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THE ALGERIAN ECONOMY AND INVESTMENT PROSPECTS IN GREEN HYDROGEN PROJECTS

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Abstract:
The study aims to analyze and highlight Algeria's tendencies to develop green hydrogen production within the strategy of achieving energy diversification, thanks to its natural and material capabilities in the field of renewable energies, through the embodiment of many programs whose horizons extend to 2035, and this is to mitigate the increasing consumption of traditional energy sources. The use of which is linked to unstable and safe economic and environmental variables on a one hand, and the exploitation of the large energies it enjoys in the green hydrogen industry in order to achieve local development goals and enhance Algeria's place in the global energy market.
The study reached a set of results, the most important of which was that Algeria is aware of the importance of activating Algeria's role to be an active and essential party in the production of green hydrogen within the directions of interest in developing renewable energies in achieving sustainable development as a safe and clean source, through its integration into the country's energy policy. Implementing these programs and achieving the desired results from them still raises many questions in light of the current financing and investment challenges.

Keywords: renewable energies, green hydrogen, fossil energy, energy transition, energy security.

Résumé
Cette étude vise à analyser, les tendances algériennes en matière de développement de la production d'hydrogène vert, dans le cadre d'une stratégie de diversification énergétique. Elle s'appuie sur les atouts naturels et matériels dans le domaine des énergies renouvelables, à travers la mise en œuvre de nombreux programmes dont l'horizon s'étend jusqu'en 2035. L'objectif est d'atténuer la consommation croissante de sources d'énergie traditionnelles, dont l'utilisation est liée à des facteurs économiques et environnementaux instables et précaires. Parallèlement, l'Algérie s'appuie sur l'exploitation de son important potentiel dans la filière de l'hydrogène vert afin d'atteindre ses objectifs de développement local et de renforcer sa position sur le marché mondial de l'énergie.
L'étude a permis de dégager plusieurs conclusions, dont la plus importante est que l'Algérie est consciente de l'importance de jouer un rôle actif et incontournable dans la production d'hydrogène vert. Ce rôle s'inscrit dans le développement des énergies renouvelables et contribue à un développement durable, en faisant de l'hydrogène vert une source d'énergie sûre et propre, grâce à son intégration dans la politique énergétique nationale. La mise en œuvre de ces programmes et l'obtention des résultats escomptés soulèvent toutefois de

nombreuses questions, compte tenu des défis actuels en matière de financement et d'investissement.
Mots-clés : énergies renouvelables, hydrogène vert, énergies fossiles, transition énergétique, sécurité énergétique.

Introduction

Global investment in renewable energy has seen increasing growth rates. According to a report by the International Renewable Energy Agency (IRENA), global investment in renewable energy reached 499 billion dollar in 2022, compared to 430 billion dollar in 2021. However, this still represents less than 40% of the average annual investment required between 2021 and 2030, based on a scenario of limiting global temperatures to 1.5C°. Renewable energy sources contribute approximately 23.7% of global electricity production, slightly more than one-fifth. Hydropower leads the way at 16.4%, followed by wind power at 2.9%, bioenergy and biofuels at 1.8%, solar photovoltaic at 0.7%, and geothermal, concentrated solar power, and ocean energy at 0.4%.

In line with the global trend towards promoting renewable energy as an alternative to traditional fossil fuels and transitioning to a green economy, Algeria has placed green hydrogen at the forefront of its list of primary clean energy sources within its energy transition strategy. This strategy aims to increase the use of renewable energy in the local energy system, contribute to green growth, create local jobs, and drive economic development (Renewable energy policy network for thecentury, 2018) .

Recent years have witnessed a surge in demand for green hydrogen as a primary fuel for power plants and the iron, steel, cement, aluminum, and petrochemical industries, among others. These industries consume large amounts of energy and have a negative impact on the environment. As the most abundant gas in the world and the cleanest fuel, green hydrogen can be used to achieve carbon neutrality, reduce the world's dependence on fossil fuels, and enhance the prospects for a successful transition to a circular economy, a goal supported by various countries worldwide. Algeria possesses enormous potential in the field of renewable energies, particularly wind and solar, making it a promising investment in the future global energy market for solar photovoltaic and wind power. These are essential components in the production of low-cost green hydrogen. Algeria is steadily progressing towards strengthening its position in the clean energy market by developing partnership projects with advanced countries in this vital sector. This aims to make it an active and key player in the production and marketing of green hydrogen at the regional and international levels, especially given its substantial clean electricity production capacity exceeding 25,000 megawatts. This opens up promising opportunities for Algeria to become a leading producer in the global and regional markets in the future (chrif, 2017).

