CRITICAL INSIGHTS TO EMPOWER YOUR BUSINESS GROWTH

Energy

OMAN

ISSUE 12 | MAR 2024

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A SUMMIT FOR PLANET EARTH: CALL TO ACTION

HARNESSING OMAN'S SEAWATER RESOURCES

THE GREEN HYDROGEN JOURNEY

DECODING OMAN'S SUSTAINABLE FINANCE FRAMEWORK

GCC COOPERATION FOR CLIMATE CHANGE

Energy OMAN
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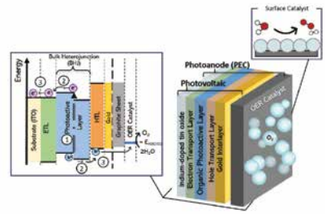

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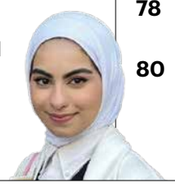

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"Overcoming the challenges posed by climate challenge is not a task for one country or one organization – hence this summit where guests from all over the world, from every continent, are in attendance, transcending national boundaries and organizational barriers": **HE Mohsen Al Hadhrami**

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Chairman's Message

Abdullah Al Harthy

Dear Readers,

Green hydrogen remains the central focus of this edition, echoing its prominence in previous editions and underscoring its pivotal role in Oman's economy and energy transition. This edition is essential reading for those keen on staying abreast of Oman's rapidly advancing clean energy sector. It presents a comprehensive array of insights unveiled at the GHSO 2023, where key officials driving Oman's green hydrogen strategy shared valuable information. Complementing this content are diverse perspectives from energy professionals on topics crucial to our clean energy future.

Moving forward, Energy Oman is dedicated to delving into other critical facets of the broader energy transition and decarbonization strategy, essential for achieving the country's Net Zero objectives. This includes exploring emerging technologies such as CCUS, Energy Efficiency, e-Mobility, Sustainable Aviation Fuels (SAF), Energy Storage, and advancements in Battery & Fuel Cell Technology. Energy Oman invites you to contribute your perspectives for potential publication in Oman's premier energy-focused magazine.

Energy Oman is committed to collaborating closely with Birba, the organization behind the renowned GHSO Summit series, to spotlight opportunities for Omani businesses throughout the energy value chain. Leveraging Birba's unparalleled expertise demonstrated through its annual GHSO events, we are working together to organize a series of high-profile events in Oman and the wider Middle East. These events are designed to facilitate connections and foster collaborations between Omani entities and regional counterparts, promoting mutually beneficial partnerships and investment opportunities aligned with our collective clean energy aspirations. We encourage you to reach out to us to explore how we can support each other in achieving our shared goals and interests.

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Advisory Board welcomes new member

Energy Oman is thrilled to welcome Dr. Yousef Hamed Al Balushi to the magazine's Advisory Board. His firsthand experience at the Central Bank of Oman, the erstwhile Supreme Council for Planning, and as an Oman Vision 2040 content expert has equipped him with a deep understanding of the evolving energy sector.

Energy Oman's focus on the critical issues driving Oman's energy transition is also a topic that Dr. Al Balushi is deeply invested in. He explains, "I am committed to leveraging my expertise to contribute meaningfully to Energy Oman. My aim is to not only inform and engage our readers but also to provide valuable guidance to policymakers as we navigate the path towards a sustainable energy future for Oman."

Board thanks outgoing member

The Chairman and Editorial Board of Energy Oman extend their heartfelt gratitude to the Honourable Eng. Saif Hamed Al Salmani, Member of the State Council, for his unwavering dedication and invaluable contributions as an Advisory Board member since the inception of the magazine three years ago.

Eng. Al Salmani's vision and commitment to excellence helped us navigate challenges and seize opportunities, ensuring that we continually deliver content that resonates with our readership. As he steps down from the Advisory Board, we thank him profoundly for his guidance, insights, and expertise that have been instrumental in shaping the direction and success of our publication.

A Summit for Planet Earth: CALL TO ACTION

“Overcoming the challenges posed by climate challenge is not a task for one country or one organization – hence this summit where guests from all over the world, from every continent, are in attendance, transcending national boundaries and organizational barriers”: HE Mohsen Al Hadhrami

Opening the Green Hydrogen Summit Oman (GHSO 2023) on a glorious Tuesday morning last December, His Excellency Mohsen bin Hamed Al Hadhrami, Under-Secretary of the Ministry of Energy and Minerals, dedicated the 3-day forum to Planet Earth.

"This Summit – indeed your Summit – is a Summit for this planet," he declared in his opening remarks. "We are here today because we unite in a vision to live a prosperous life and seek a prosperous future for all."

Around 2,000 delegates from around the world, including energy ministers, industry executives, technology providers, research scientists, and young students, were in attendance. The Chief Guest was HE Dr. Khamis bin Saif Al Jabri, Chairman of Oman Vision 2040 Implementation Follow-Up Unit.

In his keynote address, HE Mohsen emphasized the need for collective action in the face of unprecedented challenges posed by climate change. "Overcoming this challenge is not a task for one country or one organization – hence this summit where guests from all over the world, from every continent, are in attendance, transcending national boundaries and organizational barriers. We have come together united in a vision that we can work together. We can collaborate and create an ecosystem where green hydrogen plays a big role in decarbonizing our activities as humans," he stated.

The Under-Secretary highlighted in this regard Oman's advantageous position to support domestic and global decarbonization efforts. Abundant natural resources in the form of solar and wind energy are conducive to clean energy generation for domestic consumption and export as well, he noted.

Central to Oman's vision is the commitment to Net Zero 2050, mandated by a Royal Directive. It enshrines a strategy for driving the development of green hydrogen projects and fostering a conducive environment for renewable energy initiatives.

"Our vision is to produce 7.5 to 8.5 million tons per annum of green hydrogen by 2050, with an immediate goal to produce 1 million tons of hydrogen per annum by 2030," said Mr. Mohsen, stressing the importance of leadership, collaboration, and strategic planning to achieve these ambitious targets.

Alignment and Synergy

The establishment of Hydrogen Oman LLC (Hydrom), the Under-Secretary pointed out, symbolizes Oman's dedication to orchestrating cooperation between government entities and industry stakeholders, ensuring alignment and synergy in pursuit of common goals.

Looking back on the previous iteration of the Summit a year earlier, HE Mohsen acknowledged progress in Oman's hydrogen journey. Concepts discussed then have since matured over the year – as was evident in the signing of a landmark agreement on the sidelines of GHSO 2023 aimed at exploring energy storage for the first time in Oman. Storage, he noted, is a necessary element to make green hydrogen even more competitive and viable in the future.

Central to Oman's vision is the commitment to Net Zero 2050, mandated by a Royal Directive.

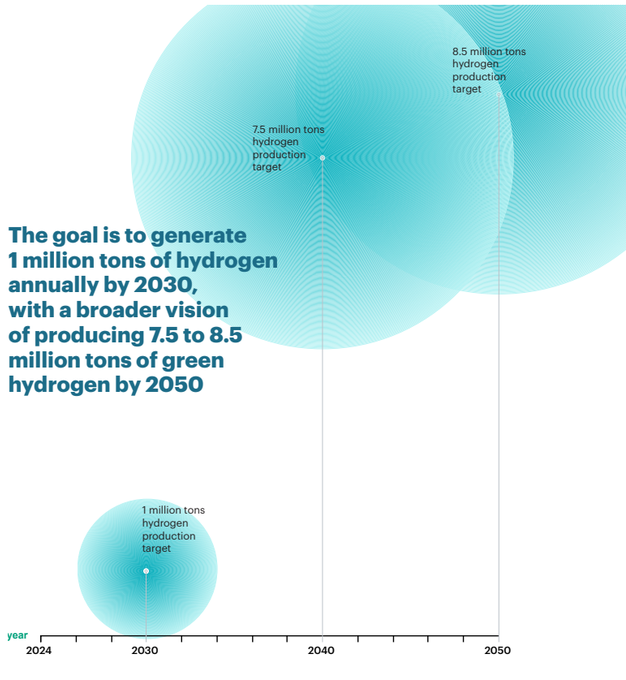
GHSO 2023 also witnessed the signing of the sixth green hydrogen project, taking total investment in the nascent sector to an impressive 38 billion dollars to date, not including commitments towards common infrastructure. "This brings us closer to our target of producing 1 million tons of hydrogen per year by 2030," he stated.

To build on this momentum, HE Mohsen outlined key factors essential for success. Firstly, he stressed the importance of developing In-Country Value (ICV), advocating for the localization of activities within the green hydrogen industry. Recognizing the significance of local capability in ensuring sustainability, he emphasized the dual imperative of social responsibility and business viability.

Secondly, HE Mohsen highlighted the necessity of securing offtakers for Oman's green hydrogen output when this zero-carbon fuel or its derivative version become available for export starting from around 2030.

"This requires us talking to the global market, collaborating, and securing the entire supply chain so that the end user of green hydrogen is getting the right product on time, reliably, sustainably, and at the right price," he said, adding that government intervention and industry orchestration are essential in this endeavour.

Finally, the Under-Secretary underscored the practical aspects of implementation, emphasizing the need for



The goal is to generate 1 million tons of hydrogen annually by 2030, with a broader vision of producing 7.5 to 8.5 million tons of green hydrogen by 2050

tangible action on the ground. "Let's keep in mind that equipment in the form of wind turbines, solar panels, and electrolyzer modules will need to be manufactured, while the required common infrastructure should be ready as well. All of this needs to come together starting from 2027 – 2028, necessitating access to resources at scale to be delivered at the right time. And for that to happen, we need to be ready. We need to act together as industry, as government, as investors to make it happen," he stressed.

Balancing the Energy Trilemma

Participating in a panel discussion during the Summit, HE Mohsen said the Sultanate of Oman undertook proactive measures to diversify its energy portfolio in light of the inherent risks of relying solely on Oil & Gas for its energy security.

This strategic shift stems from the realization that a diversified energy mix is essential for resilience and sustainability in the face of evolving global energy dynamics. As part of this endeavour, Oman has set its sights on harnessing hydrogen as a key alternative energy resource. The country's natural landscape is rich in resources conducive to green hydrogen production, positioning the nation as a potential leader in this burgeoning sector, he said.

The transition towards green hydrogen not only caters to Oman's energy needs but also aligns with broader environmental objectives.

The transition towards green hydrogen not only caters to Oman's energy needs but also aligns with broader environmental objectives, enabling the decarbonization of key industries such as steel, cement, and fertilizers, he said. Leveraging its established expertise in Oil & Gas and skillsets, Oman can spearhead the development of green hydrogen in a cost-competitive manner.

HE Mohsen also emphasized the imperative of balancing green energy costs with affordability. Acknowledging that green energy may come at a premium, he stressed the need for collaborative efforts between governments and industries to find this delicate balance. Addressing inefficiencies, waste, and policy shortcomings is crucial in catalyzing reforms that promote sustainable energy pricing, he noted.

The important role of technology in driving the transition was also highlighted by HE Mohsen in his comments. Equally imperative is the role of certain types of critical minerals that underpin these technologies – valuable resources that Oman must ensure access and in the right quantities, he said.

"To this end, over the past year, we have been paying a lot of attention to advance and modernize our mineral sector. For example, we are placing a great deal of emphasis on digitalization of data to make all relevant information available to interested investors and the public. In parallel with this effort, we have introduced HSE standards for the mining sector with the goal of raising it to the level of the Oil & Gas industry, among other sectors," he stated.

These are among the factors necessary to address the energy trilemma from a policy and strategy perspective, the official added.

Project Delivery Support Unit

With barely six years remaining to achieve Oman's 2030 green hydrogen production target of 1 million tons per annum, daunting challenges potentially await the project developers unless they are suitably geared for the tasks ahead, said the Under-Secretary.

The simultaneous progress of six green hydrogen projects has the potential to place immense strain on construction capabilities, labour resources, and logistical infrastructure, he noted.

To navigate the complexities of project delivery, the Ministry is spearheading the creation of a dedicated Project Delivery Unit, said HE Mohsen. Comprising officials and experts, this unit will anticipate potential hurdles and implement preemptive solutions. Critical considerations include ensuring adequate transportation infrastructure, sufficient skilled labour, and compliance with regulatory requirements.

By proactively addressing these concerns, the government is also demonstrating its commitment to supporting private sector initiatives and ensuring timely project completion.

In conclusion, the Under-Secretary emphasized the importance of transitioning from symbolic agreements to tangible developments on the ground. A clear roadmap for project execution is essential to ensure progress towards meeting green hydrogen targets. This necessitates concerted efforts from all stakeholders to translate commitments into actionable initiatives that drive project delivery, he added.

The Green Hydrogen Journey:

Policies, Partnerships, and Potential

Oman's Ministry of Energy and Minerals is currently crafting policies and guidelines designed to foster the growth of a robust green hydrogen industry that not only meets local energy needs but also contributes significantly to the global energy transition:
Dr. Firas al Abduwani

CONRAD PRABHU

Having set in motion an ambitious strategy to unleash a mega-scale green hydrogen industry in the Sultanate of Oman, the Ministry of Energy and Minerals is presently focused on putting in place policies aimed at underpinning the growth of this pivotal sector.

