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جمعية الشرق الأوسط لصناعات الطاقة الشمسية
Middle East Solar Industry Association

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UNLOCKING THE POTENTIAL OF GREEN HYDROGEN:

A GLOBAL AND REGIONAL OVER WITH A FOCUS ON THE MIDDLE EAST AND NORTH AFRICA (MENA)

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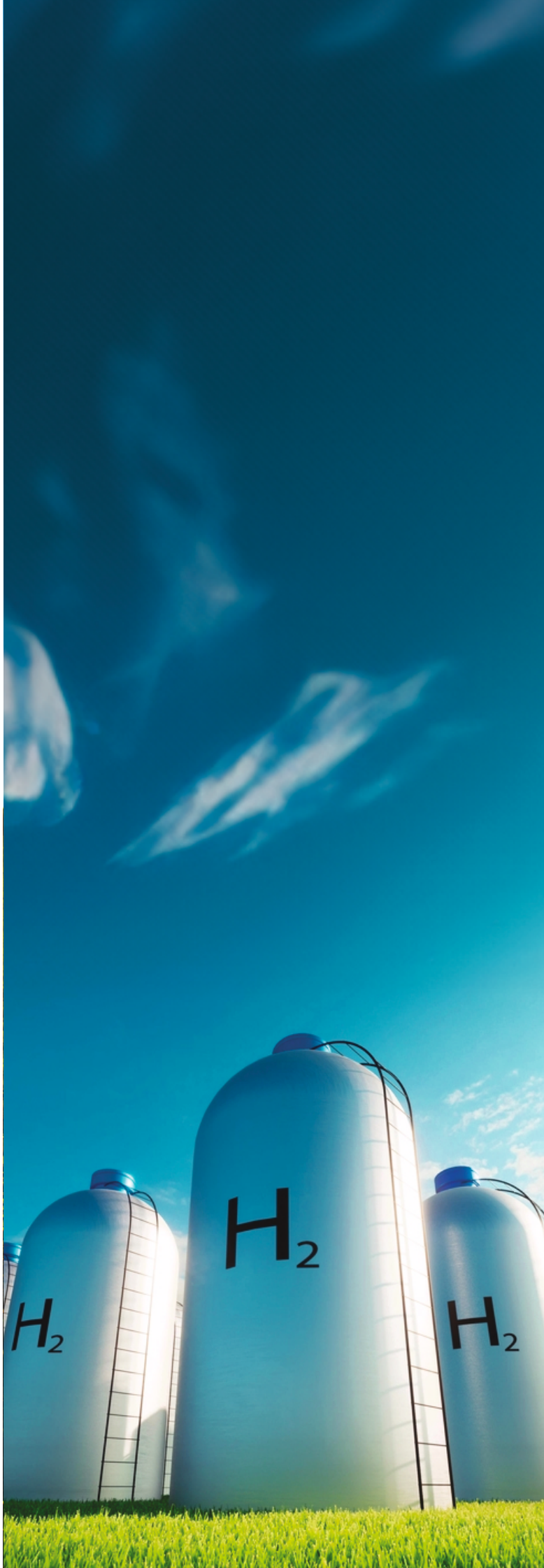
Introduction

The race towards a sustainable future has never been more pressing, and green hydrogen technology has emerged as a key player in this transition. As the world shifts towards cleaner forms of energy, the importance of green hydrogen in decarbonizing various sectors cannot be overstated. This report takes an in-depth look at the current state of green hydrogen technology, both globally and in the Middle East and North Africa (MENA) region.

Solarabic and the Middle East Solar Industry Association (MESIA) have been at the forefront of efforts to promote and advance renewables in the region and have joined forces to produce this report. Readers will get a comprehensive overview of the current state of green hydrogen technology, including updates on global developments, as well as a detailed analysis of the status of green hydrogen potential in the MENA region.



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About Solarabic:

Solarabic™ is a digital platform that enables the transition towards a Zero-Carbon economy in the Middle East and Africa. Our vision is to empower businesses and communities with the knowledge and tools to adopt renewable energy solutions and reduce their environmental impact.

We do this by leveraging our world-class commercial and technical expertise and advanced digital technologies to provide the following services:

- Market Access Services: Solarabic's Market Access Services are designed to facilitate the entry and expansion of businesses in the renewable energy sector within the Middle East and Africa. Solarabic equips clients with the necessary knowledge to navigate the market effectively.

- Market Research and Technical Papers: We conduct and publish market analyses, white papers, industry reports, and databases on renewable energy (solar, wind, hydrogen, EVs, and energy storage) based on our in-depth market knowledge and experience. We also collaborate with leading research institutions and industry partners to develop and test innovative solutions for the green economy.

- Marketing & Communications: We help multinationals set and execute effective MARCOM (Marketing & Communications) strategies in the region, including market positioning, visibility, and lead generation. We have a regionally distributed team that understands the local needs and opportunities of both private and public sectors.

At Solarabic, we are passionate about making a positive difference in the world. We believe that renewable energy is the key to a sustainable future, and we are committed to helping our clients and communities achieve their green goals. If you want to learn more about us, our services, or our projects, please contact us : **ameera.amayrah@solarabic.com**

or visit our website: **Solarabic.com**

We would love to hear from you.

About MESIA

MESIA is the only non-profit, solar association covering and bringing together the whole of the solar sector across the entire Middle East and North Africa (MENA) region.

Our aim is to:

1. Create business opportunities for our members.
2. Organize educational webinars, events, and networking workshops for solar professionals.
3. Produce reports on market trends, latest technologies, standards, and best practices.
4. Assist in the development of policies intended to strengthen the local solar industry.
5. Support our members and partners through various physical and digital activities

MESIA has over 80 local, regional, and international company members from the entire solar value chain: EPCs, integrators, subcontractors, technical advisors, law firms, components manufacturers, Investors/lenders/funds, components suppliers/components agents, or distributors. Any company that's involved in the MENA solar and broader renewable energy industry is welcome to join MESIA

Our aim is to promote the growth of solar in the region while providing opportunities for our over 80 members and partners, from the entire solar value chain. Companies, associations, and media entities interested in connecting with the MENA solar sector, as well as startups, individual consultants, students, and academic institutions, are all encouraged to become part of our expanding network or explore potential partnerships!

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Hydrogen 101

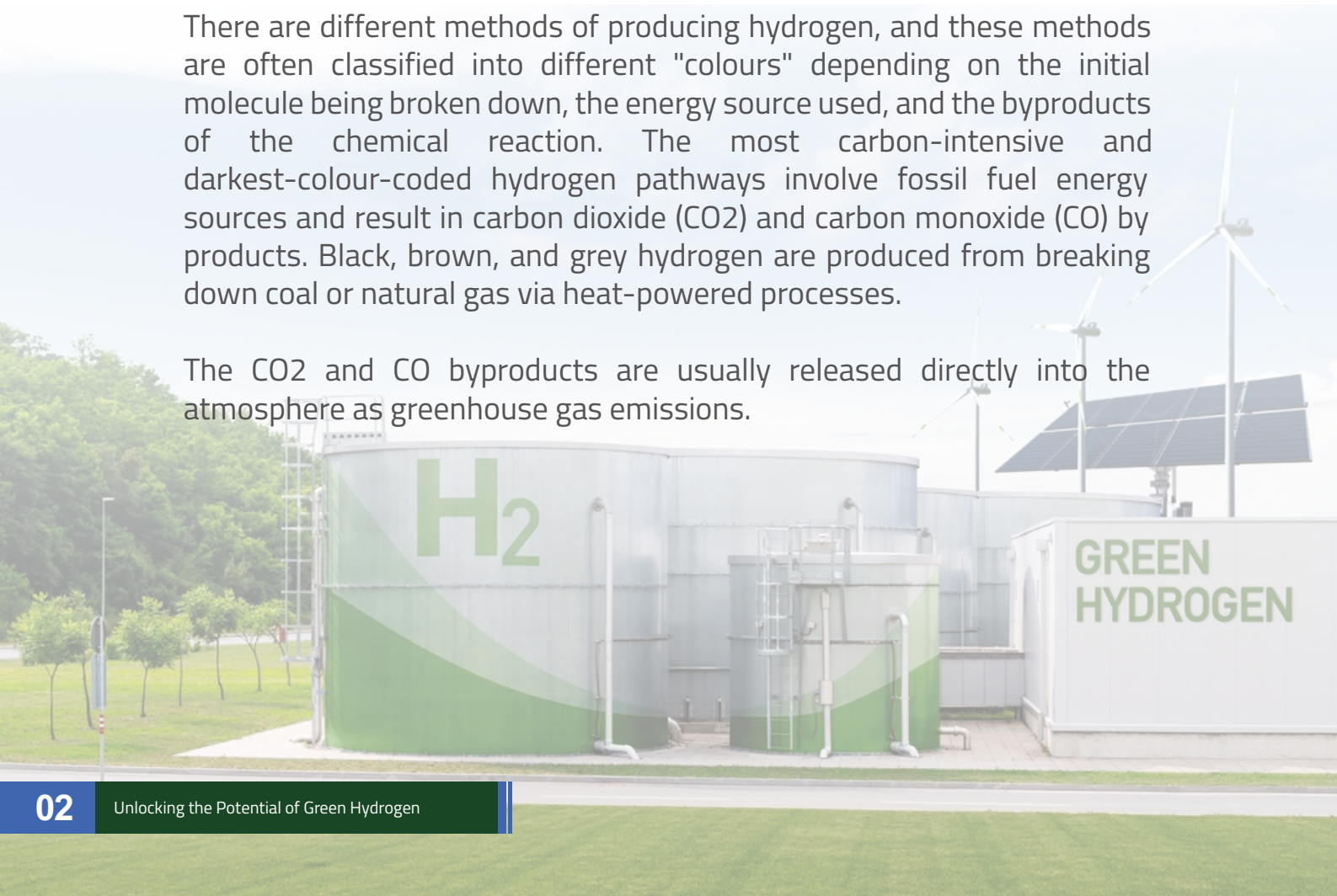
This section will serve as an introduction to hydrogen 101 from the basics of hydrogen, including its properties and how it is produced to its different forms. It will examine the benefits and challenges of using hydrogen in various industries and applications. As hydrogen becomes increasingly seen as a key solution in the global effort to decarbonize the economy, it is important to understand its potential and the role it can play in the modern energy system.

What is Hydrogen and How is it Produced?

Hydrogen is the most abundant chemical element in the universe and the lightest element on the periodic table. It is not only a highly reactive and potent energy carrier but also an essential element for life on earth, making up all living things and found in molecules like water. However, extracting hydrogen from these molecules requires a significant amount of energy, which must be supplied either by heat or electricity.

There are different methods of producing hydrogen, and these methods are often classified into different "colours" depending on the initial molecule being broken down, the energy source used, and the byproducts of the chemical reaction. The most carbon-intensive and darkest-colour-coded hydrogen pathways involve fossil fuel energy sources and result in carbon dioxide (CO_2) and carbon monoxide (CO) by products. Black, brown, and grey hydrogen are produced from breaking down coal or natural gas via heat-powered processes.

The CO_2 and CO byproducts are usually released directly into the atmosphere as greenhouse gas emissions.



01

Green hydrogen

Green hydrogen is produced using clean electricity from renewable energy sources, such as solar or wind power, to electrolyze water. The process of electrolysis splits water into hydrogen and oxygen, emitting no carbon dioxide in the process. Green hydrogen is considered the most environmentally friendly option as it does not produce any harmful greenhouse gas emissions

02

Blue hydrogen

Blue hydrogen is produced mainly from natural gas using a process called steam reforming. The process combines natural gas and heated water to produce hydrogen, but also releases carbon dioxide as a by-product. To mitigate the emissions, carbon capture and storage (CCS) is necessary to trap and store the carbon. Blue hydrogen is sometimes referred to as "low-carbon hydrogen" since the process still produces greenhouse gases.

03

Grey hydrogen

Grey hydrogen is the most common form of hydrogen production and is made from natural gas using steam methane reformation without capturing the greenhouse gases produced in the process

04

Black and brown hydrogen

Black and brown hydrogen are produced using fossil fuels such as black coal or lignite. The process is considered the most environmentally damaging as it releases a significant amount of carbon dioxide. It should be noted that hydrogen produced from fossil fuels through the process of gasification is sometimes referred to as black or brown hydrogen interchangeably.

05

Pink or purple or red hydrogen

Pink hydrogen, also known as purple or red hydrogen is produced through electrolysis using nuclear energy. Nuclear energy can also be used to generate high temperatures for more efficient electrolysis or fossil gas-based steam methane reforming. The use of nuclear energy in hydrogen production raises concerns about the safety and environmental impact of nuclear power plants

06

Turquoise hydrogen

Turquoise hydrogen is a relatively new concept in the hydrogen industry, and its production at scale has yet to be proven. It is produced through a process called methane pyrolysis, which splits methane molecules into hydrogen and solid carbon. The idea behind turquoise hydrogen is that it could be a low-emission hydrogen option, but this will depend on the thermal process being powered by renewable energy and the carbon being permanently stored or used.

Applications

Hydrogen is currently used today to refine oil products, its reactivity being leveraged to bond with other elements and decontaminate the final product, and as a chemical feedstock to produce ammonia for fertilizer and other key chemicals.

Just as carbon is the building block of the fossil fuel economy, hydrogen will be the building block of the clean energy economy in which renewable electricity, hydrogen (both gaseous and liquid), ammonia, and other synthetic fuels will dominate to produce, store, and move clean energy. Hydrogen's flexibility as a zero-carbon fuel, clean energy carrier, and bridge to clean electricity appear as the missing piece for a fully decarbonized economy.

One of the important uses of hydrogen is in decarbonizing industrial processes that rely on certain chemical feedstocks or agents. Hydrogen can be used in steel and aluminium production, where its chemical reactivity also helps reduce ore into more useful forms, instead of the currently used coking coal or natural gas. In these industrial processes, hydrogen will be consumed directly as a chemical feedstock in the production process or burned to provide the necessary heat for operation.

Another application of hydrogen is in energy storage, potentially playing a role in managing a renewable-powered electrical grid, storing the excess power generated on sunny, windy days for later use. Here hydrogen is used in a fuel cell, a technology that uses hydrogen to produce electricity, heat, and water. Fuel cells enable clean energy molecules (i.e., hydrogen) to be turned back to electricity.

In addition to these applications, hydrogen can also be used as fuel for power mobility applications, including maritime shipping, aviation, and heavy-duty trucking. Exactly how hydrogen is used in each of these mobility applications will differ depending on fuel weight or volume thresholds for each transportation mode. Sometimes pure hydrogen will be put through a fuel cell or burned directly in an engine similar to those seen today in gas-powered cars and boats.

However, given that there is no carbon in the fuel, no carbon dioxide can be formed. Other times, hydrogen will be used as the raw material to create other clean energy molecules such as synthetic fuels or ammonia, creating an energy-dense chemical and fuel that is more easily transported. Alternatively, hydrogen can be used to provide "clean electricity on the go," providing a way to power electric motors with less reliance on heavy and large batteries, given that hydrogen can be used in a fuel cell to produce electricity.

Finally, the usage of hydrogen expands to the set of locations where clean energy can be supplied and diversifies the ways in which we move energy around. Hydrogen, or its derivatives like green ammonia, can be transported via pipeline or ship. In a low-carbon energy economy, moving energy in these ways could be crucial for countries with high renewable energy capacity, like those in the middle east and Africa, to transform electricity into fuel for export to near larger markets such as Europe.

