The Importance of Green Hydrogen production in Algeria to Achieving Sustainable Global Energy Security

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Abstract:
This study aims to clarify the importance of green hydrogen produced in Algeria within the framework of its national strategy aimed at making it a leading country in clean fuels and an effective contributor to achieving global energy security, due to the distinctive characteristics that Algeria enjoys in terms of abundance and quantity of renewable energy sources, geographical and strategic location, as well as its good reputation as one of the main suppliers in the global energy market, and therefore, through this study, we tried to present the possibilities of renewable energies necessary for the production of green hydrogen from electricity, solar and wind, and the concept and principles of achieving global energy security were also discussed And projecting it on the case of Algeria, relying on the descriptive and analytical approach.

Keywords: hydrogen; énergie security; Green; hydrogen; Sustainable; Alegria.

Jel Classification Codes: Q49; Q42; F52

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1. INTRODUCTION

The first subtitle opens with an introduction that presents the specific problem under study and describes the research strategy. The first subtitle opens with an introduction that presents the specific problem under study and describes the research strategy.

In the past few years, the entire globe has been undergoing tremendous changes within the energy sector owing to two main factors, namely, the rising demand for energy at the global level and climate change. It has become imperative to seek out a reliable source of energy that will help secure global energy and minimize carbon emissions. Green hydrogen has become one of the most viable solutions because of its being a clean energy source derived from renewable sources like solar and wind energy.

Green hydrogen production could prove highly beneficial to Algeria since the country enjoys a prime geographical location and rich natural resources, mainly solar energy in the Algerian desert. Besides, Algeria boasts extensive expertise in transporting energy and gas across large distances. Thus, the country could significantly contribute to global energy security and sustainable development by focusing on green hydrogen production and exportation, particularly to European nations, and therefore in this research we will be exposed to :

- the green hydrogen and the conditions and methods of its production in Algeria ;
- The national strategy for the development and production of green hydrogen Algeria ;
- Sustainable global energy security and the green hydrogen in Algeria **.**
- **the research problem :**
  How green hydrogen production in Algeria contributes to sustainable global energy security?
- **the setting of appropriate hypotheses :**
- **subproblems :**To try to answer the research problem, we put the following subproblems :
- What is meant by green hydrogen and what are the stages and Expectations of its production in Algeria ?
- How Algeria contributes to achieving global energy security through the production of green hydrogen ?
- **setting of appropriate hypotheses :** To try to answer the research problem and subproblems .we put the following
- Green Hydrogen, as a clean and versatile energy vector, plays a crucial role in the energy transition to energy sources durable.
- The production of green hydrogen as a clean energy alternative will contribute to the energy production of Algeria and thus contribute to achieving local and global energy security.

C. the objectives and methodology of the research.

- **The objectives :**
- Getting to know the concept of green hydrogen as a clean energy alternative and the conditions and methods of its production in Algeria.

- Getting to know how the production of the green hydrogen concept in Algeria contributes to achieving energy security
- **The methodology of the research :**
- We relied on the descriptive approach in the theoretical aspect by presenting the definitions of the most important variables of the study and on the analytical approach when projecting the conditions and principles of contributing to achieving global energy security on Algeria

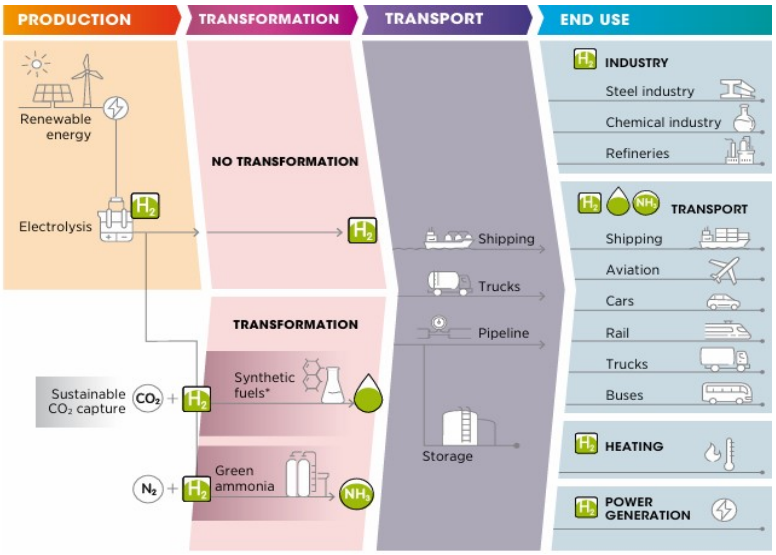
2. The green hydrogen and the conditions and methods of its production in Algeria.