According to Dr. Firas Al Abduwani, Director General of Renewable Energy and Hydrogen, policymaking will cover the gamut of elements, including energy efficiency, the electricity market, renewable energy, low-carbon hydrogen over a wide "color" spectrum, CCUS and certification. Participating in a panel discussion during the GHSO 2023 Summit and Exhibition, the official articulated a multifaceted and collaborative strategy for policymaking that transcends green hydrogen to encompass the broader renewables and low-carbon energy economy.

"As a nation, we want to leverage different levers and solutions to achieve an orderly transition towards Net Zero," said the Director-General, citing five pillars that are an integral part of the Ministry's energy transition policy.

Topping the list is energy efficiency-a "low-hanging fruit" that will be harnessed to support the decarbonization drive. "It's allows us to decouple the growth of the economy from associated emissions, effectively reducing the amount of emissions for the same amount of growth that one can achieve," Dr. Al Abduwani noted.

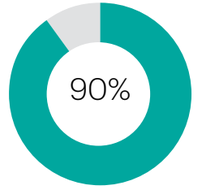
As part of the second and third pillars, the regulatory framework and structure governing the electricity market and its arrangements are being reviewed. Under the present structure of the electricity market, the generation side of the business is based on a centralized Independent Power Projects (IPP) arrangement with a single buyer – NPWP (Nama Power and Water Procurement Company). Oman had successfully pioneered this private IPP arrangement more than 15 years ago. But with significant changes taking place in this space – technological as well as the merit order associated with this market structure – a review is now timely. Liberalization of the market constitutes the second pillar, while enabling greater renewable energy contribution to the energy mix constitutes the third pillar.

"This is important particularly given the amounts of renewable energy that will be produced by the hydrogen projects," Dr. Al Abduwani explained.

Our ambition as a government is for us to bring as much value, growth, job creation, innovation and capability development as possible.

"As a base case, we are currently looking at them being isolated, but ultimately what we would like to see is to have them integrated all in one grid for the benefits they bring. If it's done properly, and that's one of the reasons why we're having the review, we can bring excess electricity into the market cost-effectively. It can help our decarbonization journey and reduce the carbon content intensity of the grid itself. In the long run, with a suitably integrated future grid, achieving 90% renewable energy in the grid becomes more viable, a milestone set by the EU to consider the generation of hydrogen from such a grid as renewable or green hydrogen. This hydrogen generation will no longer localized to a particular area."

Furthermore, as part of the fourth pillar, the Ministry is exploring avenues for hydrogen production across three key colors: green, blue, and white hydrogen. "When considering green hydrogen, its governance structure is mature, and we have Hydrom orchestrating the file. Blue hydrogen is being assessed as part of our CCUS and blue hydrogen framework. White hydrogen, also known as geologic hydrogen, is also being explored and could potentially be directed towards local requirements, given its proximity to Oman's main hydrogen consumption centered around Sohar."



In the long run, with a suitably integrated future grid, achieving 90% renewable energy in the grid becomes more viable, a milestone set by the EU to consider the generation of hydrogen from such a grid as renewable or green hydrogen.

The fifth pillar considers carbon capture, utilization and sequestration as a lever to serve as a pathway in its orderly transition. This pillar is addressed by the CCUS & Blue Hydrogen framework. The ministry along with key stakeholders are assessing Oman's potential for CCUS.

The Ministry is also working to formulate guidelines for certification standards to ensure compliance across different energy verticals. This exercise is being undertaken both internally and in consultation with different government entities, private sector elements, and international organizations as well. Upon the formation of Oman Sustainability Centre, elements of this file will be handed over to OSC.

Beyond these core issues, there are other challenges likely to materialize, particularly around supply, demand, and the intricacies of the supply chain, he said. Also potentially problematic for exporters can be market regulations at the import end.

For example, the European Union's nuanced approach, incorporating geographical and temporal factors into definitions of renewable hydrogen, along with Carbon Border Adjustment Mechanisms (CBAM), sets a high standard. Yet, alternatives like a "book and claim" system, while susceptible to greenwashing, could benefit landlocked

nations such as Switzerland, he said.

This approach involves unbundling credits from green products produced elsewhere, enabling their use in tandem with non-green products, facilitating decarbonization, and addressing transportation hurdles in the short term, he stressed.

Holistic view

As a prerequisite for the creation of a green hydrogen economy, the Ministry is working on an energy model that looks at primary energy resources across Oman in their different forms, according to the Director General. Green hydrogen and low-carbon hydrogen, among other levers, are being articulated and simulated within different scenarios in this model.

Collaboration has been key in formulating scenarios to be processed by this model, said Dr. Al Abduwani. "We set up a core team to run this model consisting of membership from key stakeholders, as well as wider targeted engagements with members from public and private sector. We have already looked into different scenarios and the role that green hydrogen can play and what that entails, for example, impact on job creation, the primary energy mix, total GHG emissions. This helps us understand and forecast what we want to achieve, and fine tune subsequent iterations of the scenarios."

With Hydrom tasked with orchestrating the green hydrogen sector, the next goal was to secure ample lands for development, he said. A total of 65,000 square kilometers was secured, including around 50,000 square kilometers of solar and wind-rich acreage. Not included in these parcels are at least 5,000 square kilometers that are also very prime, which the Ministry is seeking to obtain through discussions within the government. Offshore sites are being examined for inclusion into territory primarily reserved for renewable energy and green hydrogen, he stated.

Furthermore, to strengthen the supply and demand sides of the equation, the Ministry is actively pursuing collaboration, particularly government-to-government (G2G). A case in point is the recent successful signing of an agreement to explore the potential for establishing a liquefied hydrogen corridor between Duqm (Oman) and Amsterdam (the Netherlands) – an initiative that also opens the way for a new energy carrier pathway to be developed, he said.

Likewise, the Ministry is also working collaboratively with other entities, such as Oman Investment Authority (OIA) with its investments, OQ with Asyad Group and their pilots, and assessing suitable approaches to galvanize local demand.

Moreover, with the goal to develop in-country capabilities, the Ministry is working with universities to ensure that Oman has the right curricula -- both at the graduate level, undergraduate, and then also the technical elements -- required to reskill and retool the Omani workforce to shift towards renewable hydrogen. Inclusion of Oman's talented workforce in the consortia teams developing the different projects and potentially cross-posting further serves as a tool for capability development, he stressed.

As for whether Oman has the potential to become a hub for green hydrogen production and export, Dr. Al Abduwani added in conclusion: "I absolutely think Oman will become a hub. The key question is what form of hub would it be? Would it be a hub that is just about export? Or is it a hub that in addition to exporting energy vectors, also onshore forward-connected industries and upstream supply chain manufacturing? Our ambition as a government is for us to bring as much value, growth, job creation, innovation and capability development as possible."

Hydrom's Strategic Initiatives:

Shared Infrastructure and Local Value Creation

In addition to its fundamental mandate as the master-planner and orchestrator of Oman's green hydrogen industry, Hydrogen Oman (Hydrom) is also overseeing the delivery of shared infrastructure underpinning the new sector, as well as driving in-country value creation across the wider ecosystem:

Eng. Abdulaziz al Shidhani, Managing Director of Hydrom

Since its establishment by Royal Decree early in 2023, Hydrom has witnessed a notable expansion of the scope of its mandate, aligning with its pivotal role in planning and orchestrating Oman's burgeoning green hydrogen industry.

With two successful auction rounds of land blocks completed, the government entity has been progressing on two other crucial fronts: the rollout of common infrastructure essential for the smooth operation of future green hydrogen projects, and the exploration of localization opportunities throughout the value chain of this emerging sector during construction and operational phases.

Addressing the GHSO 2023 Summit, Eng. Abdulaziz al Shidhani highlighted the incorporation of a dedicated entity, provisionally named 'InfraCo,' to oversee the implementation of shared infrastructure.

Envisaged as a fully integrated ecosystem for green hydrogen projects, this common infrastructure will include dedicated corridors and pipelines for the transportation of pure desalination water, green hydrogen, power transmission lines, and other utilities. Various green hydrogen projects will be integrated into this shared ecosystem, relieving individual players of the need to invest in their own utilities.

All six project companies licensed thus far by Hydrom to establish green hydrogen plants in the country are now represented on an advisory board, which has convened multiple times to deliberate on the finer details of the common infrastructure. Additionally, Hydrom has convened meetings of strategic stakeholders, including state-owned utilities and logistics companies named 'National Champions,' to support the delivery of this burgeoning industry for Oman.

Underpinning all these efforts is an enduring quest to unlock opportunities for localizing manufacturing, operations, maintenance, and other services across the ecosystem of this emerging sector.

"We are giving roles for our national champions," Eng Al Shidhani said. "OQ Gas Networks, as part of their growth story, is taking on a role in the development of the hydrogen pipelines. Oman Electricity Transmission Company (OETC) has been nominated by the Ministry of Energy and Minerals as the national champion for the electricity transmission lines. And Nama Water Services has also been nominated by the Ministry as the national champion for water networks. As for desalination, it will be addressed at a later stage."

Three-phase strategy

Eng. Al Shidhani outlined a three-phase strategy to fulfill Hydrom's pledge of having the common infrastructure fully in place before any of the six green hydrogen projects become operational. Phase 1, the basic pre-FEED stage, serves as an incubation period for the shared infrastructure project, overseen by Hydrom before transferring responsibility to the new InfraCo entity. Subsequently, with the support of several Special Purpose Vehicles (SPVs), InfraCo will undertake dedicated components of the infrastructure. The initial infrastructure elements are targeted to be operational by mid-2029.

Asyad Group, Oman's integrated transport and logistics services group, has been enlisted to oversee the logistics requirements of the large-scale hydrogen projects in the country. Through an MoU signed with Hydrom in December, Asyad Group will orchestrate a robust domestic supply chain within Oman and develop the necessary infrastructure to handle the significant industrial cargo associated with green hydrogen projects and downstream facilities.

All six project companies licensed thus far by Hydrom to establish green hydrogen plants in the country are now represented on an advisory board.

Underpinning all these efforts is an enduring quest to unlock opportunities for localizing manufacturing, operations, maintenance, and other services across the ecosystem of this emerging sector, spanning upstream, midstream, and downstream sections, according to Al Shidhani.

"During meetings with different stakeholders, including project developers, we presented our analysis of the likelihood of any supply constraints concerning solar panels, wind turbines, and electrolyzers, given the scale of the projects lined up during the 2026-27 period. This sparked discussions on how Hydrom and the Ministry can assist by approaching various manufacturers, and so on."

In the context of these efforts, a significant MoU was signed by global energy technology giant Siemens Energy with Oman Investment Authority (OIA), the integrated sovereign wealth fund of Oman, to collaborate on the development of a domestic electrolyzer manufacturing facility. As part of the MoU, the two sides will explore the development, construction, and operation of an electrolyzer manufacturing facility as part of Hydrom's plans to localize the hydrogen value chain, delivering industrial and economic growth for the Sultanate, said Al Shidhani.

Similar endeavors extend to the potential manufacture of solar panels and other equipment and systems essential for the multi-billion dollar green hydrogen industry.

Urging investors to consider establishing manufacturing facilities in Oman, Al Shidhani added: "It is an opportunity for you to spend as much time as possible here in the country, engage with different stakeholders, explore the free zones and industrial estates, and meet with government officials and developers, and try to take some risk and position yourselves as one of the first movers in the localization of the supply chain."

OQ AE

Front and center in Oman's green hydrogen push

As the Omani government's preeminent 'National Champion' for green hydrogen investment and development, OQ Alternative Energy (AE) – the clean energy arm of OQ Group – currently has a stake in three hydrogen projects valued at a ballpark $20 billion, according to Najla Al Jamali, CEO of OQ AE.

> **Hopefully, the three projects will also meet the target that the country has set for hydrogen production by 2030. And in terms of the investment, it's circa $20 billion into those projects.**

With a stake in three mega green hydrogen projects currently in the early stages of development in Oman, OQ Alternative Energy (AE) enjoys perhaps one of the largest footprints in the region's nascent green industry. And given its distinctive position as a National Champion for green hydrogen development, its presence in this emerging sector is set to only burgeon going forward.

Speaking at GHSO 2023, Najla Al Jamali, CEO of OQ AE, underlined the business vertical's substantive role in driving the energy transition in the Sultanate of Oman. "So we've signed three legacy projects related to green hydrogen – that's a total of over 30 GW of renewables if we develop all the phases of the projects, including the electrolyzers that will produce hydrogen. Hopefully, the three projects will also meet the target that the country has set for hydrogen production by 2030. And in terms of the investment, it's circa $20 billion into those projects."

All three ventures are at various stages of maturity, according to Al Jamali. Wind resource and solar radiance assessments across all three project sites have yielded "very promising results", with the most advanced of the projects – widely assumed to be HYPORT Duqm – expected to kick off its front-end engineering design (FEED) as early as sometime in 2024. However, Final Investment Decisions (FID) are anticipated over the ensuing two or three years, depending upon a number of factors, she noted.

OQ AE'S GREEN HYDROGEN PORTFOLIO TO DATE:

1 **HYPORT Duqm:** This project is pomoted by a partnership of Belgium-based DEME, a leading international contractor and developer, and OQ AE. Currently in the early stages of development, HYPORT Duqm will feature around 1.3 gigawatts of renewable power capacity with the goal to produce about 330ktpa of green ammonia in the first phase. Renewable capacity will be doubled to around 2.7 GW with 650ktpa of green ammonia in the second phase.