Challenges and Future Outlook

Despite the many potential benefits of hydrogen, there are also several challenges to be addressed before it can be fully integrated into the energy system. These include the high cost of producing hydrogen from renewable sources, the lack of infrastructure for hydrogen transportation and storage, and the lack of regulations and standards for hydrogen use.
Despite these challenges, the future outlook for hydrogen is promising. A report by the Energy Transitions Commission calls hydrogen "the second vector" for decarbonization after direct electrification, projecting it will meet 13 percent of final energy demand in 2050, or 20 percent if hydrogen-based fuels are included. The long-term market for hydrogen will be huge, potentially reaching $2.5 trillion or more. The announced projects for the next five years alone will require tens of billions of dollars in investments in electrolyzers and renewable power generation.

Green Hydrogen: The Key to Unlocking a Carbon-Free Future

Introduction:

As the world faces the pressing issue of climate change, the need for clean and renewable energy sources has never been more paramount. Green hydrogen, the hydrogen produced using renewable energy sources such as wind and solar power, has emerged as a potential solution to decarbonize various sectors and achieve the zero-emission targets set by the Paris Agreement. This section will explore the benefits and barriers of using green hydrogen as a fuel and its role in the energy transition.

Benefits:

Green hydrogen has several advantages, making it an ideal candidate for decarbonization. The first and most obvious benefit being a clean energy source, producing only water as a byproduct. Additionally, it is a renewable energy source, using natural resources that are not exhausted, making it sustainable in the long term.

Another significant benefit of green hydrogen is its storage and transportability. It can be compressed and stored in special tanks for long periods, making it possible to use it when needed. Furthermore, it is a lightweight element, which makes it easier to handle and transport compared to lithium batteries.

Green hydrogen can also be used in various sectors that are currently difficult to electrify. It can be used as a fuel for transportation, such as buses and trucks, as well as in industrial processes, such as the production of steel and cement.

Barriers:

Despite its many benefits, green hydrogen is currently more expensive to produce than grey hydrogen. However, the cost of renewable energy has been decreasing significantly in recent years, making it increasingly competitive. For example, solar electricity is now 10 times cheaper than it was a decade ago, and wind energy costs less than half. This has opened a window of opportunity for the cost of green hydrogen to decrease as well.

Another barrier to green hydrogen is the significant investment required for its implementation. Estimates suggest that around $300 billion will be needed globally in the next few years for infrastructure and research.

However, according to a report by BloombergNEF, with enough policies to support its development, the demand for green hydrogen may increase to 700 million tonnes by 2050, making it a cost-effective investment in the long term.

Green Hydrogen Electrolyzers Industry

The green hydrogen electrolyzers industry is a relatively new and rapidly evolving market. Some of the key players in the industry include ITM Power, Nel Hydrogen, Air Liquide, McPhy Energy, Linde, Siemens Energy, and Hydrogenics which are all actively working on developing and commercialising green hydrogen electrolysis technology.

When it comes to the types of electrolysis technology, there are two main types: Alkaline electrolysis and Proton Exchange Membrane (PEM) electrolysis. Alkaline electrolysis uses an aqueous solution of potassium hydroxide (KOH) as the electrolyte, and it is relatively inexpensive. However, it requires a high-temperature and high-pressure operation, and the hydrogen purity is lower compared to other types of electrolysis.

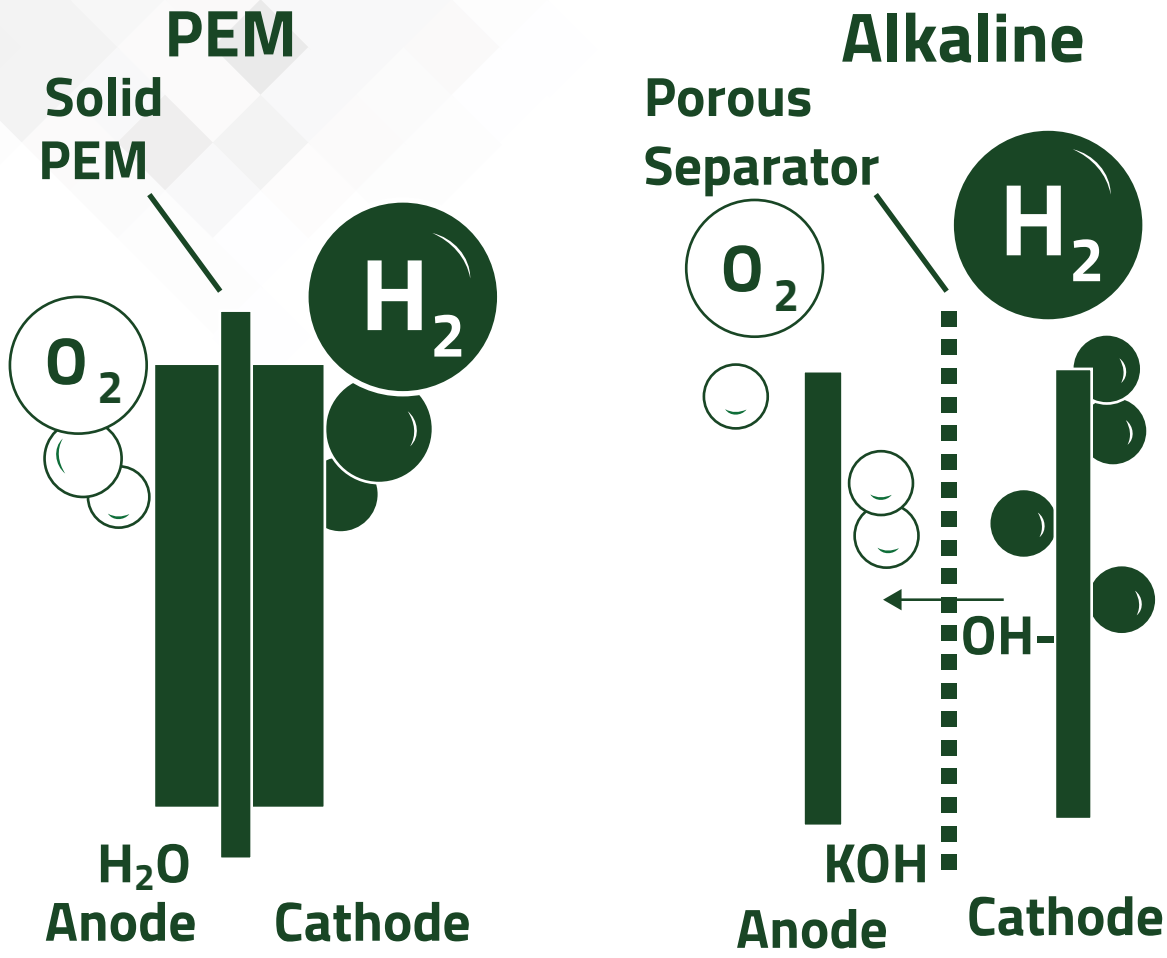


Figure 1: PEM and Alkaline Electrolysers

On the other hand, PEM electrolysis uses a proton-conducting membrane, such as Nafion, as the electrolyte. PEM electrolysis can operate at lower temperatures and pressures and it can produce hydrogen at relatively high purity. However, PEM electrolysis is more expensive than alkaline electrolysis.

In 2021, the alkaline electrolyzer segment accounted for 66.18% of the revenue share due, being the conventional electrolyzer technology used in green hydrogen projects. Alkaline electrolyzers have higher operating hours compared to PEM electrolyzers, but they have lower power and current densities with an operating temperature range of 100-105 degrees Celsius, compared to 70-90 degrees Celsius range of PEM electrolyzers.

However, PEM electrolyzers are expected to witness a higher growth rate over the forecast period. The presence of solid specialty plastic material-based electrolytes offers higher functional flexibility to the PEM electrolyzer as compared to the alkaline counterpart. The substantial growth can be attributed to high proton conductivity, lower gas permeability, and lower thickness of proton exchange membranes.

Industry players are continuously focusing on deploying PEM electrolyzer technology at a commercial scale to make the green hydrogen generation process more power efficient. For instance, in January 2020, U.K.-based company ITM Power announced a joint venture with ITM Linde Electrolysis GmBH. The companies will provide green hydrogen at an industrial scale by utilising a PEM electrolyzer capacity of more than 10 MW. This highlights the growing interest in PEM electrolysis as a viable option for large-scale green hydrogen production.

Additionally, other types of electrolysis technology such as solid oxide electrolysis, and Anion exchange membrane (AEM) water electrolysis, have their own advantages and disadvantages in terms of efficiency, cost, and environmental impact. The choice of electrolysis technology will depend on the specific application and the desired hydrogen production rate and purity.

The green hydrogen electrolyzers industry is expected to continue growing as demand for green hydrogen increases and more companies invest in the development and commercialization of this technology. The market is also likely to see more innovation and advancements in the types of electrolysis technology available, as companies work to make the process more cost-effective, efficient, and environmentally friendly.

Levelized Cost Of Hydrogen (LCOH)

The Levelized Cost of Hydrogen (LCOH) is a financial metric used to compare the total cost of producing hydrogen over the lifespan of a project, incorporating both capital and operational expenses. It provides a standardized measure for evaluating the economic viability of different hydrogen production methods.

LCOH Factors

The Levelized Cost of Hydrogen (LCOH) is influenced by a multitude of factors that collectively determine the cost efficiency of hydrogen production:

1. **Production Method:**
The chosen method of hydrogen production, such as steam-methane reforming (SMR), electrolysis, or other advanced techniques.

2. **Process Efficiency:**
The efficiency and energy consumption of the production process, which directly affect the amount of resources required.

3. **Input Costs:**
The availability and cost of primary inputs, including electricity and water, that contribute to production expenses.

4. **Technological Advancements:**
Advances in production technologies and economies of scale that impact capital (CAPEX) and operational costs (OPEX).

5. **Subsidies and Incentives:**
Government incentives, subsidies, and regulatory frameworks that can reduce production costs.

6. **Infrastructure Integration:**
The integration of hydrogen production with existing infrastructure, such as natural gas pipelines, influences transport and storage costs.

7. **Energy Landscape:**
Market volatility and pricing fluctuations in the energy sector that affect input costs and overall feasibility.

8. **Geographic Location:**
The project's location and regional energy resources, impacting costs of inputs like renewable energy.

9. **Policy Environment:**
The regulatory environment and policies that encourage or hinder hydrogen production and utilization.

10. **Storage and Transportation:**
Hydrogen storage and transportation costs affect overall production costs.

11. **Economic Factors:**
General economic conditions, inflation, and currency exchange rates can influence production costs.

LCOH of Green Hydrogen Projects

In green hydrogen projects, the Levelized Cost of Hydrogen (LCOH) is significantly influenced by electrolyzers, a crucial component. The LCOH is closely tied to electricity prices. Different water electrolysis technologies contribute to the LCOH, each varying in terms of Capital Expenditure (CAPEX) and Operational Expenditure (OPEX).

The choice of materials significantly impacts CAPEX, while the electrical efficiency of each technology affects the OPEX associated with the electrochemical process.

The different electrolysis methods have an impact on achievable LCOH values. Encouragingly, all four technologies (SOEC, PEM, AEM, and AWE) exhibit the potential to reach LCOH targets of under €2/kg by 2030, rendering green hydrogen competitive with current low-cost grey hydrogen as shown in the figure below. This achievement is pivotal in meeting ambitious hydrogen production objectives by 2030.

For instance, producing 10 million tons of green hydrogen in the EU necessitates installing 650–750 GW of electrolysis capacity, depending on the chosen technology. Although a higher penetration of Solid Oxide Electrolysers (SOECs) might mitigate this demand, the current global manufacturing capacity of around 20 GW presents a challenge in realizing such scale within the next seven years. Therefore, the attainment of climate goals hinges on contributions from manufacturers across various technologies. This challenge also signifies a significant opportunity to foster emerging industries, stimulate economic growth, and generate jobs as we shift away from fossil fuels.

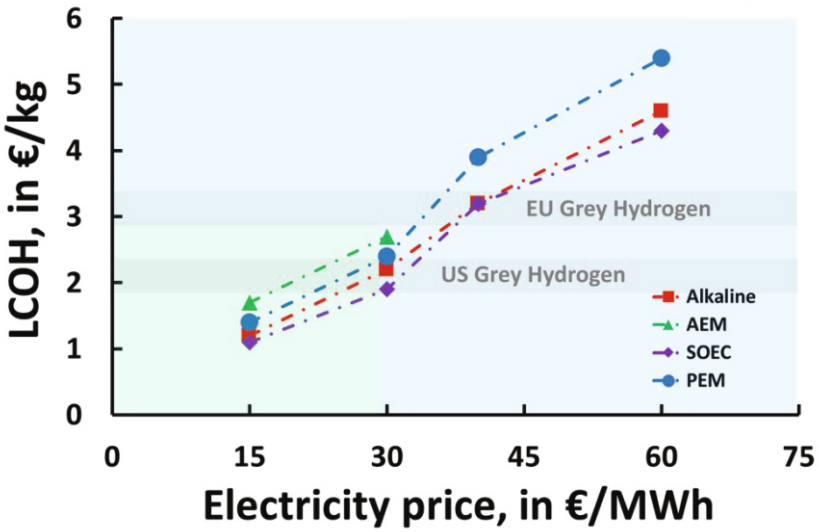


Figure 2: Levelized Cost of Hydrogen across various technologies at varying electricity rates

Recap

Alkaline technologies are suitable for big projects with stable electricity prices. PEM technologies excel in projects with high renewable variability and limited space, while SOEC suits industries with excess heat and moderate hydrogen demand. Anticipated growth in green hydrogen projects by 2030 entails lower CAPEX, OPEX, and LCOH, driven by reduced renewable costs and technological advancements. This progress will lead to more hydrogen projects in different industries.

Green Hydrogen Policies

Green hydrogen policies can take many forms, such as:

1. **Research and development funding**

Governments can provide funding or tax incentives for companies and research institutions to develop new green hydrogen technologies.

2. **Building infrastructure**

Governments can invest in the construction of hydrogen refuelling stations and pipelines to support the growth of the hydrogen economy.

3. **Setting targets and standards**

Governments can set targets for the use of green hydrogen in various sectors, such as transportation and industry, and establish standards for the production and storage of hydrogen.

4. **Subsidies and financial incentives**

Governments can provide subsidies or financial incentives to companies and individuals to encourage the use of green hydrogen.

5. **International cooperation**

Governments can work with other countries and organizations to share knowledge and collaborate on research and development of green hydrogen technology.

