Towards a National Development Policy for Southern Algeria". this study addresses the subject of Algeria's development policies for the solar and wind industry with the aim of developing renewable energy and providing energy services to isolated areas and far from

traditional distribution networks, especially southern Algeria. The two researchers divided this study into three axes, in the first, the conceptual framework of renewable energies, and in the second axis, they described and analysed the reality of solar and wind energy in Algeria, while in the third and final one, they touched on the Algeria's development policy to revitalize the South by using solar energy and wind energy.

Study by Abdelkader Badji and Rachid Bouafia (in 2021): An article in the *New Economy Magazine*, Volume 13, Issue 02, entitled " This study aims at identifying the conceptual framework of renewable energies by highlighting the most important sources and characteristics, as well as Algeria's capabilities, as well as the strategies for the development of the renewable energies sector through the established programmes until 2030, it also focuses on the reality of solar energy in Algeria based on the capabilities it possesses with reference to the most important programmes implemented in this field.

## **2. General Concepts about Solar Energy**

### **2.1 Solar Energy**

The sun is the natural source of solar energy, emitting light and heat. The intensity of solar radiation reaching the Earth's surface is estimated at 1.36 kilowatts per square meter. Approximately 50% of this radiation is reflected back into space, 15% is reflected by the Earth's surface, and 35% is absorbed by the air, water, and soil. The sun's rays are electromagnetic, with 49% visible spectrum, 2% ultraviolet rays, and 49% infrared rays.

Solar energy is a clean renewable resource that remains inexhaustible as long as the sun exists. It is the origin of all Earth's energy sources and can be converted directly or indirectly into various forms such as heat, cold, electricity, and mechanical power.

Historically, humans have utilized solar energy for cooking; heating water, drying fruits, and seeds. The Pharaohs used solar energy to heat air, while the Romans employed it for lighting at night and for long-distance communication using light signals. Legend has it that the Greek scientist Archimedes used hexagonal mirrors to burn the Roman fleet besieging his city in 215 BC.

The exploitation of solar energy has evolved over time, with the world seeking alternatives to fossil fuels. Solar energy is considered one of the primary renewable energies and an alternative to oil. It has become a significant scientific achievement, especially in the conversion of sunlight into electrical, thermal, or photovoltaic energy. (Bradford, 2006)

Solar technology primarily converts energy from sunlight into electricity, either directly using photovoltaic cells (PV) or indirectly using Concentrated Solar Power (CSP). (Hossein Ahmadi, et al., 2018, p. 343)

- Photovoltaic Energy (Active Energy): A solar cell, or photovoltaic cell (PV), is a device composed of solar panels made from semiconductor materials like silicon and germanium. These materials facilitate the photoelectric conversion process, transforming light into electric current. The first solar cell was created by Charles Fritts in the 1880s. In 1931, German engineer Bruno Lange developed a photocell using silver selenide instead of copper oxide. In the 1940s, researchers Gerald Pearson, Calvin Fuller, and Daryl Chapin invented the silicon solar cell, which was introduced in 1954. (Adolf & Volker, 2005, p. 01)

- Concentrated Solar Power (CSP) (Passive Energy): This system uses an array of reflective mirrors to concentrate sunlight onto a tank or tube containing a saline solution. The concentrated heat raises the solution's temperature, producing steam that drives a turbine to generate electricity. The residual heat can be used for industrial or domestic purposes, such as water heating or air conditioning.

**2.2 Proliferation of Solar Energy:**

The spread of solar energy can be characterized by three distinct phases, with a future phase anticipated:

**2.2.1 Growth Phase:** The initial development of solar technology in the 1860s was driven by the belief that coal would soon become scarce. However, solar technology's growth stalled in the early 20th century inside the face of the coal and petroleum economy. In 1974, information indicated that best six non-public houses in all of North America had been fully heated or cooled via useful solar electricity structures. (Dorte Norgaard & Jan Petter, 2019)