2 **Green Energy Oman (GEO)** is backed by a consortium that includes OQ AE, Oman Shell, Kuwait's energy investor EnerTech (ETC), InterContinental Energy (ICE) and Golden Wellspring Wealth for Trading (GWWT). Allocated Block Z1-04, the project will target a production of up to 150 KTPA of green hydrogen from 4 GW of installed renewables capacity.

3 **SalalaH2:** Led by Marubeni Corporation, the SalalaH2 project consortium also includes OQ AE Dutco Overseas Limited, a subsidiary of UAE-based Dutco Group, and Samsung C&T Corporation. Under a Project Development Agreement for a green ammonia project and a Sub-Usufruct Agreement signed in December 2023 with Hydrom, the consortium will conduct detailed studies for the development of the project and the supply chain of green ammonia.

Bankable offtake

The single biggest factor, the CEO pointed out, is product offtake. "That's the question: How are we going to achieve bankable offtake? While there is no shortage of demand for green hydrogen, how do we ensure that it's actually bankable so that you can move the project forward? There is a lot of interest from both Europe and Asia, and what's driving that demand depends a lot on the (market) mechanisms and legislation."

One such mechanism currently being weighed by the European Commission, for example, is the Contracts for Difference (CfDs) – a move aimed at subsidizing the purchase

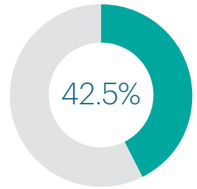
of green hydrogen by offtakers in the EU. Under the proposed scheme, offtakers receive a top-up subsidy that represents the difference in cost between the green energy option and the existing fossil-fuel-based option.

Another initiative that could drive uptake of green hydrogen is the Renewable Energy Directive (RED) III. Adopted by the European Parliament in September 2023, RED III aims to increase the share of renewable energy in the EU's overall energy consumption to 42.5% by 2030.

Additionally, the presence of carbon taxes and incentive structures can also play a significant role, according to Al Jamali. Factors such as the existence of a green premium can influence customers' willingness to invest in more expensive green hydrogen, particularly if they anticipate a higher value for the end product resulting from its use.

Transportation challenges

Beyond the challenges linked to market offtake and buy-in from end-consumers, there is the issue of green molecule transportation that must be suitably dealt with as well, says Najla. Green ammonia, presently the main vector for green molecule export, has its own challenges. For one, it needs to be cracked and converted back into hydrogen at the destination – a process that can result in some energy loss. Perhaps, more crucially, many ports in Europe



Adopted by the European Parliament in September 2023, RED III aims to increase the share of renewable energy in the EU's overall energy consumption to 42.5% by 2030.

that are likely receiving hubs for ammonia are located within cities whose residents can be averse to the unloading of a hazardous commodity like ammonia.

To overcome these challenges, OQ AE is exploring a range of alternative options and solutions, said the CEO. "We also are looking at other derivatives, such as e-methanol, for example. Can we produce SAF (sustainable aviation fuels) or can we look at green fuel bunkering?"

In collaboration with Asyad, the state-owned transportation and logistics group, OQ AE has plans to undertake a "small" green hydrogen pilot in Duqm. The initiative has the backing of the Ministry of Transport, Communications, and Information Technology (MTCIT) and the Public Authority for Special Economic Zones and Free Zones (OPAZ), according to Al Jamali. "We're hoping we can have a small pilot to test the ecosystem of producing Hydrogen and then using it within the Duqm area. This would be actually a fantastic way to do like a small test drive of the whole process," she remarked.

Shedding light on the energy transition underway at OQ Group, the CEO stressed that the transition journey will be underpinned by an emphasis on resilience and growth. "We will look at how we can make our existing businesses - upstream and downstream – resilient, and we do that by going after the 'low-hanging fruit'. For example, by switching out our power requirements where possible to a cleaner source, we think that can bring down our carbon footprint by 60%. We are also working actively towards our Net Zero by 2050, initially by having a reduction of about a quarter of that target by 2030. We think it's achievable for both upstream and downstream - through our renewable energy and green hydrogen projects."

OMAN AND KOREA:

Harnessing the full potential of a green hydrogen economy

> **The partnership between Korea and Oman in the green hydrogen sector offers substantial and mutual gains, leveraging each other's strengths and capacities,' affirmed HE Kim Kiejoo, Ambassador of the Republic of Korea to the Sultanate of Oman, in his opening remarks at the Korea-Oman Green Hydrogen Strategic Forum 2023.**

The 2023 edition of the Korea-Oman Green Hydrogen Strategic Forum, held on 12th December 2023, served to showcase the strength of longstanding bilateral relations between the Sultanate of Oman and the Republic of Korea. This was reflected in the distinguished line-up of high-level officials from both countries represented at the event, and participating animatedly in the proceedings as well.

Leading figures from Oman included Their Excellencies Khamis Al Shamakhi, Undersecretary for Transport at the Ministry of Transport, Communications and IT; Abdulsalam Al Murshidi, President of the Oman Investment Authority (OIA); and Faisal Al Rawas, Chairman of the Oman Chamber of Commerce and Industry. Dignitaries from Korea included Dr. Chang-Keun Yi, President of Korea Institute of Energy Research.

In opening remarks, HE Kim Kiejoo, Ambassador of the Republic of Korea to the Sultanate of Oman, thanked a number of Korean and Omani institutions that helped organize the forum, which has evolved into an annual event in recent years. The list included the Korea Institute of Energy Research and KOTRA from the Korean side, and the Ministry of Energy and Minerals, Ministry of Transport, Communications and Information Technology, Hydrom, Hy-Fly, OCCI and Sultan Qaboos University from the Omani side.

In his address, Ambassador Kim underscored three crucial factors: the global push towards hydrogen economy development, Korea's proactive role, and the promising Korea-Oman partnership in this endeavor.

Ambassador Kim said thus:

> **Ambassador Kim underscored three crucial factors: The global push towards hydrogen economy development, Korea's proactive role, and the promising Korea-Oman partnership in this endeavor.**

"First, the development of the hydrogen economy is gaining renewed global momentum. It is perceived as a strategic opportunity to address energy trilemma, namely environmental sustainability, energy equity, and energy security. The worsening climate crisis and the increasing demand for carbon-free energy sources necessitate an early transition to low-emission hydrogen, especially green hydrogen.

Since last year when we had the Green Hydrogen Summit Oman 2022 and the Korea-Oman Green Hydrogen Strategic Forum 2022, substantial progress and the delivery of initiatives have accumulated. In its Global Hydrogen Review 2023, the International Energy Agency (IEA) forecasts a massive increase in low-emission hydrogen projects. According to the projection, 27 Mt of hydrogen will be produced through electrolysis and low-emission electricity by 2030. The IEA makes a set of recommendations including implementation of support schemes for low-emission hydrogen production and use and stimulation of demand creation, among other strategies.

At COP28, transition to a low-carbon future remains a primary aim. More than 60 countries have supported a global initiative to triple renewable energy this decade. Furthermore, COP28 emphasized the potential of low-carbon hydrogen in unlocking climate and socio-economic benefits. One of the flagship initiatives is the Declaration of Intent on the Mutual Recognition of Certification Schemes for Low-carbon Hydrogen. It is encouraging that 39 countries including Korea and Oman participate in this initiative.

Second, the Republic of Korea is determined to contribute to the development of the hydrogen economy and the green hydrogen industry. Korea is committed to the goal of achieving carbon neutrality by 2050. As such, Korea attaches a high priority to building its hydrogen sector.

The Korean government is pursuing a comprehensive plan to establish a fully integrated hydrogen ecosystem by adopting the "3-Up strategy" in 2022, namely Scaling up, Building up, and Leveling up.

The "Scaling up" strategy intends to promote a clean hydrogen ecosystem by establishing a supply chain and creating stable demand for hydrogen. According to this plan, clean hydrogen power generation will account for 7.15% of national output by 2036

The second pillar of "Building up" aims to establish a distribution network and to utilize clean hydrogen. The plan includes building the world's largest liquefied hydrogen plant that will produce 40,000 tons per year, expanding hydrogen recharging stations nationwide, and constructing hydrogen pipelines in the central-western provinces in Korea, to name just a few.

Third, "Leveling up" seeks to advance technological innovation in core areas such as electrolysis, liquefied hydrogen carrier vessels, recharging stations, fuel cell mobility, and power generation as well as hydrogen turbines. One of the targets is to build ammonia carrier ships by 2026 and liquefied hydrogen carrier ships by 2029.

Last but not least, the partnership between Korea and Oman in the green hydrogen sector offers substantial and mutual gains, leveraging each other's strengths and capacities. The bilateral partnership will extend to stakeholders in the green hydrogen industry at regional and global levels, contributing to the fulfillment of zero-carbon emissions and the pursuit of a new paradigm of energy security.

The participation of the consortium composed of POSCO Holdings, Samsung Engineering, Korea East-West Power Company, Korea Southern Power Company together with ENGIE and Future Tech Energy Ventures Company Ltd. in the project to produce green hydrogen in Duqm is a testament to the partnership between Korea and Oman in harnessing the full potential of the new green hydrogen economy."

In closing, Ambassador Kim invoked Peter Drucker's famous quote, "The best way to predict the future is to create it," emphasizing the importance of collective vision and determination in shaping a brighter future.

Can Gulf states overcome longstanding obstacles to cooperate and meaningfully address climate change?

Necessity will drive Gulf states to cooperate on climate change

MEHRAN HAGHIRIAN, DR AISHA AL-SARIHI

The impacts of climate change are becoming starkly visible in the Gulf. Already one of the driest, hottest parts of the world, the region is heating up at a rate twice as fast as the global average. Accordingly, Gulf governments are beginning to realize that ad hoc or unilateral strategies are not sufficient to tackle these escalating, cross-border environmental crises. Rather, they need concerted and cooperative efforts. However, such a shift requires overcoming deep geopolitical divisions.

The climate challenges are acute. Several countries in the region have set alarming temperature records in recent years, and regularly top 50°C (122° Fahrenheit) in the summer months. The mercury hit 54°C in Kuwait and Iraq in 2016. Last August on Iran's Gulf coast, the heat index, which combines humidity and air temperature to reflect perceived temperature, reached 70 °C.

Water scarcity is as acute as the temperatures. The Gulf states all rank among the world's most likely to experience severe water crises in the coming decades. Qatar is the most water-stressed country in the world, and Iran, Kuwait, Saudi Arabia and the United Arab Emirates all come in the top 10. This scarcity has compounded disruptions in agriculture and food security across the region.

Moreover, coastal populations, which account for as many as 90% of residents in some Gulf countries, are particularly vulnerable to climate hazards, especially as extreme weather events such as tropical cyclones become stronger and more frequent. Wildlife and natural habitats in the region also risk being wiped out due to improper exploitation and climate change.

These problems have significant human and financial costs, as heat waves and other extreme weather events compel emergency measures such as factory shutdowns and disruptions to essential services. The ramifications of climate change also risk exacerbating existing vulnerabilities and fanning the flames of conflicts over vital resources like water and food. This could result in further human security challenges and cross-border displacement.

Coastal populations, which account for as many as

90%

of residents in some Gulf countries, are particularly vulnerable to climate hazards.

Enhanced regional cooperation could tackle issues such as escalating temperatures, sand and dust storms, water scarcity, marine pollution, and overreliance on fossil fuels, to name a few.

Fragmented Efforts

While the need to cooperate is clear, governments in the Gulf have struggled to do so, hobbled by tensions among them as well as by competition between global powers. However, as they become aware of the growing risks and costs, the region is witnessing a gradual shift and a nascent willingness to forge regional cooperation.

The Gulf states have established, or are members of, several regional institutions and initiatives on climate change and the environment. But to date, the Regional Organization for the Protection of the Marine Environment (ROPME) is the only regional platform that includes all eight littoral states of the Gulf, including Iraq and Iran, which are not members of the Gulf Cooperation Council.

Various other GCC-led initiatives remain fragmented, and do not include other countries in the region – by design. The slow pace of regional integration and the lack of a focal point or working group has meant these initiatives remain peripheral and are used only on an ad hoc basis. There is an urgent need for an inclusive and cooperative approach towards mitigating shared challenges.

Today, however, there are reasons to be cautiously optimistic. Over the past few years, diplomatic breakthroughs such as the resolution of the blockade

An aerial view of houses submerged in water in Al Khaburah, Al Batinah North Governorate, Oman, as Cyclone Shaheen makes landfall on September 24, 2021

on Qatar, which had divided the GCC, and the rapprochement with Iran by Saudi Arabia, Kuwait, and the UAE, signal a potential shift in the geopolitical landscape in ways that could facilitate more cooperation on climate change mitigation. Moreover, initiatives like the Baghdad Conference for Cooperation and Partnership demonstrate the growing realization that collective action is imperative for climate resilience and continued prosperity.

Key players in the Gulf are also keen to test these new diplomatic openings to further their respective national interests. A flurry of recent agreements on environmental cooperation, such as bilateral deals between Iran and the UAE, Iran and Kuwait, and Kuwait and Iraq, all indicate that states realize that finding solutions to shared environmental challenges is integral to their national security. Moreover, the growing participation of key regional players in environmental meetings, such as the United Nations-backed conference on Combatting Sand and Dust Storms in Tehran in September, indicates that environmental issues are an entry point for closer cooperation, both bilaterally and multilaterally.

The relative alignment between the Gulf states on the war in Gaza and the increased pace and frequency of diplomatic engagements on bilateral and multilateral fronts also suggest that regional actors are not seeking to return to the tensions that divided the Gulf before 2021. New and recurring conflicts might affect the pace of cooperation and engagements, but not the importance of cooperation in the region, especially on shared environmental challenges.