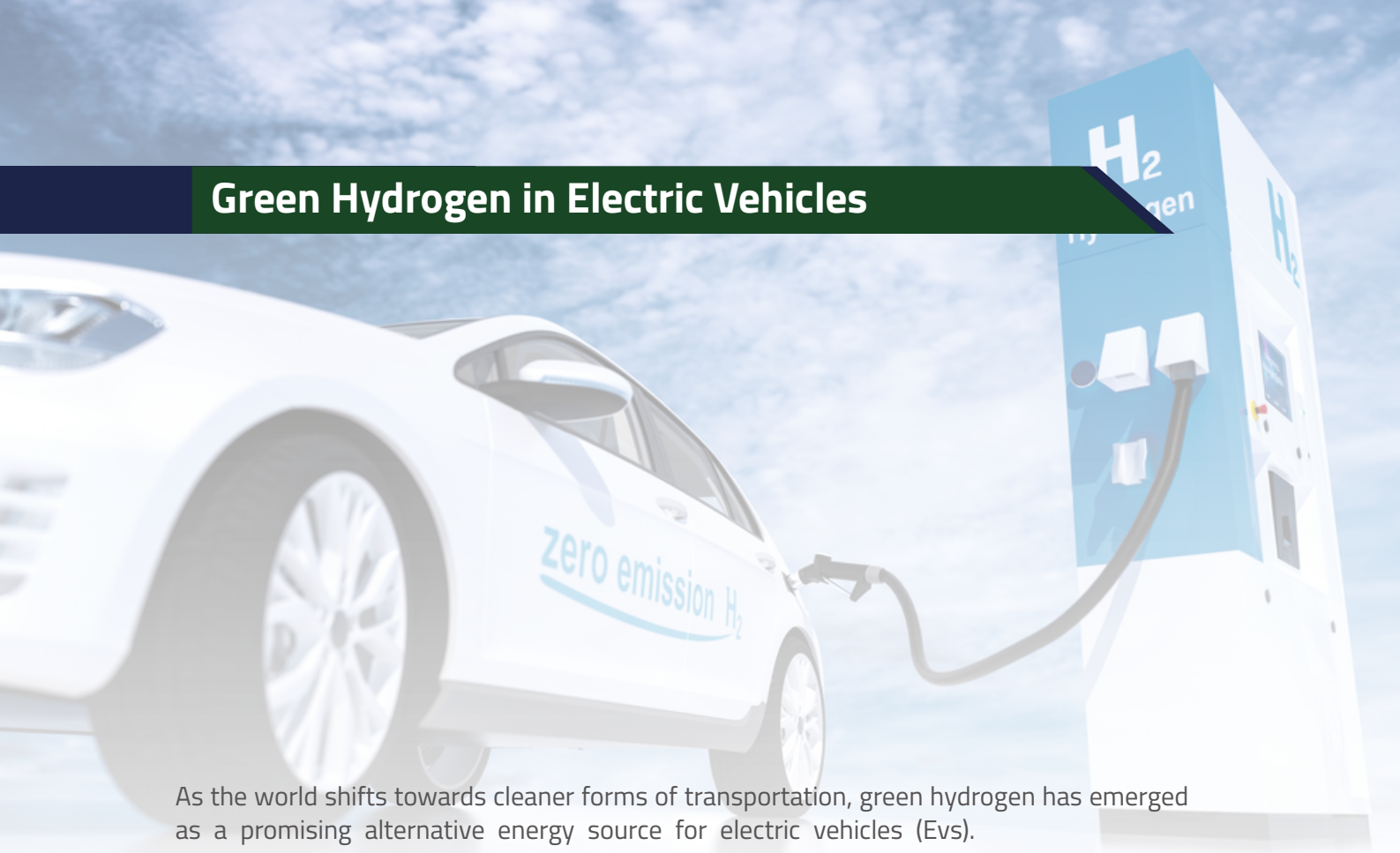
Many countries have recognized the potential of green hydrogen and have developed strategies and roadmaps for its production and utilization. These plans focus on identifying best practices for hydrogen supply, investing in hydrogen production for export, and securing a share in the international hydrogen trade.

Presented below is the meticulously compiled table providing a comprehensive overview of the green hydrogen roadmap and strategy for countries in the MENA region.

Figure 3: Status of Green Hydrogen Roadmap and Strategy Development in MENA Region Countries

Source: Solarabic database

Green Hydrogen in Electric Vehicles



As the world shifts towards cleaner forms of transportation, green hydrogen has emerged as a promising alternative energy source for electric vehicles (Evs).

One of the main advantages of green hydrogen as a fuel source for EVs is its ability to store energy for extended periods of time. This is especially useful for electric vehicles, which often have limited range and require frequent charging. By using hydrogen fuel cells instead of batteries, EVs can travel much further on a single tank of fuel, making them more practical for long-distance travel.

Fuel Cell Electric Vehicles:

Fuel cell electric vehicles (FCEVs) are the main type of EV that use green hydrogen as a fuel source. These vehicles are similar to battery electric vehicles (BEVs) in that they are powered by electricity, but instead of drawing it from batteries, they use fuel cells to convert hydrogen into electricity. This process also produces water vapour as a byproduct, making FCEVs a zero-emission form of transportation. Another advantage of FCEVs is their refuelling time. Unlike BEVs, which can take hours to charge, FCEVs can be refuelled in a matter of minutes, making them more convenient for everyday use.

Infrastructure Development:

Despite these advantages, the development of green hydrogen infrastructure for FCEVs is still in its early stages. Currently, there are only a limited number of hydrogen fueling stations worldwide, and most of them are located in California and Germany. However, as the demand for FCEVs increases, it is expected that more hydrogen fueling stations will be built, making it more convenient for EV owners to travel long distances.

Global Market Update 2023

The global green hydrogen market is experiencing significant growth in recent years, with a projected capacity of over 250 GW by 2022, which is 200 times the power produced in 2020. This can be attributed to the increasing demand for clean energy sources and the growing awareness of the negative impact of traditional fossil fuels on the environment.

One of the key drivers of the green hydrogen market is the increasing investment by government and private organizations. For example, the European Union has set a target of producing 40 GW of renewable hydrogen by 2030 while aiming to reach an increase of at least 6 GW by 2024. Similarly, various countries such as Australia, Canada, and China have also announced plans to invest in the development of green hydrogen projects.

The green hydrogen market can be segmented into different applications such as power generation, transportation, and industrial applications. Among these, the transportation sector is expected to grow at the highest CAGR during the forecast period. This is due to the increasing demand for hydrogen-powered vehicles and the growing awareness about the benefits of hydrogen as a fuel for transportation.

Gigawatt-scale green hydrogen projects:

Several gigawatt-scale green hydrogen projects are currently under development around the world, such as:

1. **HyDeal Ambition, Western Europe (Spain, France, Germany) - 67GW**

This project aims to produce 67GW of hydrogen using 95 GW of solar power. It plans to convey green hydrogen across Europe at €1.50/kg before 2030, with an aim to produce 3.6 million tons of H2 annually.

2. **Reckaz, Kazakhstan - 45GW**

This project aims to produce 30 GW of green hydrogen using 45 GW of wind and solar power. It is a collaboration between German-based Svevind Energy and KazakhInvest company and expected to produce 3,000,000 tons of green hydrogen annually.

3. **Western Green Energy Hub, Australia - 28GW**

This project, located in South-East and Western Australia, aims to produce 28GW of green hydrogen using 50GW of wind and solar power. A consortium of companies including InterContinental Energy and CWP Global is investing in the project to sell homegrown green hydrogen to the local industry and overseas. It is expected to produce up to 3.5 million tons of green hydrogen annually.

4. Aman, Mauritania - 16 to 20 GW

This project aims to produce 16-20 GW of green hydrogen using 30 GW of wind and solar power. The project is owned by CWP Global and aims to decarbonize the production of ammonia.

5. Green Energy Oman, Oman - 25GW

This project aims to produce 14GW of green hydrogen using 25GW of wind, solar, and hydropower. It is a collaboration between InterContinental Energy, Omani oil company OQ, and Kuwaiti state-owned tech organization EnerTech. It is expected to produce 33 million tons of green hydrogen annually.

6. Asian Renewable Energy Hub, Australia - 14 GW

This project aims to produce 14GW of green hydrogen using 16GW of wind and 10 GW of solar power. A consortium of companies including InterContinental Energy, CWP Energy Asia, Vestas, and Macquarie is investing in the project, aiming to produce 1.75 million tons of green hydrogen annually for the Asian market.

7. NorthH2, Netherlands - 10 GW

This project aims to produce at least 10 GW of green hydrogen using offshore wind energy. It is a collaboration between Shell, Equinor, RWE, Gasunie, and Groningen Seaports. The project aims to produce 1,000,000 tons of green hydrogen annually to assist with driving heavy industry in the Netherlands and Germany. Currently, feasibility studies for the project are underway with a goal of 1GW by 2027 and 4GW by 2030.

8. AquaVentus, Germany - 10 GW

This project aims to produce 10 GW of green hydrogen using offshore wind energy. It is a collaboration between Siemens Energy and Nordex Group and aims to produce about 800,000 tons of green hydrogen annually.

9. HyEnergy Zero Carbon Hydrogen, Australia - 8 GW

The project aims to generate 550,000 tonnes of renewables-based hydrogen per annum at full capacity over a two-phase development approach, with a total installed renewable energy capacity of 8 GW. The project also aims to export hydrogen to Asia-Pacific markets. The Memorandum of Understanding between the proponents was extended to 31 July 2022 and legally binding key terms were finalized by August 2022.

10. Murchison Renewable Hydrogen Project, Australia - 5 GW

The project aims to use a combined onshore wind and solar energy of approximately 5.2 GW capacity to produce renewables-based hydrogen which would be converted to an estimated 2 million tonnes per annum (Mtpa) of ammonia, mainly for export to emerging green energy markets with potential for domestic use as hydrogen or ammonia. The project includes several key onshore and marine components such as the installation of up to approximately 700 wind turbines, a solar PV farm, electrolyzers, hydrogen storage, an ammonia production plant, a cryogenic ammonia export pipeline and a marine export facility. The project is estimated to take 5.5 years to construct and is currently under development, with the proponent has referred the project to the Western Australian Environmental Protection Authority (EPA) and received Lead Agency Services from the Department of Jobs, Tourism, Science and Innovation.

Green Hydrogen Potential In The Middle East And Africa

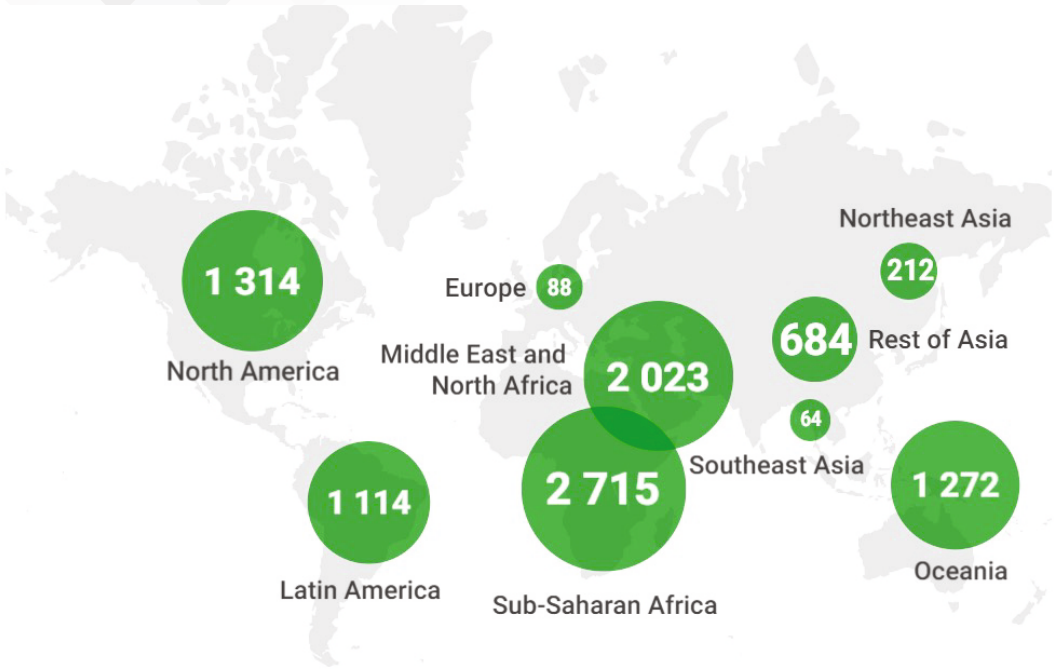


Figure 4: Technical potential for producing green hydrogen under USD 1.5/kg by 2050, in EJ
Source: IRENA

The Middle East and North Africa (MENA) region and Sub-Saharan Africa (SSA) have significant potential for the production of green hydrogen, according to the International Renewable Energy Agency (IRENA), Sub-Saharan Africa has the greatest potential for producing cost-effective green hydrogen, with a projected cost of less than $1.50 per unit by 2050. IRENA's analysis indicates that Sub-Saharan Africa has the highest technical potential, at 2,715 exajoules, followed by the Middle East and North Africa region at 2,023 exajoules, Asia-Pacific at 2,232 exajoules, Latin America at 1,114 exajoules, North America at 1,314 exajoules, and Europe at 88 exajoules.

The production of green hydrogen can also create new economic opportunities and support the development of domestic renewable energy markets in both the MENA and SSA regions. However, the development of green hydrogen projects will require significant investments in infrastructure, including electrolyzers and storage solutions. It will also require policy support and regulatory frameworks to encourage private-sector investment and enable the integration of green hydrogen into various sectors.

The increasing demand for green hydrogen in both the MENA and SSA regions presents a significant opportunity for the transition to a more sustainable and low-carbon future. As the demand for maritime trade continues to grow, particularly in Africa, green hydrogen could play a crucial role in meeting the increasing demand for electricity for synthetic fuels, while also reducing carbon emissions.

An expanding network of hydrogen trading routes, plan and agreements

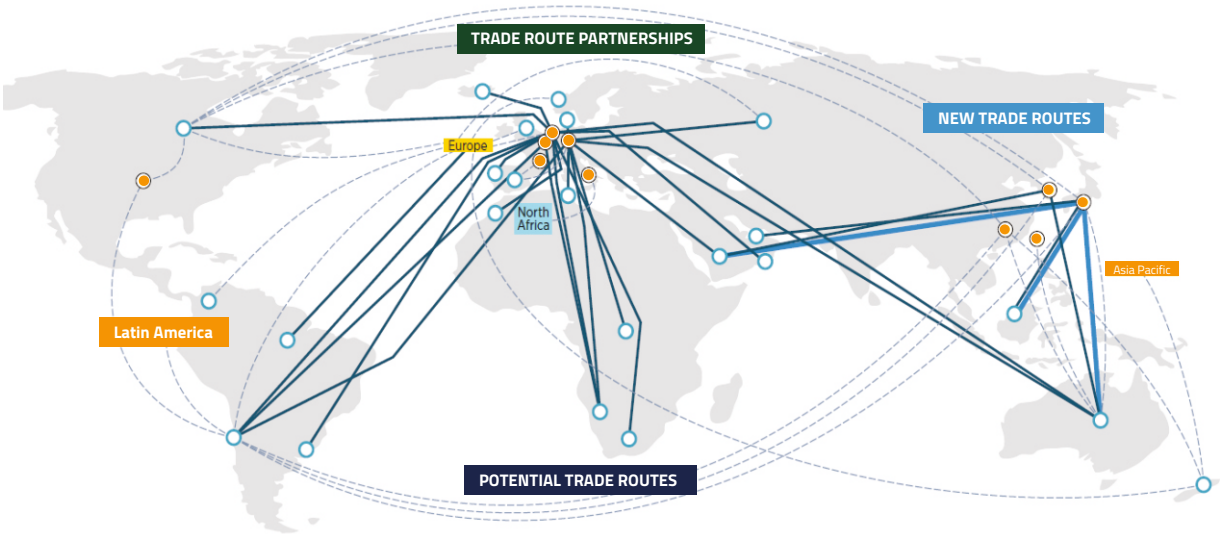


Figure 5: An Expanding Network of Hydrogen Trade Routes, Plans and Agreements,
Source: IRENA

4

Green Hydrogen: The GCC's Hidden Gem

The Gulf Cooperation Council (GCC) countries, made up of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates, have long been known for their fossil fuel-based economies. However, with the global push towards clean energy to limit global warming, the GCC countries are turning towards green hydrogen to diversify their energy mix and reduce their carbon footprint.

The Potential of Green Hydrogen in GCC's Renewable Landscape

The GCC region's high irradiation leads to low Levelized Cost of Energy (LCOE) and makes it attractive for renewable energy investments. Coupled with learning rates, green hydrogen production is expected to become more cost-effective, creating a unique opportunity for GCC countries to become global leaders in the field. The low LCOE is expected to drive the Levelized Cost of Hydrogen (LCOH) down, with cost reductions between 30-50%** by 2030. These reductions will be due to continued decreases in renewable electricity costs and scaling up of manufacturing activities, lowering capital expenditure investments.

