

Solar Energy as a Strategic Option for Green Hydrogen Production - A Case Study of Sonatrach in Light of the Algerian-German Partnership –

الطاقة الشمسية كخيار استراتيجي لإنتاج الهيدروجين الأخضر – دراسة حالة
سوناتراك في ضوء الشراكة الجزائرية- الألمانية-

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Abstract :

This study examines Algeria's potential to develop green hydrogen by analyzing national energy policies, the evolving role of Sonatrach, and international partnerships, particularly with Germany. It highlights the opportunities and challenges for implementing green hydrogen projects as a sustainable energy solution.

Principal results show that Algeria's abundant solar resources and strategic location provide a strong foundation for production, while partnerships facilitate technology transfer, capacity building, and export development. Green hydrogen emerges as a strategic tool for economic diversification, reducing dependency on hydrocarbons, and integrating Algeria into global clean energy markets, offering both environmental and economic benefits.

Key words: Green Hydrogen, Solar Energy, SouthH₂ Corridor.

JEL classification codes: Q42, Q48

1. Introduction.

The global energy sector is witnessing radical transformations in light of the growing trend towards a low-carbon economy, where interest in renewable energy is rising as sustainable alternatives to traditional fossil fuels. Algeria emerges, thanks to its enormous potential and vast natural resources, as a key player in the regional and international energy transition landscape, particularly through developing green hydrogen production, which is considered one of the most prominent future solutions for achieving energy security and reducing carbon emissions.

The role of Sonatrach as a leading national company in the Algerian energy sector is to enhance its investment in the field of renewable energy and the gradual shift towards green hydrogen production, within the framework of the Algerian-German strategic partnership that constitutes a technical and economic lever for this transformation.

Through analyzing the institutional and strategic transformations of Sonatrach and international cooperation with the German partner, in addition to reviewing existing field and experimental projects, the research seeks to assess the potentials and challenges facing Algeria in the path of transition towards a sustainable energy economy.

Based on the foregoing analysis, the following research problem can be formulated:

How can solar energy contribute to enhancing green hydrogen production in Algeria through the implementation of Sonatrach's strategy within the context of the Algerian-German strategic partnership?

To answer the main problem, the following hypotheses can be put forward:

- Algeria's high solar potential constitutes a strong strategic foundation for efficient and economical green hydrogen production.
- National policies supporting renewable energy work to provide an appropriate regulatory and investment environment to accelerate the development of green hydrogen projects.
- Sonatrach adopts innovative strategies to enhance solar energy investments in preparation for green hydrogen production, supporting its transition towards a sustainable energy economy.
- The Algerian-German partnership constitutes a fundamental technical and financial lever to accelerate the implementation of

green hydrogen projects in Algeria and enhance its position in the international market.

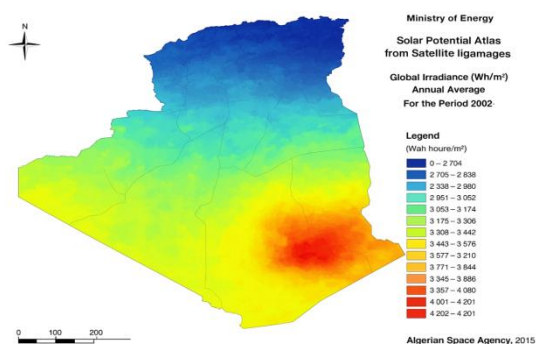
This study aims to:

- Analyze the strategic and institutional transformations of Sonatrach in its orientation towards investment in solar energy and green hydrogen.
- Evaluate the role of the Algerian-German partnership as a technical and financing lever to enhance renewable energy and green hydrogen projects in Algeria.
- Identify the economic, technical, and institutional challenges facing Algeria and Sonatrach in the transition process to a sustainable energy economy.

2. Solar Potential in Algeria: A Foundation for Investment in Renewable Energy: Algeria is considered one of the richest countries in the world in terms of solar resources, making it a promising foundation for investment in solar electricity production.