Urgent Need for Cooperation

States must explore the critical environmental issues gripping their region and seek ways to cooperate on tackling them. There is a dire need for collective action and cooperation to tackle these shared challenges. Enhanced regional cooperation could tackle issues such as escalating temperatures, sand and dust storms, water scarcity, marine pollution, and overreliance on fossil fuels, to name a few.

Other steps could include boosting regional scientific cooperation to foster trust and political will, enhancing early warning systems to prevent catastrophic damage, integrating coastal zone management to protect the Gulf's marine ecosystem, creating a regional resource pool to facilitate information sharing on sustainable practices for resource extraction, usage, and management, and establishing funding mechanism to support climate efforts locally and regionally. Existing platforms could be strengthened by broadening their mandates, while regional and GCC-led initiatives could be expanded to include Iran and Iraq.

Capacity-building, knowledge exchange, joint research, policy coordination, and raising public awareness are also paramount. So, too, is the importance of leveraging external cooperation, particularly with Europe, as well as learning from other regions and blocs, such as Association of Southeast Asian Nations (ASEAN).

By transcending historical tensions and fostering a united front against shared environmental challenges, the Gulf states have an opportunity to safeguard their future and set a global precedent for effective regional cooperation.

The authors are editors of a volume on "Pathways for Regional Environmental Cooperation in the Gulf", providing a set of initiatory steps and policy recommendations for cooperation between the Gulf states in their shared fight against climate change.

Mehran Haghirian is the Director of Regional Initiatives at the Bourse & Bazaar Foundation. He leads the Integrated Futures Initiative, a project seeking to identify areas for economic diplomacy and regional integration in the Middle East. He is a PhD candidate at Qatar University and holds a master's degree in international affairs from the American University's School of International Service in Washington, DC.

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Dr. Aisha Al-Sarihi

A sustainable energy supersystem

Wave power as an infrastructural investment in a new supersystem for a diversified energy-mix has the great potential to be the most eco-friendly and cost-effective way to Net Zero.

MATT MINSHALL

A sustainable future is the key to the survival of all flora and fauna on Earth. Humanity has been given the chance through technological research to relearn from nature to hold the rapid warming of the planet which will signal the destruction of many life forms, not least its own. The need for energy is absolute and to achieve this sustainably there must be a great reliance on renewable forms all of which are offered naturally and with a little intelligent assistance.

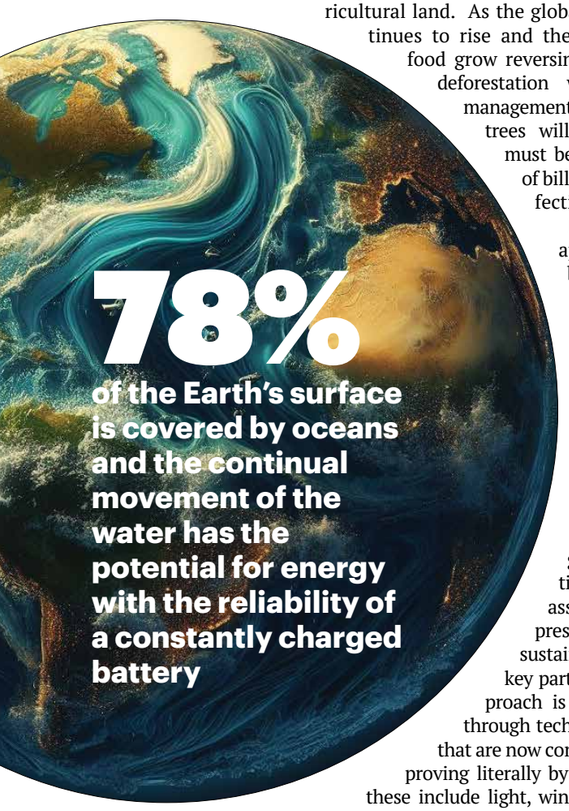
COP 28 represented a milestone of change when it declared that renewable energy dominance can and will prevail over the existing structure of fossil fuel dependence. But the idea that the extraction and usage of fossil fuels must cease forthwith is naïve and such a precipitous move would be highly counterproductive. The global economic and power structure is based on fossil fuels and although the essential need for diversifying has been identified the transition must allow a seamless transference of dependence across all sectors to avoid destabilising economies and creating voids of supply and employment.

Signs are very encouraging, and the positive activities should result in a markedly different global energy system by the end of this decade. The meteoric rise in clean energy technologies such as solar, wind, electric vehicles and heat pumps is reshaping how we power everything from industry and transport to essential domestic needs.

The most authoritative global sources of energy analysis and projections see an energy system in 2030 in which clean technologies play a significantly greater role than today. This includes at least 10 times as many electric vehicles worldwide; solar PV generating more electricity than the largest countries entire current power systems; renewables' share of the global electricity mix nearing 50%, up from around 30% today; heat pumps and other electric heating systems dominating over fossil fuel boilers globally; and three times as much investment going into new offshore wind projects than into new coal- and gas-fired power plants.

Even stronger measures will still be needed to keep alive the goal of limiting global warming to 1.5 °C, but this itself must not be set in stone as a finite goal. The laudable target must be achieved but it is just a focus on slowing the rate of warming and we must consider in tandem if we might be able to halt the rising temperature. Nature can certainly help directly and indirectly.

The direct approach generally includes reversing the human devastation of eco-systems over many millennia and while going some way to achieve this would help greatly but it is by no means a magic wand solution.



Some of the devastation is irreversible and the cost, resources and technology to make total amends are beyond the purse and wit of man. Possibly one of the most accessible is the planting of vegetation, such as the Nimr Wetlands in Oman. The wider approach includes the planting of billions of trees, but again this will not be something that will create the Hanging Gardens of Babylon in short order. It must be carefully managed and balanced against natural and developed ecosystems and agriculture. Many of the hundreds of billions of trees that the planet has lost has been in exchange for agricultural land. As the global population continues to rise and the requirements for food grow reversing the millennia of deforestation will need careful management, but while planting trees will certainly help it must be in the magnitude of billions if it is to be effective.

Part of the indirect approach includes better and more logical management of current systems and grids and an example in Oman is the Rabt interconnection project which will help save 175m litres of diesel annually. Collectively and globally such initiatives will do much to assist to support the pressing necessity of a sustainable future. The key part of the indirect approach is harnessing nature through technology in the ways that are now commonplace and improving literally by the day and while these include light, wind, and increasingly hydrogen, the least yet considered but arguably one of the most constant is wave energy.

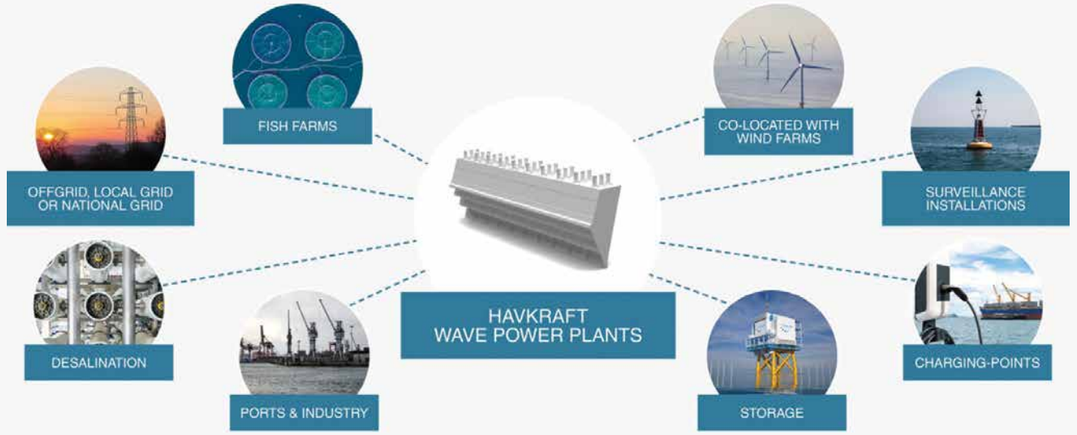
78% of the Earth's surface is covered by oceans and the continual movement of the water has the potential for energy with the reliability of a constantly charged battery; and yet the potential is largely untouched. It may not yet provide the levels of power of the other renewable options, but it offers at least a 10% global capability well within the timeframe of the UN SDGs and more importantly a constant baseload to cover the variabilities of other options, particularly wind and solar, and is confidently expected to have a much lower OPEX burden. Prediction analysis indicates the global potential for wave energy may be capable of as much as 30000 TWh/year, greater than the entire current human electricity requirement; and while that is some way from realisation the immediate accessibility is substantial. The EU has identified the 10% potential and committed to achieving such dependency by 2050. At the forefront of such strategic wave energy conversion is Norwegian company Havkraft who sees great potential for Oman for which GWs of power are reachable by 2040. As a benchmark 1GW can power up to 1 million homes.

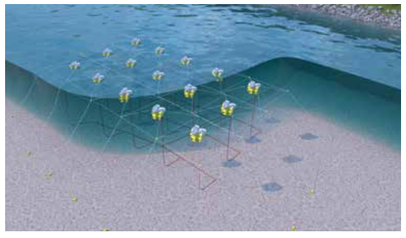
At the forefront of such strategic wave energy conversion is Norwegian company Havkraft who sees great potential for Oman for which GWs of power are reachable by 2040. As a benchmark 1GW can power up to 1 million homes.

A supporting "supersystem" concept is possible as a strategic framework to fortify the path towards a sustainable and diversified economy. This supersystem encapsulates the essence of the ability to balance resilience, and environmental sustainability and comprises three bases in a forward-thinking approach.

At the forefront of this supersystem is the emphasis on large-scale production of renewable energy, primarily from solar and wind sources. Acknowledging their intermittent nature, the first base aims to bolster electricity generation with a substantial share from renewables. This aligns seamlessly with the goal to produce 30% of electricity from renewable sources by 2030, driving the transition away from fossil fuels.

The future will require enhanced storage solutions for stability. To address the inherent fluctuations in solar and wind power, the





second base centers on storage solutions, emphasizing hydrogen and batteries. As powerful and important as these are the cost implications and energy losses associated with these technologies are acknowledged and there thus arises a critical need for a third base to enhance stability and reduce reliance on expensive storage.

Wave power integration comes in as the third base and would prove transformative for the energy landscape. This component not only contributes to increased access to clean energy but significantly improves the baseload of the entire system. Wave power's unique ability to enhance energy security while simultaneously reducing the need for costly storage solutions positions it as the ideal solution for the third base in the supersystem.

By harnessing the consistent and predictable energy generated by ocean waves, Oman can decrease its dependency on costly storage solutions, mitigating energy losses associated with current technologies like hydrogen and batteries. Wave power contributes to a more resilient energy infrastructure, crucial for energy security goals. The reliability of wave power as a consistent energy source strengthens the ability to meet demand and navigate fluctuations in renewable energy production.

Integrating wave power into the supersystem not only betters the baseload but also enables a more cost-effective journey towards achieving net zero emissions by 2050. The synergistic combination of solar, wind, and wave power minimizes reliance on expensive storage, ensuring economic viability.

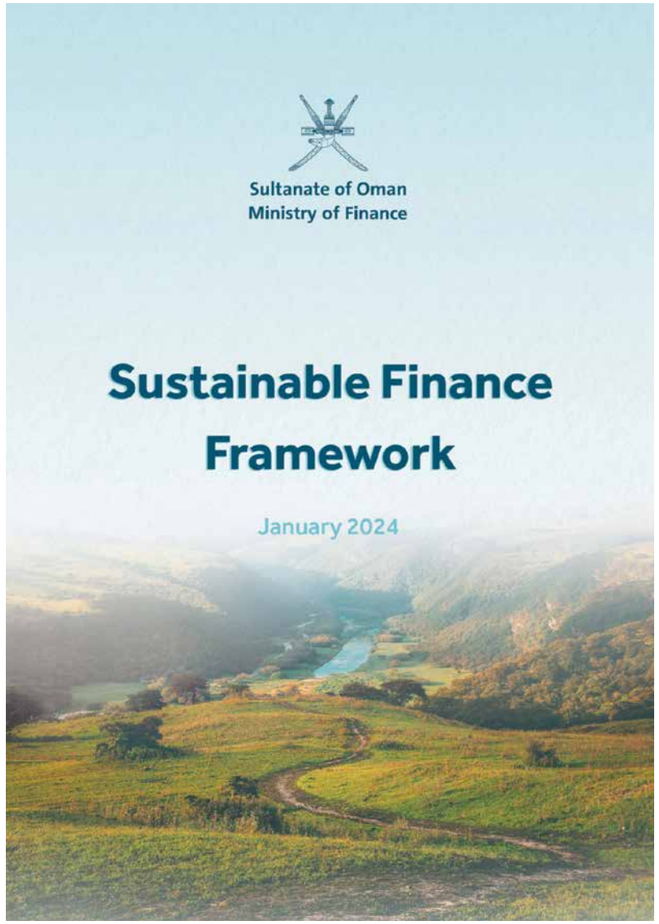
Rapidly approaching the end of the demonstration phase the commercialisation and build that is scheduled to begin in Norway the findings and data from which may be transferred or mirrored wherever wave patterns are suitable. Havkraft aligns itself as the technology provider and is now actively looking at strategic partners who would own a national project with around 80% of the total being of in country value.