- **2.1 the Concept the green hydrogen**
- **first diffinition :** Green hydrogen is **hydrogen produced by splitting water with renewable electricity, with zero emissions.** Learn how green hydrogen can help decarbonize the energy sector and what are the barriers to its large-scale deployment. (world economic forum, 2021)
- **Second diffinition :** Green hydrogen an provide a link between growing and sustainable renewable electricity generation and the hard-to-electrify sectors. (international renewabel energy agency IRENA, 2020)
- **Third diffinition :** Green Hydrogen It is hydrogen produced from renewable energy sources, such as solar, wind, hydraulic, or geothermal energy. The production of green hydrogen is considered environmentally friendly. (sonatrach, 2024/21-25/04)**.**

2.2 Green hydrogen production :

The stages of green hydrogen production can be illustrated and summarized in the following figure

FIGURE 1.1 Green hydrogen production, conversion and end uses across the energy system



)international renewabel energy agency IRENA(2020 ،

The term synthetic fuels refers here to a range of hydrogen-based fuels produced through chemical processes with a carbon source (CO and CO2 captured from emission streams, biogenic sources or directly from the air). They include methanol, jet fuels, methane and other

hydrocarbons. The main advantage of these fuels is that they can be used to replace their fossil fuel-based counterparts and in many cases be used as direct replacements – that is, as drop-in fuels. Synthetic fuels produce carbon emissions when combusted, but if their production process consumes the same amount of CO2, in principle it allows them to have net-zero carbon emissions.

2.3Advantages of green hydrogen over traditional fuels

Hydrogen is characterized by playing a pivotal role in the global energy mix due to a set of characteristics, the most important of which are :

- Its clean nature when burning, versatility, high energy content.
- The sustainability of the transport sector contributes, as it will make it possible to replace conventional gasoline-powered vehicles with hydrogen-powered vehicles and thus reduce greenhouse gas emissions.
- The use of green hydrogen helps in the generation of electricity, contributing to the integration of renewable energy sources into the grid, as well as improving energy storage capabilities.
- The possibility of storing and transporting green hydrogen easily, making it a valuable source of energy to ensure stability and energy security represents a complementary energy source to support the integration of intermittent renewable energy sources, such as wind and solar energy. (Ezzat, 2025).

In addition to the benefits of green hydrogen on the environment and the previous economy, its benefits in comparison with **traditional** fuels can be summarized in the following table

Table 01 :Advantages of using green hydrogen over traditional fuel

	Green hydrogyne	**traditional fuels**
Environmental sustainability	Production of Green hydrogen is through electrolysis, using renewable energy sources such as solar or wind power. This production process releases no greenhouse gas emissions, making it a clean and sustainable fuel option	Traditional fuels like gasoline and diesel contribute to air pollution and carbon emissions, exacerbating climate change
Resource availability	It can be produced from renewable sources like solar, wind, and hydroelectric power ensuring a virtually	Fossil fuels are finite resources and are becoming increasingly difficult and costly to extract

	limitless supply, as they are endless resources	
Air quality improvement	Combustion of hydrogen is more safe than traditional fuels as it produces only water vapor, improving local air quality and reducing pollution-related health risks	Combustion of fossil fuels is very dangerous as it releases pollutants such as sulfur dioxide, nitrogen oxides, and particulate matter, contributing to air pollution and respiratory problems which increase the risk of health problems
Decentralized energy production	Green hydrogen production can be decentralized, allowing for localized energy production and reduced dependence on centralized energy infrastructure. This can enhance energy security, especially in remote areas or regions with limited access to traditional fuel source	In contrast, Fossil fuel extraction and distribution are often centralized, leading to dependence on large corporations and centralized infrastructure
Potential for sector integration	Green hydrogen has high potential for sector integration due to its versatility and compatibility with various sectors, including transportation, industry, power generation, and heating. It can be used as a fuel for fuel cells in vehicles, as a feedstock for industrial processes like ammonia production, and as an energy storage medium for renewable energy systems	for sector integration due to its versatility and compatibility with various sectors, including transportation, industry, power generation, and heating. It can be used as a fuel for fuel cells in vehicles, as a feedstock for industrial processes like ammonia production, and as an energy storage medium for renewable energy systems
Cost reduction	Falling costs of renewable energy sources such as solar and wind power	While extraction and processing costs for fossil fuels have remained

	contribute to lower electricity costs for green hydrogen production. Decreasing costs of electrolyzer technologies and economies of scale are driving down the cost of green hydrogen	relatively stable, concerns over environmental regulations and carbon pricing may increase operational costs in the long term