2.1. Distribution of Solar Radiation in Algeria: Algeria enjoys solar brightness ranging between 2.000 and 3.900 hours annually. The country receives approximately 170 terawatt-hours daily. The highest daily rate is concentrated in southern Algeria, reaching 7.0 kilowatt-hours per square meter, particularly in provinces such as Adrar, Tamanrasset, and Illizi. (IEA, 2022)

Figure 1: Map of Annual Solar Radiation Distribution in Algeria

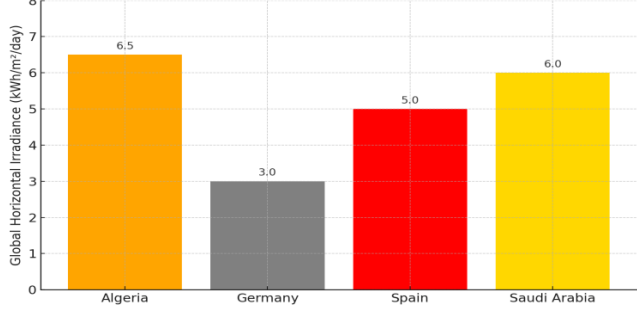


Source: Bouchouicha, K., Razagui, A., Bachari, N. E. I., & Aoun, N. (2015). Mapping and geospatial analysis of solar resource in Algeria. *International Journal of Energy, Environment and Economics*, 23(6), 740

The map confirms that the southern regions of the country (such as Tamanrasset and Illizi) receive solar radiation exceeding 2650 kWh/m² annually, making these areas ideal for large-scale solar energy applications. These capabilities place Algeria among the few

countries with sufficient natural resources to produce renewable energy with high economic efficiency. For comparison between Algeria and some countries regarding the average daily solar radiation, we have the following figure:

Figure 2: Average Horizontal Solar Radiation by Country



source :Global Solar Atlas. (2023). Global horizontal irradiance data. World Bank Group, Energy Sector Management Assistance Program (ESMAP). Retrieved from <https://globalsolaratlas.info>

The chart displays the average daily solar radiation in kilowatt-hours per square meter in Algeria, Saudi Arabia, Spain, and Germany, it can be said that Algeria excels in terms of solar radiation density with an average of 6.5 kilowatt-hours per square meter per day.

Although Germany has low radiation, it is considered a successful global model in the field of renewable energy, which indicates that advanced technology can compensate for limited natural resources.

2.2. Cost of Solar Electricity Production in Algeria: The cost of solar electricity production locally ranges between 0.094\$ and 0.118\$ per kilowatt-hour in Algeria, depending on the variation in project nature and their financing and technical conditions.(Day, 2023)

The final cost of the Biskra solar project reached approximately 0.069\$ per kilowatt-hour, which reflects relative competitiveness in the local market. (Magazine, 2019) Meanwhile, small hybrid projects that combine solar and diesel energy, especially in remote areas, recorded relatively higher prices ranging between 0.11\$ and 0.13\$ per kilowatt-hour. (Africa, 2021)

According to global estimates, the average production cost for solar energy reached approximately 0.049\$ per kilowatt-hour in 2022, which highlights the challenges facing local projects. (IRENA, 2023)

Investment in Algerian solar energy is considered profitable due to low land costs and abundant labor force. The legal framework has also begun to witness developments to encourage partnerships between public and private sectors.

3. National policies for renewable energy as an input for green hydrogen production:

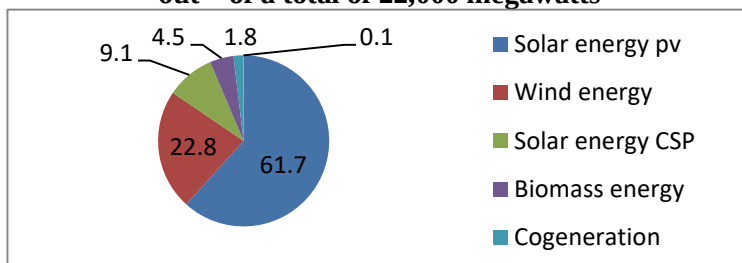
The National Program for Renewable Energy Development and Energy Efficiency (PNEREE) represents the central framework upon which Algerian energy policy relies to achieve a gradual transition towards a clean energy system and prepare the technical and institutional groundwork for developing the green hydrogen industry.

In this context, deepening the national character in analyzing these policies also requires referring to reports from specialized Algerian institutions such as the Center for Renewable Energy Development (CDER), the National Authority for Electricity and Gas Regulation (CREG), and the Sonelgaz Group, for the technical and field data they provide that contribute to a realistic and objective assessment of the program's progress.

3.1.PNEREE Objectives and Production Strategy by 2030:

Algeria has set, through the national PNEREE program, a strategic goal of achieving a total production estimated at 22,000 megawatts from renewable energy sources by 2030, distributed according to a diverse energy mix that includes approximately 13,575 megawatts from photovoltaic solar energy, 5,010 megawatts from wind energy, 2,000 megawatts from concentrated solar power (CSP), in addition to 1,000 megawatts from biomass energy, 400 megawatts from cogeneration, and 15 megawatts from geothermal energy. Algeria aspires for this production to constitute approximately 27% of total national electricity, with 10,000 megawatts directed for export.

