



Green Hydrogen Market in North Africa

with forecast to 2050

Report 2024

EXTRACT
for more details contact info@alexec-consulting.com

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Foreword

In an era defined by the urgent need for sustainable energy solutions, the strategic significance of hydrogen cannot be overstated. As the world transitions towards cleaner and more efficient energy sources, the attributes of the North African region emerge as compelling factors in unlocking its hydrogen potential.

Central to this potential is the region's geographical proximity to Europe, a key market with a burgeoning demand for green hydrogen. The North African region's strategic location offers a unique opportunity for efficient transportation and distribution of hydrogen to European markets, facilitating the establishment of robust energy partnerships and fostering regional economic growth.

Furthermore, the North African region boasts a skilled workforce equipped with the expertise necessary for the development and operation of hydrogen-related technologies. This human capital, combined with a culture of innovation and adaptability, positions the region as a leading player in the global hydrogen economy.

Moreover, regulatory policies within the North African region are increasingly aligned with the ambitious sustainability goals set forth by European counterparts. By prioritizing renewable energy initiatives and embracing environmentally conscious policies, governments in the region are laying the groundwork for a vibrant hydrogen ecosystem that is both socially responsible and economically viable.

As we delve into the intricacies of the North African region's hydrogen potential within this report, stakeholders, policymakers, and industry leaders will gain valuable insights into the opportunities and challenges inherent in harnessing this vital resource.

Idriss Alami

Managing Partner at
ALEXEC Consulting

Filip Materek

Senior Consultant at
ALEXEC Consulting

Executive Summary

This report provides an overview of the hydrogen market potential in North Africa, focusing on the strategies, government initiatives, and infrastructure developments across the region. Aimed at investors, industry stakeholders, policymakers, and hydrogen enthusiasts, the report offers valuable insights into the burgeoning hydrogen economy in North Africa.

The report presents a comprehensive analysis of the challenges and opportunities facing the hydrogen market in North Africa, highlighting the region's potential for economic growth, technological advancement, and regional cooperation. Despite challenges such as distrust in government, infrastructure limitations, and social disparities, North Africa offers a conducive environment for hydrogen investment, supported by favorable government policies and growing international interest.

Looking ahead, the forecast for hydrogen market development in North Africa is promising, with each country poised to play a significant role in the global hydrogen economy. By capitalizing on their renewable energy potential, fostering transparency and governance, and enhancing regional cooperation, North African countries can position themselves as key players in the rapidly evolving hydrogen market.

The report includes a business case study on green hydrogen production in Morocco and its transportation to Germany, highlighting one of the future key scenarios of hydrogen where African countries could become major exporters to Europe. This study, similarly to the rest of the report, examines the entire hydrogen value chain, from production to storage and distribution. It contains, among other things, a calculation of the levelized cost of hydrogen (LCOH), taking into account two different methods of hydrogen transportation, and a calculation of the return on investment.

Key Findings

Several countries in North Africa, including Morocco, Algeria, Egypt, and Mauritania, have unveiled ambitious hydrogen roadmaps intending to become significant exporters of hydrogen and hydrogen-based fuels. These strategies underscore the region's recognition of the importance of transitioning to renewable energy sources and leveraging desalinated seawater for green hydrogen production.

There is a growing awareness of the hydrogen market potential among international investors and financial institutions, leading to increased investment in hydrogen projects across the region. This influx of funding reflects the confidence in North Africa's ability to capitalize on its abundant renewable energy resources and strategic geographic location in proximity to Europe.

So far, only two countries in the region, Morocco and Egypt, have demonstrated support for entrepreneurs and investors by actively promoting hydrogen projects. These nations provide various incentives such as tax exemptions and allocation of state-owned investment land, positioning themselves as leaders in regulatory and financial backing for the green hydrogen market in the region.

It is essential to integrate green hydrogen production plants with the expansion of new renewable energy sources (RES) to address the current high dependency on fossil fuels in the electricity mix. Following the expansion of RES, there must also be additional investment in distribution infrastructure, including ports, repurposing gas pipelines, and water desalination plants. This will increase the complexity of scaling the green hydrogen market, but it is an inevitable step toward achieving sustainable energy production and distribution.

The global shift away from fossil fuels in response to climate change presents significant economic challenges for Algeria and Libya, whose economies currently rely heavily on fossil fuel exports. The transition to green hydrogen will be a necessity for these nations, requiring substantial adaptation and investment. Meanwhile, other North African countries have the potential to transition from being fuel importers to hydrogen exporters, providing them with a significant opportunity for economic development and diversification.

Hydrogen Infrastructure





Green Hydrogen Production

Green hydrogen is usually produced through a process called electrolysis, where water is split into hydrogen and oxygen using electricity. This electricity is generated from renewable sources like solar, wind, or hydroelectric power, ensuring that the hydrogen produced is environmentally friendly. Overall, green hydrogen production offers a sustainable pathway towards clean energy.

Electricity Mix

The charts on the next page depicting the electricity mix in North African countries, namely Mauritania, Morocco, Algeria, Tunisia, Libya, and Egypt, provide a comprehensive overview of the region's energy landscape. Among these nations, Morocco and Egypt emerge as leaders in embracing sustainable energy practices, boasting a significant portion of its electricity generation derived from renewable sources such as wind, solar, and hydroelectric power. This commitment to renewables underscores their dedication to reducing carbon emissions and fostering a cleaner, more resilient energy infrastructure.

Conversely, Egypt stands out for its substantial electricity generation capacity, representing a cornerstone of the region's power supply. With over 200 TWh of annual electricity production, Egypt plays a pivotal role in meeting the growing energy demands of its population and driving economic development across various sectors. Its diverse energy portfolio encompasses a mix of fossil fuels, renewables, and potentially nuclear energy, reflecting a multifaceted approach to energy security and sustainability.

In terms of growth dynamics, Egypt and Algeria have experienced a remarkable expansion in their electricity production capacity. Over the past 10 years, investments in infrastructure and energy projects have propelled both countries to achieve unprecedented gains, with an increase of more than 30 TWh in annual electricity production. This surge underscores the nation's concerted efforts to modernize its energy sector and meet the evolving needs of its populace.

Furthermore, Mauritania has demonstrated exceptional progress in percentage terms, witnessing a significant rise in electricity production relative to its existing capacity. With a growth rate of almost 200% percent over the past 10 years, Mauritania exemplifies a commitment to energy expansion and infrastructure development. Despite facing various challenges, including resource constraints and regulatory hurdles,

However, all of the countries within the region continue to rely heavily on fossil fuels for electricity generation, presenting both challenges and opportunities in the transition to cleaner energy sources. These nations, confront the imperative to diversify their energy portfolios and mitigate environmental risks associated with fossil fuel dependency. Through strategic investments in renewables, energy efficiency measures, and policy reforms, these countries can chart a sustainable pathway toward a more resilient and environmentally responsible energy future.

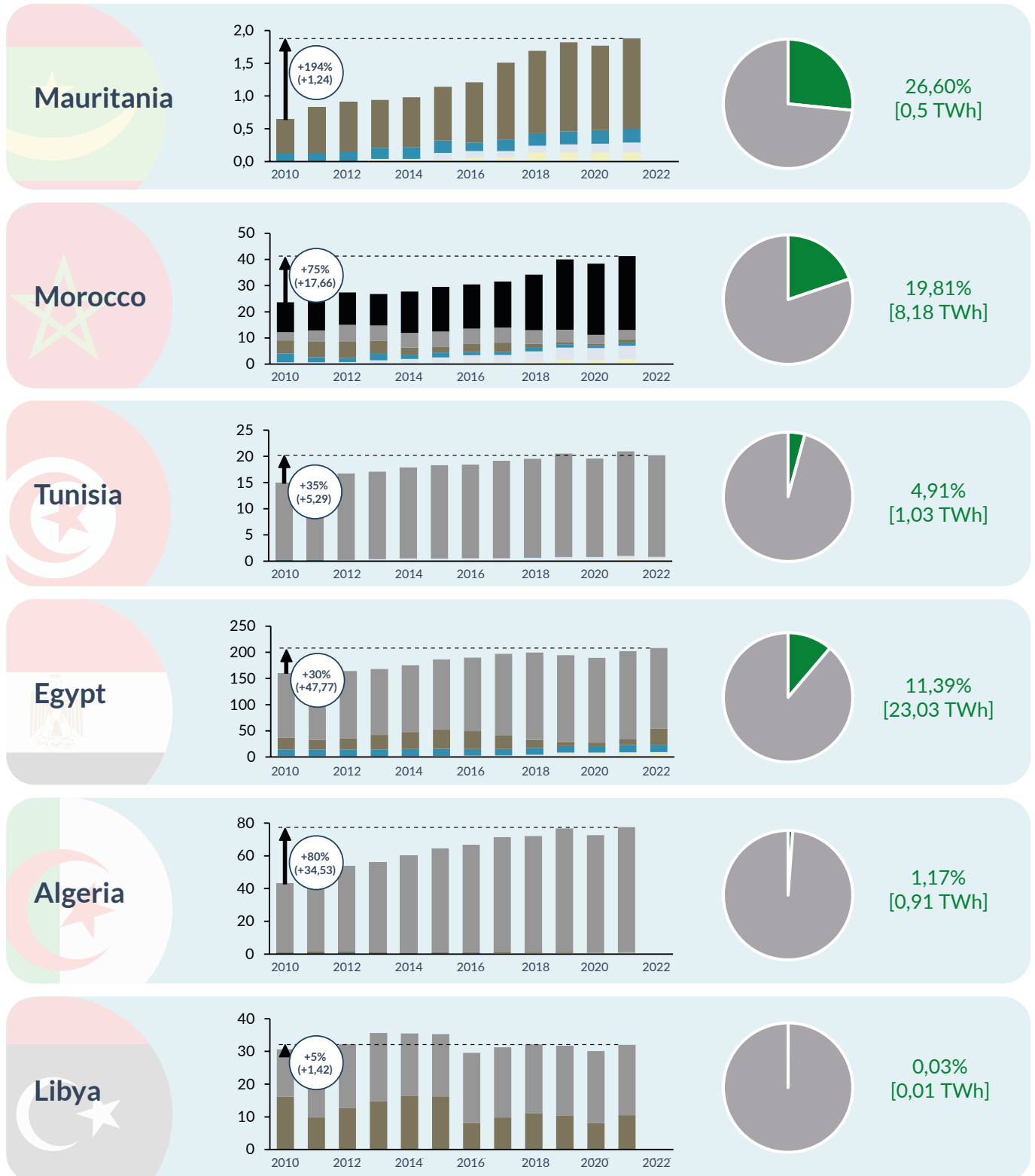
Green hydrogen production plants must go hand in hand with new RES¹ due to high fossil fuel dependency of electricity mix.