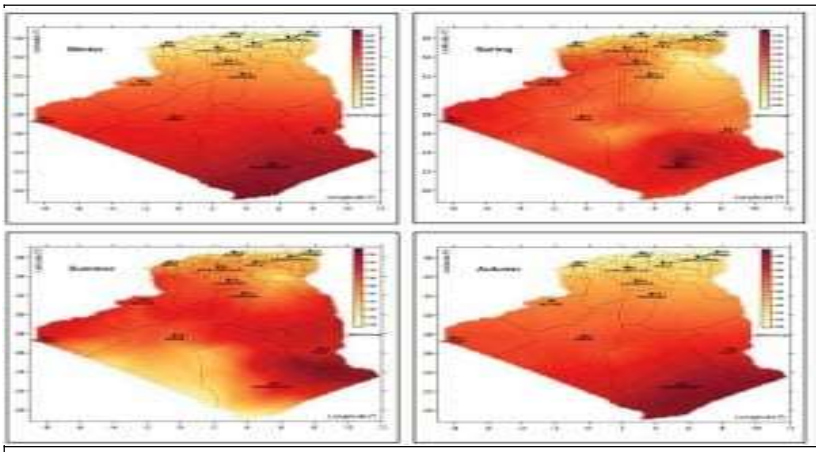
Source : (Ezzat, 2025, pp. 7-8)

3. the conditions and methods of its production the green hydrogen in Algeria.

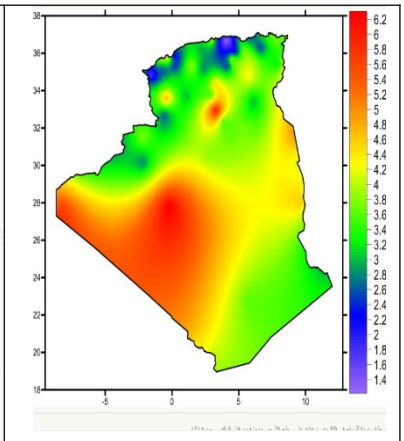
3.1 the conditions of the production the green hydrogen in Algeria.

Algeria has geographical possibilities that enable it to exploit solar and wind energy in the manufacture of green hydrogen, where the map below shows

Figure 01 : Map of solar energy in the world and wind energy in Algeria



source :https://attaqa.net



Source Prepared by the researcher based on wind speed data in Ounis) **Algeria, adapted** (2021 ،.H

Shape analysis

From the above two maps it can be concluded

- **About solar enrgy**

Algeria has one of the highest solar fields in the world. The duration of sunshine in the entire national territory exceeds almost 2000 hours annually and can reach 3900 hours

(high plateaus and desert). The energy obtained annually on a horizontal surface of 1 m2, which is approximately 3 kW/m2 in the North and exceeds 5.6 kW / m in the Great South, where the result of achievements is :.

- ✓ A hybrid power plant (solar-gas) with a capacity of 150 MW in HASI messoud (laghouat)
- ✓ 10 MW wind power plant in kabertin district, Adrar.
- ✓ Wad nsho photovoltaic Experimental Station 1.1 MW in wad nsho (gardaiya). Solar energy accounts for 97% of the renewable energy potential in Algeria, (AAPI, AAPI, 2026)

- **About Wind energy** :

  Color codes of the right side indicate the estimated speed of the wind in meters per second (m/s). Map analysis reveals that:

  • The southwestern part of the country is colored in orange and red colors, which means that the area has relatively strong wind speeds.

  • The north coast includes blue and green areas, where the strength of the wind is relatively weak.

  • Relatively strong winds can also be found in High Plateaus and other interior parts of the country.

  Some of the most advantageous regions in Algeria where wind energy can be exploited include Adrar, Béchar, Naâma, and El Bayadh and some parts of the High Plateaus.