Figure 3: Distribution of percentage ratios of energy sources in Algeria out of a total of 22,000 megawatts



Source: CREG. (2023). Report on the implementation of the PNEREE and Prospects for the Energy transition in Algeria. Algiers: Electricity and Gas Commission.

The distribution of capacities within the PNEREE program reveals the pivotal position that solar energy holds in Algeria's energy strategy. This direction clearly reflects awareness of the enormous natural potential that the country possesses in terms of solar radiation, particularly in the highlands and desert regions, which qualifies this source to be the backbone for future green hydrogen projects. In return, the inclusion of other sources comes as a major supporter to enhance system flexibility and reduce supply interruption in supplies.

when examining the current implementation data, clear challenges appear that hinder the achievement of these ambitious goals. The implementation data of the PNEREE program up to 2023 reveals a clear gap between ambitious goals and field reality, especially in priority sectors such as solar photovoltaic and wind energy.

Despite planning to produce 13,575 megawatts from solar photovoltaic energy, the actually achieved capacities did not exceed 435 megawatts, equivalent to only 3.2% of the target. In the wind energy sector, only 10.2 megawatts were completed out of 5,010 programmed megawatts, a rate not exceeding 0.2%.(CREAD, 2023)

As for other energy sources, such as concentrated solar power, bioenergy, and geothermal energy, they remain absent from the implementation reality. This disparity reflects the limitations of institutional and implementation dynamics, and highlights the need for a comprehensive review of planning, financing, and monitoring mechanisms, in order to accelerate the pace of achievement and activate the energy roadmap more realistically and effectively.

Despite the existence of a clear roadmap for renewable energy development, coordination among various active entities such as (CREG, APRUE, Sonelgaz,.Ministry of Energy) still lacks the necessary harmony for effective program implementation. (CREG, 2023)

The absence of permanent coordination mechanisms and unclear jurisdictions among actors negatively impacts decision-making speed and weakens the attractiveness of energy projects to investors, especially in the absence of a unified window to facilitate procedures.

On the other hand, the vacuum or fluctuation in the legal framework is one of the most prominent obstacles to implementing

PNEREE. Despite issuing numerous laws and decrees since 2011, their slow implementation and dispersion among several ministries prevented achieving actual implementation effectiveness.(MTEER, État d'avancement des projets du PNEREE, 2023)

3.2.Renewable Energy as an Entry Point for Green Hydrogen Production: Algeria's capacities from renewable energy sources constitute a fundamental pillar for adopting clean electricity, providing the necessary infrastructure for future green hydrogen production.

Thus, this clean electrical system is a crucial element in the production process, as it contributes to:(GIZ, 2021)

- Operating electrolysis stations using solar and wind electricity.
- Providing low-carbon hydrogen for domestic consumption and export.
- Ensuring the competitiveness of Algerian products in European markets through compliance with global green standards.

The success of the green hydrogen strategy in Algeria remains dependent on the progress of renewable energy programs and overcoming the current structural obstacles.

3.3.Implementation Mechanisms and Supporting Legislation:The legislative and regulatory framework is one of the main pillars that support the implementation of national renewable energy projects, especially the Feed-in Tariff mechanism (Feed-in Tariff or PPA), which allows investors to sell electricity produced from renewable energy at a fixed and long-term price, ensuring revenue stability and reducing financial risks over the project's lifetime.

This period may extend to 20 years for projects connected to the electrical grid, thus reducing investment risks, where:(Solidaire, 2023)

- The investor commits to the National Center for Renewable Energy Development (CDER) and the Electricity and Gas Regulation Commission (CREG) that the project has the right to sell produced electricity under a guaranteed price system for a period of up to 20 years, especially in solar photovoltaic and wind energy projects.
- If the market price is lower than the guaranteed price, the price difference is compensated through the National Fund for Renewable Energy and Cogeneration (FNER).
- If the market price rises above the guaranteed price, the distribution company – such as Sonelgaz – does not bear the difference, and financial support is canceled in this case, ensuring financial balance

for public institutions without affecting the investment attractiveness of projects.

This mechanism is considered an effective tool for reducing market risks and enhancing the confidence of local and international investors, especially in emerging sectors such as green hydrogen.