Incorporating this triple based supersystem aligns seamlessly with providing a comprehensive, resilient, and sustainable approach to energy and by embracing wave power as a fundamental component, countries with suitable wave potential such as Oman can position themselves as leaders in the global shift towards clean energy while realizing the vision of a net-zero future by 2050.

Havkraft is at the global forefront of strategic wave energy conversion technology. Havkraft has conducted the initial evaluation in Oman and finds both the wave energy potential and the business environment ideal. This is the wave!

Matt Minshall

A Sustainability Consultant, Matt Minshall is a Senior Adviser at Havkraft, and Founder and Owner of The Mayamn Sustainability Project



Decoding Oman's Sustainable Finance Framework

The Sustainable Finance Framework is the Government of Oman's blueprint to allocate financing provision to environmental and social causes to mitigate the impact of climate change, promote socio-economic development and transition to a low carbon society.

Salman Ahmed, Partner – Oman

Alyson Phung, Associate – Malaysia
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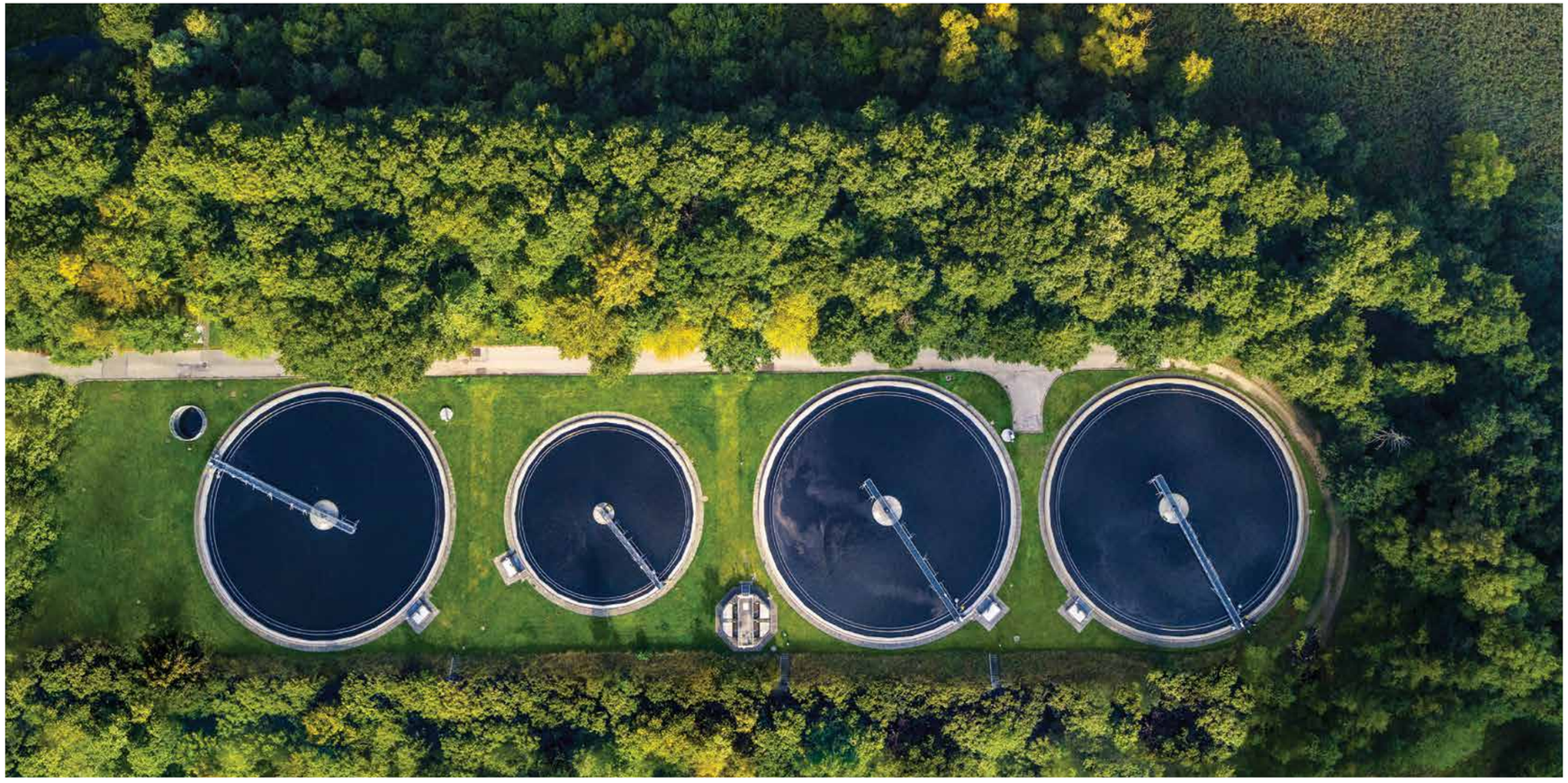
Debopam Dutta, Head – India Desk, Oman

Kasab Vora, Associate - Oman

Finance Framework



Oman's foray into renewable energy space is inspired by a timely recognition of over reliance on fossil fuels as a source for Oman's energy needs. There has been a marked shift to renewable sources of energy to meet the needs of a growing economy with the responsibility to move to a low carbon economy.

Oman's Vision 2040 is a key national strategy, which amongst other objectives, seeks to address the challenges posed by climate change and to ensure equitable access to development. A prime focus of Oman's Vision 2040 includes meeting the sustainable development goals with a view to deliver inclusive socio-economic development to its people.

Vision 2040: Oman's beacon in dealing with challenges of the future

It is critical to take a step back and understand that the Oman Vision 2040 is central to Oman's future socio-economic ambitions. It is reposed to be the guiding force for all development plans that will be implemented in Oman till 2040. Overall, the twin pillars of thoughtfully dealing with climate change and focusing on social security provisions to the people of Oman, would be key determinants of achieving the Vision 2040.

Sustainable Finance Framework: the potential financing latticework of Vision 2040?

Vision 2040 and related development goals are noble in their intent. A robust, practical and dependable financing framework that delivers on the various dynamic counts that Vision 2040 aspires to fulfil was much needed. The Sustainable Finance Framework is the Government of Oman's blueprint to allocate financing provision to environmental and social causes to mitigate the impact of climate change, promote socio-economic development and transition to a low carbon society. The Framework is central to execution of Vision 2040 and its objectives in this very context.

The Ministry of Finance of Oman (MoF Oman) prepared the Framework under which it intends to issue "Green, Social and Sustainability bonds, loans or sukuk" (the Sustainable Financial Instruments) for investments in projects that deliver environmental and/or social benefits. Generally, such Sustainable Financial Instruments may be issued in any currency or for any term. The Framework is intended to be in alignment with the International Capital Market Association (ICMA) Green Bond Principles 2021 (with the June 2022 Appendix I), the ICMA Social Bond Principles 2023, the ICMA Sustainability Bond Guidelines 2021, the Loan Market Association (LMA) Green Loan Principles 2023 and the LMA Social Loan Principles.

We briefly discuss the core components of the Framework:

1. Use of Proceeds

An amount equal to net proceeds of the Sustainable Financial Instrument issued by MoF Oman would be allocated to finance new or re-finance eligible green or social expenditure, in part or in full which qualify under the Framework as eligible expenditure (Eligible Expenditure). Eligible Expenditure is further categorised into Eligible Green Expenditure and Eligible Social Expenditure.

Certain key features of the Eligible Expenditure include:

• The expenditure must not have occurred earlier than three years prior to issuance of Sustainable Financial Instrument or two years after such issuance;

• The expenditure will be made by state agencies, local authorities and government related entities. If that entity participates in capital markets to issue the Sustainable Financial Instrument, the earmarked disbursement under the Framework would not be counted as Eligible Expenditure; and

• For co-financed projects with other stakeholders, MoF Oman would only include its pro-rated share of financing.

Some activities are expressly excluded from issuing the Sustainable Financial Instrument, such as fossil fuel related activities, generation of nuclear power, rail infrastructure dedicated for the transportation of fossil fuels etc. (Exclusions).

A prime focus of Oman's Vision 2040 includes meeting the sustainable development goals with a view to deliver inclusive socio-economic development to its people.

2. Project evaluation and selection

A special working group i.e. Sustainable Finance Working Group (SFWG) along with MoF Oman (and representation from relevant ministries as required for a specific project) will consult with various Government departments and review potentially qualifying projects within the contours of the Framework. Once a project is selected under the Framework, it will be a continuous responsibility of MoF Oman/ the SFWG to monitor that the selected project complies with the standard of Eligible Expenditure and Exclusions set under the Framework throughout the tenor of the outstanding Sustainable Financial Instrument.

3. Management of proceeds

The engine of this Framework is the mechanism to manage the net proceeds on issuance of Sustainable Financial Instrument. Proceeds not allocated to fund Eligible Expenditures must not be used to fund Exclusions. This may turn out to be the game changer in the sustainable finance ecosystem in the Middle-East. Unallocated funds of the proceeds of Sustainable Financial Instrument issuance will be maintained with MoF Oman until introduced in action only if such net receipts qualify as an Eligible Expenditure.

MoF Oman may utilise unused net proceeds by investing the same in permitted avenues under the Framework. Furthermore, during the tenor of Sustainable Financial Instrument, an expenditure that no longer qualifies as an Eligible Expenditure or is prone to ESG controversies, would be replaced with another identified Eligible Expenditure as soon as reasonably practical and in any case within one year. As part of the management of proceeds, SFWG would maintain an internal register to monitor and provide relevant report of Sustainable Financial Instrument.

4. Reporting

The Framework requires MoF Oman to publish the Sustainable Financial Instrument Annual Report (the Sustainable Report) as long as there is any outstanding Sustainable Financial Instrument under the Framework. The Sustainable Report can be clubbed with other ESG reporting. The Sustainable Report would be published one year from the first issuance of Sustainable Financial Instrument until complete allocation of net proceeds to Eligible Expenditure and in case of any material changes.

Components of the Sustainable Report

Summary – This section would include a list of all outstanding Sustainable Financial Instruments and summary of key terms such as the transaction date, principal amount of proceeds, maturity date, coupon, ISIN number etc with respect to the Sustainable Financial Instrument.

Allocation Reporting – This will detail the amount of proceeds allocated to each Eligible Expenditure, balance of unallocated proceeds and where such balance is invested, applicable stage of Eligible Expenditure alongside relevant dates, disclosure of percentage of allocation of Sustainable Financial Instruments towards new Eligible Expenditure or re-financing existing Eligible Expenditure and other relevant information, if any.

Impact Reporting – Depending on availability of information, this section would provide the environmental and social benefit flowing from use of Sustainable Financial Instrument. In case of co-financings, the relevant pro-rata share of impact would need to be reported as prescribed. This section requires disclosure of methodology and assumptions used for calculation of the impact metrics. Lastly, it is commendable that the Framework contemplates and provides for reporting indicator for each impact metric under Eligible Expenditure. For instance, the reporting indicator for metric dealing with clean transportation include amongst others, number of electric vehicle charging stations and length of electrified railway.

Some thoughts to consider

• The Framework does not provide whether an Eligible Expenditure can be incurred by private bodies participating in development functions, nor does it incentivise the private sector to participate in achieving the objectives contemplated by Vision 2040.

• In case of co-financed projects, it is not clear whether the Eligible Expenditure accounted by MoF Oman for its share would restrict the other stakeholders from participating in the capital market to explore financing options for such projects. The segregation of functions and obligations would require further clarity.

• The Framework does not provide any timelines yet on the evaluation and selection aspect by the concerned ministries in consultation with MoF Oman. While the assessment process outlined under the Framework looks robust it would be helpful for the stakeholders involved to be provided with soft indications as to the timeframe within which the review and selection process would be completed.

• In relation to management of net proceeds earmarked for Eligible Expenditure, the Framework provides for replacement of any such Eligible Expenditure if it is subject to "ESG controversies" – it remains to be seen what constitutes "ESG controversies".

Impact of the Framework

Climate finance has massive funding gaps which need to be plugged. For instance, estimates of International Monetary Fund (IMF) to meet the goals of the Paris Agreement require global investments of USD 3 trillion to USD 6 trillion per year till 2050. Oman has taken the step in the right direction to guide the Middle-East to initiate orderly financial planning to start meeting the emergent climate finance needs. Green bonds account for not more than three percent of global bonds markets. Geographically, most of these bonds are issued in the developed markets and China. In this context, Oman's Framework will contribute to globalise the green finance ecosystem by initiating a change in how such financing options are perceived in the Middle-East. Additionally, the Framework enhances the pool of investors by attracting and adding ESG investors to its fold.

In broader terms, Oman's actions will inspire the oil economies to fund and spend towards the climate needs and will underline a direct flow of funds received from sale of oil being utilised to fund a greener future.

The Framework: A step in the right direction

Moody's assessment of the Framework is worth mentioning. It asserts that the Framework demonstrates a significant contribution to sustainability. A lot will depend on the working of the Framework and sound implementation of its tenets. We will have to wait and watch to observe how Sustainable Financial Instrument issuances proceed under the Framework and whether the Government walks the tightrope in ensuring strict monitoring and compliance with the letter and spirit of the Framework. Overall, the Framework is a step in the right direction that would inspire Oman to stick its nose to the grindstone and sustainably achieve its magical Vision 2040.