¹Renewable Energy Sources

Annual Electricity Production per Source

TWh

Renewables Shares in 2021



Source: ourworldindata.com

Bio energy Hydropower Gas Wind
 Solar Nuclear Coal Oil

Renewable Sources Potential

North Africa exhibits substantial potential for renewable energy generation, particularly in solar and wind power. In the last decade, the growth rates of fossil fuel usage worldwide have slowed down, partly due to the increased utilization of renewable energy sources such as wind and solar, attributed to their declining costs.

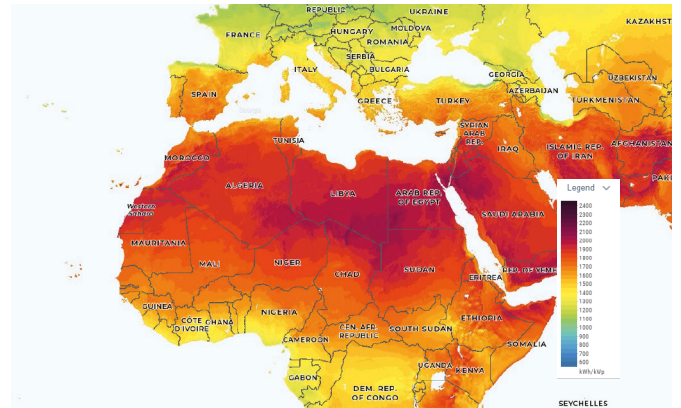
Solar energy, in particular, holds immense promise for the region. The vast Sahara Desert receives abundant sunlight annually, making it an ideal location for solar power generation. Over the past five years, the region has witnessed a significant increase in installed solar capacity, reaching over 3,000 megawatts (MW) in 2020. This capacity accounts for 2.7% of North Africa's total installed electricity generation capacity, with regional variations observed.

Notably, Morocco has emerged as a key player, exporting solar energy to Europe and hosting the world's largest concentrated solar power (CSP) plant – NOOR III, while Egypt and Algeria have also made substantial contributions to solar PV power plants (i.e. Benban PV plant). Additionally, Mauritania's potential for both solar and wind energy is considerable, with estimates suggesting a capacity four times its current production.

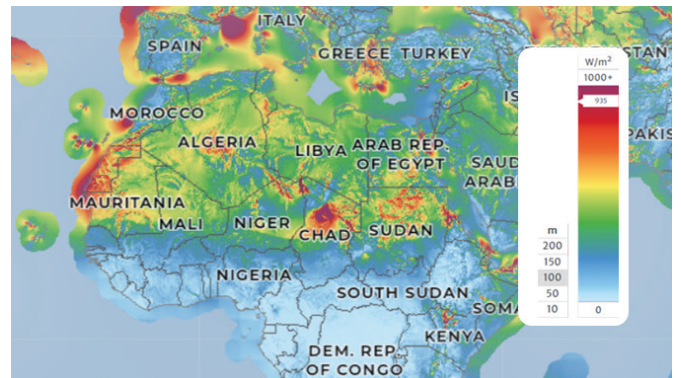
NOOR III, Morocco
Source: worldmorocconews.com



Benban, Egypt
Source: africa21.africa



Global Solar Atlas



Global Wind Atlas

Wind energy is another area of focus in North Africa. Algeria stands out with the potential to produce over 7,000 gigawatts (GW) of wind energy if fully harnessed. Mauritania and Morocco also exhibit significant wind power potential. Despite regional disparities, the average total installed cost for solar PV and wind energy projects has declined significantly in recent years, making them increasingly economically viable options for electricity generation in the region.

In summary, while solar and wind power currently represent a relatively small portion of North Africa's electricity mix, their growing importance reflects their potential to replace fossil fuel-based generation and contribute to a more sustainable energy landscape.

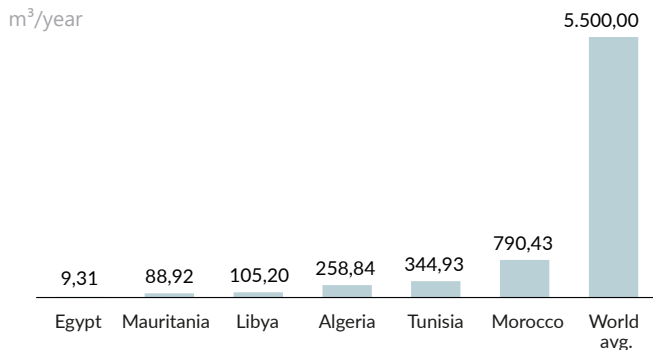
Water Scarcity

Water scarcity in North Africa is a critical issue that has historical roots in the region's long-standing water management practices. Over generations, North African communities have developed sophisticated systems for water storage and collection, reflecting the importance of water conservation in the region. However, the growing impact of climate change is placing unprecedented stresses on North Africa's water infrastructure, disrupting the hydrologic cycle and exacerbating water scarcity. So far climate change has led to shifts in rainfall patterns and increased the frequency of droughts and wildfires in the region.

North Africa is one of the most water-stressed regions globally, with countries like Libya facing extreme water stress, while others, including Tunisia, Algeria, and Morocco, are categorized as under high water stress. The region's water scarcity is compounded by rapid population growth, urbanization, and changing climatic conditions. With an average of less than 1.000 cubic meters of renewable freshwater per person per year, North Africa's water resources are stretched thin.

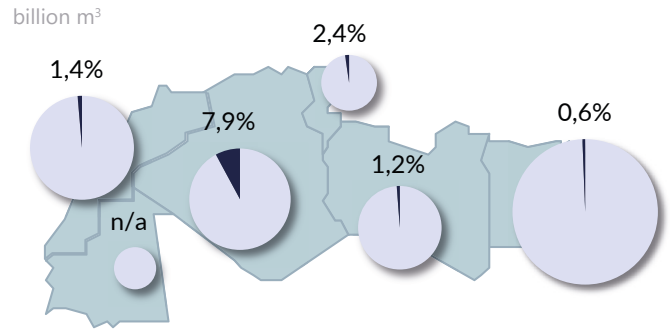
In the context of future green hydrogen production, ensuring a sustainable water supply is paramount. Therefore, the availability and management of water resources are crucial con-

Renewable freshwater resources per capita



Source: ourworldindata.org

% of desalinated water to annual freshwater usage



Source: ourworldindata.org, worldpopulationreview.com

siderating the establishment of hydrogen production plants in North Africa. Given the region's water scarcity challenges, innovative solutions such as seawater desalination and wastewater recycling may play a pivotal role in providing the necessary water for green hydrogen production while minimizing strain on freshwater sources. Additionally, strategic siting of hydrogen production facilities, taking into account proximity to coastal areas for seawater access or locations with existing wastewater treatment infrastructure, can optimize water use efficiency and support the sustainable growth of the hydrogen economy in the region.

Desalination already plays a pivotal role in addressing water scarcity across North African countries. Algeria, for instance, boasts Africa's largest desalination plant, meeting a significant portion of the national freshwater water demand. Algeria plans to further enhance its desalination capacity by developing new plants, aiming for substantial growth by 2030. Similarly, Egypt, Morocco and Tunisia are also expanding their desalination infrastructure to bolster water security and adapt to climate challenges. These efforts underscore the increasing importance of desalination as a solution to water scarcity in the region.

Average Water Availability per person

● <500m³ ● 500-1.000m³ ● 1.000-1.700m³ ● >1.700m³

Source: worldwater.io

Hydrogen Distribution

Hydrogen distribution refers to the transportation of hydrogen from production facilities to end-users or storage locations. This process involves various methods such as pipelines, trucks & trailers, ships, and railroads. Pipelines are likely to be the most common means for large-scale distribution, while trucks and ships are used for smaller quantities and remote locations. Distribution infrastructure for hydrogen still requires massive resources (financial, human, materials) to be established on a level enabling big-volume transportation. Its deployment is crucial for enabling the widespread adoption of hydrogen as an energy carrier, supporting local and regional applications like zero-emission hydrogen mobility, sustainable ammonia and fertilizer production, and many more as well as hydrogen export.

Hydrogen Storage

Green hydrogen, as a sustainable energy carrier, offers diverse storage solutions critical for its integration into the energy landscape. Compressed hydrogen stands as a prominent method, involving the compression and storage of hydrogen gas in robust, high-pressure tanks. Alternatively, the liquefaction of hydrogen into liquid form, achieved through extreme cooling, presents a spatial advantage by having slightly higher energy density over gaseous storage. However, cryogenic containers are required in this process to maintain the low temperatures. Another solution involves storing hydrogen in chemical compounds such as ammonia, metal hydrides or efuels, enabling even higher energy density at the expense of energy loss associated with the synthesis of these chemical compounds.

One promising form of hydrogen storage is underground storage in salt caverns or depleted fossil fuel deposits. Morocco exemplifies this innovative approach by exploring underground storage possibilities. Its saliferous massifs, featuring expansive cavities, become potential reservoirs capable of accommodating hundreds of tonnes of green hydrogen. A partnership between HDF Energy and a Moroccan Storage Society (SOMAS) aims to examine and potentially develop a green hydrogen storage infrastructure within salt caverns along the Casablanca-Rabat axis. Tunisia and Egypt, too, have utilized underground caverns for hydrocarbons storage, presenting an analogous opportunity for hydrogen storage infrastructure development. However, it's noteworthy that available data for underground storage in Libya, Algeria, or Mauritania is currently unavailable, indicating the need for further exploration in these regions.

There is another possibility of using existing infrastructure for hydrogen storage, but it involves adapting the fuel buffer tanks at loading terminals, particularly in hydrocarbon-exporting countries (such as Algeria or Libya). In this context, an in-depth techno-economic analysis is necessary to assess the cost-effectiveness of reconstructing the infrastructure for the production of synthetic fuels from hydrogen.