3.4.Challenges and Obstacles Facing the Implementation of the Renewable Energy Program, and Key Recommendations:

Despite Algeria's adoption of an ambitious renewable energy program, the practical reality reveals a set of organizational, financial, and human resource challenges that hinder the rapid and effective implementation of planned projects. The following table shows the most important of these challenges, along with proposed recommendations for addressing them, based on specialized national and international reports:

Table 1: Implementation Challenges of the National PNEREE Program

Main Challenge	Recommendation or proposed action for treatment
Bureaucracy and administrative procedural complexity	Establishing a central coordinating entity to unify decision-making and celebrate procedures
Absence of sustainable financing mechanisms	Developing financing instruments directed towards renewable energy, encouraging banking and independent financing
Lack of technical competencies	Launching national training programs in renewable energy and hydrogen fields
Absence of a national clean energy market	Supporting the legal framework and gradually liberalizing the electricity market to attract new investors
Delays in project implementation	Digitization and periodic monitoring from a central authority with executive powers

Source: Prepared by the researcher based on reports from the Ministry of Energy Transition (2023), World Bank (2022), and GIZ (2021)

The table highlights that the main challenges hindering renewable energy and green hydrogen projects in Algeria go beyond technical and financial aspects to include more complex organizational and structural dimensions. Bureaucracy and administrative procedural complexity remain among the most prominent obstacles to accelerating project implementation, which calls for establishing a central coordinating entity with executive powers to unify decision-making and ensure effective follow-up.

The weakness of local financing also shows the urgent need to develop specialized financial instruments and encourage the involvement of banks and national financial institutions in financing this strategic sector.

The scarcity of qualified technical competencies is one of the most prominent weaknesses facing project implementation, which highlights the importance of launching national training programs to provide the necessary human capital.

4.Sonatrach's Transformations toward Investment in Solar Energy as a Prelude to Green Hydrogen: Sonatrach, as the backbone of the energy sector in Algeria, represents a pivotal actor in the national energy transition. With increasing environmental pressures and the expected decline in global demand for fossil fuels, the company has begun redirecting its strategy toward renewable energy, especially solar energy, as a preliminary step for green hydrogen production. This was done by considering the following points:

4.1.Institutional Context and Strategic Transformation: Sonatrach began transitioning from complete reliance on oil and gas exports to adopting a more diversified and sustainable energy vision. This transition was embodied in establishing internal executive frameworks that reflect a clear commitment to clean energy transition, and translated into tangible structural decisions within the company, mainly represented in:

- Including renewable energy among investment priorities, whether through strategic partnerships or field projects(Sonatrach, Annual Report 2021, 2022)
- Establishing the Energy Transition Department in 2020, which is an administrative unit that oversees planning and monitoring for solar energy and green hydrogen projects(MTEER, National Energy Transition Strategy, 2021)
- Working to adapt the internal governance model to align with principles of environmental sustainability, social responsibility, and good governance (ESG), including environmental assessment of new projects and involving local competencies in the transition phase. (Sonatrach, Sustainability Report 2022, 2023)

It is worth noting that this interaction takes place within a supportive national environment, where Sonatrach coordinates with public institutions and research centers such as the Renewable Energy Development Center (CDER) and the National Center for

Clean Production Technologies (CNTPP), to exchange knowledge, support applied research in the fields of electrolysis and hydrogen storage, and ensure the suitability of its projects with the national green hydrogen strategy, and enhance Algeria's ability to attract foreign partnerships in this field. (Sonatrach, 2023)

4.2.Climate Objectives and Emissions Reduction: In light of its climate commitments and new strategy, Sonatrach aims, according to its annual reports, to reduce its carbon emissions by more than 20% by 2030, particularly in refining and production activities. To achieve this goal, the company seeks to use clean electricity to operate its industrial facilities, which makes solar energy a strategic choice for powering the electrolysis units necessary for green hydrogen production.(IRENA, 2023)

Sonatrach's stakes are not limited to the environmental aspect, but also include achieving local social and developmental impact, especially in the southern provinces. Solar energy projects contribute to reducing dependence on fossil fuels, improving living conditions, and creating new job opportunities especially for youth, through integrating micro-enterprises into renewable energy supply chains. This aligns with sustainable development goals, especially Goal 7 (Clean Energy) and Goal 13 (Climate Action).(Nations, 2023)