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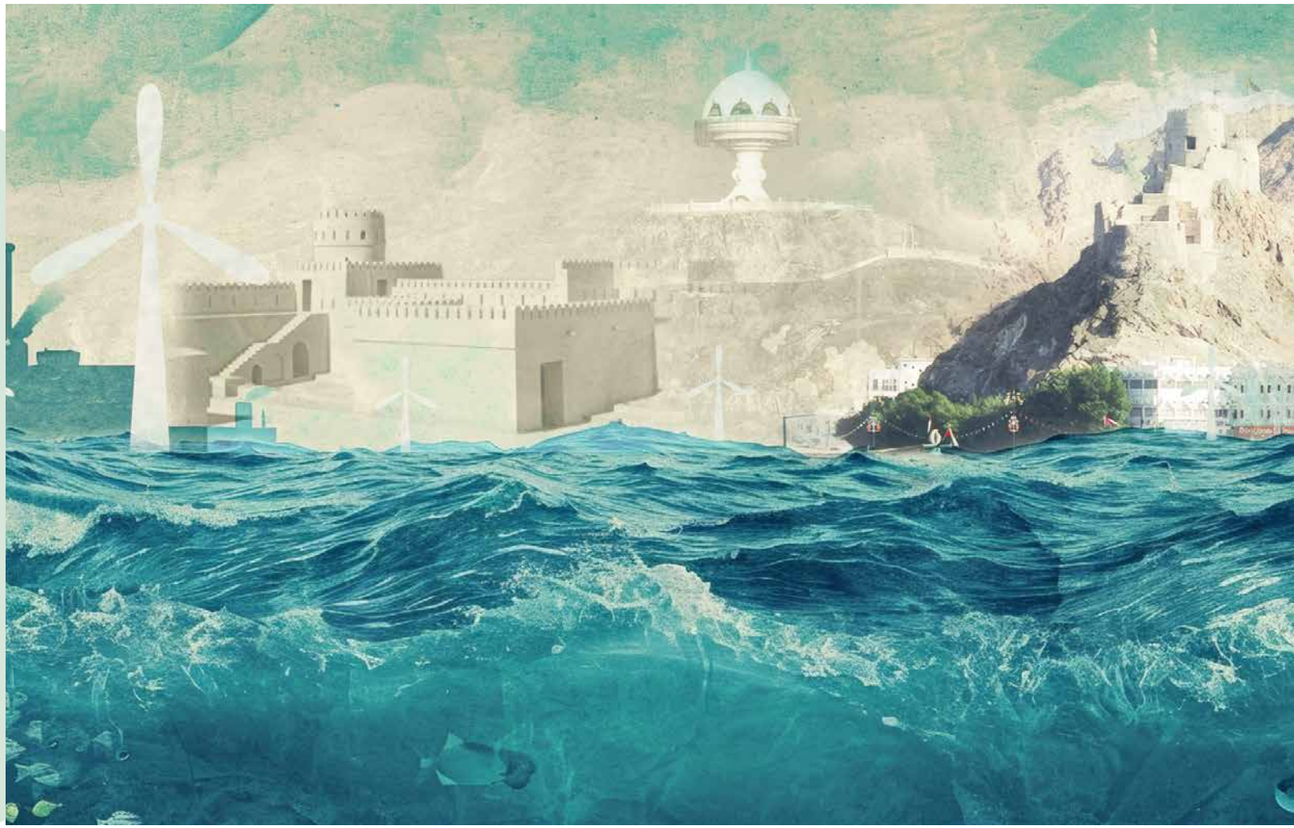
Harnessing Oman's seawater resources to support the Green Hydrogen Revolution

Transitioning to sustainable energy is not just a global imperative but a local opportunity. For Oman, this shift promises both a brighter global future and tangible benefits for its citizens. Oman's journey towards green hydrogen is not just a step towards sustainability, it's a leap into a promising future.



IMAN HUMAID AL-RUBAIAI, HUSSEIN A KAZEM

Oman's strategic location on the Arabian Peninsula and its extensive coastline of 3,165 km, connecting the Arabian Gulf, the Sea of Oman and the Arabian Sea, provides the country with abundant seawater resources. Desalinated seawater has been produced since 1976 to meet the growing water demand and reduce reliance on groundwater. This strategic decision has since safeguarded Oman's access to pure and potable water, an essential component of the Omani lifestyle. The imperative need for pure water in Oman underscores the importance of harnessing the potential of seawater for green hydrogen production. By leveraging this abundant and low-cost resource for environmentally friendly hydrogen generation, Oman not only addresses its freshwater needs but also contributes to a sustainable and greener future.

The Sea of Oman is a dynamic marine environment driven by seasonal monsoon events and is subject to pollution from oil tankers. The Arabian Sea is a semi-enclosed sea located in the subtropical region of the Middle East. It is characterized by low precipitation, high aridity, and high sea temperatures. The Arabian Gulf, part of the Arabian Sea Ecoregion, is a shallow sedimentary basin with an average depth of 35 m and a total area of approximately 240,000 km2. The Gulf is known for its harsh marine environment, with marked fluctuations in sea temperatures and high salinities. It is considered one of the most adversely affected marine environments worldwide due to combined pollution drivers such as climate change, oil and gas activities, and coastal anthropogenic disturbances. Consequently, further research is needed to determine the specific effects of hydrocarbons in seawater on green hydrogen production in Oman.

The article's objectives are to explore:

1. *The Promise of Green Hydrogen in Oman*
2. *Seawater Electrolysis: Techniques and Challenges*
3. *The Global Perspective: Oman's Role in the Hydrogen Economy*

Seawater electrolysis involves the use of cost-effective electrocatalysts to split seawater without chloride corrosion. Direct seawater electrolysis has shown promise in producing high-purity green hydrogen using common, low-cost materials and affordable fabrication methods. The presence of impurities

in seawater, such as foreign ions, microorganisms, and insoluble salts, poses challenges for electrolysis. However, non-noble metal electrocatalysts have been developed to improve performance in saline electrolyte medium. Zinc-doped nickel-iron (oxy) hydroxide nanocubes passivated by negatively charged polyanions have shown outstanding catalytic activity, stability, and selectivity for seawater oxidation. Another approach involves the use of metal-organic framework (MOF)-templated pyrolysis to prepare cobalt/nitrogen-codoped carbon nanosheet arrays, which act as highly efficient bifunctional electrocatalysts for hydrazine-assisted seawater electrolysis. This strategy reduces energy consumption and overcomes anodic corrosion problems caused by chlorine oxidation reactions. The optimization of operating parameters, such as electrolysis time, electric voltage, and catalyst amount, is critical for enhancing hydrogen production in water electrolysis.

Seawater splitting through photocatalysis is also considered a greener approach, utilizing the abundant resources of seawater and solar irradiation. Overall, the sustainability aspect of using seawater for green hydrogen production lies in its availability, low cost, and ongoing research to overcome technical challenges.

Oman may face several challenges in implementing green hydrogen production using seawater. One challenge is the need for highly active and selective catalysts for seawater electrolysis in the presence of contaminants such as metal ions, chloride, and bio-organisms. Another challenge is the undesired chlorine gas evolution reaction at the anode and corrosion induced by chloride ions in seawater electrolysis. Furthermore, the economic viability of the hybrid energy system used for green hydrogen production needs to be considered. The successful implementation of green hydrogen production in Oman will require supportive government policies and investments from both the private and governmental sectors. Utilizing solar and wind technologies for hydrogen production is influenced by the harsh conditions of high temperatures and dust in the environment. These factors must be carefully assessed before installation. Additionally, when selecting installation sites for renewable energy technology, the potential impact of cyclones on these locations should be taken into account. Lastly, it is crucial to prioritize securing advance agreements for the sale of the produced hydrogen.

The Arabian Gulf, part of the Arabian Sea Ecoregion, is a shallow sedimentary basin with an average depth of 35m and a total area of approximately 240,000 km2.

The type of seawater can have an effect on hydrogen production. Different impurities and ions present in seawater can cause problems such as blocking of active sites and reduction in membrane activity, which can affect the stability and activity of the electrolyzer. The salinity of seawater, specifically the total dissolved solids (TDS), has been found to play a role in the hydrogen evolution rate in a photoelectrochemical system. Seawater with higher TDS has been shown to be a more effective electrolyte for hydrogen production. TDS typically refers to the total concentration of inorganic and organic substances dissolved in water. While some heavy metals may contribute to TDS, TDS is a broader measurement that encompasses various dissolved substances, including salts, minerals, ions, and other organic compounds.

To ensure the success of green hydrogen projects in Oman, it's crucial to assess Total Dissolved Solids (TDS) levels in local seawater for a specified green hydrogen project. Understanding these levels can optimize electrolysis efficiency, resource availability, and environmental sustainability. It's a vital step towards unlocking the potential of green hydrogen production in Oman. Evaluating the suitability of renewable energy technology at the chosen locations is crucial. Moreover, establishing markets for the produced hydrogen is of utmost importance.

We strongly advocate for Oman to actively engage with the world in the hydrogen sector and securing clients is a critical first step in attracting funding and ensuring project viability, providing a stable market for hydrogen production, supporting project scalability and economic development and positioning Oman as a key player in the growing hydrogen market.

Transitioning to sustainable energy is not just a global imperative but a local opportunity. For Oman, this shift promises both a brighter global future and tangible benefits for its citizens. Oman's journey towards green hydrogen is not just a step towards sustainability, it's a leap into a promising future. So, embrace this transition and be part of a brighter, greener tomorrow.

We strongly advocate for Oman to actively engage with the world in the hydrogen sector and securing clients is a critical first step in attracting funding and ensuring project viability, providing a stable market for hydrogen production, supporting project scalability and economic development and positioning Oman as a key player in the growing hydrogen market.

Policymakers and global energy models are increasingly looking towards hydrogen to decarbonize hard-to-abate sectors, projecting significant growth in hydrogen consumption in magnitude of hundreds of megatons! This global shift towards hydrogen holds tremendous promise not only from an environmental perspective but also in terms of economic development and strategic positioning for Oman. In our view, it is imperative for Oman to actively engage with international stakeholders, both as a producer and consumer of green hydrogen, for many reasons:

- **Economic opportunities:** Oman can tap into a burgeoning global market. Hydrogen is poised to become a multi-billion-dollar industry, offering lucrative opportunities for investment, job creation, and revenue generation.
- **Energy Security:** Diversifying Oman's energy portfolio to include green hydrogen production and export will enhance energy security. By exporting green hydrogen to international markets, Oman can reduce its dependence on traditional oil and gas exports, mitigating economic risks associated with fluctuating fossil fuel prices.
- **Technological Advancements:** Collaboration with global players in the hydrogen industry can facilitate knowledge exchange and technology transfer. This can accelerate the development of cutting-edge electrolysis and storage technologies, positioning Oman as a leader in the green hydrogen revolution.
- **Carbon Neutrality Commitment:** As nations worldwide commit to achieving carbon neutrality, there will be increasing demand for low-carbon and green products. Oman's engagement in the global hydrogen market aligns with these environmental goals and enhances its international reputation as a responsible and sustainable energy producer.

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Our Carbon Budget: Navigating emissions in a changing climate

Understanding the carbon budget is crucial in shaping strategies towards sustainable practices

NAJAH AL RIYAMI

Our history with carbon has long been intertwined with industrialization. From the burning of fossil fuels like coal, oil, and gas significantly increasing our carbon dioxide levels in the atmosphere since the late 19th century to the rising in CO2 levels alongside the expansion of these fossil-fuel reliant industries.

With rapid industrial growth throughout the 20th century continuing to escalate carbon emissions, an awareness of its consequences and an urgency towards its regulation grows with our challenge of balancing industrial development with environmental sustainability.

We tackle these challenges collectively with advancing technologies and policies addressing ways to reduce CO2 emissions through innovation and transitioning to renewable energy sources.

What is our Carbon Budget?

The Paris Agreement, with its temperature rise limit to well below 2 degrees Celsius above pre-industrial levels, signifies the allowable amount of carbon dioxide emissions that can be released into the atmosphere while remaining within its target.

This is known as our "carbon budget", and refers to the finite amount of carbon dioxide that can be released into the atmosphere while limiting global warming to specific thresholds; essentially setting a boundary on total emissions.

Understanding this budget is crucial in shaping strategies towards sustainable practices.

International agreements and policies play a crucial role in guiding and regulating efforts to manage and reduce carbon emissions globally, with countries and industries implementing measures from transitioning to renewable energy sources, improving energy efficiency, adopting carbon capture and storage technologies, reforestation, and investing in sustainable practices across sectors.

Oman's Blue Carbon project intends to plant 100 million mangrove trees along 20,000 hectares of coastline, targeting a CO2 reduction of 14 million metric tonnes in four years in an initiative aligning with Oman's National Zero Carbon Strategy 2050, potentially generating $150 million through carbon credits.

Carbon Credit

Our carbon budget is directly linked to the concept of carbon credits, this fundamental initiative is aimed at reducing greenhouse gas emissions with a permit or certificate that gives organisations the opportunity to offset their own emissions; investing in projects that reduce emissions elsewhere and effectively staying within the designated carbon budget.

Article 6.4 of the Paris Agreement establishes a mechanism for international cooperation on emissions reduction, aiming to create a market where countries can trade emissions reductions, called Internationally Transferred Mitigation Outcomes (ITMOs), to help fulfil their climate commitments.