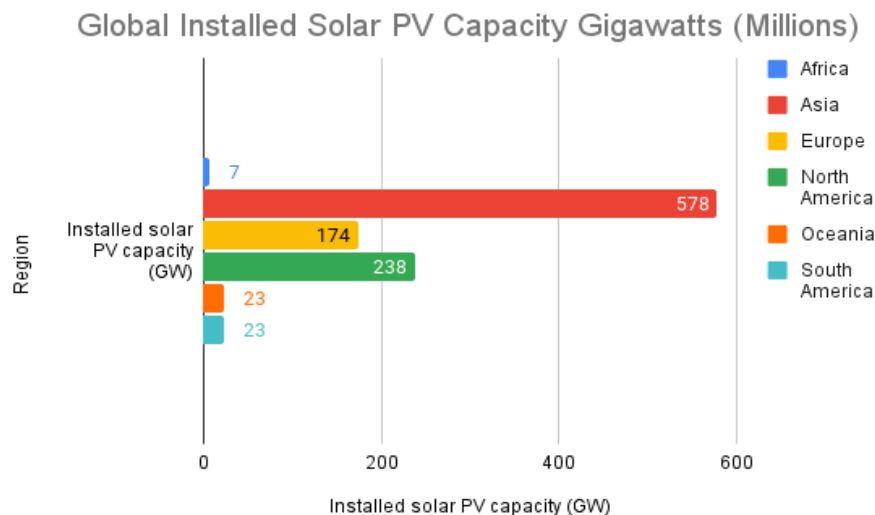
The 1973 oil embargo and the 1979 energy crisis reorganized energy policies around the world and renewed interest in the development of solar technologies. Proliferation strategies focused on incentive programs such as the US Federal Photovoltaic Program (NREL, SERI), Japan's NEDO, and Germany's Fraunhofer ISE. Between 1970 and 1983, photovoltaic device installations grew rapidly. However, the decline in oil prices in the early 1980s limited the growth of photovoltaic cells from 1984 to 1996.

**2.2.2 Development Phase:** In the mid-90s, the development of photovoltaic solar power plants on both residential and commercial roofs began. The acceleration returned due to oil and natural gas supply issues, global warming concerns, and the improved economic viability of photovoltaic cells compared to other energy technologies.

In the early 2000s, an automated tariff policy was adopted in Europe, prioritizing renewable energy sources and setting a fixed price for the electricity generated. This led to a high level of secure investment and an increasing number of photovoltaic deployments.

**2.2.3 Competitive Phase:** For many years, global solar PV growth was driven by European expansion. It then shifted to Asia, particularly China and Japan, and to an increasing number of countries and regions worldwide, including but not limited to: Australia, Canada, Chile, India, Mexico, South Africa, South Korea, Thailand, and the USA. The growth of photovoltaic cells globally averaged 40% annually since 2000, and the total installed capacity reached 139 GW at the end of 2013. The most accumulated installations were in Germany (35.7 GW), and Italy had the highest percentage of power generated from Solar PV (7.0%). The largest manufacturers are in China. Concentrated Solar Power (CSP) also began to grow rapidly, increasing its capacity nearly tenfold from 2004 to 2013. By the end of 2013, the combined capacity worldwide had reached 3,425 MW. (Adimi & Yahyaoui, 2020, p. 123)

**Fig.1.**Global production of solar energy 2024



**Source:** (<https://www.iea.org/data-and-statistics/data-explorers>)

According to the [International Energy Agency \(IEA\)](#), renewable capacity will meet 35% of global power generation by 2025. The IEA foresees solar PV to reach 4.7 terawatts (4,674 GW) by 2050 in its high-renewable scenario, of which more than half will be deployed in China and India, making solar power the world's largest source of electricity. This growth is expected to continue, with the International Energy Agency projecting that solar PV will account for 4.5% of total global electricity generation.

### 2.3 Principle of Operation of Solar Power System and Fields of Use:

Solar energy harnessing techniques include the use of solar thermal energy to convert solar radiation into thermal energy. This energy is exploited directly for heating or indirectly for generating electricity by rotating generators. Additionally, photovoltaic energy is harnessed by generating electricity through the photovoltaic effect using photovoltaic panels. (Mehedi Hasan, Shakhawat, & Mofijur, 2023)

Solar energy is utilized in various fields, such as:

- Cooking, Heating, and Cooling: This field is notably successful in solar energy use. Heating systems are designed into buildings with special features, like roofs made of plastic layers capable of collecting sunlight. Water pipes run through these layers, heating the water as it passes through. For cooling, specialized chemical systems are developed, which are more complex than heating systems. The need for cooling increases with the intensity of solar radiation, which is also harnessed for cooking and drying using solar cookers.