4.3.Field and Experimental Projects in Solar Energy: Sonatrach has taken practical steps in the field of renewable energy, through field projects aimed at securing its self-sufficiency in energy, especially in remote areas that witness intensive activity in oil and gas extraction. Among the most prominent of these projects we find:

a.Hassi R'Mel Solar Station: Established in 2011 with a capacity of 150 megawatts (including 25 megawatts from concentrated solar power CSP) in partnership with Abengoa through NEAL, as the first experience integrating solar energy into gas facilities. Despite its pioneering nature, solar energy's contribution to the national electricity mix does not exceed 2%, revealing the slow expansion despite technical feasibility.(Monitor, 2025)

b.Ain Amenas Onshore Station: It aims to operate drilling facilities with solar energy, which is a practical test to reduce dependence on diesel in the desert. However, it remains in a limited experimental scope, which calls for doubling investments to generalize the experience to other fields.

c.Adrar Solar Station: With a capacity of 1.1 megawatts, it serves as a platform for experimenting with energy storage and connecting

it to industrial control systems. Despite its limited capacity, it is a strategic step toward decentralized production that facilitates the operation of electrolysis units in the future.(PVPS, 2021)

d.Reggane Solar Station: With a capacity of 13 megawatts, it represents a model for industrial use of solar energy in gas facilities, with the possibility of connecting it to hydrogen production plans in the future. (CDER, 2022)

e.Mini solar stations in the South: Covering sites such as Ain Salah and Bordj Omar Driss, and testing the operation of microgrids to reduce operating costs and improve environmental efficiency, which enhances Sonatrach's ability to deploy models for local low-emission energy production.

The field investments that Sonatrach initiates in the solar energy sector reflect a gradual transformation toward a production model more compatible with sustainability and carbon neutrality requirements.

The company has completed about 11 small and medium solar projects by 2023 in the operational or experimental phase, but the contribution of solar energy to the national electricity mix remains extremely limited. This disparity between great potential and current achievements poses institutional and planning challenges, and reinforces the need to coordinate Sonatrach's efforts with local and international actors, while enabling national research and development to play a pivotal role in accelerating the energy transition. (GIZ, 2021)

4.4.Institutional and Strategic Challenges: Despite the clarity of Sonatrach's intentions to enhance solar energy projects and connect them to green hydrogen production in the future, achieving this requires doubling investment efforts, accelerating the completion of transportation and storage infrastructure, and ensuring long-term financing. The success of this transition also depends on the institution's ability to restructure its business model based on hydrocarbons and invest its current expertise in building a leading position within the green economy.

5.The Algerian-German Partnership as a Driver for Developing Green Hydrogen Projects in Sonatrach: The Algerian-German partnership plays a key role in advancing green hydrogen initiatives in Algeria. It facilitates technology transfer, capacity building, and investment, laying the groundwork for strategic cooperation agreements.

5.1.Cooperation Agreements as a Strategic Determinant for Energy Transition in Algeria: Algerian-German relations have witnessed remarkable development in recent years, particularly in the field of renewable energy, amid the profound transformations in European energy policies after 2022. This partnership includes the following aspects: (Action, 2022)

a.Institutional and Technical Aspects: This partnership constitutes a dual strategic step, as it frames technological and institutional cooperation with one of the most prominent European countries in the field of clean energy on one hand, and on the other hand, it enhances Algeria's position as a potential supplier for green hydrogen to European markets.

Sonatrach Company has been tasked with studying the technical and financial feasibility of major model projects that rely on solar energy as a source of electricity in the electrolysis process. The H2Global initiative has also been integrated within the cooperation framework, which is a German government-supported initiative aimed at financing green hydrogen production outside Europe and providing it at competitive prices to German markets.

This framework has allowed opening the door to pilot partnerships between Sonatrach and specialized German companies, which enhances technology transfer and builds Algerian capabilities in the complete value chain of hydrogen, including storage, transportation, and grid connectivity.

b.The Central Economic Aspect in Energy Transition:Through this partnership, Algeria seeks to achieve a long-term strategic model, as well as access to European green financing, and to modernize the national regulatory framework and encourage private sector investments in renewable energy.