3.2 The national strategy for the development and production of green hydrogen Algeria

The road to the development of renewable (green) and clean (blue) hydrogen in Algeria translates the firm will of the Algerian state to accelerate the energy transition and embodies the vision of the highest authorities of the country for the development of a diversified and sustainable economy, as it provides the main axes of the national strategy for the development of hydrogen, allowing to ensure a harmonious development of the hydrogen division.in fact, the development of this division falls within the government's action plan to implement the program of the president of the Republic, as a strategic axis and lever for sustainable economic, social and environmental development. On the other hand, the policies, regulations and incentive and encouragement measures that will be developed by the public authorities within the framework of the implementation of this map will give national and international actors the necessary vision regarding the deployment of the hydrogen division in our country.Renewable hydrogen called "green hydrogen", produced from renewable energies, is a future path for the development of large-scale renewable energies, especially those of an intermittent nature such as solar and wind. And that's because :

- It is a suitable way to store surplus green electricity produced from solar or wind energy, by converting it into hydrogen.

- It helps to take advantage of the presence of means of transportation, transformation and distribution intended for Fossil Energy Resources (Oil Pipelines, Gas Pipelines, tankers, ammonia and urea production units...).

Diversifying the economy away from hydrocarbons Therefore,

the strategic objectives of hydrogen production are:

* Reduce natural gas consumption
* Emission reduction (decarbonization)
* Development of renewable energies
* Creation of filled positions * Building a new hydrogen industry
* Enhancing energy security

The strategic vision of the Algerian state in hydrogen production 2023-2040

Algeria aims to become a leader regional and international in the field of the production and marketing of renewable and clean hydrogen and its derivatives. To this end, it aspires to take advantage of its technical production potential hydrogen and its comparative advantages to produce and export between 30 to 40 TWh in the form of gaseous, liquid hydrogen and/ or its derivatives. These quantities are intended to supply the European market up to about 10% of its needs, by 2040. As such, and with a price very competitive sales price of this molecule of hydrogen, Algeria could attract about $10 billion a year To this is added about 10 TWh of hydrogen own (blue) which will be produced for satisfy the needs of the national market. To achieve this goal, Algeria will first try to achieve pilot projects from 2 MW to 50 MW of electrolysis capacity allowing it to testing different production technologies and the use of hydrogen and its derivatives and to evaluate different "**business models**". Then, she will focus on applications the most advantageous and the most adapted to the national energy context as well as on the most important financing mechanisms appropriate. This will achieve, in the medium and long term, the costs of very competitive production and export of hydrogen and/or its derivatives to Europe in particular.)A governorate for renewable energies and energy efficiency(2026 ،

4 Sustainable global energy security and the green hydrogen in Algeria

4.1 the diffintion of Sustainable global energy security

- **first difinition :** the uninterrupted, affordable availability of energy, transitioning toward low-emission systems that meet current and future needs without degrading the environment. It involves balancing the "4 A's": Availability, Accessibility, Acceptability, and Affordability, focusing on resilient infrastructure, diverse, cleaner energy sources, and long-term environmental, social, and economic sustainability. (Nations, 2026, p. 12)
- **Second difinition :** Sustainable global energy security is the reliable, affordable, and sustainable supply of energy, rapidly transitioning from fossil fuels to renewables to combat climate change while ensuring equity, resilience, and economic stability. Key strategies include investing in

renewable energy, enhancing energy efficiency, diversifying supply sources, and securing supply chains for critical minerals. (IEA, 2026, p. 5)

- **Third difinition :** energy security is defined by the International Energy Agency as the secure and affordable supply of energy. (Bradshaw, 2026, p. 3)

From the above, it can be concluded that sustainable energy security is ensuring the continuous and uninterrupted availability of energy sources (oil, gas, renewable energy) at reasonable prices to guarantee stable economic development. Achieving energy security relies on diversifying energy sources, protecting production and transportation infrastructure, and responding quickly to supply and demand crises, with a recent focus on the sustainability of clean energy sources. (salime, 2023)

4.2The Principles dimensions of global sustainable energy security

Achieving sustainable scientific energy security depends on the availability of a set of conditions or principles are as follows :

- **Energy availability** The availability dimension focuses on ensuring an adequate supply of energy to meet domestic needs.
- **Price** Energy prices, on the other hand, are a significant factor in determining the affordability of energy supplies. Price levels, volatility, and competition in energy markets all contribute to the overall energy price dimension.
- **Environmental** Environmental issues are closely linked to energy due to the emissions, especially carbon emissions, that contribute to some environmental problems including global warming, ozone depletion and air pollution.
- **Governance** Government policies play an important role in protecting and dealing with short-term energy disruptions and ensuring long-term energy security.
- **Accessibility** The accessibility dimension relates to the development of access or infrastructure to distribute energy, from the point of supply to the point of demand.
- **Additional Dimensions** Other aspects that are also mentioned in some articles include technology, efficiency, infrastructure, social, military, health. Technology and efficiency become important because it reveals technological progress, adds information regarding technological innovations.