The credits, typically generated by activities or projects that either reduce or remove greenhouse gas emissions from the atmosphere, are assigned a specific value and traded in the carbon market. Companies or entities that have exceeded their allocated emission limits can purchase these credits as a way to compensate for their excess emissions, effectively offsetting their carbon footprint. Carbon credits thus create a financial incentive for entities to invest in emission reduction projects and help promote a more sustainable approach to managing greenhouse gas emissions.

Oman's Blue Carbon project, for example, intends to plant 100 million mangrove trees along 20,000 hectares of coastline, targeting a CO2 reduction of 14 million metric tonnes in four years in an initiative aligning with Oman's National Zero Carbon Strategy 2050, potentially generating $150 million through carbon credits while reviving the endangered Avicennia marina species.

The transformation of Al-Sawadi creek into an 88-hectare mangrove forest reflects a commitment to conservation and carbon emission reduction with economic benefits.

The Challenges of our Carbon Budget

The carbon market faces several challenges from credibility to regulatory uncertainty, market volatility, integrity and policy agreement alignment. Addressing these challenges are crucial for the carbon markets to function effectively. Detailed guidelines and rules are needed to ensure transparency, prevent double counting, and promote sustainable development through these traded outcomes.

As Fabian Mueller, Managing Director of Green Tech explains, "Carbon credits undoubtedly play an increasingly large role on our path to worldwide decarbonization, however, there is currently no functioning international carbon exchange and private markets are in disarray. It will take intense and disciplined collaboration from the international community to ensure that carbon trading projects and their platforms can effectively contribute to climate change mitigation".

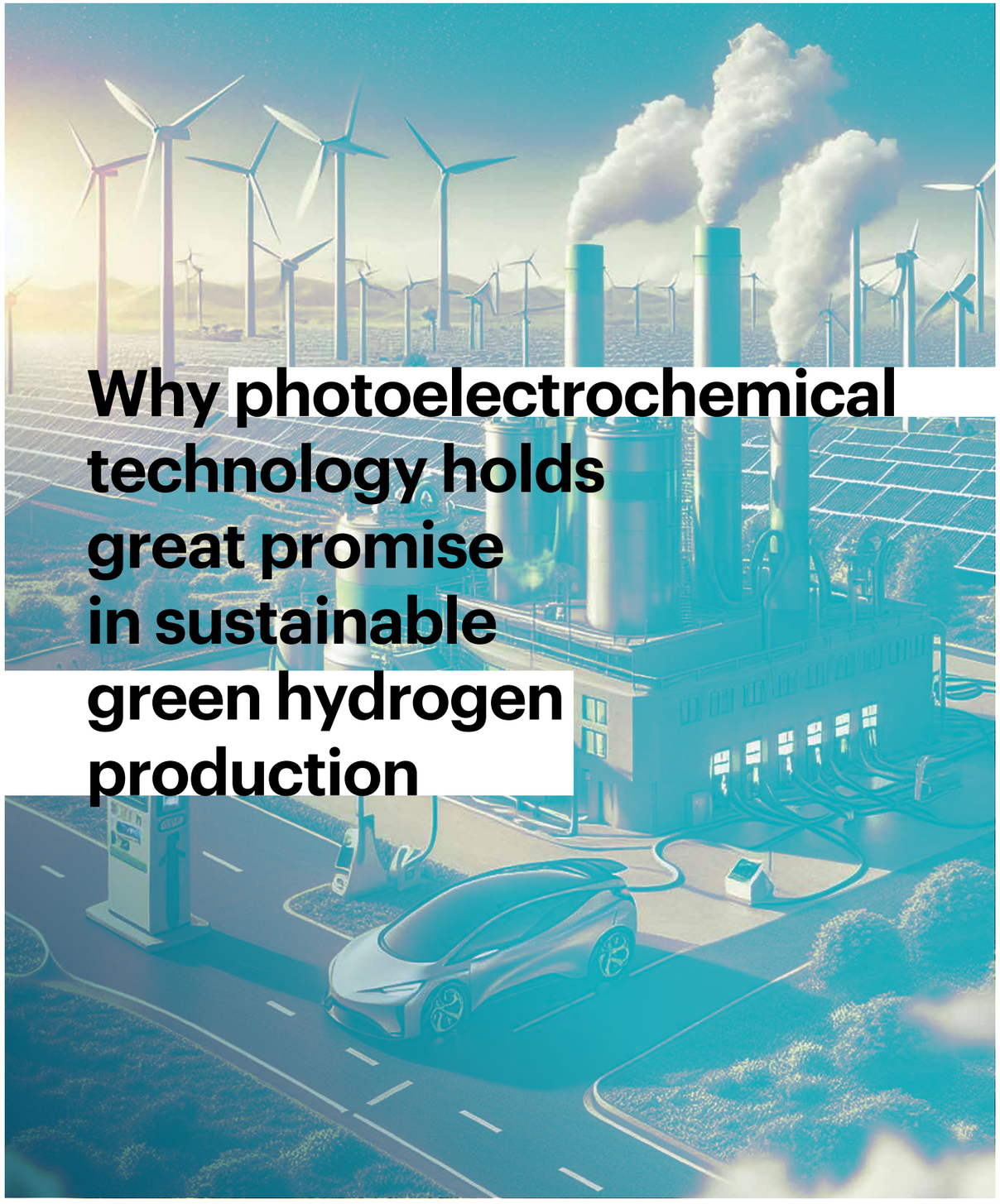
In 2023, carbon markets faced challenges with doubts about their impact and integrity, leading to a downturn. Nature-Based Global Emissions Offsets (NGEOs) significantly dropped, compliance markets fluctuate, and numerous nations joined the carbon market landscape. Despite these hurdles, there was increased corporate involvement in carbon offset markets due to new transparency requirements. NASDAQ's entry into the market introduced technology to digitise carbon credit processes, aiming for scalability and emphasising quality and impact over quantity in the market's evolution.

In conclusion, navigating our carbon budget remains a critical endeavour to mitigate climate change. Despite the challenges faced by the carbon market, such as credibility issues and regulatory uncertainties, notable efforts like Oman's Blue Carbon project exemplify tangible steps towards emission reduction and sustainable practices.

Moving forward, collaboration, stringent guidelines, and a unified approach are imperative in effectively managing our carbon budget. As the landscape evolves, prioritising quality over quantity, as evidenced by NASDAQ's technological leap, will pave the way for a more impactful and credible carbon market, crucial in our collective journey towards a sustainable future.

Najah Al Riyami

The author specializes in crafting compelling narratives of the evolving global energy landscape



Why photoelectrochemical technology holds great promise in sustainable green hydrogen production

Green hydrogen generated through the photoelectrochemical process can provide a clean alternative for transportation and energy storage. The versatility of this technology positions it as a key player in the transition towards sustainable energy solutions.

One of the most urgent hurdles in reaching a net-zero carbon emissions goal set by Oman for 2050 under His Majesty Sultan Haitham bin Tarik's leadership and in line with the Paris Climate Agreement, is the development of affordable eco-friendly fuel alternatives.

Currently, fossil fuels dominate the energy sector to serve the global energy demand, which should be replaced by developing more sustainable energy sources. Solar energy stands out as the largest exploitable renewable resource, providing more energy to Earth in just one hour than humanity consumes throughout an entire year. However, due to the intermittent nature of sunlight, the effective utilisation of solar energy as a primary energy source necessitates its storage and on-demand distribution to end-users. An attractive approach involves the engineering of photosynthetic systems capable of storing solar converted energy within chemical bonds of chemical fuels in alignment with current fossil fuel consumption as a critical step in pursuit of achieving a sustainable, carbon neutral society. Recently, hydrogen (H2) has gained attention for use in energy storage due to its high energy density.

Based on the International Energy Agency (IEA) analysis, Oman could become the 6th largest exporter of hydrogen globally by 2030 and the largest exporter in the region. While Oman is transitioning towards a producer economy with a focus on renewable energy, the cost of renewable hydrogen remains a challenge for its economic feasibility, given that electricity currently contributes significantly to the total cost. To date, the economic competitiveness of hydrogen production through water electrolysis using grid electricity falls behind that of grey or blue hydrogen produced by fossil fuels. This is primarily due to the extensive requirements for electricity grid infrastructure in large-scale production and the reliance on scarce materials, such as iridium, in the most efficient systems.

Solar-driven photoelectrochemical (PEC) H2 production from water electrolysis is one of the promising technologies that can utilise 120,000 TW of continuous solar radiation to provide clean and economic energy. PEC devices have a great potential of harvesting solar energy and electrolysing water cost-effectively in a single device.

When an efficient photoelectrode is immersed in an aqueous electrolyte and irradiated with sunlight, photon energy is converted to electrochemical energy, which directly drives water splitting reaction to produce H2 (within which energy is stored) and O2, as illustrated in Figure 1. Thus, enables storing intermittent solar energy within H2 which can be transformed into electricity or fuels and used for commercial, industrial or mobility purposes (e.g., in cars, shipping, steel and concrete industries).

Noof Al Lawati

The author holds a Master's degree from Imperial College London in Advanced Chemical Engineering

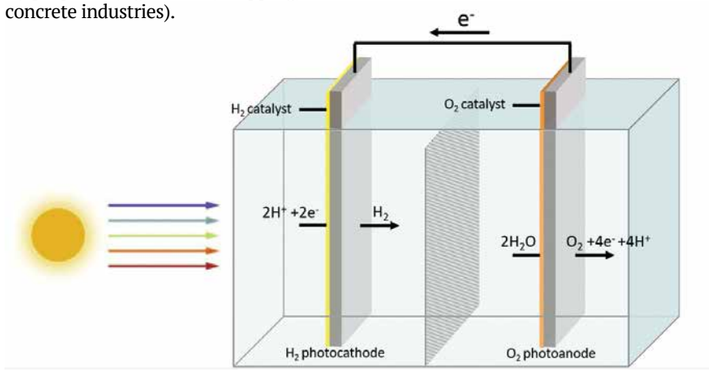


Figure 1. Illustration of the photoelectrochemical system for green H2 production through water splitting using solar energy.

However, this technology faces numerous challenges that decrease its solar-to-hydrogen (STH) efficiency, including complex and slow reactions, water degradation, and sensitivity to oxygen and light. The efficiency of PEC cells relies on the careful selection and integration of materials. Therefore, the materials constituting PEC should exhibit sufficient earth abundance, aqueous stability, and STH efficiency of above 10% for commercial feasibility. Exploring these components is essential for understanding the potential of this technology.

In contrast to existing technologies constituting of inorganic materials like silicon, organic materials offer the promise of rapid large-scale manufacturing using inexpensive, Earth-abundant, solution-processed and sustainable materials, leading in remarkably swift energy and payback periods when compared to their inorganic counterparts, resulting in a theoretical maximum STH efficiency of over 30% for PEC water splitting.

How is solar energy transferred into electrochemical energy:

The ability to harvest solar energy efficiently is paramount in photoelectrochemical water splitting. Various semiconductor materials absorb photons and generate electron-hole pairs, initiating a flow of charge that ultimately drives water-splitting reaction. Understanding the mechanisms of solar energy harvesting is crucial for optimising the overall efficiency of the process.

Fundamentals of photovoltaic (PV) working principles are the starting point for organic PEC (OPEC) cells. PEC solar H2 production enables a direct route towards renewable energy conversion in comparison to conventional photovoltaic technologies.

Like photovoltaics, a PEC consists of two electrodes, anode for the oxidation reaction and cathode for the reduction, where at least one of them should be a semiconductor to absorb light. The absorbed photons generate excitons which separate and travel in opposite directions through the semiconductor. The photogenerated charges can directly drive an electrochemical reaction at the electrolyte interface, which is the major difference to photovoltaics.

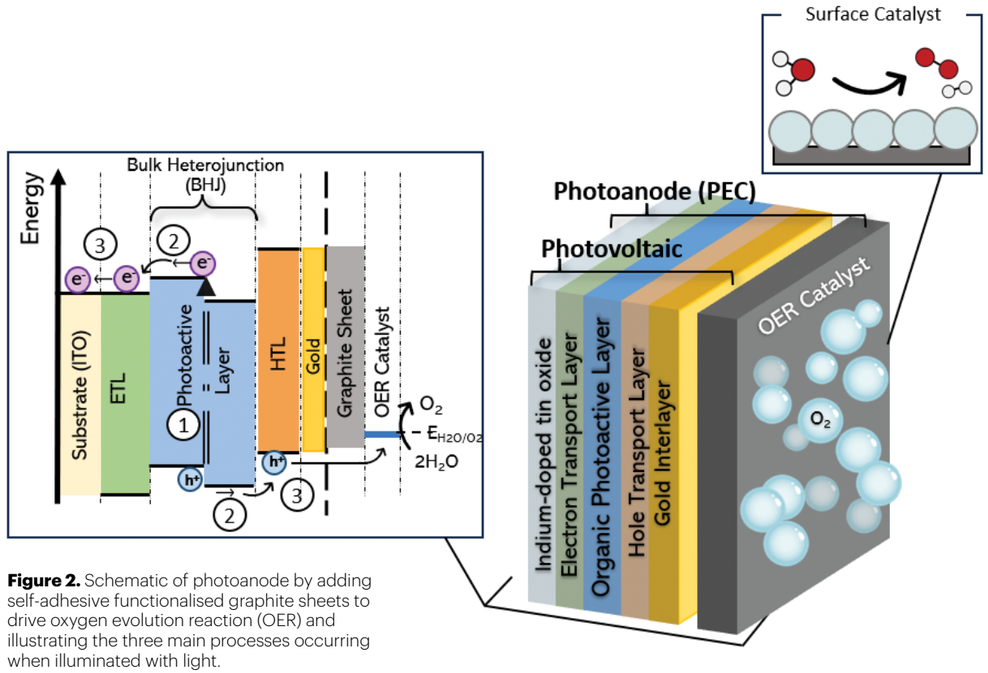


Figure 2. Schematic of photoanode by adding self-adhesive functionalised graphite sheets to drive oxygen evolution reaction (OER) and illustrating the three main processes occurring when illuminated with light.