Table 02: the development of the Algerian-German partnership in renewable energy and green hydrogen projects

year	Event or project	Active parties	Notes
2020	Memorandum of understanding between the Algerian ministry of energy and the german ministry of economic cooperation and development	BMZ- Algerian ministry of Energy	Initial framework for cooperation in renewable energy and green hydrogen
2021	Publication of joint report on hydrogen	GIZ-Algerian ministry of	Basic reference document for

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	potential in Algeria	Energy	future planning
2022	Launch of “ H2 Diplo” initiation for technical cooperation	GIZ-Sonatrach renewable energy development center	Technical support and exchange of expertise
2023	Algeria’s announcement as a partner country within the SouthH2 corridor project	Hydrogen Europe – German and Italian partners	Targeting hydrogen export to Europe via dedicated pipelines
2024	Technical discussions on utilization of gas pipelines for hydrogen transport	Sonatrach Wintershall Dea – GRTgaz	Expanding the scope of cooperation to include infrastructure and transport

Source: GIZ. (2021). Green hydrogen in Algeria – Rapport PE_21_12_07 (pp. 14–19). Deutsche Gesellschaft für Internationale Zusammenarbeit. Retrieved from <https://www.giz.de/en/downloads/green-hydrogen-in-algeria-pe-21-12-07.pdf>

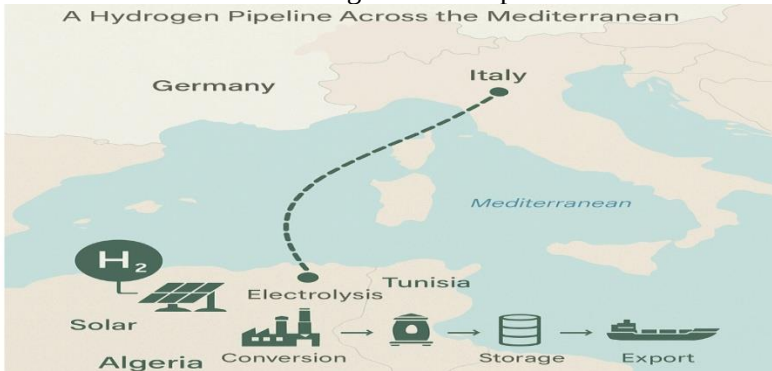
This chronological sequence reveals a typical and gradual development in the Algerian-German partnership, starting from the exchange of documents and memoranda, leading to structural projects such as the SouthH2 Corridor project.

The involvement of institutions like GIZ and Hydrogen Europe in this partnership confirms that Germany sees Algeria as a strategic partner in European energy security.

5.2.The SouthH2 Corridor Project: A Trans-Mediterranean Vision towards the European Hydrogen Market: The SouthH2 Corridor project represents one of the prominent features of the geographical and economic transformation in the European energy market, where it transcends the bilateral dimension of Algerian-German cooperation to rise to a trans-Mediterranean vision, redrawing the map of energy flows towards Europe in the post-fossil fuel era. The project aims to establish a dedicated pipeline corridor for transporting green hydrogen from North Africa, specifically Algeria and Tunisia through Italy than Germany and Austria.

a.Economic and Strategic Dimensions of the Project: The SouthH2 Corridor project represents an actual embodiment of the European Union's response to the Green Deal objectives and the REPowerEU plan, where it seeks to diversify energy sources and reduce dependence on Russian gas through importing green hydrogen from North Africa. (Reuters, 2023) Below is a figure illustrating the Southern Corridor route as well as the green hydrogen value chain:

Figure 5: SouthH2 Corridor Project for Transporting Green Hydrogen from Algeria to Europe



Source: Hydrogen Europe (2023). SouthH2 Corridor Project Overview. Retrieved from: <https://hydrogeneurope>.

The figure illustrates the map of Algerian partnerships in the field of green hydrogen, where Algeria emerges as a key hub connecting European markets with energy resources in North Africa.

The project includes the establishment of a pipeline extending approximately 3,300 kilometers connecting Algeria through Tunisia and Italy to Germany, with an export capacity reaching more than 4 million tons annually, representing about 40% of the European import target by 2030 (Corridor, 2024).

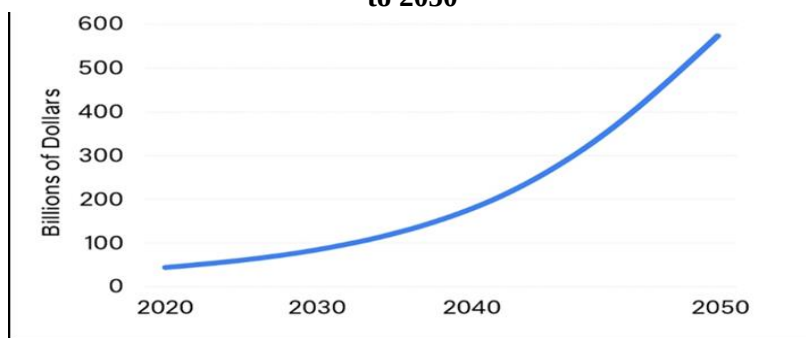
This project is not just an energy infrastructure, but a strategic option that reflects the intersection of European interests and environmental challenges, with Algeria investing in its competitive resources to enhance energy security and achieve economic growth.

b.Technological Transformations and Environmental Benefits: Algeria's plan for transitioning to green hydrogen constitutes a qualitative leap in developing energy infrastructure, particularly regarding gas transmission networks. The strategy relies on modifying and using currently existing pipelines so they can transport hydrogen, thereby reducing the need to establish costly new networks.