(Nyayu Aisyah1, 2023, pp. 9-12)

According to another point of view, the dimensions of global energy security are typically involve four main pillars known as the "**4 A**s":

- **Availability (or Security of Supply):** The long-term existence of energy resources and the short-term capability of energy systems to meet demand.
- **Affordability (or Economic Dimension):** Energy must be available at prices that are stable and affordable for consumers and businesses.

- **Accessibility (or Geopolitical Dimension):** Physical access to energy infrastructure and resources, including the diversification of supply sources and transportation routes (pipelines, shipping lanes).
- **Acceptability (or Environmental/Social Dimension):** The need for environmental sustainability and social acceptance of energy sources, particularly as the world transitions away from fossil fuels. (Surwillo, 2025)

4.3Green hydrogen in Algeria and its contribution to achieving global energy security

The green hydrogen produced in Algeria will contribute to covering a large part of the global energy market, especially the European market, in order to provide all the dimensions of the aforementioned principles in it and the two ways of presenting them :

- **Availability** of energy resources: Algeria has all the necessary energy sources for the production of hydrogen from electricity, solar energy and water

✓ **Electricity** :the Ministry of energy and renewable energies undertakes the implementation of the government's program related to achieving the energy transition by producing 15 thousand megawatts of solar photovoltaic energy, of which an important part has been implemented, the share of which reaches 3200 megawa/tHs by completing power plants across 12 states of the south and the upper plateaus, with a capacity ranging from 80 to 220 megawatts. It is a project in the implementation phase. In this context, the ministry, through the Algerian electricity and gas company **(sonelgas),** is responsible for the operation of electricity production plants with renewable energies, the development of the electric base structure of the barn, and the operation of power generation plants that fall within its competence., Marketing the energy produced for the benefit of sonelgas-distribution. (A governorate for renewable energies and energy efficiency, 2026)

✓ **Renewable energy development program**:

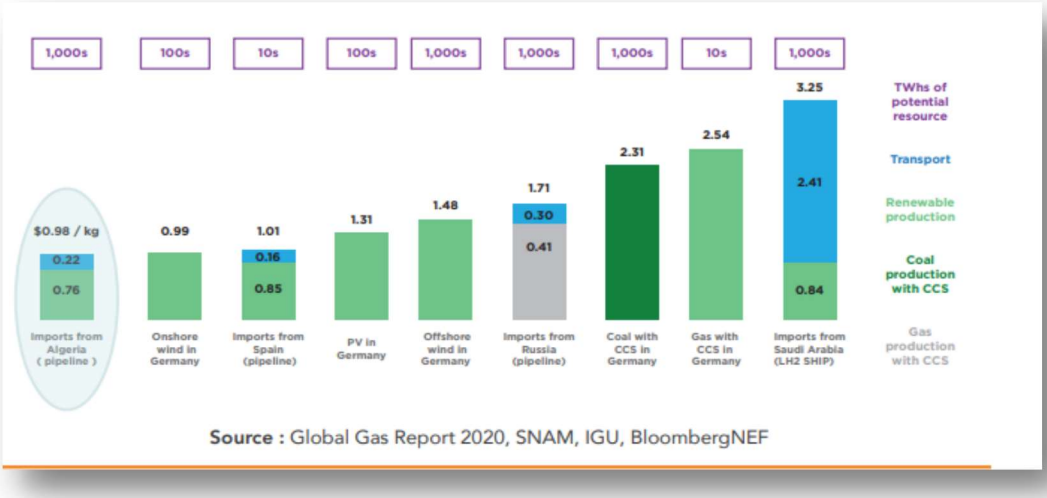
37% of the installed capacity until 2030 and 27% of the electricity production for national consumption will be of renewable origin.
Launching several projects for the construction of wind power farms and implementing pilot projects in the field of biomass, geothermal and cogeneration.
The energy projects for the production of electricity directed to the national market will be implemented in two stages:

- **First phase 2015-2020:** this phase will see the realization of a capacity of 4010 MW, between photovoltaic and wind energy, as well as 515 MW, between biomass, cogeneration and geothermal.