- Electricity Generation and Lighting in Agricultural Activity: The agricultural sector aims to enhance the use of solar energy to boost the productivity of cultivated plants.

This involves organizing planting seasons according to the year's periods, combining different plant varieties to improve yields, and employing solar energy in water pumping, crop drying, poultry farming, and drying organic poultry manure. Solar panels' energy is also used to produce fruit juices.

- Desalination of Seawater and Treatment of Contaminated Water: Solar distillation is employed to render brackish water and moth water potable. It is also used to detoxify contaminated water through photolysis, although this process is subject to debate and controversy.

### 3. Exploiting Solar Energy in the Context of Sustainable Development

The sustainable development should be built on three main objectives as following: (Mahi, 2011, p. 15)

- The sustainable development of economic factors such as the development of economic growth or increasing per capita gross domestic product or GDP growth (%).
- The sustainable development on social factors that are mainly based on the satisfaction of human needs, equity and social cohesion (transparency, participation of the local, educational actors, improvement of the human development index).
- The sustainable development is mainly based on environmental factors and countries could not reach the sustainability in this area without reducing dioxide carbon emissions and greenhouse gas emissions.

The sustainable development scenario is built based on the economic perspective. It also examines what activities will be required to meet shared long-term climate benefits, clean air and energy access targets. The short-term details are based on the IEA's sustainable recovery strategy, which aims to promote economies and employment through developing a cleaner and more reliable energy infrastructure. In addition, sustainable development includes

utilizing renewable-energy applications, smart-grid technologies, energy security, and energy pricing, and having a sound energy policy. (Ali & Jamal, 2022, p. 479)

### **3.1 Solar Energy and the Economic Aspect:**

Economic development hinges on the availability of essential energy services, which are crucial for enhancing productivity and boosting local income through agricultural advancement and job creation outside the primary sector. Without access to modern energy services and fuels, opportunities for savings, employment, and productivity are severely limited, thus constraining economic prospects. The availability of such services is instrumental in establishing small enterprises and facilitating livelihood activities and private businesses. Solar energy is a key driver of economic growth and development, and it is prioritized in the strategic plans of various countries. (Mehedi Hasan, Shakhawat, & Mofijur, 2023, p. 118)

The benefits of solar energy that contribute to sustainable economic development include:

- Solar energy is an inexhaustible, freely accessible, and renewable natural resource.
- The feasibility of implementing solar energy projects with straightforward, safe technology minimizes risks to workers and mitigates material and human losses.
- Solar energy initiatives foster job creation, bolster local development, and stimulate investment, particularly in the agricultural and industrial sectors.
- It promotes the rationalization of energy consumption amid growing populations and households.

### **3.2 Solar Energy and the Social Aspect:**

Solar energy addresses social issues by using energy to alleviate poverty and create opportunities. Limited access to energy marginalizes impoverished groups and significantly hinders their ability to improve living conditions. Approximately one-third of the world's population lacks access to essential energy sources, while another third has only weak access. The reliance of rural populations on traditional fuels for heating and cooking negatively impacts both the environment and public health. Moreover, there is a substantial disparity in energy consumption rates between countries; the wealthiest nations consume energy at a rate twice that of the poorest nations.

Solar-based applications, such as solar heaters, photovoltaic cells, and agricultural waste recycling processes, help eliminate unemployment and prevent poverty. The use of solar energy in remote areas for thermal heating or electricity generation breaks the isolation of these regions, fostering local development. Solar energy is an ideal solution for electrical systems in remote areas. (Laib & Aaraba, 2021, p. 117)

Infrastructure projects, including health facilities, hospitals, and schools, can be powered by solar energy, particularly in remote and isolated desert regions. Employing green building techniques, where energy is derived from solar sources, can reduce the costs associated with conventional power connectivity, wire maintenance, and the construction of traditional plants. This approach also stimulates investment in the sector and contributes to equal opportunity distribution across different regions within a country. (Laib & Aaraba, 2021, p. 117)

### **3.3 Solar Energy and the Environmental Aspect:**

Sustainable development aims to achieve various environmental goals, such as the rational use of exhaustible resources, to leave a suitable and comparable environment for future generations. Solar energy is one of the most significant and inexhaustible sources of renewable energy. As a clean source, it does not pollute the environment. Furthermore,

improving living conditions in rural areas through solar energy will naturally reduce environmentally harmful energy consumption patterns in these regions.