This approach contributes to reducing investment costs and enhances the project's chances of economic success, while also supporting Algeria's position as a strong competitor in the global hydrogen market. "Hydrogen-ready" pipeline systems are among the vital technological developments that support the energy sector's transition toward the green economy, as they allow for the transport of pure hydrogen or hydrogen mixed with natural gas at high ratios without the need for complete replacement of infrastructure, thus reducing hydrogen transport costs by up to 30-50% compared to establishing new networks. (Council, 2021)

Economically, these transformations grant Algeria a strategic position in the emerging hydrogen market, which is expected to exceed \$600 billion globally by 2050 (BloombergNEF, 2023). The following figure illustrates the expected growth of this market:

Figure 6: Expected Growth of the Hydrogen Market from 2020 to 2050



Source : BloombergNEF. (2023). Hydrogen Economy Outlook 2023. Retrieved from <https://about.bnef.com/hydrogen-economy-outlook/>

the importance of developing technical and technological capabilities locally emerges, including technology transfer, training national cadres, and building specialized research support systems in hydrogen technology. International partnerships, such as the Algerian-German cooperation, represent a key driver for technology transfer and enhancing local innovation.

c. Differences in Algerian and German Approaches to Building the Green Hydrogen: Chain Countries' experiences in developing green hydrogen value chains reflect clear differences in visions and priorities, where financial, technical, and regulatory factors play a crucial role in determining the speed and success of energy transition. In this context, the following table illustrates a comparison

between the Algerian and German approaches in building the green hydrogen chain across five main dimensions:

Table 03: Comparison between the Algerian Approach and the German Approach in Developing the Green Hydrogen Value Chain

Dimension	Algeria	Germany
Financing	Mixed financing (governmental, international partnerships, Sonatrach investment)	Massive governmental support, federal financing, industrial and private investments
Infrastructure	Adaptable gas networks (TransMed, Medgaz) Electrolysis projects under planning	National hydrogen network (9400 KM) under construction, using gas pipelines and new expansions
Innovation	Limited, under supervision of emerging institutions like CDER and CNTPP	Established industrial research ecosystem with strong government support Fraunhofer & DLR
Regulatory Framework	Absence of explicit hydrogen legislation, scattered efforts	Clear national roadmap supported by federal regulation and specialized agencies (BNetZA)
International partnerships	Cooperation with Germany and Italy within the SouthH ₂ Corridor project	European alliances, and integrated structures to accelerate exchange, storage, and production

Source: Hydrogen Europe (2024). Hydrogen Infrastructure in the MENA Region.<https://www.hydrogeneurope.eu>

there are fundamental differences between the Algerian experience and the German experience, and these data show that Algeria is still in a foundational stage that requires strengthening investments and building capacities, while Germany has reached an advanced stage of integration in the green hydrogen value chain, providing it with higher competitive capacity at the international level.

5.3.The Dual Impact of the Partnership on Sonatrach and the National Economy: The Algerian-German cooperation in the field of green hydrogen represents a prominent structural milestone in the trajectory of Algerian energy policy, as it transcends the technical dimension to redefining the role of Sonatrach Company and enhancing Algeria's position in global energy value chains. The dual impact of this cooperation is embodied in three interconnected axes

that reflect the depth of transformation in the national energy infrastructure, which are:

a-Transformation of Sonatrach into an innovative energy institution: Sonatrach is no longer limited to being a company that relies primarily on oil and gas exports, but has begun adopting a new model based on innovation and modern technologies. This internal transformation requires intensive efforts to rehabilitate various organizational and structural aspects of the institution, and necessitates deep qualification at several levels, the most important of which are: (Sonatrach, 2025)

- Building human capabilities in fields such as solar energy, electrical analysis, carbon management, and energy modeling.
- The gradual transformation in Sonatrach's investment portfolio towards low-carbon projects, with special focus on southern Algerian regions rich in solar radiation.
- Sonatrach's gradual engagement in pilot projects with international partners, which provides it with practical experience in operating renewable energy plants, an experience that has accumulated since its previous experiments and constitutes a preparatory step towards managing hydrogen production, storage, and export systems.