Favorable Economics

The economics of green hydrogen are driven by renewable electricity and electrolyzer, which account for the majority of green hydrogen production costs. The GCC has a significant advantage in this regard, as its low-cost renewable electricity can be used to power electrolyzers, making green hydrogen production more cost-effective.

National Strategies and Projects

The GCC countries have recognized the potential of green hydrogen and are actively working towards developing a sustainable hydrogen economy. Saudi Arabia and the United Arab Emirates are developing a general hydrogen strategy, with green hydrogen already viewed as a critical component of existing policies or roadmaps, such as Saudi's Circular Carbon Economy (CCE) program and UAE's Hydrogen Leadership Roadmap. Oman recently announced a national specific green hydrogen strategy with a production target of 1 Mt p.a. by 2030. Oman has set up special economic zones (SEZs) in Sohar, Duqm, and Salalah to streamline land allocation and provide export infrastructure for hydrogen production.
One of the world's largest-scale projects, the NEOM green hydrogen project, is expected to be operational by 2026, boasting a 2 GW electrolyzer plant facility. Several other large-scale projects are also being developed in Oman, Saudi Arabia, and the United Arab Emirates by state-owned oil and gas and power and water utility companies.

Exports and Domestic Demand

GCC countries are also seeking to secure long-term offtake agreements with the EU and Asia through programs such as the H2 global initiative. The GCC countries' proximity to large demand centres in Europe and Asia enables them to realize economies of scale, which reduces hydrogen production costs. Additionally, there is also domestic demand for green hydrogen in oil refining, ammonia, and transportation sectors.

**Source: (IEA, 2019), (Hydrogen Council, 2020)

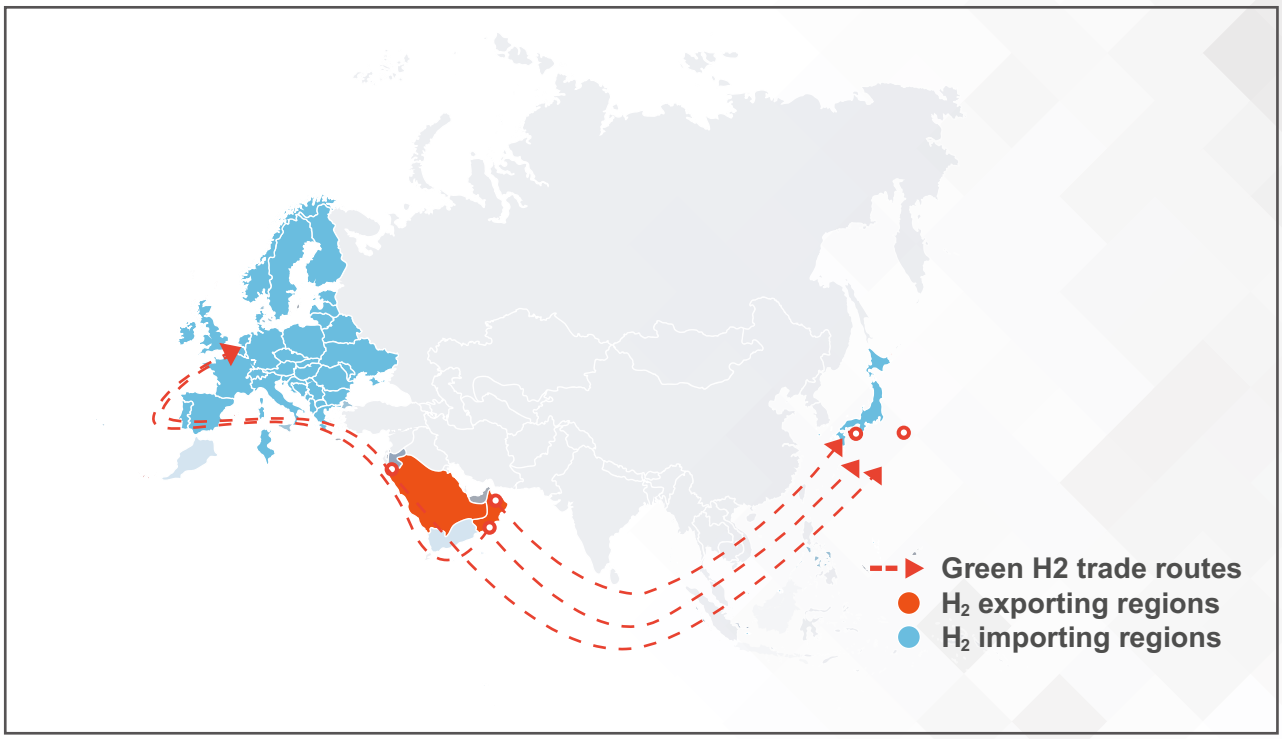


Figure 6: Key Positioning of the GCC with Declared Hydrogen Commerce Corridors

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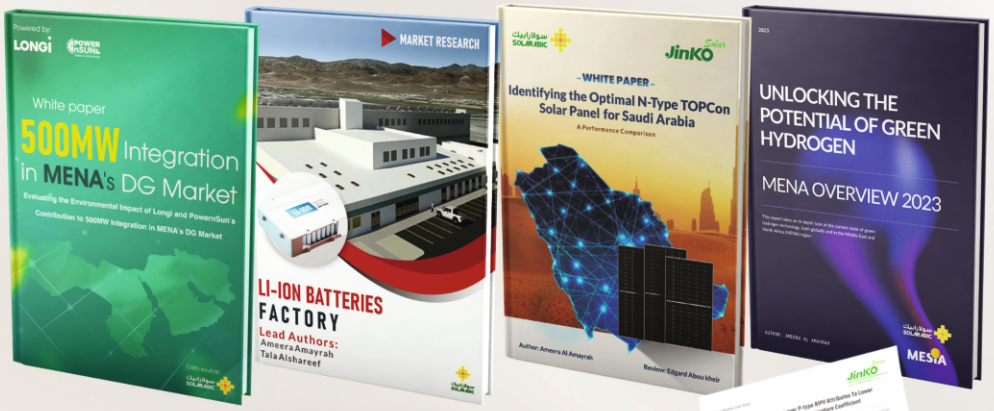

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HYDROGEN ANALYSIS IN MENA BY COUNTRY

According to Meed magazine, there are 75 renewable energy projects in the MENA region, and 85% of them are aimed at producing green hydrogen. The reason behind this increase in hydrogen projects is the sudden drop in renewable energy costs.

The second reason is the advancements in technology, which continue to drive positive changes. As a result, there is an expectation that the average cost of green hydrogen will further decrease to approximately $2 per kilogram by 2030, compared to the present cost of $5.

The demand for hydrogen is set to increase due to factors like net-zero goals, diverse supply, security, and rising gas prices. Gulf countries and Egypt are working on projects to benefit from cheap renewable energy, aiming to boost their global energy supplier status. Meanwhile, countries like Morocco and Jordan are focused on exporting clean energy and cutting down on imports. This section will provide a detailed analysis of hydrogen initiatives in each country.

Saudi Arabia

Saudi Arabia has announced its plans to become a global supplier of hydrogen, with a focus on low-carbon and renewable sources. The country's energy ministry is setting production standards that will meet the requirements of both the European and Asia-Pacific markets. Saudi Arabia aims to produce 4 million metric tons of "clean" hydrogen annually by 2030, with the potential to exceed this amount as demand increases. Instead of differentiating between "green" and "blue" hydrogen, Saudi Arabia is focusing on carbon intensity. The country is prioritizing emissions in line with its net-zero objectives.

Green Hydrogen projects and programs

Green Hydrogen in NEOM

NEOM, a planned city in northwest Saudi Arabia, is focusing on utilizing green hydrogen as a key part of its energy mix. The city is aiming to establish itself as a global hub for the production and export of green hydrogen.

The NEOM green hydrogen project plans on producing 650 metric tons per day of green hydrogen starting in 2026, backed by 4 GW of solar and wind power. The hydrogen will be produced through an integrated 4 GW renewable solar and wind energy system which is expected to generate about 1.2 million metric tons of green ammonia, equivalent to 600 metric tons of carbon-free green hydrogen per day.

The NEOM green hydrogen production facility has signed a long-term exclusive agreement with Air Products, which will make all green hydrogen produced available for global export, when the plant is fully operational in 2026.

The future vision of the "NEOM Green Hydrogen" company is to benefit from the experience and vision of its partners to accelerate the global green hydrogen economy and employ renewable natural resources, which contributes to accelerating the pace of transformation in the energy sector towards a new phase of clean and sustainable energy.

Saudi Arabia is working towards its goal of becoming a global supplier of hydrogen, focusing on low-carbon and renewable sources, with the NEOM project playing an essential role in reaching thisgoal.

ARAMCO projects and vision

Saudi Aramco, the state-owned oil company of Saudi Arabia, is exploring potential investments in green hydrogen as part of its broader efforts to diversify its business and reduce its reliance on oil exports.
In October 2021, the company signed several memorandums of understanding (MoUs) with various partners to explore potential investments in green hydrogen manufacturing, green energy services, advanced non-metallic building materials manufacturing, and industrial digital technologies.

- A memorandum of understanding with Modern Industrial Investment Holding Group and the Intercontinental Energy Company to develop green hydrogen and ammonia technologies in the Kingdom of Saudi Arabia.
- Two memorandums of understanding with South Pole Carbon Asset Management Ltd. and Youssef Abdul Rahman Al-Dobayan Agricultural Corporation to assess the feasibility of establishing a national green services company to innovate and develop natural solutions, including planting trees on a large scale, to reduce greenhouse gas emissions.
- A memorandum of understanding with BFG to focus on the localization of the manufacturing sector of advanced non-metallic building materials in the construction sector and cooperation in the research and development sector. This potential investment supports the trend of using oil outside the field of fuel
- A memorandum of understanding with ABB to explore the possibility of localizing digital technologies in the fields of measurement, and automation systems for industrial processes and the energy sector, including training and developing local capacities.

In addition to this, Saudi Aramco has announced that it will initially focus on exporting low-carbon hydrogen, targeting 11 million metric tons per year by 2030. The company plans to use existing markets such as refining and fertilizer production as its first use cases for hydrogen.

However, it is acknowledged that hydrogen currently is a very expensive fuel with a carbon price in the hundreds of dollars per ton, thus, the company is being transparent about the carbon intensity of its products and is encouraging customers to commission them.

As the world's largest oil exporter, Saudi Aramco is well positioned to take advantage of its low-cost natural gas resources and existing infrastructure to produce hydrogen at scale, which would help Saudi Arabia achieve its net-zero emissions targets and diversify its economy by investing in hydrogen production and other clean energy sources.

The Manar Agreement

One significant agreement is the "Manar" agreement between Saudi Arabia and Japan, aiming to develop clean energy projects related to hydrogen, ammonia, and carbon recycling. Multiple other agreements and memorandums of understanding were signed between Japanese companies and Middle Eastern counterparts during the trip.
Japan is investing heavily in hydrogen and plans to secure supplies both domestically and internationally, with an increasing demand for hydrogen expected over the next few decades. Hydrogen will be used to reduce carbon emissions in various industries currently reliant on fossil fuels, such as car manufacturing and power plants.
The Gulf countries plan to export one million tons of low-emission hydrogen by 2030, presenting an opportunity for Japan's energy security. However, Japan needs to strengthen its relations with the Gulf states to compete with China, a leading producer and consumer of hydrogen investing significantly in clean energy.

Saudi Arabia Signing MoU with Engie for the Development of Green hydrogen projects

ENGIE, a company specializing in low-carbon energy services, has signed a memorandum of understanding with the Public Investment Fund to develop green hydrogen projects and derivatives in Saudi Arabia. The partnership aims to explore opportunities that align with the objectives of the Kingdom's Vision 2030 and enhance the transformation process in the energy sector.

ACWA Power's Strategic Partnership for Green Hydrogen Export to Europe

ACWA Power, a Saudi company, has partnered with Zenith Energy, GasLog, and the Port of Amsterdam to explore the creation of a pathway for exporting green hydrogen from ACWA Power's production sites to Europe. The memorandum of understanding was signed during the Saudi-European Investment Forum and builds on a prior agreement between Saudi Arabia and the Netherlands. The collaboration aims to enhance cooperation in green hydrogen and maritime transport technologies, set international standards, and establish efficient supply chains. The parties will conduct a feasibility study for a liquefied green hydrogen commercial pathway, with the potential for a joint development agreement based on the results.

Zenith Energy is working on a flexible liquid hydrogen import facility in Amsterdam, facilitating storage and distribution. The collaboration also involves GasLog, to developing specialized ships for safe and efficient hydrogen transport.

ACWA Power continue driving its global green hydrogen production with projects.like NEOM, the world's largest, and others in Uzbekistan. The company plans to export green hydrogen, particularly focusing on the European market.

The Saudi-Korean Agreement

Saudi Arabia and South Korea signed various agreements during President Yoon Suk Yeol's visit, covering green hydrogen, transportation, tourism, and renewable energy. The deals include establishing a strategic partnership council, initiating the Hydrogen Oasis collaboration for green hydrogen, and implementing visa exemptions for specific passport holders.

First Hydrogen Train

Saudi Arabia has initiated the testing phase of the first hydrogen-powered train in the Middle East. The trial operations began recently, marking a significant step in the country's efforts towards sustainable transportation and a transition to renewable energy sources. The hydrogen train, a pioneering project in the region, operates without carbon emissions, aligning with Saudi Arabia's commitment to clean energy and environmental conservation.

G20 Leaders Unveil Landmark Transport Corridor: Linking Middle East, India, and Europe

Leaders at the G20 summit in India have agreed to establish a comprehensive transportation corridor, connecting the Middle East, India, and Europe. The initiative, announced by Saudi Crown Prince Mohammed bin Salman and U.S. President Joe Biden, aims to create opportunities for clean energy, electricity, and digital connectivity.

The economic corridor, signed by Saudi Arabia and the U.S., envisions green cross-continental transit routes, leveraging Saudi Arabia's strategic location. It seeks to facilitate the transfer of renewable energy, promote clean energy development, enhance energy security, and boost trade through railways, ports, and digital infrastructure. The project is seen as a significant step toward stability, prosperity, and integration in the Middle East. The European Union, India, Saudi Arabia, the UAE, the U.S., and other G20 partners signed a memorandum of understanding outlining two separate corridors connecting India to the Gulf and the Gulf to Europe.

ACWA POWER Forms Green Hydrogen and Water Desalination Alliances in Italy

ACWA POWER, Saudi Arabia's leading energy transformation and water desalination company, has established strategic collaborations with Italian partners, including Confindustria, Eni, A2A, Industrie De Nora, Italmatch Chemicals, and RINA. The agreements focus on green hydrogen, water desalination, and research and development.
ACWA POWER aims to contribute to Saudi Arabia's carbon reduction goals and promote sustainable progress in Italy and Europe. The alliances seek to exchange expertise and technologies, creating opportunities for Italian companies in Saudi Arabia.

The agreements emphasize long-term partnerships, supply chain collaboration, and sustainable projects across various sectors. The Saudi-Italian Investment Forum serves as a platform to discuss investment opportunities and strengthen diplomatic ties between the two nations. The trade volume between Saudi Arabia and Italy reached $11 billion in 2022.

Egypt

Egypt continues to strengthen its position in the green hydrogen sector, showcasing the potential to be a prominent player. The nation benefits from abundant renewable energy sources, particularly solar and wind power, which contribute to the production of green hydrogen. The competitive advantage is further enhanced by Egypt's relatively low energy prices, ensuring cost-effective green hydrogen production.