Study problem: This study focuses on analyzing the answer to the following main question:
What are Algeria's opportunities to achieve energy transition by utilizing renewable energies to enhance green hydrogen production?

This main question branches into several sub-questions, including:

- What are renewable energies and what is their importance in ensuring energy security?
- What motivates Algeria, as an energy-producing nation, to invest in renewable energy and green hydrogen?
- Study Hypothesis: To answer the main problem and sub-questions, we will start with the following hypothesis:
- Green hydrogen represents a key energy source within Algeria's energy transition strategy.

To test the validity of the main hypothesis, it has been broken down into two sub-hypotheses:

- The increasing demand for energy in Algeria is one of the most important factors driving the development of renewable energy in its various forms.
- The Renewable Energy Program (2011-2030) represents an opportunity for Algeria to achieve its energy transition.

Study Objectives: This study aims to analyze the current state and future prospects of renewable energy development in Algeria. It examines the various natural and material resources, both utilized and untapped, available in this sector, and analyzes the different programs and projects adopted by the relevant authorities to enhance their contribution to local development, achieve energy transition goals, and reduce reliance on traditional energy sources.

Importance of the study: With increasing domestic demand for various traditional energy sources, particularly gas and hydrocarbons, strategic reserves of these resources are threatened with depletion. Furthermore, the ability to utilize these resources for export development is diminishing due to a significant portion of production being directed towards meeting domestic demand. Therefore, it has become essential for Algeria to expand its investments in renewable energy and dedicate itself to its use as a cleaner, more stable, secure, and renewable energy source for the future. This is what we attempt to analyze in this study given, that Algeria recognized early on the importance of investing in renewable energy to achieve its energy security.

Study Methodology: Our study employs a descriptive-analytical approach to present and analyze the various aspects of the research.

Study Plan: The scientific methodology necessitates dividing the study topic into three main sections:
1/ Green Hydrogen Technology - Basic Concepts;
2/Algeria and the Motivations for Investment in Renewable Energies and Green Hydrogen;
3/ Prospects for Developing Green Hydrogen in Algeria.

1- Green Hydrogen Technology - Basic Concepts

Hydrogen is the simplest and most abundant chemical element on Earth. It combines with other chemical elements in molecules, such as water, hydrocarbons, and cellulose (biomass). Dihydrogen (H_2), the molecule composed of two hydrogen atoms, is a very hot, light, highly flammable, odorless, and colorless gas, commonly referred to simply as hydrogen.
Hydrogen can be used as an energy carrier or as a raw material in many industrial sectors, particularly in the chemical industry. Hydrogen is generally produced either from fossil fuel resources (coal, natural gas, oil) through highly efficient processes that do not emit greenhouse gases, such as steam methane treatment (VRM), or from the electrolysis of water using electricity. When electricity of green or renewable origin is used, hydrogen is then called "green" because its production emits no carbon dioxide (CO2). In Algeria, hydrogen is primarily produced from natural gas and is mainly used in the chemical and petroleum industries. It also serves as a feedstock for the production of ammonia and methanol, and as a reagent in hydrocarbon refining and processing. Depending on the process and/or energy source used to produce hydrogen, color-based classification is generally accepted today to distinguish between its different types. The most common types of hydrogen are as follows: Gray hydrogen is obtained from fossil fuels using conventional processes such as steam reforming of natural gas. Currently, over 95% of the hydrogen marketed worldwide is gray.

Bluish hydrogen is produced industrially; where polluting carbon is separated, it is either used or buried underground.

Green hydrogen is produced by the electrolysis of water using electricity from renewable sources. This process allows for the partial decomposition of water under the influence of an electric current, which generates electricity. Green hydrogen is produced when water is separated by electrolysis, which involves passing an electric current through it.