b-Impacts on the national economy and diversification of the production base: On a broader scale, this transformation represents a strategic opportunity to restructure the Algerian economy in a more sustainable way. The hydrogen sector can play a pivotal role in diversifying income sources and stimulating new productive sectors, which enhances economic resilience and reduces its dependence on traditional oil and gas, where the hydrogen sector can contribute to: (IEA, 2022)

- **Creating new local production chains:** The development of the green hydrogen industry allows for the establishment of new industrial sectors including the manufacturing of electrolysis converters, solar and wind energy equipment, storage systems, and specialized infrastructure for transportation and distribution. This industrial diversification enhances the Algerian economy's ability to achieve added value locally instead of limiting itself to exporting raw materials only.

- **Supporting employment and vocational training:** The green hydrogen sector supports the employment of national cadres by providing new job opportunities in high-technology sectors and manufacturing industries, in addition to the services sector related to

maintenance and operation. It also encourages the development of specialized professional and technical training programs, contributing to bridging the gap between educational outputs and market requirements, and enhances youth capabilities in clean energy and technological innovation fields.

- **Economic diversification and reducing dependence on oil and gas:** Investment in green hydrogen helps reduce the fragility of the Algerian economy resulting from oil and gas price fluctuations in global markets. Through building a diverse and sustainable production base, the state can achieve more stable economic growth, while enhancing its competitiveness in international clean energy markets.

- **Developing integrated infrastructure for transportation and export:** Upgrading existing gas networks for hydrogen transportation use is one of the most important components of industrial transformation, as this infrastructure provides wide investment opportunities and contributes to reducing transportation costs, thereby enhancing Algeria's attractiveness as a strategic partner in the European clean energy market.

- **Enhancing environmental and economic sustainability:** Green hydrogen reduces carbon emissions and helps Algeria fulfill its international commitments related to climate change, which opens the door to benefiting from green financing mechanisms such as climate bonds and sustainable financing, and contributes to improving the national economy's image regionally and globally.

The Algerian-German partnership in the field of green hydrogen embodies a fundamental strategic pillar to support the national energy transition. Through enhancing technical capabilities and developing infrastructure, Algeria is redefining its role in the global energy market.

While establishing strong foundations for diversifying the national economy, achieving this goal remains contingent on intensifying institutional and legislative reforms, as well as deepening international cooperation to ensure sustainability and future growth in the green hydrogen sector.

6.ConclusionAlgeria has the capacity to emerge as a regional leader in green hydrogen production, leveraging its vast solar potential and strategic proximity to European markets. Although national policies set ambitious energy transition targets, practical implementation

remains constrained, underscoring the need for stronger governance, effective financing frameworks, and better institutional coordination.

The ongoing shift of Sonatrach toward renewable energy, together with the Algerian–German partnership, creates opportunities for technology transfer, export through initiatives such as the SouthH₂ Corridor and integration into global clean energy value chains. Ultimately, green hydrogen represents a strategic pathway for Algeria to diversify its economy, reduce hydrocarbon dependence, and strengthen its role in the global energy transition.

The following results provide an overview of the most significant insights from the analysis :

1-Algeria's vast solar resources provide a strong foundation for large-scale green hydrogen production.

2-National energy strategies set ambitious goals, yet implementation remains limited, requiring improved governance and financing mechanisms.

3-Sonatrach is progressively shifting from hydrocarbons toward renewable energy and hydrogen, marking a strategic repositioning.

4-The Algerian–German partnership offers significant opportunities for technology transfer, capacity building, and joint export projects such as the SouthH₂ Corridor.

5-Green hydrogen constitutes a strategic lever for economic diversification, reducing reliance on hydrocarbons and creating new opportunities for investment and employment.

Based on the analysis conducted in this article, and in line with the strategic direction Algeria is pursuing in the field of renewable energy, particularly green hydrogen projects, the study suggests the following:

1-Develop the legal and regulatory framework progressively to open the electricity market to competition and secure fair, attractive tariffs for clean energy.

2-Encourage Sonatrach to adopt an export-oriented vision by creating specialized units for renewable energy and hydrogen within its organizational structure to strengthen its global role.

3- Based on Sonatrach's experience and analysis of the Algerian-German partnership dynamics, this study suggests the following research axes to expand the scope of understanding and guide future studies:

4-Economic feasibility analysis of Sonatrach's investments in green hydrogen.

5-Comparative study of the legal and regulatory framework for hydrogen projects in Algeria, and proposing reforms inspired by successful European experiences.

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