#### 4. The Contribution of Solar Energy to Achieving Sustainable Development in Algeria:

##### 4.1 The Perspective of Solar Energy:

Solar energy investments can meet energy target and environmental protection by reducing carbon emissions while having no detrimental influence on the country's development. In countries located in the 'Sunbelt', there is huge potential for solar energy, where there is a year-round abundance of solar global horizontal irradiation. Consequently, these countries, including the Middle East, Australia, North Africa, China, The USA and Southern Africa, to name a few, have a lot of potential for solar energy technology. The average yearly solar intensity is >2800 kwh/m<sup>2</sup> illustrates the optimum areas for global solar irradiation. (Ali & Jamal, 2022, p. 480)

Solar energy is the most abundant natural resource in Algeria. It becomes imperative for Algeria to exploit this important resource. The overall installed photovoltaic (PV) power is about 1.2 MW. The insolation time over the quasi-totality of the national territory exceeds 2000 h annually and may reach 3900 h (Sahara). The daily obtained energy on a horizontal surface of 1 m<sup>2</sup> is 5 kWh over the major part of the national territory ,or about 1700 kWh/(m<sup>2</sup> year) for the north and 2650 KWh/(m<sup>2</sup> year) for the south. (Himri, 2009, p. 100)

Algeria holds a prominent position among nations in terms of its vast land area. It is distinguished by a diversity of seasons throughout the year, especially in its desert regions, which constitute a significant portion of the country's total land area. The average annual sunshine duration in Algeria exceeds 2,000 hours, and the total solar energy received is estimated at 169,400 terawatt-hours per year, which is about 5,000 times the nation's yearly electricity consumption.

##### 4.2 Areas of Investment / Exploitation of Solar Energy in Algeria:

Algeria possesses the world's largest potential for solar energy. When compared to natural gas, Algeria's solar energy potential is equivalent to about 37,000 billion cubic meters, which is more than eight times the country's natural gas reserves. Notably, 18 villages with approximately 1,000 homes are now powered by solar energy in the Deep South states. Plans are underway to extend this service to an additional 16 villages, encompassing around 600 homes. Efforts are also being made to expand the use of renewable energies to all isolated areas far from the power grid. (Badji & Bouafia, 2022, p. 62)

**Table 1.** Data on solar radiation in Algeria

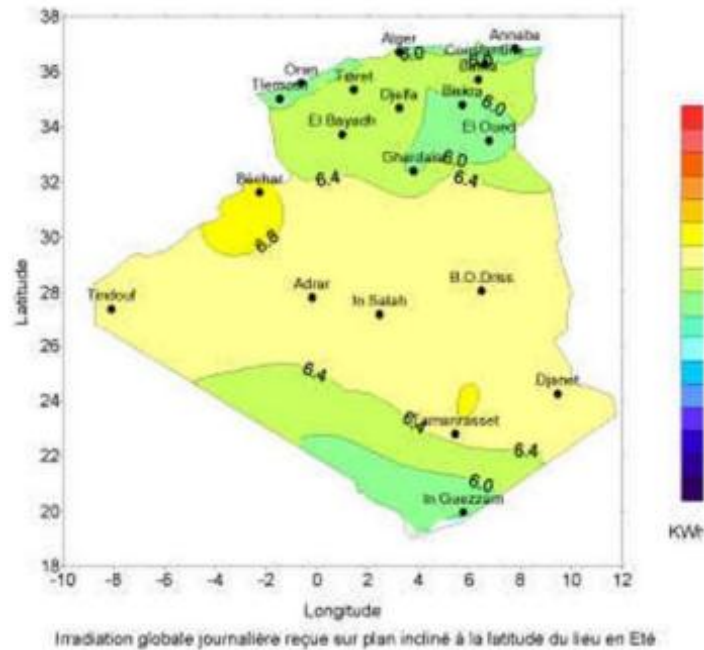
Areas	Surface %	Sunshine rate (hour/year)	Energy rate obtained (kilowatt/m2/hour/year)
Coastal area	04	2650	1700
Hautes Plaines	10	3000	1900
Desert	86	1900	2650