This process separates water molecules into hydrogen and oxygen. In this way, hydrogen can be extracted from the water, and oxygen will be released into the air. Gray hydrogen is traditionally produced from methane (CH4), which is decomposed into carbon by steam.

Gray hydrogen is also increasingly produced from coal, but with significantly higher carbon dioxide emissions per unit of hydrogen produced. It is often called brown or black hydrogen rather than gray.

Depending on the production methods, hydrogen can be gray, blue, or green, and sometimes pink, yellow, or turquoise. However, green hydrogen is the only type produced in a climate-neutral manner, making the achievement of carbon neutrality by 2050 crucial.

Green hydrogen is now a key element in accelerating the energy transition by decarbonizing business sectors.

The development of low-carbon hydrogen plays a vital role in achieving energy security as a key component of clean energy solutions. It can contribute to transforming and optimizing the energy mix, diversifying export revenues, and reducing energy-related emissions, in line with the 2030 Agenda for Sustainable Development.

Hydrogen is emerging as a leading option for storing energy from renewable sources, with hydrogen-based fuels potentially capable of transporting energy from renewable sources over long distances—from energy-rich regions to energy-starved areas thousands of kilometers away.

Green hydrogen was mentioned in several emissions reduction pledges at the UN Climate Change Conference in Glasgow (COP26) as a mean of decarbonizing heavy industry, long-distance shipping, and aviation. Hydrogen is an excellent energy carrier and can be used to store and deliver energy as needed. When used in a fuel cell, the hydrogen atom dissociates into a positively charged hydrogen ion and a negatively charged electron, which is then converted into an electrical load. The fuel cell can be used to power almost anything, much like a battery.

The key advantage of green hydrogen is its ability to generate enormous amounts of energy with zero harmful emissions. Green hydrogen is also an explosive chemical, meaning it's a source of energy. This makes it a potential energy source that could replace more than 10 billion barrels of oil in global energy consumption by 2050.

Production using wind and solar power is a form of energy storage, converting the energy generated from sunlight or wind currents into hydrogen energy that can be used to power car engines or other mechanical applications, while ensuring that this energy production process is free of harmful gas emissions.

Green hydrogen can also be used as an alternative to polluting energy sources in some industries, such as oil refining and steel production.

Burning 1 kg of hydrogen releases approximately four times more energy than burning 1 kg of gasoline. In 2021, green hydrogen production represented only 5% of the 94 million tons of total hydrogen produced globally (University of tecnology sydny Australlia, 2021).

Green hydrogen is priced at approximately 3$ to 6$ per kilogram, a relatively high cost. Nevertheless, the technology associated with this industry represents a major area of innovation and creativity, which will enhance opportunities to reduce costs across the green hydrogen value chain in the short term.

2- Algeria and the Motives for Investing in Green Hydrogen:

In recent years, as the global energy sector seeks to reshape itself in the wake of the pressures it faces as a result of the repercussions of the Russian-Ukrainian war, many countries around the world have begun, one after another, to increase their investments in strengthening their portfolios of sustainable energy solutions from clean energy sources. Among the most prominent of these renewable sources is hydrogen in its various forms, which has become one of the most important future opportunities for achieving energy security. Unlike gray hydrogen produced from fossil fuels, which is a major greenhouse gas, green hydrogen is generated through the electrolysis of water, which is then powered by electricity generated from renewable energy sources. Hydrogen can be used as an energy carrier or as a raw material in many industrial sectors, particularly in the chemical industry. In 2020, oil refining and ammonia production accounted for more than 80% of all hydrogen used globally.

Like other countries around the world, Algeria is experiencing a growing demand for energy resources from various economic sectors and households year after year. In 2005, the population was approximately 33 million, and energy consumption was 17 million tons, equivalent to 0.51 tons per capita annually. This consumption increased to 58.2 million tons in 2015, while the population grew to approximately 40 million, equivalent to 1.45 tons per capita annually. By 2030, domestic energy consumption is expected to jump to 100 million tons, equivalent to 2 tons per capita annually, for a population of nearly 50 million (Zaghba Abdelmalek Center for Renewable Energy Development, 2016).