Export prospects are promising, leveraging Egypt's existing natural gas pipelines to transport and export green hydrogen, meeting the increasing demand for clean energy in the European Union. The strategic geographical location, with the Suez Canal, positions Egypt to utilize green hydrogen in various industries, such as the production of green ammonia and green methanol for shipping.

The Egyptian government is actively supporting the development of green hydrogen projects through initiatives like tax exemptions, research funding, and collaboration with international partners to attract investments. These measures align with Egypt's aspirations to become a key player in the green hydrogen sector.

Recent developments reveal Egypt's leadership in the Arab world, with 23 green hydrogen projects, outpacing the UAE, Oman, and Saudi Arabia. The Central Agency for Public Mobilization and Statistics announced this achievement on World Ozone Day 2023. Additionally, Egypt has experienced a 2% increase in electricity from renewable sources, reaching 10.4 thousand gigawatt-hours between 2020/2021 and 2022/2021. Notably, Egypt secured the 20th position in the 2023 Climate Change Performance Index (CCPI), surpassing Turkey (47) and the USA (52). World Ozone Day, celebrated annually on September 16th, marks the signing of the 1987 Montreal Protocol, emphasizing Egypt's commitment to addressing ozone-depleting substances.

These combined advancements underscore Egypt's trajectory toward becoming a regional and global leader in the green hydrogen sector, driven by its favorable conditions, strategic initiatives, and notable achievements in renewable energy.

Green Hydrogen Challenges In Egypt

While Egypt has many opportunities for the development of green hydrogen, there are also a number of challenges that must be overcome. These include

1. **Limited renewable energy production projects**

The country has a relatively small number of renewable energy production projects currently, which may not be sufficient to support a large-scale production of green hydrogen.

2. **Lack of financing**

Electrolysis systems, which are used to produce green hydrogen, are expensive and may be difficult to finance for companies and organizations in Egypt.

3. **Safety, security, and infrastructure**

Transporting and storing hydrogen requires certain safety measures and special infrastructure which may not yet be in place in Egypt.

4. **Lack of regulatory and legal frameworks**

There is currently no comprehensive regulatory and legal framework in place in Egypt to support the development of green hydrogen projects.

5. **Water scarcity**

The production of 1 kg of green hydrogen requires about 10 cubic meters of water, and at a time when Egypt depends on the freshwater of the Nile River, it is not possible to use seawater because it will cause corrosion to the components of the electrolysis systems. Desalination requires huge investments and challenges.

6. **High operation costs**

The high costs associated with building, running, and maintaining green hydrogen facilities will be a major challenge.

7. **Lack of skilled workforce**

There is a lack of skilled workforce in the field of hydrogen and electrolysis technologies, this could be another obstacle for developing the green hydrogen sector in Egypt
These challenges will need to be addressed in order for Egypt to fully realize its potential for green hydrogen production and achieve its goals for sustainable energy. It is important for authorities and companies to work together to find ways to overcome these challenges and create a conducive environment for the growth of the green hydrogen sector.

Localization Of Green Hydrogen Projects In Egypt

There are a number of factors that have helped to increase the localization of green hydrogen projects in Egypt. These include:

Government initiatives and support

The Egyptian government has taken a proactive approach to foster green hydrogen development in the country, through various initiatives and partnerships with international organizations such as the EBRD. Additionally, the government has also provided various incentives to attract investments in green hydrogen projects.

The abundance of renewable energy sources

Egypt's location in the middle of the global sunbelt, with high levels of solar radiation and annual brightness hours, makes it an attractive location for green hydrogen production as it can harness solar and wind power.

Strategic location

Egypt's location at the crossroads of Europe, Asia, and Africa makes it a key location for transporting green hydrogen to Europe, which has a growing demand for clean energy.

Feasibility studies

Preparing feasibility studies for new hydrogen projects with investments ranging between 3-4 billion dollars by a number of competent authorities such as Ministries of Electricity, Environment, Petroleum, and Mineral Resources, in cooperation with the Sovereign Fund of Egypt.

Private sector engagement

The private sector cooperated with the government by preparing feasibility studies and pilot projects to understand the financial and technical risks associated with green hydrogen projects.

Partnerships with international companies

Several international companies cooperate in building, developing, and operating the "Egypt Green" facility, including Fertiglobe, one of the largest international companies exporting ammonia, and the Norwegian company «Scatec ASA» and «Orascom» company, which is one of the most prominent engineering and construction groups in the region.

Green Hydrogen Projects And Programs

There are several green hydrogen projects in various stages of development, including

1. The "Egypt Green" facility:

Egypt Green is the first green hydrogen production facility in Egypt, being built in the Suez Canal Economic Zone. Once operational, the 50 to 100 MW wind and solar facility will produce up to 15,000 tons of green hydrogen annually for use in the production of green ammonia and export. The facility is being developed by a consortium of Scatec, Fertiglobe, ADNOC, and TSFE; the hydrogen facility is expected to be commissioned by 2024.

2. The Masdar and Hassan Allam partnership:

This project involves the development of green hydrogen production plants with a production capacity of 4 GW in the Suez Canal Economic Zone and on the Mediterranean coast. The first phase of the project is set to be implemented in 2026, and it will produce 100,000 tons of green methanol annually to supply shipping vessels in the Suez Canal.

3. Al-Fanar Company project:

this project is with the aim of building a facility for manufacturing green hydrogen and green ammonia in the Sokhna region with an investment amounting to $4 billion, This facility will have an annual production capacity of 100,000 tons of green hydrogen and 500,000 tons of green ammonia, with the possibility of exporting green ammonia to multiple locations around the world.

4. AMEA Power project:

AMEA Power signed a memorandum of understanding with the Suez Canal Economic Zone, the Ministry of Energy, and the Sovereign Fund of Egypt to develop a green hydrogen project with a capacity of 500 megawatts and an annual production capacity of one million tons of green ammonia. The company plans to produce green ammonia in Egypt and export it to Europe as an environmentally friendly fuel in response to the increasing global demand for sustainable energy sources.

5. TAQA Arabia & Voltalia partnership:

The partnership signed a memorandum of understanding with the Egyptian government. With the aim of developing, financing, and operating a facility that combines green hydrogen production with electricity generation from solar and wind energy.

The initial project includes the construction of a new green hydrogen production facility at a site near the port of Ain Sukhna in Egypt.

The facility will have a capacity of 15,000 tons of hydrogen annually and will be powered by an electrolyzer with a capacity of 100 megawatts.

The renewable energy to run the electrolyzer comes from 283 megawatts of solar and wind energy. Additionally, the project will be expanded in the future to produce 150,000 tons of green hydrogen annually, with an electrolyzer capacity of 1 GW, which will be obtained from 2.7 GW of solar and wind energy.

6. Siemens Energy pilot project:

The pilot project between Siemens Energy and the Egyptian Electricity Holding Company (EEHC) focuses on the development of a hydrogen-based industry in Egypt with export capability.

Siemens Energy and EEHC announced working on the development of a pilot project which will include a capacity of 100 to 200 MW of electrolyzer capacity.

This will help in the early deployment of technology, the establishment of a partner landscape, the establishment and testing of regulatory environment and certification, the setup of off-take relations, and defining logistic concepts.

With an abundance of renewable energy resources, a strong industrial base, and a developed infrastructure, Egypt provides a solid foundation for the development of a robust green hydrogen industry.

7. Green Hydrogen and Ammonia Plant project:

The project is a joint effort between Helwan Company and two other companies, aiming to provide an environmentally friendly alternative to traditional ammonia production. This move is in line with the global trend towards sustainable industries. The goal is to transform Egypt into a global hub for green hydrogen manufacturing.

Hassan Abdel-Alim, the head of Helwan Fertilizers Company, emphasized the importance of prioritizing environmental protection and adapting to industry developments. The new plant is expected to begin operations soon.

To protect the environment, the Helwan fertilizer chimney has been connected to the Environmental Affairs Agency for monitoring ammonia emissions. Additionally, two other chimneys have also been linked to the agency for environmental monitoring.

To further conserve resources, a partnership was formed with the Water and Wastewater Company in Greater Cairo to establish a drainage line for water reuse instead of relying on the Nile water. This project includes a triple treatment unit, resulting in significant water savings.

The company is also exploring ways to reduce carbon emissions by collaborating with an Egyptian-German consortium, aligning with European standards on carbon reduction. This step demonstrates their commitment to sustainability and responsible environmental practices.

8. Electrolyzer Production in Trabol:

GV Development, a company in Egypt, plans to collaborate with German and Chinese companies to establish a project in the Egyptian industrial city of Tarbol. The project aims to produce electrolyzers for green hydrogen generation, with a capacity of 500 megawatts. They have allocated $100 million in capital for this initiative. The chosen technology for the electrolyzers is alkaline, specifically using a liquid alkaline solution of potassium or sodium hydroxide due to its ease of use and cost-effectiveness.

Additionally, GV Investments has signed contracts for other green hydrogen and green ammonia production projects in Tarboul Industrial City to support Egypt's efforts in response to the global energy crisis.

9. Burg El Arab Green Hydrogen Project

The Egyptian government has granted approval for the Ministry of Transport to proceed with a $1.3 billion project for the production of green hydrogen, its derivatives, and green ammonia. The collaboration involves the General Authority for the Port of Alexandria, the New and Renewable Energy Authority, and the global company "Deme Hydrogen Energy NV." The project aims to localize the green hydrogen industry, solidifying Egypt as a regional and global exporter of green energy and fuel. The initiative will be located near the Burg El Arab seaport and the Burg El Arab Special Economic Zone in western Egypt. The first phase, fully funded by the company, is set to establish Egypt as a key player in renewable energy production.

10. Green Hydrogen production Project with ACWA Power

ACWA Power has signed a framework agreement for the first phase of a Green Hydrogen project in Egypt. The project aims to produce up to 600,000 tons of green ammonia annually, with total investments exceeding USD 4 billion. The agreement involves multiple entities, including the Egyptian Sovereign Fund and the Suez Canal Economic Zone. ACWA Power, with a record in renewable energy projects, sees Egypt as a key player in the global green hydrogen market. The company is also involved in similar projects in Saudi Arabia and Uzbekistan, further expanding its presence in the green hydrogen sector.

11. Longi Green Hydrogen Facility

The Chinese solar energy company, Longi, plans to build a green hydrogen production facility in Egypt, targeting the manufacturing of 50 gigawatts of solar energy components and 30 gigawatts of green hydrogen. The project aims to create around 180,000 jobs and establish a major hub for global green energy exports. The initiative includes manufacturing equipment for green energy and utilizing solar energy for desalination, expanding agriculture, accommodating population growth, and increasing crop yields. This project aligns with Egypt's focus on solar photovoltaic energy and holds significant economic and environmental implications.

12. Demi's Green Hydrogen Project in Gergoub Port, Egypt:

Belgian company Demi is embarking on a three-phase green hydrogen project in Egypt's Gergoub Port, with the initial phase requiring approximately $3 billion in investment. The primary objective of this phase is to generate green hydrogen for export to the European market. The Egyptian government has shown eagerness to back Demi's initiative, providing support to facilitate the company's expansion within Egypt's growing green hydrogen sector. Demi's CEO has affirmed notable advancements in finalizing the agreement, signaling the imminent commencement of project implementation.

13. Memorandum of Understanding in the Petroleum Sector:

The Minister of Petroleum and Mineral Resources signed a Memorandum of Understanding with the Chinese International Energy Corporation Group, the Egyptian General Petroleum Corporation, and the North Abu Qir Fertilizers Company, aiming to establish a joint project for green hydrogen production in the latter and explore renewable energy utilization in diverse petroleum and gas sites across Egypt.

14. Egypt and BP Collaborate for Green Energy and Hydrogen Production

Egypt has announced its intention to enhance collaboration with British Petroleum (BP) in the areas of emission reduction, energy transition, and green hydrogen production. President Sisi expressed appreciation for BP's growing investments and activities in Egypt's gas and petroleum sector, emphasizing its pivotal role in supporting the country's transformation into a regional energy hub. The collaboration aims to boost exploration and production efforts, maximizing Egypt's utilization of resources for current and future generations. BP's CEO highlighted the strategic partnership spanning 60 years, acknowledging Egypt's developmental achievements, particularly in infrastructure and energy. The company presented investment plans of $3.5 billion for research, exploration, and development in Egypt over the next three years.

15. Renew Power to Invest $7.8 Billion in Egypt's Green Hydrogen Production

Renew Power, an Indian company, plans to invest around $7.8 billion in green hydrogen production in Egypt, particularly in the Suez Canal Economic Zone, according to an Egyptian government source. The six-year project aims to produce 20,000 tons of hydrogen annually, expandable to 220,000 tons. The plant, set to start construction in early 2024, will utilize a 150 MW electrolyzer powered by 570 MW of renewable energy, producing 100,000 tons of green ammonia yearly. Egypt, with a goal to become a regional energy hub, anticipates significant foreign direct investment in its green hydrogen projects, totaling over $107 billion.

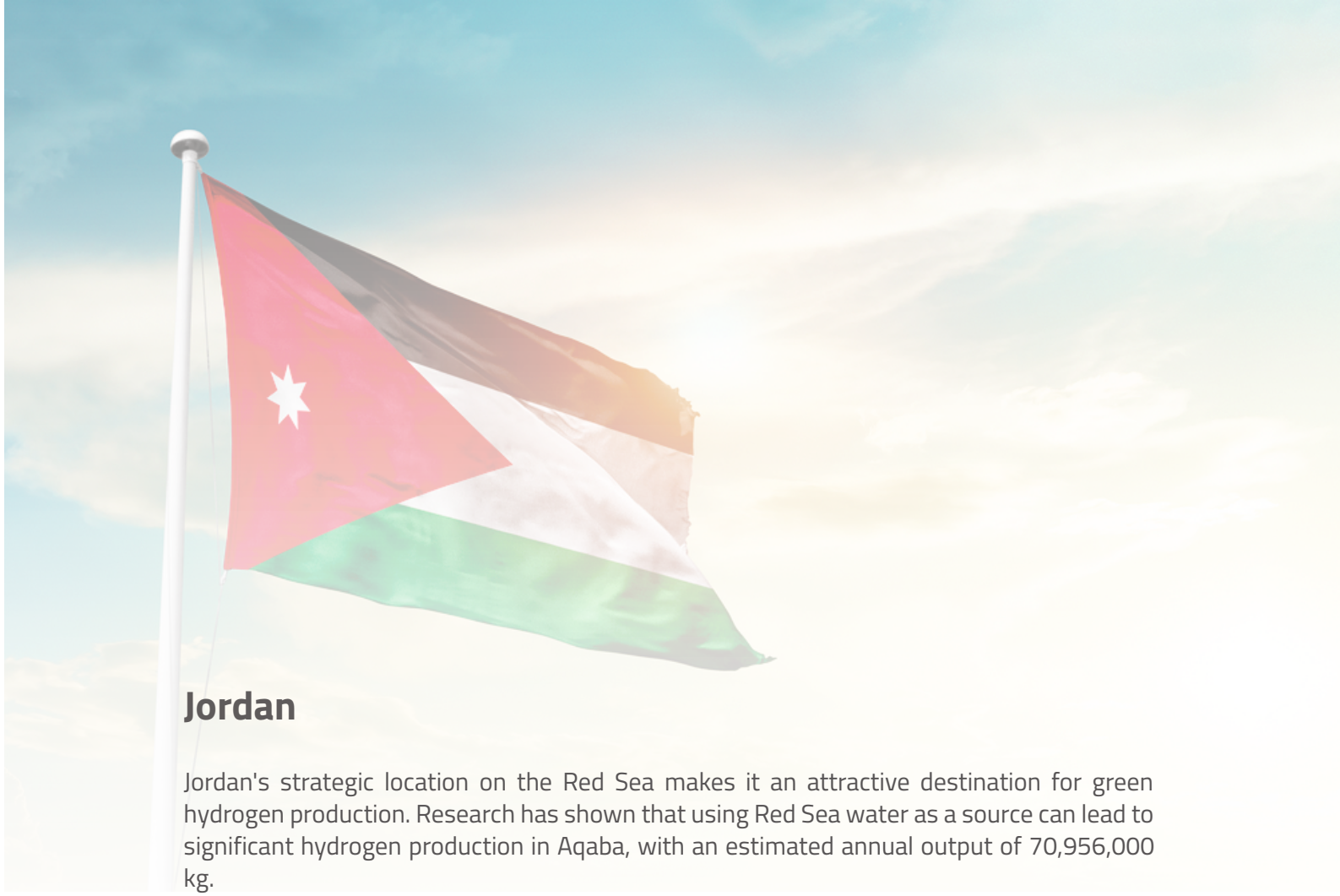
Bahrain

Bahrain is taking steps towards the development of green hydrogen, as demonstrated by a recent Memorandum of Understanding (MoU) signed between Bahrain Petroleum Company (Bapco), Aluminum Bahrain (Alba), and the world's largest aluminum smelter ex-China. The MoU sets the stage for a feasibility study on the use of surplus hydrogen from Bapco for use in Alba's operations.