**Source:** (Abada & Bouharkat, 2018, p. 02)

Through the table, we observe the diversity of geographical areas and their climatic characteristics in varying proportions. The vast expanse of the Algerian desert, constituting 86% of the national territory, positions it as one of the most significant solar fields, boasting an estimated energy rate of 2,650 kWh/m<sup>2</sup> per year.

The climatic conditions in Algeria are favorable for the development of solar energy due to abundant sunshine throughout the year, especially in the Sahara region-see figure (02).

**Fig.2.** Algeria's Daily Global Solar Irradiance received on Inclined Plane in summer



**Source:** (Benazza, 2023,p. 52)

### 4.3 Solar Energy Projects in Algeria and Their Alignment with Sustainable Development Objectives:

Algeria has significantly advanced in diversifying its energy sources by tapping into solar energy, evidenced by the numerous projects completed or in the pipeline. Below is an overview of the most pivotal solar energy projects and their contributions to sustainable local development in Algeria:

#### 4.3.1 Renewable Energies Program in Algeria:

In view of the increasing energy intensity, the government has emphasised energy efficiency and RE options. Algeria has created a green momentum by launching an ambitious programme to develop RE and promote energy efficiency. This programme 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 prepares Algeria of tomorrow. (Stambouli, 2012)

Subsequently, the complementary and revised national program for renewable energy development (2015-2020-2040) was sanctioned by the government in February 2015. This program, an implicit admission of the shortcomings of its predecessor, was invigorated by the oil shock following the collapse of oil prices.

The initial plan, aligned with the Center for the Development of Renewable Energies, established several objectives covered in its various chapters, such as:

- Building capacity with renewable assets projected at around 22,000 megawatts for the period 2011-2030, with 12,000 megawatts designated to meet national energy demand and 10,000 megawatts intended for export. The goal is to achieve 40% of the total national power production from renewable sources by 2030 (37% from solar energy, 3% from wind energy).
- The renewable energy program from 2011 to 2020 includes the construction of sixty solar photovoltaic and solar thermal stations, wind power fields, and various facilities aimed at enhancing and expanding the solar energy industry.
- By 2020, the target is to establish a total capacity of about 2,600 megawatts for the national market, with the potential to export approximately 2,000 megawatts.

- By 2030, the aim is to establish a capacity estimated at about 12,000 megawatts for the national market, with the possibility of exporting around 10,000 megawatts.

Algeria has also taken a crucial step in implementing its strategy to supply 15,000 megawatts of solar energy by 2035, thereby reducing reliance on hydrocarbons for power generation. This initiative will facilitate the realization of the energy transition program in Algeria and usher in a new era of clean and sustainable energies.

This program was established to stabilize the increasing demand for domestic consumption and the aspiration for future exports, contributing to the diversification of exports beyond hydrocarbons.

▸ **Using Solar Energy to Revitalize the Great South:**

Electricity requirements have increased significantly in recent years due to diverse applications across various regions, particularly in the south. In this context, Algeria has implemented several energy programs to rejuvenate the Algerian south, the most notable being: (Ouaar & Marouch, 2021, p. 599)

▸ **Grid-Connected System Using Photovoltaic Cells in the State of Ghardaïa:**

This project comprises a field of panels oriented towards the sun, with the current varying according to the photovoltaic cells' characteristics, which are influenced by temperature and sunlight. Since the system is grid-connected, it can accept all the produced energy, functioning as a battery with infinite capacity and allowing for the recovery of more stored energy.

▸ **Improving the Photovoltaic Solar Lighting System in the State of Adrar:**

The project's goal is to evaluate the solar lighting system for different lamp types and to provide electricity to the population, considering location data and the types of equipment used. The area's abundant sunlight and high temperatures will impact the project's long-term performance.