On the other hand, reported issues by the official Algerian government confirms that about 78% of total energy consumption is directed towards households, reflecting a state of imbalance and irrationality in the distribution of energy consumption in the economy across all key value-creating sectors such as industry and services, in light of the decline in traditional energy reserves of oil and gas, whose hard currency revenues constitute about 97% of the structure of foreign trade. Estimates indicate the short lifespan of the oil wells in the three main fields of Hassi Messaoud, Hassi R'mel and Ain Amenas, around 2025 for oil and 2040 for natural gas (Ministry of Energy Algeria, 2016).

It is difficult for Algeria to maintain an unlimited growth rate in the limited fossil fuel (oil and gas) energy supply, which is linked to multiple factors such as production capacity, reserves, control of technology, and the ability to invest. This necessitates that it rely on new and diverse energy sources that ensure energy security and sustainable development, especially if we realize that approximately 98% of electricity is produced from natural gas, that the largest part of the energy consumed by households is from electricity, and that national consumption of natural gas represents more than 35% of total domestic energy consumption, a rate that exceeds the global average estimated at about 22% (Ministry of Energy Algeria, 2016).

Population growth, urbanization, and improved living standards have been accompanied by a significant increase in electricity and gas consumption, particularly in recent years. Algeria has experienced a surge in energy demand from various sources, reaching peak levels during the summer months. This has presented new challenges for authorities, necessitating increased investment in renewable energy and a diversified energy mix to meet growing energy needs, especially in remote areas, while simultaneously preserving non-renewable fossil fuel resources for future generations.

To achieve its energy transition and diversification goals, Algeria is now focused on producing and utilizing low-carbon, renewable hydrogen. It has developed ambitious plans to capture a share of the hydrogen production and export market, alongside developing and boosting its gas and oil exports. This strategy aims to develop the country's resources and

strengthen its position in the global energy market as a key partner in achieving global energy security.

Algeria is accelerating its efforts to double its renewable energy production, including solar power, green hydrogen, and green ammonia, in partnership with several countries such as Germany and Italy. The goal is to free up more gas for export and, in the future, export green hydrogen and green ammonia to Europe. Algeria possesses significant potential that qualifies it to play a prominent regional role in the green hydrogen sector, particularly its vast solar potential, extensive electricity grid, and national and international natural gas transportation infrastructure, which can be leveraged in the future for hydrogen exports, especially to Europe, Algeria's primary energy partner.

The country also aims to export electricity to Europe, given its substantial surplus production capacity. Algeria generates 25,000 megawatts, while its peak summer consumption is only 17,000 megawatts, decreasing to 11,000 megawatts in winter (Renewable Energy Development Center).

Algeria is considered by energy experts to be among the leading countries poised to play a significant role in the renewable energy sector, given its vast and diverse natural resources spread across its varied geographical expanse, encompassing steppes, plateaus, deserts, and seas. Algeria has an ambitious renewable energy program, spanning from 2011 to 2030, adopted by the government on February 2, 2011. Its content reflects the government's commitment to a strategy for developing and integrating renewable energy sources as a key component of its energy mix, in order to conserve fossil fuel resources and achieve sustainable development.

The renewable energy and energy efficiency program aims to meet a portion of domestic market needs and export a portion of 22,000 megawatts during the period 2011-2030, with 4,500 megawatts targeted for completion by 2020 (chrif, 2017).

By 2030, this program will allow Algeria to achieve a 27% share of renewable energy in its national electricity production. The production of 22,000 megawatts of renewable energy will allow for savings of 300 billion cubic meters of natural gas, equivalent to eight times the national consumption for 2014.

In accordance with applicable regulations, the implementation of this program is open to both national and foreign public and private sector investors.

The implementation of this program receives significant and multifaceted support from the state, which intervenes through the National Fund for Renewable Energy and Cogeneration.

Algeria possesses enormous potential in the production, transmission, and distribution of energy and renewable energies, including:

- **The Electricity Grid:**

Algeria has three continuous-extension electricity grids:

- The Adrar-Ain Salah-Timimoun Pole Grid (PIAT);
- The Deep Southern Interconnected Grids (RIGS);
- The Northern Interconnected Grid (RIN).

The latter is a large-scale network covering a significant portion of the national territory, with border connections to neighboring countries. Its length reached 33,775 km, with 387 transmission stations and a transformation capacity of 69,898 MVA. The electricity distribution network, as of 2022, spanned approximately 383,014 km.