Comparison of different hydrogen storage technologies

Items	CGH ₂		LH ₂	LOHC	NH ₃
	35 MPa	70 MPa			
Vol. Capacity (w/o tank) [g/L]	23,3	39	71,7	56	123
Operating Temperature [deg. C]	-40 to 80	-40 to 80	< -253	n/a	20 (at 1MPa)
Energy cons. to prepare storage condition [kWh/kgH ₂]	1-2,8	1-3,3	6-10	-9	8,2-13-3
Energy cons. to release hydrogen [kWh/kgH ₂]	0	0	0	9	6,3
TRL	9	9	9	4-6	9
Long-dist. hydrogen transport	yes	no	yes	yes	yes
Long-term hydrogen storage	yes	yes	no	yes	yes

Source: A review of hydrogen storage and transport technologies, Clean Energy, 2023, Vol. 7, No. 1

CGH₂: Compressed Gaseous Hydrogen ; LH₂: Liquid Hydrogen
LOHC: Liquid Organic Hydrogen Carrier ; NH₃: Ammonia

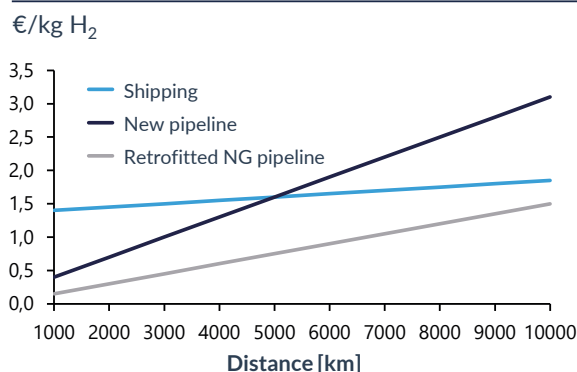
Hydrogen Shipping

The shipping of green hydrogen from North Africa presents both challenges and opportunities, contingent upon the existing fuel infrastructure in the regional ports. Algeria and Libya, as established fuel exporters, boast extensive cargo infrastructure across numerous ports tailored for hydrocarbon exports. Leveraging this existing infrastructure for the transportation of green hydrogen could offer a viable pathway for these countries to diversify their energy exports and capitalize on the burgeoning green hydrogen market. A compelling solution for these countries could involve the production of e-fuels and the utilization of existing transport infrastructure, thereby avoiding costly modifications.

Conversely, Morocco, Tunisia, and Egypt primarily serve as fuel importers, with limited cargo infrastructure dedicated to storing hydrocarbons. However, with strategic adaptation and investment, these countries could transform their ports into exporting hubs for green hydrogen or e-fuels.

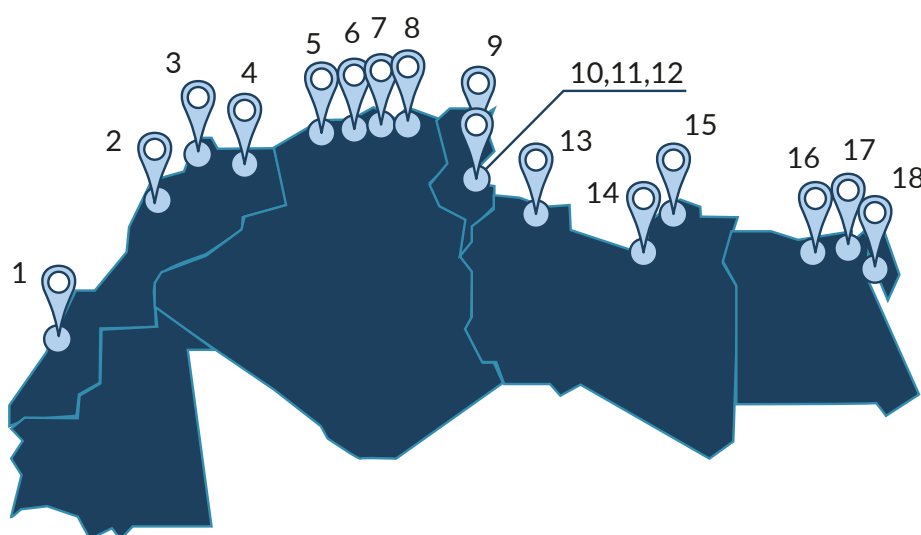
On the other hand, exporting liquid hydrogen poses a more significant challenge, necessitating a comprehensive upgrade of the infrastructure. Unlike gaseous hydrogen, which is impractical for shipping due to its low density, liquid hydrogen offers a viable alternative but requires specialized storage and transportation facilities. The construction of liquefaction plants and cryogenic storage tanks, along with retrofitting existing cargo terminals, would incur substantial costs and time investments.

Hydrogen transport cost



Source: A review of hydrogen storage and transport technologies, *Clean Energy*, 2023, Vol. 7, No. 1
NG: Natural Gas

Notably, there is a lack of data regarding Mauritania's port infrastructure, suggesting limited large capacity fuel infrastructure in the country. However, if Mauritania were to explore green hydrogen production and exportation, significant investment in port infrastructure would likely be required to facilitate transportation.



1. Port of Dakhla
2. Port of Jorf Lasfar
3. Tanger Med
4. Port of Nador
5. Port of Arzew
6. Port of Oran
7. Port of Bejaia
8. Port of Skikda
9. Port of Tazerka
10. Port of Sfax
11. Port of Skhira
12. Port of Gabes
13. Port of Tripoli
14. Marsa-El Brega Port
15. Port of Benghazi
16. Port of Alexandria
17. Port of Damietta
18. Suez Port

Ports with major fuel storage and distribution infrastructure
Source: marineinsight.com

Distribution via Pipelines

—	Trans-Saharan
To be commissioned in 2030 4000 km long, 30 billion m ³ /year	
—	Maghreb-Europe
Commissioned in 1996, closed since 2021 1350 km long, 12 billion m ³ /year	
—	Medgaz
Commissioned in 2011 757 km long, 8 billion m ³ /year	
—	Galsi
Delayed since 2014, resumption planned 930 km long, 8 billion m ³ /year	
—	Trans-Mediterranean
Commissioned in 1983 2475 km long, 33,5 billion m ³ /year	
—	Greenstream
Commissioned in 2004 520 km long, 11 billion m ³ /year	



Existing or planned gas pipeline infrastructure in North Africa
Source: gem.wiki

In the Mediterranean region, where existing gas infrastructure facilitates the import of natural gas from countries like Algeria and Libya to Europe, repurposing these pipelines for hydrogen transport presents a viable solution. In the short-to-medium term, initiatives to repurpose infrastructure such as the Trans-Mediterranean pipeline between Algeria, Tunisia, and Italy can enhance the required capacity for hydrogen transmission. Additionally, efforts to repurpose the Maghreb-Europe pipeline or establish new hydrogen pipelines between Morocco and Spain are essential steps to ensure the efficient distribution of hydrogen between the continents.

Repurposing natural gas pipelines for hydrogen distribution holds significant potential for advancing the transition toward a hydrogen-based economy. Studies indicate that utilizing existing natural gas grids for hydrogen transport can be up to four times more cost-effective than constructing new pipelines. This cost advantage is attributed to the limited disparity in operating expenses between repurposed natural gas pipelines and newly built hydrogen transmission networks, primarily due to the heavier capital expenditure associated with transportation infrastructure.

However, the feasibility of repurposing natural gas pipelines for hydrogen distribution hinges on addressing technical challenges related to pipeline transmission. These include issues such

as hydrogen embrittlement of steel and weld, as well as hydrogen permeation and leakage. Hydrogen's unique properties, including its ability to dissociate on metal surfaces and permeate through materials, pose significant challenges to the integrity of existing steel natural gas pipelines.

Hydrogen pipeline investment costs

		Scenarios		
		Low	Avg	High
Diameter		(million €/km)	(million €/km)	(million €/km)
(in)				
New pipeline	<28	1,3	1,5	1,8
	28-27	2	2,2	2,7
	>37	2,5	2,8	3,4
Repurposed NG pipeline	<28	0,2	0,3	0,5
	28-37	0,2	0,4	0,5
	>37	0,3	0,5	0,6

Source: European Hydrogen Backbone (Guidehouse, 2021)

Regulatory Environment



Political Involvement to Green Hydrogen Economy

The vast majority of governments in the region are already aware of the importance of implementing hydrogen projects and their significant strategic relevance for the energy security of the region, Europe, and achieving climate goals. Morocco stands out as an early adopter, having published its national strategy as the first African country back in 2021. While other countries in the region have yet to finalize their strategic documents, most of them, including Algeria, Egypt, and Tunisia, have officially announced the commencement of work on their preparation.

Among the North African countries, the majority have published their roadmaps defining goals for hydrogen economy development in each state, including Algeria, Mauritania, Morocco, and Egypt. Furthermore, half of these Arab countries belong to the African Green Hydrogen Alliance, a platform aimed at fostering collaboration with the private sector, development finance institutions, and civil society. The primary objective of the alliance is to intensify collaboration and accelerate the development of green hydrogen projects across the African continent.

						
Hydrogen Roadmap	yes	yes	yes	in the making	no	yes
National Hydrogen Strategy	in the making	no	Yes	in the making	no	in the making
Government Green Hydrogen Lead	Ministry of Energy and Mines Ministry of Energy and Mines	Minister of Petroleum, Energy, and Mines	Moroccan Ministry of Energy, Mines and Environment Research Institute for Solar and New Energies (IRESEN)	Ministry of Industry, Mines and Energy	Ministry of Oil and Gas	The Cabinet. Ministry of Electricity and Renewable Energy
Belongs to AGHA ¹	no	yes	yes	no	no	yes
National Hydrogen Initiatives or Associations	n/a	n/a	GH2A	n/a	n/a	Hydrogen Egypt
National Hydrogen Incentives	n/a	n/a	Morocco Offer	n/a	n/a	Yes (tax exemptions)

¹African Green Hydrogen Alliance
Source: GH2

National Hydrogen Incentives - Overview



Egypt

Egypt offers a range of incentives to encourage the development of hydrogen projects, as President Abdel Fattah El-Sisi has signed tax incentives into law, providing a credit of 33-55% off project taxes and VAT exemptions on various project-related equipment and materials. Producers are granted rights to export and import without licensing requirements, and discounts on fees for port usage and industrial land rights are provided for up to ten years after project agreements with the government. However, these incentives come with conditions, including securing 70% of project investment from foreign financial institutions, starting operations within five years, and using locally-made components to meet a minimum 20% local-content requirement. Additionally, while foreign workers may be employed, they are capped at 30% of the total workforce for up to ten years after project approval, underscoring the government's efforts to balance incentives with local economic development goals.



Morocco

Morocco offers substantial incentives to investors or consortiums interested in developing green hydrogen projects within the kingdom, aiming to address both domestic and export markets. These incentives encompass integrated projects covering the entire value chain of green hydrogen production, from renewable energy generation to downstream transformation into various derivatives, such as ammonia and synthetic fuel. The state provides access to significant public land, approximately 1 million hectares, specifically designated for green hydrogen production, with plans to allocate 300,000 hectares in the initial phase. Additionally, investors can benefit from tax and customs incentives, including import duty and value-added tax exemptions on both domestic and imported goods.