The MoU also establishes a platform for the sharing of knowledge and collaboration on implementing Environment, Social, and Governance (ESG) initiatives of common interest. These initiatives include the exploration of ways to reduce the carbon footprint of aluminum production and the development of green hydrogen as a renewable energy source.

The partnership between Bapco and Alba represents an important step towards the adoption of green hydrogen in Bahrain. By working together, the two companies can leverage their expertise and resources to advance the use of this clean and sustainable energy source. This is particularly important given the increasing global demand for hydrogen as a fuel and the need to reduce reliance on fossil fuels.

In general, the memorandum of understanding between Bapco, Alba, and the world's largest aluminum smelter ex-China demonstrates Bahrain's dedication to the advancement of green hydrogen and the encouragement of sustainable energy solutions. This partnership is probably going to open the path for more improvement in this field in the coming times.



Jordan

Jordan's strategic location on the Red Sea makes it an attractive destination for green hydrogen production. Research has shown that using Red Sea water as a source can lead to significant hydrogen production in Aqaba, with an estimated annual output of 70,956,000 kg.

The port of Aqaba is well-equipped to support the export and transportation of hydrogen, providing essential infrastructure for storage, transportation, and distribution.

As a leading country in the Arab world's energy sector, Jordan ranks first in the region in terms of renewable energy participation in the total energy mix. It has taken significant steps to promote solar energy use through initiatives like the National Action Plan for Energy Efficiency and Renewable Energy (NEEAP) and programs by the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) supporting various sectors.

Jordan aims to increase the share of renewable energy in its total energy mix by 50% by 2030, having already made considerable progress with renewable energy accounting for 27% of the total energy mix as of February 2023.

Green hydrogen roadmap

Since last year, Jordan has actively worked on developing this roadmap, aiming to establish regulatory frameworks and policies for green hydrogen production and export, ensuring both environmental and economic sustainability.

On July 18, 2022, the Jordanian-German Energy Partnership hosted a workshop titled "Developing a Green Hydrogen Roadmap in Jordan," in collaboration with the GFA Consulting Group. The workshop aimed to contribute to formulating regulations and policies for green hydrogen development, involving key stakeholders from government ministries, technical institutions, regulatory authorities, and various associations to discuss opportunities and challenges in the country's green hydrogen advancement

Green hydrogen strategy in Jordan

Jordan has crafted its preliminary green hydrogen strategy through a collaborative effort involving the Ministry of Energy and Mineral Resources and the Ministry of Environment.

The strategy outlines a multi-faceted approach that includes the development of policies to foster investment, innovation, and partnerships in the green hydrogen sector. It also emphasizes the importance of integrating green hydrogen into the national energy grid, thereby enhancing energy security and reducing carbon emissions. By capitalizing on its renewable energy resources, Jordan aims to establish a robust infrastructure for green hydrogen production, distribution, and utilization.

Green Hydrogen projects and programs

First Green Hydrogen Project

On November 4, 2021, Fortescue Future Industries (FFI) and Jordan signed a framework agreement to develop green hydrogen production using large-scale wind and solar energy. The agreement allows FFI to acquire specific land areas for preliminary studies for potential solar and wind energy production and for the construction of final production facilities. On February 27, a discussion was held in Jordan, organized by the EDAMA Association for Energy, Water, and the Environment and the Energy Sector Support Program funded by the USAID. The meeting aimed to address current measures and future directions for the country's energy transition roadmap. During the session, the Minister of Energy Dr. Saleh Kharabsheh mentioned the framework agreement, which seeks to establish a project for green hydrogen and green ammonia production in the Aqaba Economic Zone, marking the country's first of its kind initiative.

Jordan signs four deals to boost green hydrogen production

The Ministry of Energy and Mineral Resources in Jordan, signed four memoranda of understanding with four companies: Kawar Energy and Philadelphia Solar Energy, both local, and Amarenco MoU Services Co. from Ireland and Enertrag from Germany. The aim of these memorandums is to prepare feasibility studies for developing green hydrogen projects in Jordan.

The memorandums of understanding outline the following goals:

- -Kawar Energy aims to generate 100,000 tons of green ammonia annually.
- -Philadelphia Solar Energy aims to generate 100,000-200,000 tons of green ammonia annually.
- -Enertrag aims to produce about 200,000 tons of ammonia per year.
- -Amarenco aims to produce 1 million tons of green ammonia per year.

Tunisia

Tunisia is working to develop a green hydrogen industry as a way to promote sustainable development and a carbon-free economy. The country has abundant renewable energy resources, such as solar and wind power. In recent years, the Tunisian government and various organizations have announced plans and initiatives to develop a green hydrogen industry in the country.

Green Hydrogen projects and programs

Green hydrogen project for the service of sustainable development and a carbon-free economy

The Tunisian Ministry of Industry, Energy, and Mines launched a green hydrogen project in the service of sustainable development and a carbon-free economy, in cooperation with the German Agency for International Cooperation. The goal of the project is to help Tunisia achieve its goal of carbon neutrality.

The project is based on four main axes:

- Preparing a national strategy for green hydrogen
- Supporting the creation of a green hydrogen economy,
- Supporting research,
- Training, and innovation
- Creating a Tunisian-German technology center for green hydrogen.
-

The green hydrogen production process will take place through the use of electric energy generated from renewable sources such as wind and solar energy.

The project will be implemented in Tunisia by the "German Agency for International Cooperation" in cooperation with the Ministry of "Industry, Energy and Mines" with the support of the "German Federal Ministry for Economic Cooperation and Development", where 31 million euros have been allocated to support this project, including 6 million euros for follow-up and technical support.

This project aims to develop a national green hydrogen strategy and to support the creation of a green hydrogen economy in Tunisia. Additionally, the creation of the Tunisian-German technology center for green hydrogen would help to develop research, training, and innovation in the sector. This could be a good indication that the government is actively working on establising the right conditions for the development of the hydrogen industry, and paving the way for the utilization of green hydrogen in various sectors such as transportation, power generation, and industrial processes. This will also likely support the country's effort to achieve its goals of carbon neutrality.

It is also worth noting that the cooperation with the German Agency for International Cooperation and the support of the German Federal Ministry for Economic Cooperation and Development will bring technical expertise, knowledge, and resources which would be beneficial for the implementation and success of this project. Furthermore, the allocation of 31 million euros for this project, including 6 million euros for follow-up and technical support, suggests its significance for the country.
Overall, it seems that the green hydrogen project launched by the Tunisian Ministry of Industry, Energy, and Mines has the potential to make a significant impact on the country's energy system and economy and support its efforts to achieve carbon neutrality.

AMEA power project

A green hydrogen project is being developed in Tunisia by "Amea Power". The project has a total capacity of 100 MW, with an investment cost that ranges between 130 and 140 million dollars. The project is wholly owned by "Amea Power" and the financing will be provided by the International Finance Corporation (IFC) and the African Development Bank. The financial closure of the project was on December 2022, which means that the project is ready to move to the next phase.

Green hydrogen production and export platform

The German investor, Peter Schermann, head of the "SUNfarming" company, specializing in the green hydrogen industry and the exploitation of renewable and alternative energy in the agricultural field, expressed his desire to establish the first platform for the production and export of green hydrogen in Tunisia, with the establishment of an academy for vocational training in related specializations. This was in a private meeting inside the headquarters of the Tunisian Ministry of Employment and Vocational Training with Minister Nasreddine Nassibi.

Morocco

Green hydrogen is an exciting and rapidly growing industry in Morocco, with the country positioning itself as a leader in the field of sustainable hydrogen production. The Moroccan government has set ambitious goals for the development of green hydrogen, aiming to create an economic and industrial sector around the production and use of hydrogen, ammonia, and methanol as part of its energy transition and efforts to reduce greenhouse gas emissions.

Morocco has exceptional potential in renewable energy sources, with abundant sunlight and a strong focus on the development of solar and wind energy. This, combined with the country's expertise in the field, is providing momentum to the green hydrogen development in Morocco. The government's vision is to use green hydrogen production to promote the economy and strengthen energy security by exporting green energy to Europe.

Green Hydrogen development road map

In 2021, the Moroccan Ministry of Energy, Mines and Environment set out a roadmap for the development of green hydrogen under the National Hydrogen Commission, which was established in 2019. The plan aims to meet a demand for hydrogen of 30 TWh by 2030 and 307 TWh by 2050, which would require 2 GW of renewable energy sources.

The strategy for green hydrogen development in Morocco is based on three pillars: market and demand, technology, and investment.

- The short-term plan includes pilot projects with government and international financial support.
- The medium-term efforts aim to reduce production costs and increase local usage of green hydrogen in the electricity sector
- The long-term efforts aim to improve the business case for green hydrogen at the global level and expand its usage to the heat production sector for residential and urban mobility, including heavy vehicles and aviation.

The government also prioritizes the local production of ammonia, an industry in which Morocco has traditionally relied on imports. With this strategy in place, Morocco aims to become one of the main suppliers of green ammonia to Europe.

The green hydrogen industry in Morocco has the potential to create significant economic and environmental benefits. The government estimates that the industry could create more than 15,000 direct and indirect jobs and capture up to 4% of the global demand for green hydrogen by 2030.

Green Hydrogen projects and programs

Morocco is positioning itself as a leader in the African green hydrogen market with the announcement of an $850m green hydrogen-powered ammonia project, the largest of its kind in the continent to date. The project, which is a joint venture between Greece-based Consolidated Contractors Company (CCC) and Ireland's Fusion Fuel, aims to produce 183,000 tonnes of green ammonia by 2026, with an annual production capacity of 31,000 tonnes of green hydrogen. The green hydrogen for this project will be supplied by Fusion Fuel's off-grid solar-to-hydrogen HEVO Solar generator. The project began in 2022 after the completion of a feasibility study. Commodity trading company Vitol will manage the offtake agreement for the scheme.

Morocco is a significant producer of phosphate, but because of its limited domestic ammonia production, it has had to rely on imported ammonia to produce fertilizers, one of Morocco's key industries. This project is expected to change that and establish Morocco as a major exporter of ammonia to international markets.

This ambitious project is in line with Morocco's long-term goal of producing 80% of its energy mix from renewable sources and reaching net-zero emissions by 2050. The country has been investing heavily in upgrading its renewable energy infrastructure, including a multi-billion dollar push in solar and wind power generation projects since the late 2000s.

Pilot project

The Research Institute for Solar Energy and New Energies (IRESEN) in Morocco has announced the successful installation of its first micro-pilot green hydrogen production system. This pilot project, which is part of the "Power-to-X µPilot" initiative launched by IRESEN and the Mohammed VI Polytechnic University (UM6P), aims to advance sustainable mobility and renewable electricity storage in Morocco through the use of hydrogen and fuel cells.

The system consists of a 20kW electrolyzer and photovoltaic (PV) solar panels. The electrolyzer will undergo testing in the coming days to assess its performance and efficiency. Additionally, the micro-pilot will provide training and upskilling opportunities for students, researchers, engineers, technicians, and managers from IRESEN, UM6P, the National Hydrogen Commission, and the Green H2 Morocco Cluster.

The project is located at the Green Energy Park of Benguerir and is part of Morocco's efforts to upgrade its renewable energy infrastructure and meet domestic demands for green hydrogen.

Morocco is expected to have the third-lowest green hydrogen production cost in 2050, according to the International Renewable Energy Agency (IRENA), which also predicts that Morocco will produce 80% of its energy mix from renewable sources and reach net zero by 2050.

Green hydrogen project plans with Adani Group

Morocco is considering partnering with Indian private conglomerate Adani Group on a large-scale hydrogen project as part of the country's renewable energy push to meet demand at home and in Europe.

Moroccan Energy Transition Minister Leila Benali said in an interview that authorities are thinking of signing final investment decisions for "at least two competitive industrial projects" in 2023, and confirmed that Adani Group is among the firms interested in the Moroccan hydrogen proposition.

Morocco plans Ammonia Plant

The Office Cherifian Phosphate Group (OCP) in Morocco plans to invest $7 billion in an ammonia plant that will use green hydrogen produced from renewable energy sources. OCP, owned by the Moroccan government, aims to reduce energy imports and strengthen the local supply chain. The plant is set to produce 200,000 tons of ammonia annually by 2026, increasing to one million tons by 2027 and three million tons by 2032. The use of hydrogen from solar and wind electrolysis is part of the company's $13 billion strategy to shift to renewable energy. Morocco's investment in renewables is driven by its abundant land, sun, wind, and long coastline, as well as its lack of oil and gas and complex relations with neighboring Algeria, an oil and gas producer.

Taqa Morocco Project

"Taqa Morocco" is considering a renewable energy project in southern Morocco, with a 6,000 MW capacity for green hydrogen production, requiring an investment of around $10 billion. The initiative, led by the private electricity producer "Taqa Morocco," in collaboration with Abu Dhabi's National Energy Company (Taqa), aims to be Morocco's largest in investment and capacity. It aligns with the country's goal to surpass 50% renewable energy in electricity production by 2030. The project awaits the Moroccan government's policy on green hydrogen, anticipating financial support. "Taqa Morocco" aims to shift from coal, reducing its share to half by 2035, investing $1.6 billion in renewable energy, and contributing to seawater desalination projects.