- **Gas Network:**

Algeria produces approximately 130 billion cubic meters of natural gas annually. In 2022, it exported a record 56 billion cubic meters, while consuming around 50 billion cubic meters. It

also reinjects approximately 30 billion cubic meters into wells to maintain their activity (Sonatrach Company, 2022).

Algeria has entered into partnerships with multinational companies such as Italy's Eni, France's Total, and the US's Occidental Petroleum to develop its gas fields and increase production.

Europe is Algeria's most important natural gas customer, supplied via three pipelines: the Maghreb-Medgas and Medgaz pipelines to Spain, and the Galce pipeline to Italy. In addition to annual shipments of liquefied natural gas (LNG) to Turkey, the UK, France, Italy, and Spain, these supplies have enabled Algeria to capture approximately 12% of the European natural gas market. Its market share in Spain and Italy has reached over 30% and continues to grow. In 2022, the gas transmission network reached 24,193 km and the gas distribution network 150,337 km. This could represent a fundamental infrastructure for exporting hydrogen, mixed with natural gas, to the European market. This network can be extended with the installation of new gas pipelines.

Through the Renewable Energy Program 2011-2030, Algeria intends to develop its electricity production capacity by investing in renewable energy sources, particularly photovoltaic and wind power, through the integration of biomass, combined heat and power, and geothermal energy. These energy sectors will be the engines of sustainable economic development, capable of stimulating a new model of economic growth.

The renewable energy program required to meet national market needs during the period 2015-2030 is estimated at 22,000 MW, with 4,500 MW to be achieved by 2020.

The program aims to increase renewable energy production capacity to approximately 37% of total energy and 27% of electricity production for domestic consumption from renewable sources.

Investment in renewable energy has become a higher priority than ever before, especially with the increasing domestic demand for various energy sources, particularly electricity. Algerian citizens are known for their excessive electricity consumption. According to 2014 statistics from the Electricity and Gas Regulatory Commission, the average consumer's electricity consumption reached 6,117 kWh, a 4.5% increase compared to 2013. This is further compounded by the decline in global oil prices and the trend among various countries worldwide to adopt policies aimed at reducing their consumption of fossil fuels and replacing them with renewable and clean energy sources. The government has taken this into account in its current priorities and given it utmost importance within its energy transition strategy.

In February 2011, the government adopted the National Renewable Energy Program 2011-2030 to bolster energy sources by developing renewable energy capacities and sources as alternatives to traditional fossil fuels. The program aims to achieve a production capacity of 22,000 MW, of which 12,000 MW is intended to meet domestic electricity demand and 1,000 MW for export.

This will be implemented in two phases:

- **Phase 1 (2015-2020):** This phase will see the development of 4,010 MW from photovoltaic and wind power, and 515 MW from biomass, combined heat, and geothermal energy.
- **Phase 2 (2021-2030):** This phase will focus on developing the electricity grid between the north and the Sahara by installing large renewable energy facilities in areas such as Ain Salah, Adrar, Timimoun, and Bechar, and integrating them into the national energy system (Ministère de l'enseignement supérieur et de la recherche scientifice, 2011).

At the regulatory level, the Ministry of Energy adopted a series of support measures aimed at developing renewable energy through the establishment of a regulatory legal framework and

a national renewable energy fund, financed by petroleum revenues. Renewable energy support takes two forms:

-**The first form:** is encouraging electricity production from renewable energy sources through a system called "guaranteed purchase prices." This system guarantees renewable energy producers access to tariffs that provide them with a reasonable opportunity to increase the profitability of their renewable energy investments. The validity period is 20 years for wind energy and 15 years for combined heat. After this period, facilities continue to operate without benefiting from these incentives. However, production will be rewarded at conventional energy tariffs, and the renewable energy fund will bear the additional costs resulting from the difference between the guaranteed purchase price and the actual tariff. Therefore, the distributor who purchases this energy at the guaranteed purchase price will be compensated for the difference between the guaranteed purchase price and the reference rate, which is the average price of conventional electricity.

-The second form: consists of various support and incentive measures to encourage investment in renewable energy through tax exemptions, facilitated access to loans and real estate, and other incentives.