Furthermore, the government plans to establish industrial acceleration zones to support the industrial ecosystem around green hydrogen. Evaluation criteria for project proposals include financial strength, experience across the value chain, and the projected positive impact on Morocco's industrial integration and economy. Initial negotiations with selected investors are expected to commence by the third quarter of 2024.

Implementation of national incentive programs is recommended to accelerate the development of the green hydrogen market.

Business Landscape



Business Landscape Insights

Navigating the business landscape of the burgeoning green hydrogen industry in North Africa requires a keen understanding of its dynamic nature. While a multitude of projects have been announced, it's essential to recognize that not all of them may come to fruition. A significant proportion of these ventures are still in the proof-of-concept phase or were initiated through non-binding Memoranda of Understanding (MoUs), highlighting the speculative nature of the current landscape. Notably, countries like Egypt, Morocco, and Mauritania have garnered heightened interest, boasting a considerable number of hydrogen projects in the pipeline. Despite the enthusiasm surrounding these initiatives, stakeholders must exercise caution and diligence in assessing their feasibility and viability.

Seizing the opportunities presented by the nascent African green hydrogen industry necessitates a collaborative approach involving diverse stakeholders. This includes government ministries, project developers, financiers, financial institutions, civil society organizations, and academic institutions. Visionary private sector partners and international collaborators play a pivotal role, offering expertise, capacity, and access to capital crucial for supporting hydrogen project development. Collaborating closely with host governments and local institutions, these partners can bolster permitting processes and project structures aligned with national priorities for sustainable development and economic growth.

While urgency is warranted in capitalizing on the vast potential of the green hydrogen market, it's equally essential to ensure the establishment of durable contracts conducive to long-term stable investments. Transparency and stakeholder engagement are fundamental in building broader trust and capabilities essential for rapid, large-scale industry development. Furthermore, realizing the socioeconomic and environmental benefits of the green hydrogen industry necessitates substantial investment. Funding mechanisms at the national level can support the development of critical infrastructure, while facilitating access to financing for private ventures. With the global green hydrogen market poised for exponential growth, North Africa stands to emerge as a significant player in the sector, potentially exporting billions of dollars' worth of green hydrogen annually. This underscores the region's immense potential for economic growth and prosperity through strategic investments in green hydrogen projects.

Internal Usage

Green hydrogen presents significant opportunities for internal use within North Africa, particularly for decarbonizing energy-intensive industries such as steel, cement, and chemicals production. Mauritania, for example, could benefit greatly from using green hydrogen in its steel industry. Additionally, companies like Egypt's Fertiglabe and Morocco's OCP Group have already initiated green hydrogen pilot plants to produce green ammonia for fertilizer production. By harnessing green hydrogen domestically, North African countries can generate clean electricity and heat, use it as a green fuel for transportation, and power industrial processes, thus reducing reliance on fossil fuels and contributing to their climate goals. This internal use of hydrogen can also enhance energy security and sustainability within the region.

Hydrogen for Exports

The green hydrogen industry in North Africa presents significant export potential, with projections from Deloitte suggesting the region could generate around \$110 billion annually by 2050, making it a leading global exporter. This would position North Africa as a key player in the international hydrogen market alongside North America, Australia, and the Middle East. However, contrasting estimates from the McKinsey Global Energy Outlook suggest that Africa may only hold a minor market share in hydrogen production and exports. Given the differing projections, it is crucial to develop more precise forecasts for Africa's hydrogen market potential, accounting for both the region's capacity for growth and the challenges it faces.

While consulting reports may reflect the financial interests of their corporate clients, including some of the world's largest carbon polluters, the regulatory environment and high market awareness among local societies in North Africa suggest the region will strive to play a pivotal role in the global hydrogen market. This awareness, combined with the strong potential for hydrogen production, points to North Africa as an area to watch in the development of the hydrogen industry.

Strategic Hydrogen projects in North Africa¹

Morocco



Project Amun – CWP Global and Bechtel

» 2-2,5 Mt of annual green ammonia production

The PtX Initiative - MASEN

» 100 MW of electrolyzers installation for green H2 production

Hevo Ammonia Project

» 0,183 Mt of annual green ammonia production by 2026

Total Eren

» 10 GW of RES for green hydrogen and green ammonia production

Egypt



AMEA Power

» 0,8 Mt of annual green ammonia production for export

MASDAR, Infinity, Hassan Allam

» 0,48 Mt of annual green H2 production by 2030

Globeleq

» 3 phase project totaling 3,6 GW of electrolyzers for green H2 production

Total Eren, Enara

» 1,5 Mt of annual green H2 production

Fortescue

» 0,33 Mt of annual green H2 production

ACWA Power

» 2 Mt of annual green ammonia production

ReNew Power

» 0,22 Mt of annual green H2 production

Alfanar

» 0,5 Mt of annual green ammonia production

EDF, ZeroWaste

» 0,08 Mt of annual green H2 production

H2 Industries

» 0,3 Mt of annual green H2 production from waste-to-hydrogen plant

Egypt Green Project – Scatec, Fertiglobe, Orascom, OCI

» First integrated hydrogen plant in Africa producing up to 15,000 tons of green H2 annually

Mauritania



Project Nour – Chariot and Total Eren

» 1,2 Mt of annual green H2 production by 2030

Project Aman – CWP Global

» Initially 0,5 Mt of annual green H2 production
» Green ammonia production

Masdar Infinity Conjuncta

» 8 Mt of annual green H2 production

bp

» Potential 2 Mt of annual green H2 production

Tunisia



H2Vert.TUN - GIZ

» Development of a framework for the hydrogen value chain

SouthH2 Corridor

» Gas pipeline conversion from Algeria to Germany (through Tunisia, Italy, and Austria) enabling 4 Mt of hydrogen imports to Europe

UNIDO Green Hydrogen – Tunisian-Austrian partnership

» Joint cooperation for new market development and opportunities seeking

Algeria



German-Algerian Partnership VNG, Sonatrach

» Pilot project with 50 MW electrolysis for green hydrogen production

SouthH2 Corridor

» Gas pipeline conversion from Algeria to Germany (through Tunisia, Italy, and Austria) enabling 4 Mt of hydrogen imports to Europe

Libya



n/a

¹The list of projects may not be exhaustive
Sources: gh2.org, own research

Business Case Study - Exporting Green Hydrogen from Morocco to Germany

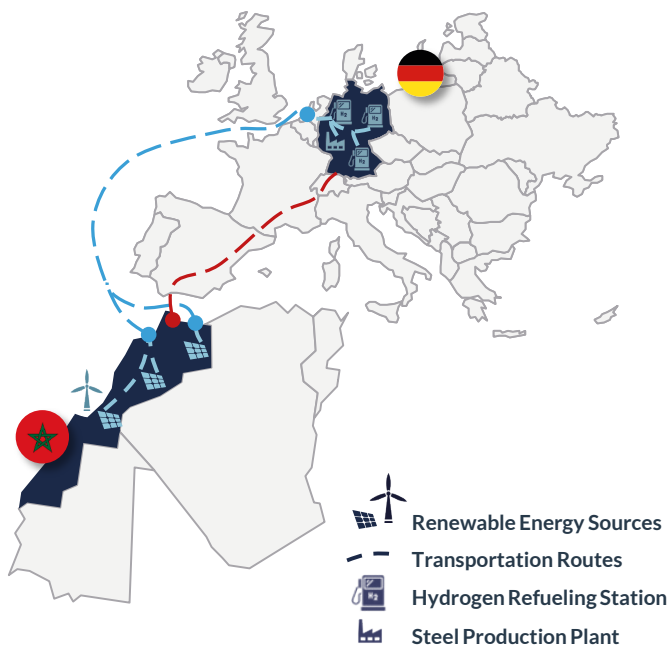
Introduction

Initial Situation

A German fuel and gas distribution company is considering importing green hydrogen from Morocco to supply to a network of hydrogen refueling stations (HRS) and industrial plants in the country. A Pre-Feasibility Study shall be done considering demand situation, potential project locations, cost structures, supply situation, risks and initial profit possibilities.

Objectives

- Profit from introducing new products onto the market and providing for demand for Green Hydrogen within Germany
- Foster sustainable growth of the company and partners
- Receive European funding for sustainable development and zero-emission technologies



Goals & Forecasts

2027 - (Pilot production)

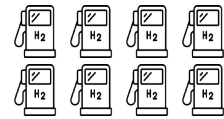
2030 - (Ramp-up)

GOAL 1: Supply Green Hydrogen to Hydrogen Refueling Stations (HRS)

20 HRS



80 HRS



Assumption: 1 HRS has a daily turnover of 1 ton of hydrogen

= 10 Hydrogen Refueling Stations (HRS)

GOAL 2: Supply Green Hydrogen to Steel Industry

3% of Steel Industry Energy Supplies



15% of Steel Industry Energy Supplies



Assumption: German steel industry produces 40 Mt of steel per year and 50 kg of H₂ is required for 1 ton of steel

GOAL 3: Achieve 100% ROI by 235.