▸ **Photovoltaic pumping system in the desert environment:**

The Adrar region, known for its groundwater abundance and agricultural potential, seeks to identify suitable methods for water extraction using photovoltaic pumping systems. The goal is to irrigate agricultural lands and supply drinking water to the populace. This initiative is in collaboration with the Energy Development Center for Renewable Energy in Algeria (CDER) as part of the Euro-Mediterranean Cooperation Projects (MEDA).

**Irrigation system using solar energy in Temacine (State of Ouargla):**

A forthcoming project will install a solar-powered irrigation system on a farm in Temacine, aiming to irrigate 14 hectares of palm groves and greenhouses to boost agricultural productivity. The photovoltaic solar pumping system is deemed an ideal solution for water supply in the absence of an electrical network.

▸ **Project of Hassi R'mel:**

The objective here is to establish stations for generating solar gases.

▸ **Smart solar station for electrical feeding and irrigation in the State of Laghouat:**

In areas lacking an electricity grid, groundwater is often the sole drinking water source for isolated communities. Photovoltaic solar pumping offers a viable solution to meet these needs while preserving the aquifer's integrity. This socio-economic project aims to supply isolated sites in the Laghouat region with photovoltaic energy, utilizing underground resources for irrigation and conserving electricity throughout the day.

► **Integration and Optimization of Photovoltaic Lighting Based on White Semiconductor LEDs:**

The lighting industry has undergone a radical transformation with the advent of energy-saving lamps, also known as energy-efficient and environmentally friendly lighting, facilitated by replacing traditional lamps with semiconductor transistors.

► **Production of solar cooling through absorption in the state of Biskra:**

This project explores the feasibility of using solar energy's thermal conversion to produce refrigerants. It aims to provide solar energy technology solutions to mitigate global warming effects, reduce electricity consumption, and enhance comfort conditions in homes through air conditioning and food product cooling, particularly dates.

Algeria is also committed to bolstering the industrial sector with photovoltaic solar energy, particularly in the Great South Horizons 2030. This includes developing the electrical interconnection network between the north and south of the desert in Adrar, with plans for large renewable energy stations: In Saleh, Adrar, Timimoun, Bechar, and work to integrate it into the national energy system: (Ouaar & Marouch, 2021, p. 601)

**4.3.2 Solar Energy Projects Realized in Algeria:**

The most significant completed projects that have contributed to achieving sustainable development goals include:

► **Electrification Project for 20 Villages in Southern Algeria:**

Initiated in 1998, this project was spearheaded by the Sonelgaz company. It aimed to provide rural lighting by solar energy to remote areas lacking electricity networks in the far south of Algeria. State funds were allocated for the benefit of a thousand families across four southern states: Tamanrasset, Adrar, Illizi, and Tindouf.

► **Establishment of Hybrid Power Plant in Hassi Rmel:**

Inaugurated on January 14, 2011, this power plant operates on both natural gas and solar energy. It resulted from a collaboration between the Algerian company NEAL and the Spanish company ABENER, with an investment of 350 million euros. The plant, considered the largest gas deposit in Africa, has a capacity of 150 megawatts -120 megawatts from gas and 30 megawatts from solar energy and is integrated into the national electricity grid. (Aouadj, Zebirate, Smail, & Saidi, 2021)

Algeria boasts considerable renewable energy potential, particularly in solar energy, which is central to its strategy to achieve its 2030 objectives, as illustrated in Table 02:

**Table 2.** Renewable Energy Capacity Installed Between 2015-2030

	First phase 2015 - 2020	Second phase 2021 - 2030	Total
Solar cells	3 000	10 575	(...)
Wind	1 010	4 000	5 010
Solar heat	-	2 000	2 000
Cogeneration	190	250	440
Biomass	360	640	1 000
Geothermal heat	05	10	15
<b>Total</b>	<b>4 525</b>	<b>17 475</b>	<b>22 000</b>

**Source:** prepared by the researcher based on the Renewable Energies Program of the Ministry of Energy and Mines. (<https://www.cder.dz>)

The table also indicates that renewable energy projects for electric power production are executed in two phases:

- First Phase (2015-2020): Achieved a capacity of 4,525 megawatts, with solar cells contributing the largest share of 3,000 megawatts.
- Second Phase (2021-2030): The electrical connection between the north and the desert (Adrar) will be established, facilitating the installation of large renewable energy stations in the regions of In Salah, Adrar, Timimoun, and Bechar, and their integration into the national power system. By this date, solar heat is also expected to become economically viable. Furthermore, it is anticipated that by 2030, solar power production will exceed 37% of the total national energy output.