The program includes the construction of 60 power plants, encompassing solar, photovoltaic, concentrated solar power (CSP), wind farms, and other technologies. By 2017, 22 of these were photovoltaic solar power plants, constructed by the Sonelgaz subsidiary, the Electricity and Renewable Energy Company, in the High Plateaus and the South, with a total capacity of 343 MW. Additionally, a 30 MW "Aures Solar" unit for producing photovoltaic solar panels became operational in 2017.

The pilot phase of the program (2011-2014) saw the completion of numerous projects, procedures, and studies, the most significant of which were:

- **Power Generation Plants:**

- 150 MW hybrid solar power plant (solar-gas) in Hassi R'mel, including 25 MW of concentrated solar power (CSP), which commenced production in July 2011; - A 10 MW wind farm built by the Algerian electricity generation company Sonelgaz in the Adrar region, which began production in July 2014;
- 1.1 MW pilot photovoltaic unit in Ghardaia, which began production in July 2014;
- 3 MW photovoltaic power plant in the Djanet-Illizi region, commissioned in February 2015;
- 20 MW photovoltaic power plant in Adrar, which began production in October 2015;
- 3 MW photovoltaic unit in the Kabertine area of Adrar, which began production in October 2015;
- 13 MW solar power plant in Tamanrasset, which began production in November 2015;
- 9 MW photovoltaic solar power plant in Tindouf, which began production in December 2015;
- The 6 MW photovoltaic power plant in Adrar entered production in 2016;
- The 9 MW photovoltaic power unit in Timimoun, Adrar, entered production in February 2016;
- The 5 MW photovoltaic power unit in Reggane, Adrar, entered production in January 2016;
- The 5 MW photovoltaic power unit in Ain Salah, Tamanrasset, entered production in February 2016;
- The 5 MW photovoltaic power unit in Aoulef, Adrar, entered operation in March 2016;
- The 20 MW photovoltaic power plant in Ain El Ibel, Djelfa, entered service in April 2016;

- The 20 MW photovoltaic unit in Khnaq, Laghouat, entered service in April 2016; - The 15 MW photovoltaic unit in Wadi El Kebrit, Souk Ahras region, became operational in April 2016;
- The 20 MW photovoltaic plant in Sedret Ghezal, Naâma region, became operational in May 2016;
- The 30 MW photovoltaic power plant in Ain Skhouna, Saïda region, became operational in May 2016.

- **Studies:**

- Updating the National Wind Atlas by the National Meteorological Office;
- Identifying suitable sites for wind farms in the Touggourt, Hassi Messaoud, and Ghardaïa regions by the Renewable Energy Development Center;
- Developing the Solar Atlas of Algeria by the Algerian Space Agency (ASAL).

However, the program achieved only 9.9% of its planned renewable energy target by 2020, with a total of 390 MW of photovoltaic power generation and 50 MW of installed wind turbines, bringing the total to 440 MW in 2020. The renewable energy development program was revised and updated in 2020 to align with the achieved results and the established objectives related to energy conservation, the construction of new power plants, and the development of a new energy model for 2030-2035. This revision was necessary given the imperative to accelerate the energy transition, the results of which remain weak compared to the experiences of neighboring countries in the Maghreb and even Africa.
The program included a plan to produce 15,000 MW of solar energy by 2035, supporting green hydrogen production plans. By 2023, 500 megawatts of clean energy had been generated.
This comes despite the obstacles encountered in launching the tender for the Solar 1000 MW project, which aims to generate electricity from solar power in Algeria at a cost of $1 billion.
The Solar 1000 project involves establishing a group of companies to implement photovoltaic solar power plants with a total capacity of 1000 megawatts, distributed across five different provinces within the country, with each province receiving between 50 and 300 megawatts.
The five provinces that will host the project's plants have been identified as Ouargla, Bechar, El Oued, Touggourt, and Laghouat. The project allocates the total production to each province as follows:
• 50 megawatts in Bechar Province.
• 100 megawatts in Ouargla Province.
• 250 megawatts in Touggourt Province.
• 300 megawatts in Laghouat Province.
• Production of 300 megawatts in El Oued Province.