- **The second phase 2021-2030**: the development of the North-Sahara electrical interconnection (Adrar) will allow the installation of large renewable energy plants in the en Saleh, Adrar, Timimoun and Bashar regions and their integration into the national energy system.
- Where solar thermal energy could be economically feasible at that time. Renewable energy development program capacity The capacity of the renewable energy program to be completed to meet the needs of the national market during the period 2015-2030 is estimated
- at 22000 MW, distributed by sectors as follows:
- The photovoltaic capacity is 13575 MW.
- Concentrated solar power project 5010mw.
- Cogeneration is 2000 MW.
- The power generated through the wind is 400 MW.
- The biomass is 1000 MW. Geothermal heat is 15 MW. (AAPI, SOLAR ENRGY , 2026)**.**

- **Affordability (or PRICE):**

FIGURE 02 :Comparison of the cost of hydrogen delivered to Germany (production + transport) from different countries, horizon 2040



From the figure above, we note that the cost of transporting and producing green hydrogen in Algeria is the lowest among most countries, and this gives preference to Algeria at a cost of 0.98 dollars per kg divided by 0.22 for transportation and 0.78 for production

- **Accessibility (or Geopolitical Dimension):** Geo-strategic location Due to its geo-strategic location and reputation as an energy exporter, Algeria has the potential to enter into strategic agreements and hydrogen supply deals with regards to renewable and clean energies. It has the potential to use its many resources to produce hydrogen through :
  - Pure methane vapor reforming (VRM).
  - Steam reforming of methane with carbon capture and storage (CCS) or carbon capture, use, and storage (CCUS).
  - Electrolysis of renewable sources.

-Combination of several hydrogen production resources (biomass, electrolysis, VRM plus CCS or CCUS).
- Waste gases utilization.

- **Acceptability (or environmental/social dimension):** The acceptability is scattered over several points

✓ **political acceptability :Law No. 04-09** was adopted on 14/08/2004 on promotion of renewable energies within the framework of sustainable development. It is a legislative acknowledgment of the need for the shift towards the adoption of cleaner forms of energy where:

* The main goal is the valuation of renewable energy sources (solar, wind, geothermal, organic waste) and promotion of their uses .
* The field of action covers multiple electric, thermal and gaseous applications in addition to energy efficiency.
* Sustainable development links energy promotion, environment protection and sustainable development.
* The mechanisms include the preparation of national programs for development and integration of these energies, followed by supplementary decrees
* Executive Decree No. 69-15 of 11/02/2015 on procedures for the proof of the certificate of origin of the renewable energy and its usage
* Executive Decree No. 167-17 of 22/05/2017 amended and supplemented Executive Decree No. 69-15 of Rabi al – Thani 21, 1436 corresponding to February 11, 2015, which defines how to prove the certificate of origin of renewable energy and the use of these Certificates.

(2026 ،Ministry of Environment and quality of life)

✓ **Awards on an international level:** the mandate of Algeria received an award from the United Nations regarding sustainable development in cities "Shanghai Award" one of the best five cities in the world for the year 2025. As a reward for its huge efforts in the domain of Sustainable Urban. (ibrahim, 2025) ، Development

✓ **Admission to academic institutions**

Higher National School for Environment, Renewable Energies and sustainable development in Batna, established its first batch of graduates in the year 2024, receiving a lot of demand from students despite its relatively low acceptance rates, due to the academic interest towards

5. CONCLUSION

To conclude, green hydrogen production in Algeria is of high importance as it presents an excellent opportunity for Algeria to realize economic growth and secure its place among the prominent players in the energy sector in the context of the world's transition towards renewable energy sources. The significant natural resources Algeria holds, specifically sunlight, make Algeria suitable enough to become one of the major green hydrogen producers and exporters in the coming years.

This investment will contribute positively to minimizing reliance on fossil fuel consumption, minimizing GHG emissions, and job creation, besides enhancing the world's energy security in an environmental-friendly manner. Although there are certain obstacles associated with cost issues, lack of infrastructure, and water availability, careful planning and collaboration with other nations will ensure that Algeria becomes a center for clean energy in the future.

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