**Table 3.** Shows the Development of Completed Solar Photovoltaic Projects Under the Renewable Energies Program

Energy type	Years from 2011 to 2020		Years from 2021 to 2030	
Photovoltaic solar energy	2011-2015	Completion of projects estimated at 800 MW	2021- 2023	Completion of projects estimated at 200 MW
	2011-2013	Completion of two projects with storage estimated at MW 150 for each project	2021-2030	Completion of projects estimated at 500 MW
		Completion of the project of a solar-gas mixed plant in HassiRmel with an estimated capacity of 150 MW, of which 25 MW is from solar energy.		
2011- 2013	The completion of two air farms estimated at MW 1200	2016- 2030	Completion of projects estimated at 1700 MW	

**Source:** prepared by the researcher based on Renewable Energy Development Center of Algeria. (<http://portail.ceder.dz>)

This energy is harnessed through the thermal conversion of solar power for various uses, such as domestic heating of water, space heating and cooling, and in agriculture for drying crops. It also serves industrial needs, including seawater desalination and the production of distilled water for use in various applications (batteries, laboratories, etc.).

### 5. Development Dimensions for Solar Projects in Algeria:

Through the renewable energies program adopted by Algeria and the completed solar energy exploitation projects, the following dimensions related to achieving sustainable development can be identified:

### **5.1 The Economic Dimension:**

- Achieving optimal utilization of available resources, which provides a great opportunity for future generations to benefit from these resources, as well as preserving financial and material resources, which is an advantage available in solar energy projects.
- Encouraging investment and involving the private sector in contributing to economic development and creating direct or indirect job opportunities.
- Adoption of the solar energy system contributes to the rationalization of energy consumption, especially in the residential and agricultural sectors.
- Use of solar energy contributes to remote areas for thermal heating, generating electricity by steam, or drying crops, supporting craft and agricultural activity to achieve local development, and reducing migration towards the city.

### **5.2 The Social Dimension:**

- Enhancing environmental awareness among community members, encouraging them to invest in solar energy and sustainable development projects, thus creating jobs and achieving sustainable local development.
- Improving the standard of living in remote areas to achieve a better life for the population, uphold the principle of equality, and improve the level of social services.
- Breaking the isolation of remote areas and acquiring many experiences and skills, including achieving local development.

### **5.3 The Environmental Dimension:**

- Solar energy is clean, renewable, and non-polluting because it does not require the combustion process needed by other fuels.
- Generation of electricity through solar energy significantly reduces greenhouse gas emissions, especially carbon dioxide and methane emissions.

## **6. CONCLUSION**

Solar energy projects in Algeria have made significant impact on achieving sustainable development goals. These projects not only diversify energy sources but also strengthen economic resilience by expanding solar energy utilization. They invigorate the renewable energy sector, driving technological advancements and generating employment opportunities within industry. Such investments catalyze both domestic and international funding, fostering economic expansion and bolstering the nation's balance of payments.

Additionally, solar energy initiatives help reduce energy expenditures and improve the energy system's efficiency. This contributes to financial sustainability and reduces dependence on fossil fuels, which are expensive and detrimental to the environment.

Thus, solar energy projects are crucial in supporting Algeria's economic aspect of sustainable development.

Regarding the social aspect, it is realized through the deployment of solar energy for human development. This includes enhancing social services in rural and desert regions, raising living standards, alleviating isolation in remote areas, and utilizing solar energy in various agricultural and artisanal activities. These efforts contribute to skill development and the acquisition of valuable experience.

The environmental aspect is addressed by substituting traditional energy sources with renewable ones, solar energy, being a clean and non-polluting source, aligns with environmental protection principles and the pursuit of holistic sustainable development.

To fulfill the objectives outlined in the Horizons 2040 renewable energy program, it is imperative to devise future policies and strategies. These will ensure the parallel achievement of these goals and the attainment of energy security in Algeria.

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