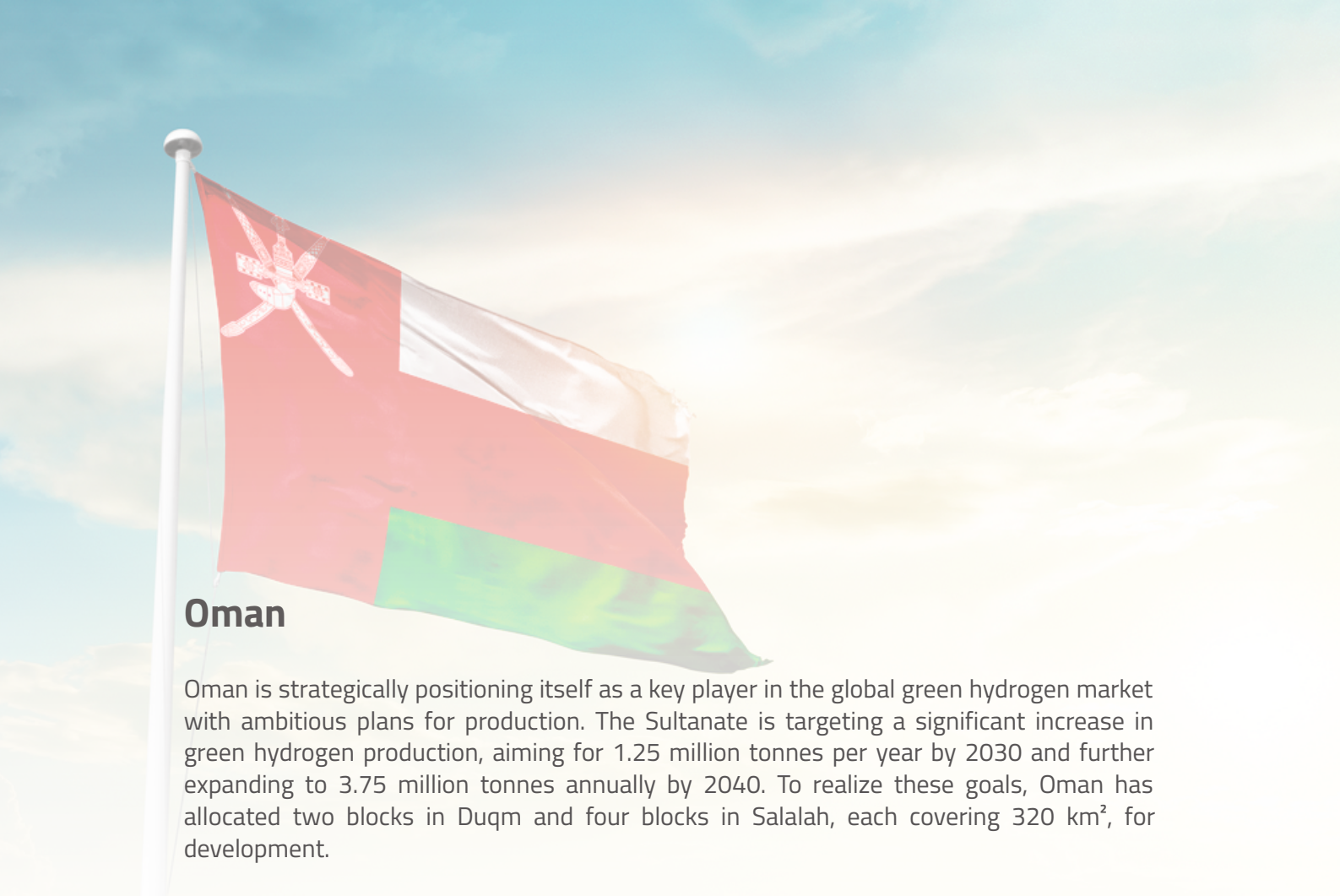
Morocco and Belgium Forge Green Hydrogen Collaboration at Business Forum

The Moroccan Association for Hydrogen and Sustainable Development has partnered with the Belgian Research Center in Mining to boost collaboration in green hydrogen research. This agreement was reached during the seventh Moroccan-Belgian Business Forum in Tangier, which focuses on facilitating investments and partnerships between companies in northern Morocco and Belgium. The forum included bilateral business meetings and a seminar on 'Hydrogen and the Energy Transition,' emphasizing renewable energy and hydrogen's role in carbon reduction, particularly for export-oriented industries.

Power-to-X Project

Morocco aims to produce three million tons of green hydrogen by 2030 through the Power-to-X project in the Laâyoune-Sakia El Hamra region.

The initiative, led by the Moroccan Agency for Sustainable Energy (MASEN), involves a hybrid power station harnessing solar and wind energy to produce green hydrogen with an electrolysis capacity of 100 megawatts. Morocco seeks to position itself as a regional leader in green hydrogen production, contributing to environmental preservation and fostering economic opportunities in renewable energy.



Oman

Oman is strategically positioning itself as a key player in the global green hydrogen market with ambitious plans for production. The Sultanate is targeting a significant increase in green hydrogen production, aiming for 1.25 million tonnes per year by 2030 and further expanding to 3.75 million tonnes annually by 2040. To realize these goals, Oman has allocated two blocks in Duqm and four blocks in Salalah, each covering 320 km², for development.

In support of its green hydrogen initiative, Oman is planning to construct a 2,000-kilometer pipeline network connecting three regions within the country, with potential extensions to neighboring nations. This infrastructure is designed to alleviate the challenges faced by industrial developers and enhance Oman's standing as a major green hydrogen exporter.

The produced hydrogen will not only meet domestic demand but also be exported, with Europe and Asia identified as key potential markets. Oman foresees a cumulative investment of $140 billion by 2050 to achieve its production targets. To facilitate the transition to green hydrogen, targeted factories will receive natural gas for 5 years, valued at over $43.94 billion.

The comprehensive strategy aligns with Oman's commitment to sustainability, emphasizing its role in contributing to global green energy markets. Investors and international organizations, including the International Energy Agency, have shown interest in Oman's green hydrogen projects, anticipating the country's emergence among major fuel-exporting nations by 2030. Additionally, Oman aims to establish the necessary infrastructure for water and electricity transport in key regions, namely Duqm, Al-Jazir, and Salalah, further solidifying its position in the growing green hydrogen sector.

Hydrogen Oman (Hydrom)

To support this effort, Oman has created a new state-owned company, Hydrogen Oman (Hydrom), which will be a subsidiary of the state-owned Energy Development Oman (EDO). Hydrom will be responsible for the demarcation of large tracts of state-owned land and the construction of associated large-scale green hydrogen projects.

The company will work closely with the Special Economic Zones and Free Zones Administration (OSZ) to manage the allocation of projects to sponsors and promote the development of common infrastructure and related industry and ecosystem centers.
Furthermore, during the Green Hydrogen Summit in Muscat, Hydrogen Oman (Hydrom) signed agreements for the storage and production of green hydrogen, securing investments totaling USD 38 billion.

Green Hydrogen projects and programs

Oman Green Energy Project (GEO):

Oman Green Energy Project (GEO) in Al Wusta Governorate, is a large-scale renewable energy project. The project is being led by a consortium of companies that includes the state-owned oil and gas company OQ, the Hong Kong-based renewable hydrogen developer InterContinental Energy, and the Kuwait-based energy investor Enertech.

The project is expected to cost $30 billion and is scheduled to begin construction in 2028, with the aim to be at full capacity by 2038. The plant will be powered by 25 GW of wind and solar energy. Once online, the plant will use renewable energy to split water into hydrogen and oxygen, with the hydrogen produced being carbon-free and exported to Europe and Asia, either as hydrogen or converted into green ammonia which is more convenient to ship and store. The facility aims to produce 1.8 million tonnes of green hydrogen and up to 10 million tonnes of green ammonia a year.

The Highport project, located in the Special Economic Zone at Duqm, is a joint venture with Belgium's DEME and Uniper

Oman's HYPORT Duqm project has signed a cooperation agreement with energy company Uniper, in which Uniper will provide engineering services and negotiate an exclusive offtake agreement of green ammonia.

The partnership will support HYPORT Duqm in demonstrating a strong business case for the offtake and securing optimal financing for the project. The HYPORT Duqm project aims to develop a 250-500 MW green hydrogen facility in the Special Economic Zone at Duqm, Oman, which will come into operation in 2026 to respond to the global demand for green hydrogen and its derivatives. The project is part of a larger plan to transform the Special Economic Zone into a Green Hydrogen hub in Oman and the wider region.

The H2Oman joint venture with ACWA Power and Air Products, in the Salalah Free Zone

ACWA Power, OQ, and Air Products have signed a joint development agreement (JDA) towards a multibillion-dollar investment in a world-scale green hydrogen-based ammonia production facility in Oman. The facility will be located in the Salalah Free Zone and will use innovative technology to integrate renewable power from solar, wind, and storage to produce hydrogen by electrolysis, nitrogen by air separation, and green ammonia. The facility will be equally owned by the three project partners. This agreement follows a memorandum of understanding that was signed in December 2021.

Salalah H2 joint venture with the Japanese company Marubeni, German company Linde, and Dubai Transport Company Dutco in the Salalah Free Zone.

Marubeni Corporation has signed a Joint Development Agreement (JDA) with the alternative energy business unit of OQ SAOC, Oman's global integrated energy company, Linde plc, a global industrial gas company, and Dutco Group to conduct a technical and commercial feasibility study on the development of a green hydrogen and green ammonia production infrastructure in the Salalah Free Zone in Oman. The project will include the construction of a renewable power plant.

The Oman Project

The Oman Project is the first green hydrogen project at Duqm, Oman being developed by GHC under the guidance and supervision of ACME Group. The facility is located in the Duqm Special Economic Zone of Oman.

The first phase of the project is expected to produce 100,000 tonnes of green ammonia annually. It will be expanded to 1.2 million tonnes per annum with about 3.5 GW of electrolyser capacity, which will be powered by 5.5 GWp of the solar PV plant. The facility has potential for further expansion in later phases at the same location.

BP projects

BP and the Ministry of Energy and Minerals in Oman have signed a Strategic Framework Agreement (SFA) and a Renewables Data Collection Agreement to support the potential development of a multiple gigawatt, world-class renewable energy and green hydrogen development in Oman by 2030. Under the agreement, BP will capture and evaluate solar and wind data from 8,000km2 of land. The evaluation will support the government of Oman in approving the future developments of renewable energy hubs at suitable locations within this area, to take advantage of these resources. The renewable energy resources could also supply renewable power for the development of green hydrogen, targeting both domestic and global export markets. This partnership is a significant evolution of BP's business in Oman and aligns with BP's strategy to rapidly grow its developed renewable generating capacity and take early positions in hydrogen.

Amna Consortium's Green Hydrogen Project

The initial agreement is with the Amna consortium, comprising infrastructure companies Copenhagen & Partners, Blue Power & Partners, and Green Partners. This project aims to generate 200,000 tonnes of green hydrogen annually, utilizing 4.5 GW of renewable energy. The green hydrogen will be used in the production of green steel, and the project is strategically situated in the port of Duqm within the Special Economic Zone at Duqm.

Namaa Water Services and GUtech Partner to Produce Green Hydrogen from Treated Water

Namaa Water Services and the German University of Technology in Oman (GUtech) have signed a memorandum of understanding to collaborate on producing green hydrogen from treated water. The agreement aims to enhance cooperation between the industrial sector and the university in academic research related to water technologies. The partnership will involve joint research projects, support for student research, and the organization of events like lectures and workshops. The green hydrogen production project from treated water has completed its technical and economic feasibility study, and the second phase will involve laboratory experiments and practical applications. Both parties emphasize the importance of cooperation in finding innovative opportunities for optimal use in the water sector.

Volcan Project

Vulcan Green Steel, a part of the Jindal Steel Group, is set to build the world's largest green hydrogen-ready steel plant in the Special Economic Zone at Duqm (SEZAD), Oman. The groundbreaking ceremony, attended by dignitaries including Dr. Ali bin Masoud Al Sunaidy and Naveen Jindal, marked the start of this significant project aligned with Oman's goal of achieving Net Zero by 2050. Scheduled for completion by 2026, the plant aims to produce 5 million metric tonnes per annum of green steel, with approximately 85% fewer CO2 emissions than the global average, contributing significantly to global emissions reduction. The project emphasizes the utilization of renewable energy sources, with plans to explore additional storage options for 24x7 green energy.

Oman Collaborates on Green Hydrogen Fueling Station Project in Duqm

Oman, in collaboration with OQ, Asyad Group, and Air Liquide, is undertaking a joint study for a green hydrogen fueling station in the Duqm Special Economic Zone. The station, powered by solar and wind energy, aims to support green transportation, and the agreement aligns with Oman's commitment to carbon neutrality. The study covers renewable energy generation, green hydrogen production, and the establishment of a fueling station for hydrogen-powered vehicles.

Algeria

Recently In Algeria, the government has announced a national plan for the development of renewable energies, with a target of 15,000 MW by 2035, in order to diversify energy sources and reduce dependence on hydrocarbons.

The Minister for Energy Transition stated that "green hydrogen is emerging as the strategic alternative clean fuel of the coming decades. It has an important role to play in a clean energy transition. It is a vector that will become essential for our economy."

Green Hydrogen potential in Algeria

As part of the Algerian-German energy partnership, an exploratory study on the potential of Power-to-X (green hydrogen) for Algeria has been published by the German development agency, Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) GmbH. The study proposes an integrated assessment of the hydrogen sector in Algeria and highlights areas for improvement of the legal, regulatory and institutional framework in order to foster large-scale investments in decarbonization.

The study shows that it is technically and economically possible to develop a green hydrogen industry in Algeria, which would contribute to the decarbonization of several sectors and the reduction of dependence on hydrocarbons.

The study defines three basic stages for the development of a green hydrogen industry in the country:

1. 2022-2030: Piloting, demonstration phase.
2. 2030-2040: Scaling up and market creation phase.
3. 2040-2050: Competition market.

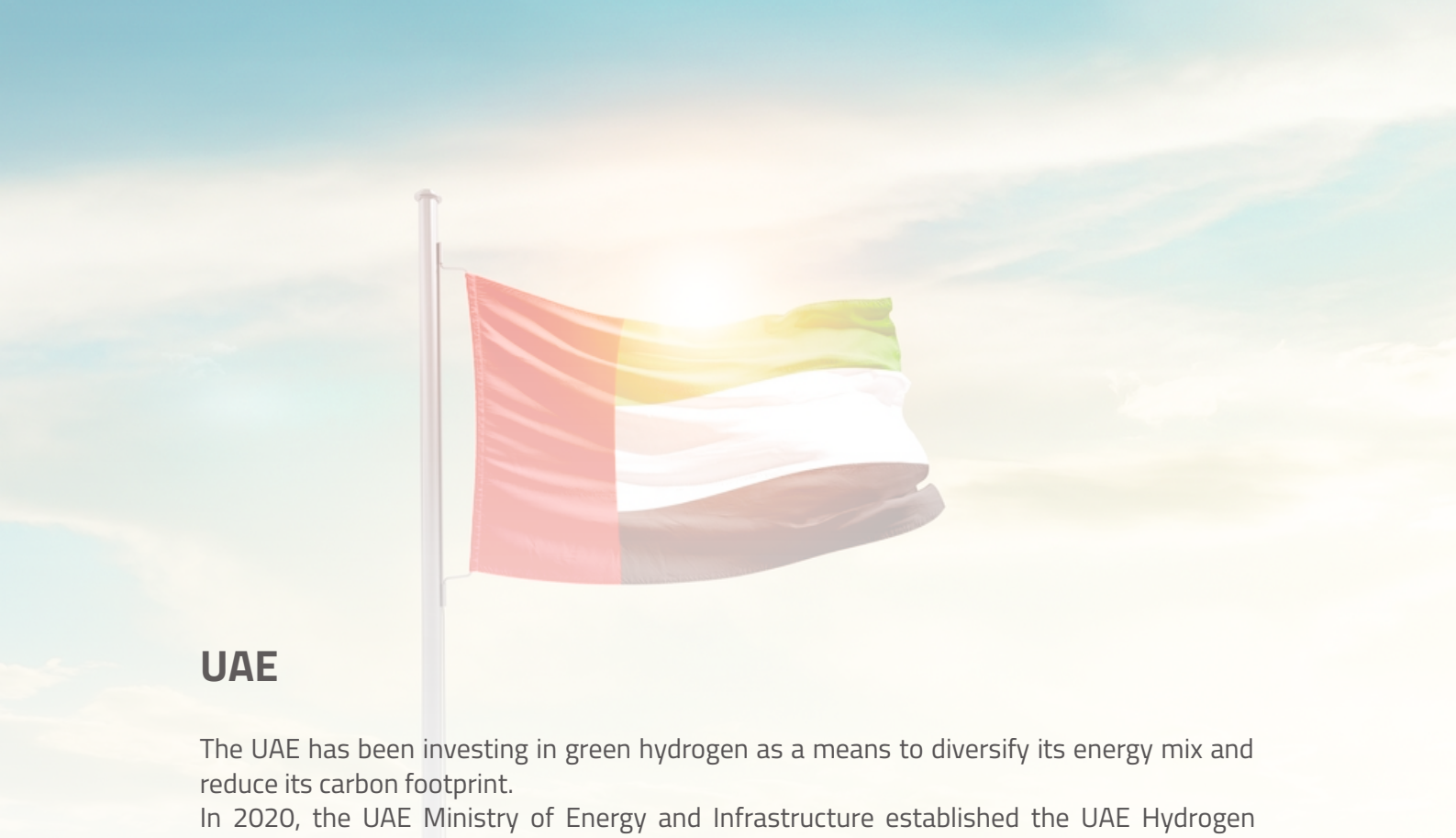
Regulations and Framework for Green Hydrogen in Algeria