Total Demand for Hydrogen

million tons (Mt)

HRS

Steel Industry

Σ 0,095

0,088

0,008

Σ 0,470

0,030

0,440

Assumption: investment starts in 2024

Production Plant

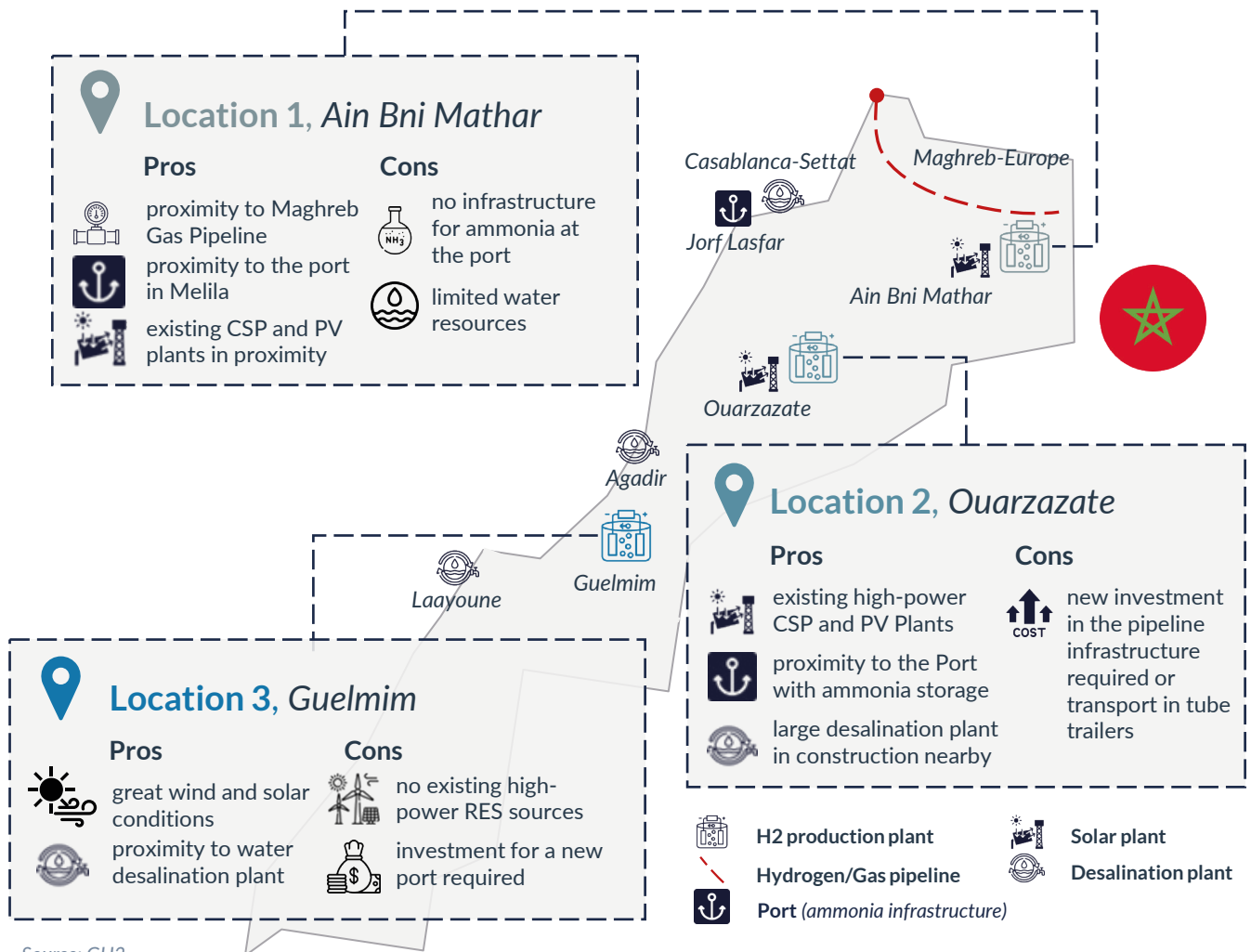
Location Selection Criteria

Three examples of locations for a hydrogen production plant are shown in the graphic on the left. Each has its pros and cons, and the choice of the final location depends on a thorough analysis, which should be a continuation of this case study.

Some key factors need to be considered when considering a green hydrogen production plant in Morocco. The success of an investment depends largely on its location and the surrounding infrastructure.

Key Factors

- Electricity Supplies (from renewable sources),
- Water Supplies (obligatory from desalination plants due to water scarcity in the region),
- Human Resources (engineering and operation),
- Proximity and availability of storage systems and distribution systems of hydrogen or its derivatives



Export

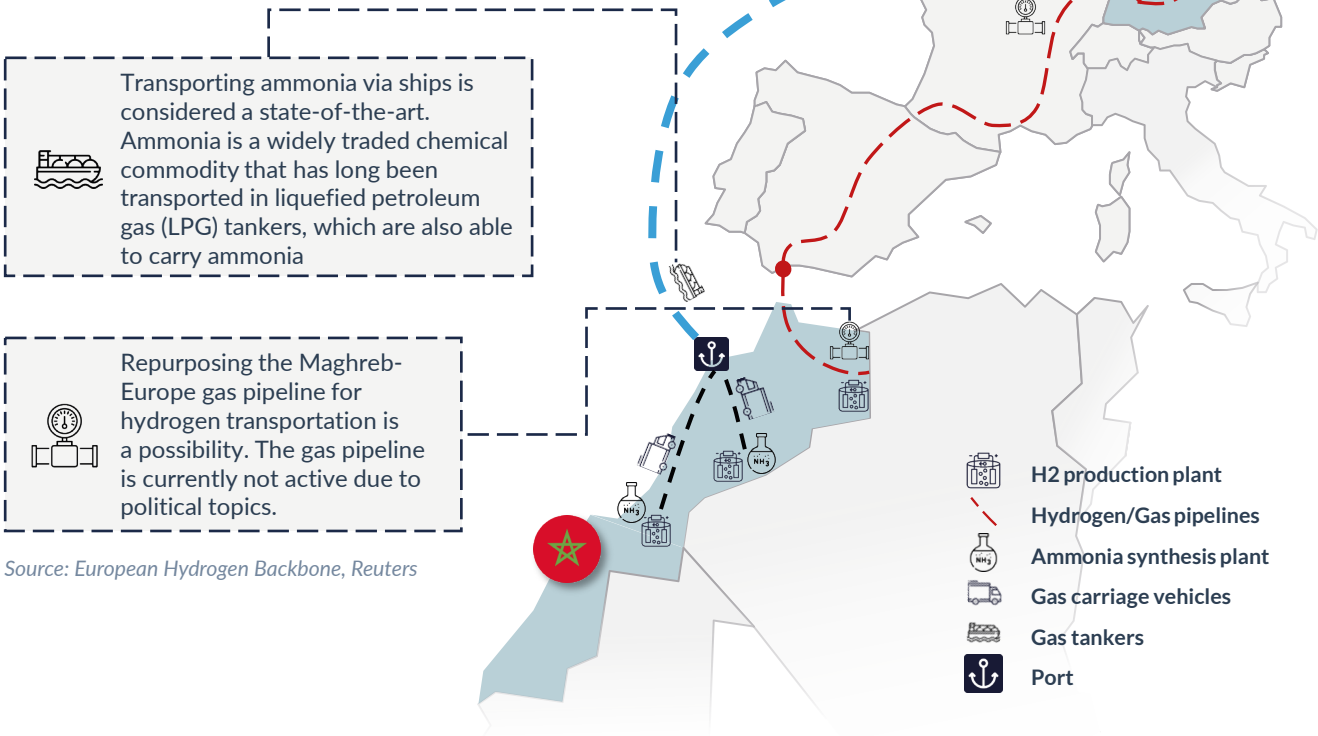
Hydrogen transportation methods

When considering green hydrogen export from Morocco to Germany, a few alternative solutions need to be considered.

- Large-scale hydrogen production and transporting it via tube trailers for export is becoming unfeasible. One alternative is transporting hydrogen in railcar-mounted tanks, but it's beyond the scope of this study.
- Another option for transporting hydrogen in the short term is to synthesize it into ammonia. This has a higher volumetric energy density, making it more economical to transport.
- Yet another option is injecting hydrogen into new or repurposed gas pipelines. This transport method significantly reduces the operational costs of hydrogen supply but entails high initial investment. However, it needs to be considered in the long-term perspective (2030).

Further in this case study the cost of hydrogen is calculated for the last two methods of transportation.

According to the European Hydrogen Backbone (EHB) initiative, the hydrogen infrastructure network is expected to grow significantly by 2030. The EHB aims to develop 28,000 km of hydrogen pipelines by 2030, covering 28 European countries



Source: European Hydrogen Backbone, Reuters

Storage & Distribution

Hydrogen Storage

The storage of hydrogen is as necessary as the storage of any other fuel. It provides a safety buffer in the event of a supply shortage. Hydrogen can be stored in salt caverns, hydrogen pressure vessels or hydrogen derivatives such as ammonia itself.



Large scale and long-term hydrogen storage will be mostly done in underground caverns. Germany could be a central location for hydrogen storage in Europe.



Most of Germany's steel production industry is located on the western side, which is close to the border with the Netherlands and France, thus close to hydrogen supply points. Due to the high demand for hydrogen, the connection of production facilities directly to gas pipelines is recommended.

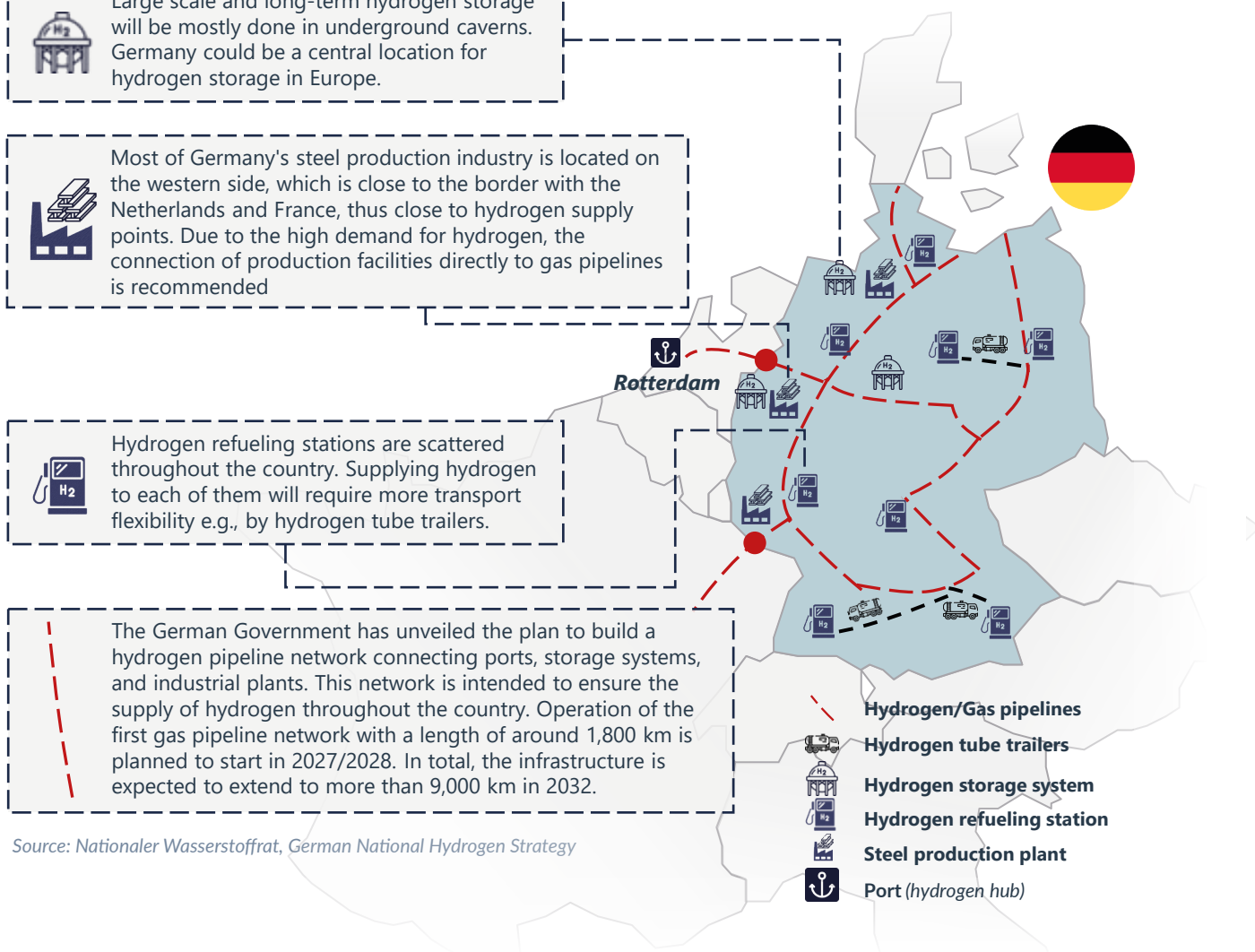


Hydrogen refueling stations are scattered throughout the country. Supplying hydrogen to each of them will require more transport flexibility e.g., by hydrogen tube trailers.