Algeria was scheduled to begin producing its first solar-generated electricity in January 2023 in Bechar Province. However, delays in opening bids and selecting contracts have thwarted the government's plans to launch its first solar energy project in Algeria.
The Algerian Renewable Energy Company (Shems) extended the deadline for submitting bids in July for companies interested in competing to implement the 1000-megawatt solar project due to the lack of confirmation regarding the availability of external financing.
Project financing is the main obstacle preventing the company from completing the procedures. The Prime Minister's Office (Council of Ministers) and the Ministry of Finance have not responded to numerous communications from the Ministry of Energy Transition, which was recently merged with the Ministry of Environment.

Algeria was scheduled to finalize the deals for the Solar 1000 project before the end of 2022. However, the project stalled due to the lack of a designated ministry overseeing it—whether it was the Ministry of Energy and Mines or the Ministry of Environment and Renewable Energies—especially after the Ministry of Energy Transition and Renewable Energies was dissolved and its responsibilities merged with those of the Ministry of Environment.

However, some justified the postponement of the bid opening by citing investor requests to complete studies related to land and other environmental aspects, as well as to gain a better understanding of the Algerian market for potential investors. This was particularly relevant given the requirement that the Solar 1000 project must have at least 30% local content. The head of Shams Company explained that his company benefited from this delay, allowing for better project "maturing," referring to the completion of all surrounding aspects, especially financing, as current legislation mandates that financing must be local. Ismail Moukari, CEO of Shams Energy, confirmed that the first power plant, located in Bechar (994 kilometers southwest of Algiers) with a production capacity of 50 megawatts, will be commissioned before the end of 2023.

The Shams CEO stipulated that everything must be proceed as planned, with construction beginning before June of next year, in order to start electricity production before the end of 2023. He pointed out that this type of project, during the construction and commissioning phase, does not require much time, and therefore, the first 1,000 kilowatt-hours could be produced before the end of next year.

As for the other 300-megawatt plants, he anticipated that their completion would extend to 2024. He added that the other planned projects are being completed within the same timeframe and will not be affected by this "delay" in the first project, as Shams Energy has set a target of producing 1,000 megawatts annually. The Solar 1000 project involves establishing project companies to develop solar power plants with a total capacity of 1000 megawatts, distributed across several Algerian provinces, with each project ranging from 50 to 300 megawatts.

Algeria opened the bidding process for national and international companies interested in implementing the project on December 23, 2021, allowing them to obtain the terms and specifications document.

3- Prospects for Green Hydrogen Development in Algeria

The hydrogen sector in Algeria is expected to witness a strong launch in the coming period, amidst government efforts to capture a share of the market for this vital resource, which is viewed as the fuel of the future.

Algeria has taken concrete steps to develop the hydrogen sector by introducing a roadmap for a national strategy and opening discussions with stakeholders to identify potential, legal frameworks, and objectives.

In this regard, the Minister of Energy and Mines stated during the opening of the National Hydrogen Development Strategy Workshop in Algeria on March 23, 2023, that this sector is one of the most promising energy solutions globally.

He indicated that the workshop, which is a follow-up to the meeting's outcomes, reveals the potential for developing the hydrogen sector in Algeria, explaining that this step confirms the strong management and political vision for adopting this option.

Algeria aims to become a regional and international leader in the production and marketing of hydrogen and its renewable and clean derivatives. It aims to leverage its technological capabilities and competitive advantages to produce and export between 30 and 40 terawatt-hours (TW/h) of gaseous and liquid hydrogen and its derivatives, supplying the European

market with approximately 10% of its needs by 2040 at a highly competitive price (Aziez, 2022).

The national roadmap for hydrogen development in Algeria aims to achieve the following strategic objectives:

• Diversifying energy supplies and accelerating the energy transition, in addition to strengthening the country's energy security in the medium and long term, and reducing the carbon footprint of various sectors.

• Reducing domestic consumption of fossil fuels, particularly natural gas, and preserving the country's energy resources.

• Establishing a suitable and appropriate ecosystem for the development of renewable and clean hydrogen, including industrial integration.

• Ensuring technological and technical control over the entire hydrogen value chain, particularly human capital development (research and development and training).

• Gradual establishment of a national economy based on hydrogen and its derivatives (ammonia, methanol, and synthetic fuels).