GIZ study recommends the development of a legal, regulatory and institutional framework to support large-scale investments in decarbonization. This includes the need for a clear and stable policy environment, adequate regulations and incentives, and the establishment of an institutional framework to support the development of the green hydrogen industry.
In addition, the study suggests that Algeria's existing infrastructure in the oil and gas industry, its industrial gas industry, its exceptional potential in wind and solar energy and its geographical proximity to Europe, make it a potential supplier of green hydrogen or other valuable gases. However, the production costs will differ greatly depending on the location

Green Hydrogen projects and programs

50 MW Green Hydrogen project

Algeria and Germany have signed a memorandum of understanding for the construction of the first green hydrogen plant in Algeria. The MoU was signed between Sonatrach, Algeria's state-owned oil company, and the German gas company VNG AG. The proposed plant will have a production capacity of 50 MW, and will produce electricity from solar energy. The MoU aims to explore opportunities for cooperation for the realization of projects in the field of hydrogen and of green ammonia to be exported to Germany. The first step of the project will focus on feasibility studies on the hydrogen value chain, from production and transport to commercialization.



UAE

The UAE has been investing in green hydrogen as a means to diversify its energy mix and reduce its carbon footprint.
In 2020, the UAE Ministry of Energy and Infrastructure established the UAE Hydrogen Leadership Initiative to increase research and development into the use of hydrogen in industrial decarbonization. The Abu Dhabi Hydrogen Alliance and the National Hydrogen Technical Committee were also formed as part of the initiative.

Green Hydrogen projects and programs

The Dubai Green Hydrogen Project "Mohammed bin Rashid Al Maktoum park Green hydrogen project"

Siemens Energy, in collaboration with Dubai Electricity and Water Authority (DEWA) and Expo 2020 Dubai, has inaugurated the first industrial scale, solar-driven green hydrogen facility in the Middle East and North Africa. The plant was located at DEWA's Outdoor Testing Facility of the Research and Development (R&D) Centre at the Mohammed bin Rashid Al Maktoum Solar Park in Dubai.
The integrated facility was developed with electrolysis, storage, and re-electrification capabilities, to maximize the benefits of the pilot project. Daylight solar power from the solar park will enable the pilot project to produce around 20.5kg/hr of hydrogen at 1.25MWe of peak power.
The main objective of this project is to demonstrate the production of green hydrogen from solar power, as well as the storage, and re-electrification of hydrogen. This is a system that allows for buffering renewable energy production, both for fast response applications, as well as for long-term storage. The plant has been built to accommodate future applications and test platforms for the different uses of hydrogen, including potential mobility and industrial uses.

The Abu Dhabi Hydrogen Power Plant, 2 GW

France's Engie and Masdar have established a strategic alliance to develop projects related to green hydrogen. The companies announced that they will explore the co-development of a UAE-based green hydrogen hub and will look to develop projects with an electrolyzer capacity of 2 gigawatts. The total investment for the initiative will be approximately $5 billion.

The companies plan to leverage existing infrastructure to initially target local supply, with the aim of expanding capacity to create a giga-scale green hydrogen hub for the GCC, with the potential to export to other markets.

Abu Dhabi Port, 2 GW

Abu Dhabi National Energy Company (TAQA) and port operator Abu Dhabi Ports have announced plans to develop an industrial scale green hydrogen to ammonia export project in Abu Dhabi. The two companies will work together on developing proposals for a green ammonia export facility to be based in Khalifa Industrial Zone Abu Dhabi (KIZAD).
The new plant would be fueled by hydrogen produced by an electrolyzer facility paired with a 2 GW solar photovoltaic (PV) power plant. The green hydrogen would be turned into liquid ammonia to supply ships converted to use ammonia as a bunker fuel and for export from Abu Dhabi Ports via specialized gas carriers. Ammonia, which is relatively easier to transport than pure hydrogen, has a number of industrial uses and can also be easily turned back into hydrogen.
This project is seen as a significant step towards placing Abu Dhabi at the heart of a new emerging global market for green energy.

Khalifa Industrial Zone Abu Dhabi (Kizad)

Abu Dhabi has announced plans for a $1 billion facility to produce green hydrogen and ammonia, called Helios Industry. The facility will be powered by an 800 MW solar photovoltaic (PV) plant, and is expected to produce 200,000 tonnes of green ammonia for export annually once completed.
The project's initial phase includes a 300 MW solar PV plant and an estimated 35,000 tonne-a-year ammonia production facility. The green ammonia production facility will target regional and international markets. ThyssenKrupp was awarded a technical study contract for the project and has completed the study, project partners are being finalized. This project is one of many green hydrogen and ammonia projects announced in the Middle East and North Africa (MENA) region since July 2020, with a total worth of $60 billion.

First Hydrogen Refueling station in Masdar City

ADNOC announced the construction of the Middle East's first high-speed hydrogen refueling station in Masdar City. The plant will produce clean hydrogen using an electrolyzer powered by a clean electricity grid, without emitting carbon. ADNOC is collaborating with Toyota and Al-Futtaim Motors to test the ultra-fast hydrogen fueling station with hydrogen-powered vehicles. The project aligns with the UAE's low-carbon growth strategy to reduce emissions and combat climate change. The station will be operated by ADNOC Distribution, and a second station with conventional hydrogen fueling will be set up in Dubai Golf City. ADNOC has allocated significant funds to develop low-carbon solutions and achieve climate neutrality by 2050.

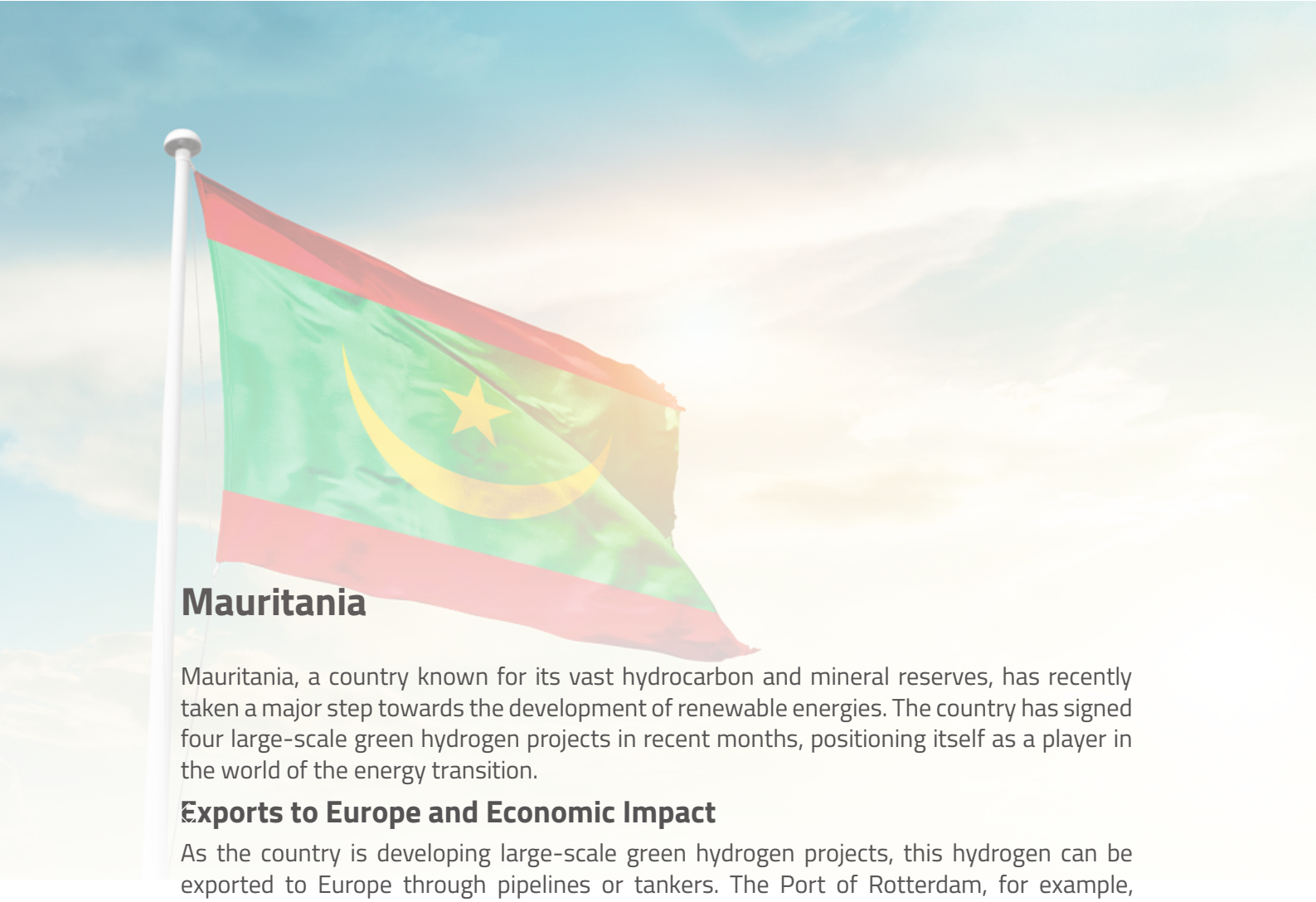
H2GO Refueling Station

ADNOC has opened the H2GO green hydrogen refueling station in the UAE to test emission-free hydrogen-powered vehicles. The station produces green hydrogen using a clean electric-powered electrolyzer, certified by international standards.

ADNOC's initiative aligns with the UAE's hydrogen strategy and involves collaboration with local and international companies to implement low-carbon solutions. The project is supported by the Abu Dhabi Integrated Transport Centre and backed by Linde, a global leader in industrial gases and engineering.

Green Steel Production Project between Masdar and Emirates Steel Arkan

Masdar and Emirates Steel Arkan have collaborated on an innovative green hydrogen project targeting emissions reduction in the UAE's energy-intensive steel sector. Situated in Emirates Steel Arkan's Abu Dhabi facilities, this groundbreaking project, the first of its kind in the Middle East and North Africa, is currently under construction. Equipped with electrolyzers, it aims to produce green iron, a high-quality product sought by global steel companies committed to achieving net-zero emissions. The facility is set to commence operations in early 2024, utilizing green hydrogen instead of natural gas for iron ore reduction, a pivotal step in steel production. Notably, the steel industry contributes 7-8% of global carbon emissions. The partnership aligns with climate change mitigation efforts, coinciding with the UAE hosting COP28.



Mauritania

Mauritania, a country known for its vast hydrocarbon and mineral reserves, has recently taken a major step towards the development of renewable energies. The country has signed four large-scale green hydrogen projects in recent months, positioning itself as a player in the world of the energy transition.

Exports to Europe and Economic Impact

As the country is developing large-scale green hydrogen projects, this hydrogen can be exported to Europe through pipelines or tankers. The Port of Rotterdam, for example, announced plans to construct a terminal exclusively dedicated to hydrogen by 2026, and Project Nour has already signed a partnership with the port for the export of 600,000 tonnes of green hydrogen per year.

Green Hydrogen projects and programs

Project Nour

Project Nour is a green hydrogen project in northern Mauritania spanning two onshore areas totaling approximately 5,000km². It aims to take advantage of the large-scale wind and solar potential in the area to produce low-cost hydrogen for export to Europe. Chariot is working in partnership with the Government of Mauritania and the Port of Rotterdam to support the country's ambition to become a leading producer and exporter of green hydrogen. The project has the potential to positively impact Mauritania through increased investment, job creation, skill development, and increased government revenues, as verified by a Pre-Feasibility Study. A Framework Agreement is in place and a partnering process is underway to form a world-class consortium to further develop the project.

Aman

Mauritania and renewable energy developer CWP have signed a Memorandum of Understanding to develop a $40 billion green hydrogen production facility, called AMAN. The project will involve the construction of hybrid wind and solar generators with a total capacity of 30 GW, which will generate 110 TWh of electricity per year and is expected to produce 1.7 million tons of green hydrogen and 10 million tons of green ammonia.

The project is expected to boost the country's GDP by 50-60% by 2035, reduce unemployment by a third, and give access to freshwater reserves for the housing sector and farmers. Additionally, it will promote the development of fuel cell transport and the use of hydrogen in heavy industry, such as iron ore production, which could reduce CO2 emissions.

Who's who in the green Hydrogen market

Company	Type	Website
Air Liquide	Electrolyzer supplier	https://www.airliquide.com/
Longi Hydrogen	Electrolyzer supplier	https://www.longi.com/en/products/hydrogen/
ITM Power	Electrolyzer supplier	https://www.itm-power.com/
Nel Hydrogen	Electrolyzer supplier	https://www.nelhydrogen.com/
Linde	Electrolyzer supplier, Hydrogen production and distribution	https://www.linde.com/
Siemens Energy	Electrolyzer supplier, EPC, Hydrogen production and distribution	https://www.siemens-energy.com/
Air Products	EPC, Hydrogen production and distribution	https://www.airproducts.com/
McPhy	Electrolyzer supplier, EPC, Hydrogen production and distribution	https://www.mcphy.com/
Plug Power	EPC, Hydrogen production and distribution	https://www.plugpower.com/
Ballard Power Systems	Electrolyzer supplier, Fuel cell manufacturer	https://www.ballard.com/
Hydrogenics	Electrolyzer supplier, Fuel cell manufacturer	https://www.hydrogenics.com/

Company	Type	Website
H2 Energy	EPC, Hydrogen production and distribution	https://www.h2-energy.com/
Hydrogenious Technologies	Hydrogen production and distribution	https://hydrogenious.net/
Hexagon Purus	Hydrogen production and distribution	https://hexagonpurus.com/
Iwatani Corporation	EPC, Hydrogen production and distribution	https://www.iwatani.co.jp/english/
Solarabic	Hydrogen MEDIA outlet	https://www.solarabic.com
ARAMCO	National Oil and Gas Company	https://www.aramco.com/
NEOM	The world's largest utility-scale, commercially-based green hydrogen facility	https://neom.com/
ADNOC	National Oil and Gas Company	https://www.adnoc.ae/
Masdar	UAE-government owned renewable energy Development Company	https://www.masdar.ae/
OQ	National Oil and Gas Company	https://oq.com/en

MESIA

جمعية الشرق الأوسط لصناعات الطاقة الشمسية
Middle East Solar Industry Association

سولارابيك
SOLARABIC