The German Government has unveiled the plan to build a hydrogen pipeline network connecting ports, storage systems, and industrial plants. This network is intended to ensure the supply of hydrogen throughout the country. Operation of the first gas pipeline network with a length of around 1,800 km is planned to start in 2027/2028. In total, the infrastructure is expected to extend to more than 9,000 km in 2032.

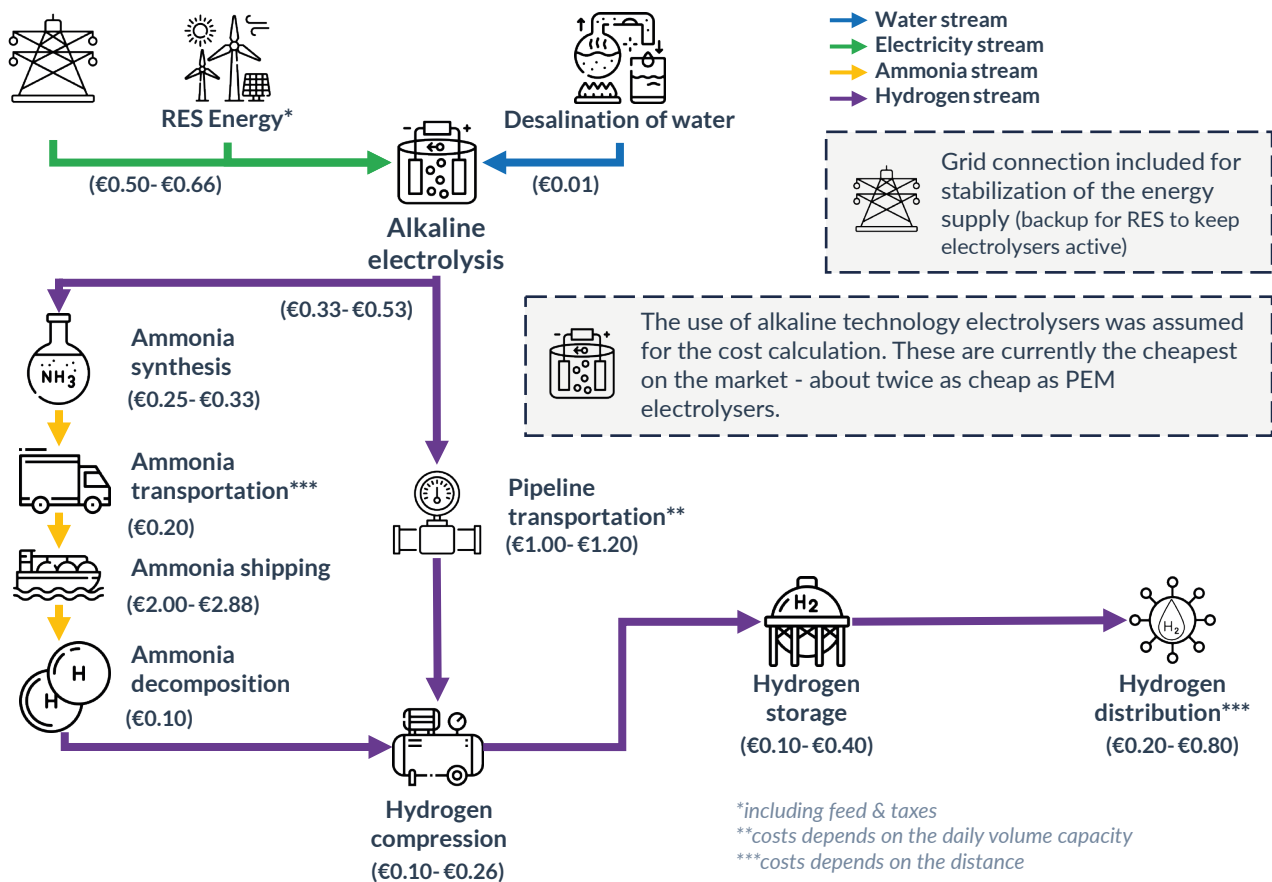
Hydrogen Distribution

For the distribution of hydrogen in the country, hydrogen gas pipelines will be mainly used, the construction of which is an important strategic objective of the German government. However, hydrogen tube trailers will be used to distribute hydrogen to remote areas where the hydrogen refueling stations are located. The drawback of this distribution method is the low capacity of the trailer, which can carry on approximately 500 kg of hydrogen. Thus, the transportation cost of hydrogen significantly increases.



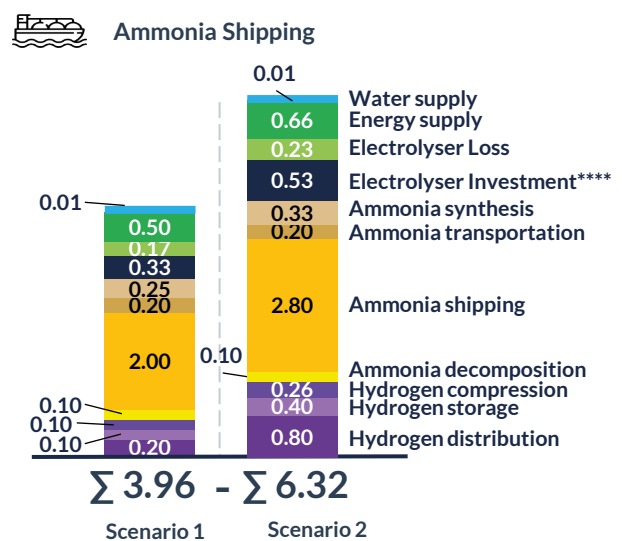
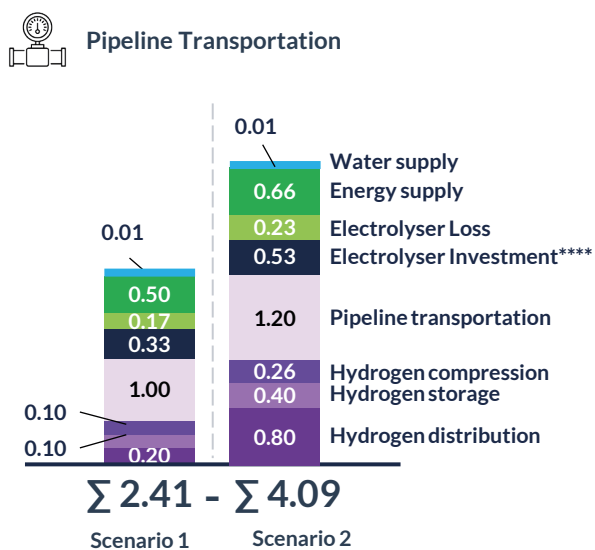
Source: Nationaler Wasserstoffrat, German National Hydrogen Strategy

H2 Cost Calculation



Levelized Cost of Hydrogen (LCOH)

€/ kg H₂



Source: IRENA, Hydrogen Council, own analysis

**** amortization of investment for 20 years

ROI Calculation

Investment value

The estimated investment value of the hydrogen production plant project in Morocco is marked in light gray on the chart. The range from EUR 3 billion to EUR 4.8 billion is due to the dynamically changing prices of electrolyzers on the market. Almost half of the total value is related to the electrolyzer and balance of plant costs with the estimated electrolyzer power output equal to approximately 4-4.5 GW. The remaining value is related to indirect CAPEX costs like contingency, design work, and construction work.

Achieving goals – 100% ROI by 2035

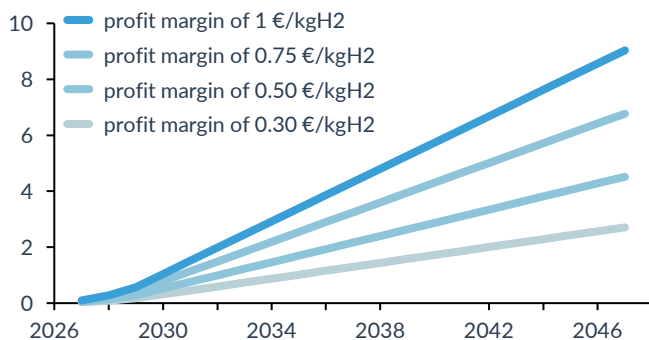
As part of this case study, different scenarios of profit margin were calculated to determine what margin should be set to achieve the goal of this project case study. 100% ROI can be achieved in a scenario where the margin value per kilogram of hydrogen is around EUR 1 or more. This scenario considers pure profit and does not take into account the residual value of the equipment.

Final price of hydrogen - note

The final cost of hydrogen and the expected margin should be determined by the overall demand for hydrogen on the German market. The overall demand will also largely determine the method of transporting the hydrogen, which accounts for a large part of its total cost.

Accumulated Profit before tax

Billion €



Sources: IEA, KPMG

Conclusion

This case study presents an initial overview and analysis of the feasibility of locating a green hydrogen production plant in Morocco for export to and distribution in Germany. The main conclusion of this study is the business opportunity arising from the estimated low levelized cost of hydrogen [LCOH] (€ 2.41 - € 4.09 per kg H₂ via pipeline; € 3.96 – € 6.32 per kg H₂ via ammonia shipping), compared to current local prices (€15,25 on domestic HRS in Berlin, December 2023). The lowest price for hydrogen can be achieved by using gas pipeline infrastructure, given that it needs to be adapted and is a promising solution for 2030 or beyond. The transport accounts for half or more of the final cost.