• Establishment of a center for hydrogen production and export.

The national roadmap for the development of renewable and clean hydrogen considers two types of hydrogen:

Blue hydrogen, obtained from methane conversion, where carbon dioxide is captured and stored or captured and used.

Green hydrogen, produced by water electrolysis using electricity from renewable sources.

The new sector faces a number of challenges and opportunities, primarily technological control, the gradual decarbonization of the energy production and consumption system, export, the gradual development of an efficient industrial base, and financing.

The development of the hydrogen sector in Algeria will proceed in three phases: the initiation and learning phase, the expansion phase, and the manufacturing and export phase.

Strategic international partnerships covering the entire hydrogen value chain are expected to be established, and significant training, research, and development programs will be implemented to lay the foundations for the industrial hydrogen sector, thus contributing to efforts to combat climate change. The strategy outlines reveal that Algeria does not It is essential to secure international funding and grant opportunities to bring these projects to fruition, as their benefits will be tangible economically, socially, and environmentally.

However, the development of hydrogen in Algeria will depend on several factors, notably the decreasing cost of renewable energy production (solar and wind power), strengthening the electricity grid to increase the integration rate of renewables, and the decreasing cost of electrolysis equipment (from $1,000/kW to $400/kW), which will follow advancements in electrolysis technologies. Indeed, the European energy policy, based on carbon neutrality to replace fossil fuels, is geared towards the massive development of renewable energies and hydrogen, particularly green hydrogen. The Commissioner for Renewable Energies and Energy Efficiency, Noureddine Yacine, explained that this situation has created a "strong regional dynamic," clarifying that green hydrogen is produced exclusively from renewable energies. The Algerian official emphasized that "Algeria could become a major supplier of hydrogen to Europe." Furthermore, there has been no shortage of requests, and several agreements have already been signed. Agreements.

It worths noting that during President state visit to Italy last May, Rome and Algiers strengthened their energy cooperation by signing several agreements related to electricity supply, green hydrogen development, and increased natural gas deliveries.

The Italian energy company ENI and the Algerian hydrocarbon giant Sonatrach also signed a new agreement for the development of gas fields in Algeria and green hydrogen

decarbonization projects, in the presence of former Italian Prime Minister Mario Draghi and the Algerian President.
In addition to developing these gas fields, a pilot project for green hydrogen production will be launched at the Bir Rebaa North oil field, where the two companies are collaborating in the Algerian Sahara.
Furthermore, Algeria has partnered with Germany to produce, and potentially export, this much-needed green hydrogen via pipelines to Europe.
During her visit to Algeria on June 14, German Deputy Foreign Minister announced plans for hydrogen-based energy production in Algeria.
She revealed that it would be "a pilot hydrogen project in Algeria with German companies," explaining that "this will be followed by an industrial-scale hydrogen energy production project."

Conclusion:
This study analyzes the current state and future prospects of renewable energy development in Algeria and its impact on supporting green hydrogen production as a crucial energy resource in the global energy market. It examines the various utilized and untapped natural and material resources available in this field and analyzes the different programs and projects implemented by the government to increase the effectiveness of renewable energy within the energy mix. By answering the main research question and its sub-questions, and by verifying the established hypotheses, the study arrives at the following conclusions:
- Public authorities are aware of the need to activate the role of renewable energy and expand its use within the energy mix as a future alternative to fossil fuels. This is necessary to meet the significant increase in domestic energy demand and to optimize the use of available resources, particularly clean energy sources such as green hydrogen, which represents an opportunity for Algeria to strengthen its position in global markets experiencing growing demand for this energy resource. - Renewable energy and green hydrogen development projects and programs represent a real opportunity for Algeria to develop its investments and capabilities in the clean energy sector and achieve the energy transition in the future, which is moving towards intensified global investment in expanding the use of clean energy and replacing fossil fuels, which have a negative impact on the environment and climate.
In light of the findings, the study recommends the following:
- The necessity of involving various economic stakeholders in implementing the projects of the National Renewable Energy Development Program 2011-2030 by reconsidering the role of the state through activating the legal and regulatory framework to incentivize local and foreign investment to participate in financing and utilizing renewable energy and expanding green hydrogen projects based on economic viability and profitability.

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