The total return on investment can be achieved, according to this case study, in 2035, at a margin of 1 €/kg or more. Knowing the estimated costs of hydrogen and the assumed margin, the final price to the consumer is attractive, irrespective of the method of transporting the hydrogen.

Given the rapid pace of legislation, announcements of financial support for green projects, and constantly evolving technologies, the success of a project will depend on a well-structured project development plan, flexibility in action, and excellent stakeholder management.

CAPEX costs and subsidies - disclaimer

This case study does not take into account the capital expenditures for hydrogen storage, export, and distribution technologies, as well as any downstream technologies like water desalination plants, ammonia synthesis plants, or renewable energy sources. This case study also does not include any subsidies or tax deduction aspects.

Possible next steps

- Establishing comprehensive project requirements
- In-depth feasibility study
- Acquiring stakeholders for the project

Challenges and Opportunities



Challenges



Distrust in Government



Infrastructure and Technological Advancement



Elite Rent-Seeking Behavior



Social and Economic Disparities



Opportunities

Economic Growth



Transparency and Governance



Regional Cooperation



Youth Empowerment



□□ – not relevant OR lack of information ; ■□ – slightly relevant ; ■■ – much relevant
Source: PBL Netherlands Environmental Agency, own assessment by ALEXEC Consulting

The development of green hydrogen in North Africa presents both challenges and opportunities intertwined with complex socio-economic and geopolitical dynamics. While the prospect of significant investments in hydrogen projects holds promise for economic development, there are risks that such efforts may divert attention from pressing domestic issues.

One of the foremost challenges lies in balancing the allure of hydrogen investments with the urgent need to address social and economic disparities within North African nations. The influx of billions of dollars into hydrogen projects may inadvertently perpetuate rent-seeking behavior among political and economic elites, exacerbating existing inequalities and undermining social cohesion.

Furthermore, there are concerns that the focus on hydrogen may overshadow the necessity of addressing pressing domestic issues, such as unemployment, corruption, and economic diversification. The persistence of distrust in government institutions and perceptions of corruption pose significant hurdles to effective governance and inclusive economic growth.

Moreover, the transition to green hydrogen necessitates significant infrastructural investments and technological advancements. While projects are under consideration, such as a multi-billion-dollar Aman project in Mauritania, there will be challenges in establishing the necessary infrastructure for hydrogen transportation, particularly for exports to Europe.

In light of these challenges, there are opportunities for North African nations to leverage the development of green hydrogen for sustainable economic growth and regional cooperation. Initiatives aimed at maximizing the benefits of hydrogen production for citizens, promoting transparency, and fostering a dynamic private sector are crucial for achieving long-term socio-economic development.

Regional cooperation among North African nations could also facilitate market integration and attract further investment, akin to the European Union's model. By prioritizing domestic reforms, fostering trust, and providing opportunities for youth empowerment, North African countries can navigate the complexities of green hydrogen development while addressing underlying social and economic challenges.

Future Outlook





Algeria

Algeria's proposals for pilot projects are aimed at advancing technological expertise in the Operation & Maintenance of hydrogen systems, aligning with the strategic vision for hydrogen development. These projects, ranging in size from approximately 2 to 10 MW, will be conducted in collaboration to mitigate risks and leverage the knowledge of leading companies in the hydrogen sector. The suggested pilot projects draw inspiration from a technology watch, which reports on previous initiatives addressing comparable concepts.

2030

A comprehensive study was undertaken to explore the second phase of the hydrogen sector development roadmap, spanning from 2030 to 2040, focusing on the execution of industrial-scale projects. These initiatives encompass the entirety of the Green Hydrogen value chain.

Central to the roadmap's objectives is Algeria's ambition to supply the European market with 10% of its hydrogen demand by 2040. According to media reports, Algeria is targeting the production and exportation of 30-40TWh of gaseous and liquid hydrogen, along with hydrogen derivatives, by the same timeframe.

2040

While there have been no public announcements regarding specific national goals or targets for 2050 in Algeria's hydrogen roadmap, it outlines a strategic vision for the third phase of hydrogen development from 2040 to 2050. This phase is earmarked for intensifying industrialization efforts and enhancing market competitiveness.

2050

Algeria is strategically positioning hydrogen as a pivotal component of its energy transition agenda and climate commitments. The nation's roadmap delineates a trajectory from gray hydrogen production towards blue and ultimately green hydrogen, while also facilitating the shift from pilot initiatives to large-scale industrial projects. The success of this transition hinges on various dynamic factors, including the cost-effectiveness of renewable energy sources and electrolysis, advancements in production, storage, and transportation technologies, as well as the evolution of competitive markets.

Algeria boasts significant potential and advantages for both renewable energy (RE) projects and the burgeoning hydrogen sector. Leveraging these strengths offers substantial competitive advantages. However, realizing the full potential of these initiatives necessitates technology transfer, risk-sharing through collaborative partnerships, and mutually beneficial cooperation. By embracing these principles, Algeria aims to foster an environment conducive to innovation and sustainable development.

The pursuit of a low-carbon energy transition in Algeria is not merely a futuristic aspiration but a present-day imperative. By exploring synergistic pathways today, the nation is laying the groundwork for tomorrow's energy landscape characterized by security, reliability, abundance, sustainability, and environmental stewardship. Through strategic planning, innovative partnerships, and a commitment to technological advancement, Algeria seeks to position itself as a leading proponent of clean energy solutions on both regional and global scales.



Morocco

According to projections outlined in the country's roadmap, the green hydrogen sector and its associated derivatives in Morocco are anticipated to satisfy a demand ranging from 14 TWh up to 30 TWh (in the optimistic scenario) in 2030.

Short-term goals are directed toward using hydrogen locally as a raw material and exporting it to selected countries. The development will be based on pilot projects with higher production costs before exploring large-scale production in next decades.

2030

According to projections outlined in the country's roadmap, the green hydrogen sector and its associated derivatives in Morocco are anticipated to satisfy a demand ranging from 68 TWh up to 133 TWh (in the optimistic scenario) in 2040.

Medium-term goals are directed toward reducing hydrogen production cost and increasing local usage for fertilizer production. The use case of hydrogen in the electricity sector as an energy storage will be evaluated.

2040

According to projections outlined in the country's roadmap, the green hydrogen sector and its associated derivatives in Morocco are anticipated to satisfy a demand ranging from 150 TWh and 300 TWh (in the optimistic scenario) in 2050.

Long-term goals focus on enhancing the economic viability of hydrogen production and increasing exports of hydrogen and its derivatives, primarily to Europe. Additionally, there will be local initiatives to expand the use of hydrogen in sectors such as heat production and mobility.

2050

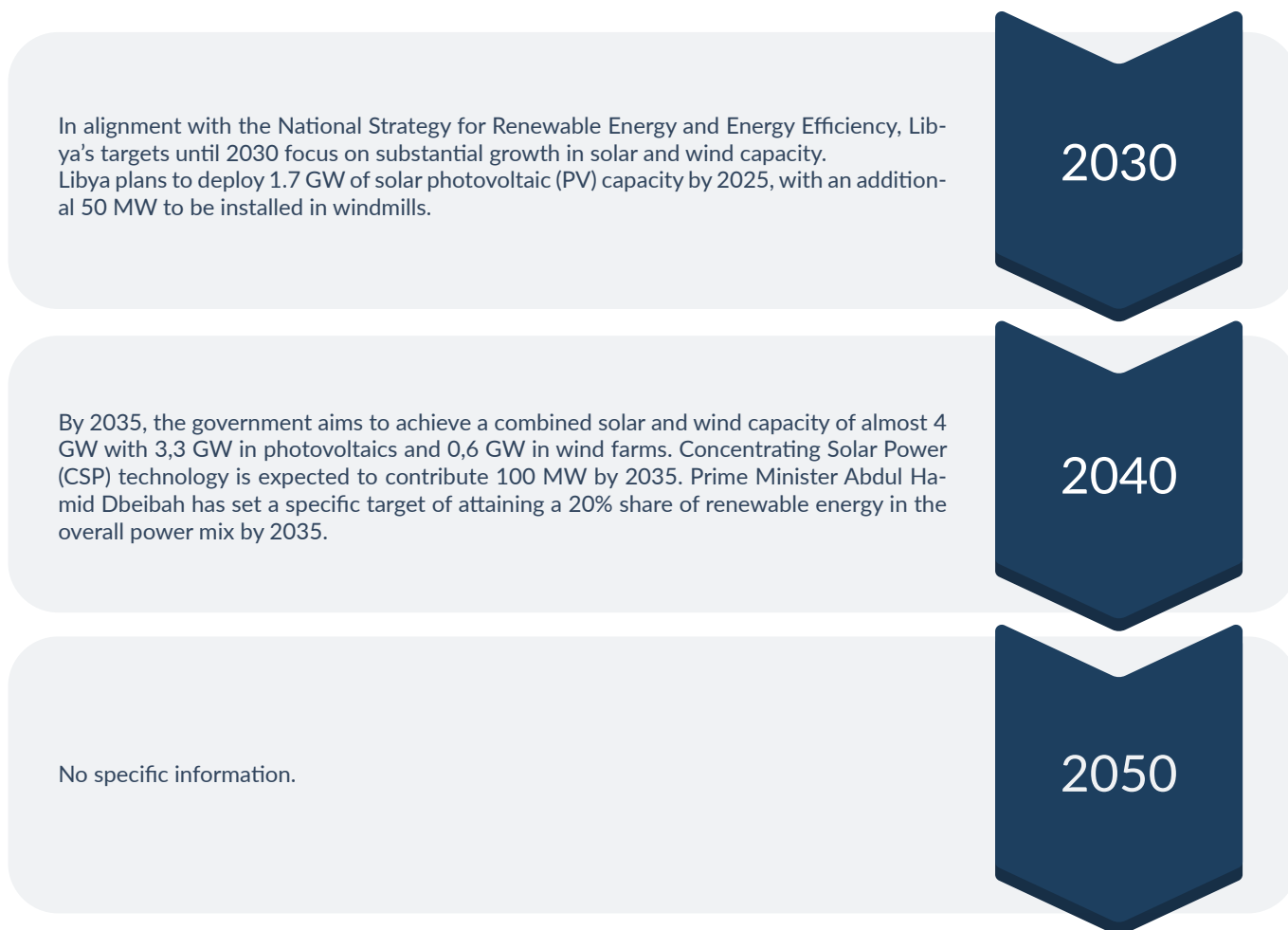
The Kingdom of Morocco, under the enlightened vision of His Majesty the King, has emerged as a regional champion of renewable energies over the past decade, contributing significantly to their competitiveness. With its optimal geographical location and exceptional renewable energy resources, Morocco has the potential to become a key player in the development of the green hydrogen sector at the regional level, capturing up to 4% of the global demand for hydrogen molecules.

The ambitious energy strategy of Morocco aims to position the country as a leader in green hydrogen technology, following in the footsteps of nations such as Japan, Germany, France, Denmark, and Spain. This strategic objective aligns with the country's efforts to leverage its renewable energy assets for sustainable development and economic growth.

Overall, Morocco's strategic focus on green hydrogen underscores its dedication to sustainable development, energy security, and climate action. By capitalizing on its renewable energy potential and fostering a conducive environment for investment and innovation, Morocco is poised to emerge as a leading player in the global green hydrogen market, driving economic growth and environmental stewardship in the region and beyond.



Libya



Despite enduring political and social instability, Libya is looking to attract private investments from local, regional, and international sources to advance its renewable energy objectives. With a focus on expanding renewable energy capacity, particularly in solar and wind sectors, Libya aims to meet growing sustainable energy demands and to become a major exporter of green hydrogen and its derivatives to Europe and specifically Italy.

Libya is exploring opportunities in the green hydrogen sector and seeks collaboration with EU partners to assess the potential for green hydrogen production. This involves evaluating the necessary infrastructure for the entire supply chain, including production, storage, transport, and end-use. The country also plans to review existing regulations and adopt new ones conducive to green hydrogen production, ensuring a supportive regulatory framework for its development.

To kickstart green hydrogen initiatives, Libya is considering pilot projects to demonstrate technological readiness. Coastal sites, particularly near Tripoli with favorable wind and solar conditions, are being evaluated for these projects. Additionally, efforts are underway to raise awareness and develop skills in renewable energy through educational programs and training courses at universities, high schools, and research institutions, further supporting the country's transition towards sustainable energy solutions.



Mauritania

By 2030, Mauritania aims to achieve a significant reduction of 92% in conditional greenhouse gas (GHG) emissions compared to business as usual. In 2020, the nation embraced a national strategy aimed at overhauling its energy sector. This strategy entails boosting the proportion of renewables in its energy blend to 60% by 2030.

2030

By 2035, Mauritania's total potential for green hydrogen production is estimated at 12.5 million tons per year. This capacity will not only meet local demand but also drive domestic economic growth, uplift local communities, and enable exports to international markets.

2040

The Mauritanian Ministry of Energy, in collaboration with consulting firm AFRY, has released a strategic roadmap to foster the growth of a low-carbon hydrogen sector in the country. It aims to position Mauritania to capture 1.5% of the global hydrogen market and 1% of the global green steel market by 2050. To realize these targets, Mauritania aims to leverage its estimated total hydrogen production potential of 20.1 million tonnes per year.

2050

Mauritania emerges as a prominent contender in the transition towards sustainable energy, particularly in the burgeoning hydrogen market. Fueled by its abundant renewable energy resources, the nation positions itself as a key player in shaping the future of green hydrogen production and export.

The International Renewable Energy Agency (IRENA) highlights Mauritania's substantial capacity, estimating a maximum development potential of approximately 457.9 GW for photovoltaic solar projects and 47 GW for wind projects.

Several multi-billion dollar projects outlined in many MoUs signed by the government bodies and international companies favor Mauritania, providing an opportunity for rapid state development. According to a McKinsey study, the AMAN project alone could potentially increase Mauritania's GDP by 40-50% by 2030 and by 50-60% from 2035 onwards. Additionally, in terms of job creation, the project has the potential to boost industry employment by 23% and decrease total national unemployment by nearly a third by 2035.



Tunisia

The country is poised to publish its national hydrogen strategy in 2024, outlining comprehensive targets and development plans for the burgeoning hydrogen industry.

Tunisia aims to bolster its energy landscape significantly, aiming for a 35% share of clean energy by 2030. This initiative seeks to reduce reliance on fossil fuels while enhancing energy security within the nation.

2030

No specific information.

2040

Tunisia aims to become a significant player in the green hydrogen market by 2050, with ambitions to export between 5.5 million tonnes and 6 million tonnes of green hydrogen to Europe. Belhassen Chiboub, the Director General of Electricity and Energy Transition at the Ministry of Industry, Mines, and Energy, emphasized Tunisia's potential to contribute significantly to the European green hydrogen supply chain.

2050

Tunisia emerges as a promising contender in the green hydrogen arena, boasting favorable conditions to produce competitive green hydrogen and potentially serve as a supplier to Europe's high-demand market.

Nevertheless, Tunisia faces challenges in hydrogen production, primarily stemming from its limited land surface available for installing renewable energy systems (RES) necessary for green hydrogen production and heavy dependence on fossil fuels for energy generation in the country.

While Tunisia's aspirations for green hydrogen are well-defined, the path to achieving specific targets remains uncertain, requiring further clarity on the nation's future outlook. Although the trajectory appears promising, definitive plans and timelines for reaching set objectives are yet to materialize with the long-awaited national hydrogen strategy.



Egypt

Egypt is actively pursuing short-term goals in the hydrogen industry up to 2030, focusing on supporting and incentivizing renewable energy projects for electricity generation. This includes facilitating entrepreneurs to expand renewable energy capacities and reducing investment costs for electrolyzer production through grants and soft loans. Additionally, Egypt aims to secure financial support from potential importers for electrolyzer manufacturing and infrastructure projects. The country is establishing a comprehensive financing platform for green hydrogen initiatives and providing financial incentives to both consumers and producers to promote the adoption of greener technologies.

2030

Egypt unveiled its national low-carbon hydrogen strategic framework during COP27 in November 2022, signaling its ambitions to spearhead the supply of hydrogen and its derivatives. With aspirations to become a prominent hub for low-carbon hydrogen, Egypt aims to achieve an export capacity of 12.5 million tonnes of green hydrogen by 2035, positioning itself competitively in the global hydrogen market.

2040

With a dedicated focus on carbon emission reduction and the promotion of renewable and alternative energy sources, Egypt is strategically advancing its National Climate Strategy 2050, aiming to integrate green hydrogen into its energy landscape. As part of this comprehensive strategy, Egypt's ambition is to lead in global green hydrogen production, targeting a cost of \$1.7 per kilogram by 2050 and capturing 8 percent of the global hydrogen market share. These ambitious goals underscore Egypt's commitment to becoming a prominent player in the rapidly evolving hydrogen industry worldwide.

2050

Algeria is strategically positioning hydrogen as a pivotal component of its energy transition agenda and climate commitments. The nation's roadmap delineates a trajectory from gray hydrogen production towards blue and ultimately green hydrogen, while also facilitating the shift from pilot initiatives to large-scale industrial projects. The success of this transition hinges on various dynamic factors, including the cost-effectiveness of renewable energy sources and electrolysis, advancements in production, storage, and transportation technologies, as well as the evolution of competitive markets.

Algeria boasts significant potential and advantages for both renewable energy (RE) projects and the burgeoning hydrogen sector. Leveraging these strengths offers substantial competitive advantages. However, realizing the full potential of these initiatives necessitates technology transfer, risk-sharing through collaborative partnerships, and mutually beneficial cooperation. By embracing these principles, Algeria aims to foster an environment conducive to innovation and sustainable development.

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Recommendations

Based on the information gathered, the following comprehensive recommendations can be made to foster the development of the hydrogen market potential in North Africa.

Encourage Further Development of Hydrogen Strategies:

Countries that have not yet released official roadmaps for hydrogen should prioritize the development and implementation of comprehensive strategies tailored to their specific needs and resources. These strategies should outline clear goals, timelines, and action plans for advancing hydrogen production and utilization within each country.

Foster Collaboration Among North African Countries:

Despite challenges stemming from difficult relations, efforts should be made to foster collaboration among North African countries to leverage regional strengths and address common challenges in hydrogen development. This collaboration could take the form of joint research and development initiatives, knowledge sharing, and coordinated infrastructure development projects.

Prioritize Investment in Renewable Energy Infrastructure:

To support green hydrogen production, countries should prioritize investment in renewable energy infrastructure, such as solar and wind farms. Additionally, the development of seawater desalination plants can provide a sustainable source of water for hydrogen production, addressing concerns related to water scarcity.

Support Feasibility Studies for Hydrogen Projects:

Engaging national funds to support the implementation of feasibility studies for hydrogen projects can help assess the viability and potential impact of proposed initiatives. These studies should consider technical, economic, and environmental factors to inform decision-making and investment.

Enhance Transparency and Governance Frameworks:

Drawing from successful examples like the Moroccan offer, countries should enhance transparency and governance frameworks to attract international investors and ensure the efficient allocation of resources. Clear and predictable regulatory environments can instill confidence and incentivize investment in hydrogen projects.

Promote Public-Private Partnerships:

Public-private partnerships play a crucial role in accelerating the deployment of hydrogen projects by pooling resources, expertise, and networks. Governments should actively promote and facilitate partnerships between public entities, private companies, research institutions, and civil society organizations to drive innovation and capacity building in the hydrogen sector.

Establish Supportive Regulatory Frameworks:

Governments should establish supportive regulatory frameworks that incentivize investment and mitigate risks associated with hydrogen development. This includes streamlining permitting processes, providing financial incentives or tax breaks for hydrogen projects, and ensuring compliance with environmental and safety standards.

Encourage Education and Training Programs:

Investing in education and training programs is essential to develop a skilled workforce capable of supporting the growth of the hydrogen industry. Governments should collaborate with educational institutions and industry stakeholders to design and implement specialized training programs that address the specific needs of the hydrogen sector.

Address Environmental Impacts:

Paying particular attention to the environmental impacts associated with the production of green hydrogen is crucial for ensuring sustainability. Governments should comprehensively assess environmental risks and mitigation measures, particularly regarding seawater brine disposal and waste management. Additionally, promoting research and innovation in green hydrogen production technologies can help minimize environmental footprints.

By implementing these recommendations, North African countries can unlock the full potential of the hydrogen market, driving economic growth, energy security, and environmental sustainability across the region.

Authors

Contact our Experts



Idriss Alami
Managing Partner at
ALEXEC Consulting



Filip Materek
Senior Consultant at
ALEXEC Consulting

We support you in boosting your strategy and operational projects.
Visit us at:

 www.alexec-consulting.com

 www.linkedin.com/company/alexec-consulting