Three main processes occur when solar cell is illuminated with light as illustrated in Figure 2:

1) Light is utilised to photoexcite electrons by leaving positively charged holes.
2) Charge carriers are transported from the bulk of photovoltaic layer to interfaces
3) Charge carriers are extracted into external circuit

Where electrons are collected by the cathode and the holes by the anode. At least one of the electrodes should be conductive to absorb light enabling it to reach the photoactive layer. Electron transfer layer (ETL) and hole transfer layer (HTL) are carefully chosen to enable selective transport of holes and electrons and are deposited sandwiching the photoactive layer.

To enable effective charge separation, blending two organic semiconductors to form bulk heterojunction system for the photoactive layer has obtained major performance breakthrough for solar water splitting in addition to enabling fabrication at minimum cost by the large-area printing methods.

PEC devices have a great potential of harvesting solar energy and electrolysing water cost-effectively in a single device.

Nevertheless, the utilisation of organic materials in PEC applications has been impeded by challenges associated with photoelectrode operational stability and efficiency, including energy losses, particularly those associated with photoanodes for driving kinetically slow oxygen evolution reaction (OER). This hinders the buildup of sufficient photovoltage to drive the reaction without any applied bias.

In practice PEC devices require photovoltages in the range of 1.7-2.0 V to overcome the kinetic limitations of water oxidation and to facilitate bias-free water splitting. This suggests that improving photovoltage is another challenge to be addressed. Tandem architectures, which connect two sub-cells in series, have emerged as potential routes to achieve higher photovoltages while harvesting more of the solar spectrum. This discovery sustains standalone (bias-free) water splitting, illustrating the ongoing development and promise in this evolving field.

Photoelectrochemical water splitting holds great promise for practical applications. Green hydrogen, generated through this process, can provide a clean alternative for transportation and energy storage. The versatility of this technology positions it as a key player in the transition towards sustainable energy solutions. Ongoing innovations and advancements in materials and architectures bring us closer to realising the full potential of this technology in real-world applications. As research progresses and breakthroughs continue, the integration of this technology into mainstream energy solutions could play a pivotal role in shaping a sustainable and clean energy future.

Water challenges in the emerging hydrogen economy

Global shifts have revitalized the move toward hydrogen as an energy source. However, discussions often center on cost and technical barriers, neglecting critical questions regarding water as a feedstock in hydrogen production.

TOBIAS ZUMBRÄGEL

Global shifts, including geopolitical changes and the push for a fossil fuel phase-out, have revitalized the move toward hydrogen as an energy source. The European Union, along with governments in Europe and regions such as the Middle East and North Africa, has prioritized hydrogen development. Germany, aiming for a pioneering role, has formed energy partnerships with countries including Morocco, Saudi Arabia, and the United Arab Emirates. These alliances aim to drive the global energy transition, enhance international climate protection, alleviate global resource competition, and create export opportunities. However, discussions often center on cost and technical barriers, neglecting critical questions regarding water as a feedstock in hydrogen production.

Water Needs

According to hydrogen experts, freshwater is crucial in the hydrogen production process, requiring approximately nine liters to produce one kilogram of green hydrogen and 12-19 liters for one kilogram of blue hydrogen. This is particularly relevant for arid Gulf countries positioning themselves as key hydrogen hubs, such as Oman, Saudi Arabia, and the UAE.

Current debates and analyses primarily focus on the economics of hydrogen, centering on factors such as cost and technical barriers, with minimal attention given to feedstock concerns for producing clean hydrogen. One notable exception is a recent discussion paper from the Germany-based Research Institute for Sustainability

that asserts a significant expansion of green hydrogen production in the Gulf states is highly unlikely due to the insufficient availability of required renewable energy and water resources.

When the issue of water availability comes up, the go-to solution is expanding desalination facilities. The UAE's hydrogen strategy, developed with input from the German Fraunhofer Institute, tackles the water challenge, noting that desalination compensates without hiking hydrogen production prices. Likewise, a study by the King Abdullah Petroleum Studies and Research Center, Saudi Arabia's top energy think tank, found that desalination costs don't significantly affect hydrogen prices.

The EU and its member states have not sufficiently considered natural water availability as a prerequisite for establishing a global hydrogen economy. The benefits of producing hydrogen through methods like electrolysis gasification with carbon capture and storage lies in its potential to offer a versatile, clean energy solution, contributing to decarbonization and energy security in the transition to a sustainable future. This omission appears to be motivated by concerns that such a requirement could exclude various pertinent supply regions in the Middle East. Also, in the declarations of intent for hydrogen partnerships between Germany (as the main offtake market) and countries on the Arabian Peninsula, such as Saudi Arabia and the UAE, the issue of water is not addressed.

Freshwater is crucial in the hydrogen production process, requiring approximately nine liters to produce one kilogram of green hydrogen.

Nevertheless, it is important that discussions about the water issue, currently relatively limited, take on a more prominent role. The Gulf countries rely on desalination for nearly all their water needs – and their hydrogen aspirations are based on continued use and expansion of desalination. In its current form, desalination is not a sustainable solution. From an environmental sustainability standpoint, desalination includes the dispersion of byproducts, such as brine and chemicals, into the seas. The majority of desalination plants are also powered by fossil fuels, so expanding desalination will increase greenhouse gas emissions. The Gulf countries are actively working on developing more sustainable desalination technologies that are powered by renewable energy and avoid brine discharge, but that does not solve the water question.

Climate Challenges

Many installed solar photovoltaic panels encounter operational challenges, with efficiency significantly decreasing above 25 degrees Celsius, a problem that might grow with accelerating global warming. Furthermore, the increase of climate-induced disasters, such as sand and dust storms, affects clean power production. For example, sand and dust particles settle on solar panels and need to be regularly cleaned with fresh water to ensure their functionality. Pure brushing without water or rinsing with seawater would scratch the coating of the solar modules. Thus, the fresh water use exacerbates the region's chronic water challenges and escalates the demand for water for green hydrogen production and solar-powered desalination.

Worsening climate change has further consequences. Amplified salinity in the marine environment, less exchange with the Indian Ocean, and elevating sea temperatures heighten the nutrient levels of the waterways surrounding the Arabian Peninsula. These changes in water quality encourage the proliferation of "red tide," which is characterized by highly toxic algae blooms that can obstruct desalination plants by clogging intake filters. More frequent shutdowns due to red tide necessitate the installation of additional desalination plants, thereby perpetuating and exacerbating these phenomena through the discharge of warm, saline byproducts in an unsustainable self-reinforcing cycle.

Besides green hydrogen using renewable energy, alternative methods of hydrogen production, such as blue hydrogen (involving gasification and carbon dioxide capture) and turquoise hydrogen (using nuclear energy), require even more water resources. Moreover, the carbon sequestration essential for the production of blue hydrogen poses potential ecological hazards, including soil erosion and an overabundance of nutrients (by increasing toxicity and acidification), ultimately negatively impacting water quality and affecting ecosystems. Depending on the geological location of the stored carbon emissions, leakages may penetrate groundwater aquifers, introducing hazardous uranium and barium contaminants into freshwater resources.

It is important that discussions about the water issue, currently relatively limited, take on a more prominent role.

This would be particularly problematic for Saudi Arabia, which possesses extensive aquifer reservoirs.

Talks surrounding the development of a hydrogen economy should not only concentrate on financial and technical aspects but also integrate environmental sustainability as an important component. There is great potential for more sustainable water management in the Gulf, including through wastewater management, rainwater collection, efficiency enhancement, and innovative seawater desalination technologies. Industrialized countries that are in dire need of hydrogen imports should integrate these pertinent ecological aspects into their hydrogen partnerships and agreements and support sustainable water policies in the target countries by providing technology, knowledge, and innovation. A one-dimensional focus on the primacy of carbon dioxide reduction without considering the escalating threats of climate change and sustainable resource management is short-sighted and may potentially create more problems than solutions.

Tobias Zumbrägel

The Author is a postdoctoral researcher and lecturer in the Department of Human Geography at Heidelberg University, Germany.

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Future Energy Leaders Programme

Empowering the next generation to lead the energy transition

NAJAH AL RIYAMI

Building and scaling our future industries requires the brightest minds. Those prepared to think outside the box and challenge the status quo will drive the world towards a more sustainable and equitable future. With the right mindset, knowledge and intention, our youth have the capacity to harness the beacon of our past efforts and to stride forward, continuing this momentum into a carbon free future.

Our collective transition to net zero and a sustainable future is in all of our hands, as we progress this transition we hand it over to the future generations with a belief in their capabilities to accelerate this progress further as they navigate us into the future that we envision.

As part of the Green Hydrogen Summit 2024 Agenda, The Future Energy Leaders' Competition invited young minds to confront our global energy dilemmas; providing them a platform to share their ideas and the opportunity to showcase their work and do their part in making a difference in our global transition towards a greener future. Platforms such as these have the potential to inspire out-of-the box ideas and accelerate the transformation of entire industries by bridging classroom knowledge with real-world challenges, fostering innovation and problem-solving, providing hands-on experience, and encouraging collaboration and networking among peers and professionals.

Participating students shared their solutions in support of green hydrogen, with challengers presenting their solutions to industry leaders, collaborating with like-minded peers, and competing for a chance to make a global impact.

The program was chaired by Dr. Sausan Al Riyami, Director of Oman Hydrogen Centre (OHC) of German

University of Technology in Oman (GUtech), alongside Program Leader Dr Intisar Al-Busaidi, Petroleum Engineer of Sultan Qaboos University, and Program Advisor Alaa Al Zarafi - Reservoir Navigation Services Engineer at the Ministry of Energy & Minerals. Program Coordinators included Abdulhadi Al-Saadi - Hydrogen Safety Engineer from Ulster University, Muzna Al Jufaili - Chemical Engineer from University of Technology and Applied Sciences, and Future Energy Leaders Alumni Abdulaziz Al-Hashemi.

The international competition gathered participation from 55 universities worldwide, with a diverse pool that included institutions from the UK, US, Sweden, Iran, Australia, Egypt, Gulf Arab countries and

Morocco. The program received over 60 abstracts, from which the top 10 were meticulously selected based on their innovative contributions to green hydrogen research. The final ten comprised five master's level and five bachelor's level submissions.

With a comprehensive judging process involving evaluation by both industry experts and academic professionals, elected students presented their work to international visitors and experts via poster presentations during the Summit. Culminating on the last day, these students showcased their research to esteemed judges, representing academic institutions from within Oman, such as Sultan Qaboos University and GUtech, as well as from Japan.

First Place: Motaz Khaled and Islam Shaker (The British University in Egypt)

Second Place: Nawaf Al-Aisaee (University of Exeter)

Third Place: Noof Al Lawati (Imperial College London)

As part of the Green Hydrogen Summit 2024 Agenda, The Future Energy Leaders' Competition invited young minds to confront our global energy dilemmas; providing them a platform to share their ideas and the opportunity to showcase their work and do their part in making a difference in our global transition towards a greener future.

The Future Energy Leaders' Programme concluded with Student Awards that celebrated top participants in a ceremony sponsored by Plug Power and Oman Cables. Beginning with a warm welcome by Cinzia Farzia of Oman Cables and Rajesh Malhotra of Plug Power, the event took place in the prestigious setting of a Gala Dinner, entertained by a talented live Omani band. Guests included Ministry of Energy and Minerals under-secretary HE Mohsen Al Hadhrami, Managing Director of Hydrom Abdulaziz Al Shidhani, and delegates from Oman Cables and Plug Power, among others.

The competition culminated in the announcement of three winners:

- First Place: Motaz Khaled and Islam Shaker (The British University in Egypt)
- Second Place: Nawaf Al-Aisaee (University of Exeter)
- Third Place: Noof Al Lawati (Imperial College London)

The deserving winners received awards of 1000 OMR for first place, 500 OMR for second place, and 300 OMR for third place. Furthermore, their work will be supported by the EJAAD platform, connecting them with industrial opportunities.

Looking ahead, the program aims for a third iteration, aiming to engage a broader audience with a renewed vision. The Future Leader Programme continues to foster global collaboration and innovation in the realm of green hydrogen research, providing a platform for emerging talent to shine and make significant contributions towards a sustainable future. Competitions such as these inspire emerging talents and gain insights into diverse energy sectors, from sustainable technologies to policy frameworks.

Founder of Birba Energy and Energy Oman Magazine, Abdullah Al Harthy, expressed: “We are extremely proud of the results of this programme and the immense potential of our youth. We can see that our future is in good hands.”

GHSO 2023 Conference & Exhibition: Pivotal moments

Energy Oman presents a curated selection of images capturing the essence of the 3-day GHSO 2023 Conference & Exhibition held at the Oman Convention & Exhibition Centre, Muscat during 12 – 14 December 2023. This pictorial journey encapsulates the key events and pivotal moments that collectively made for a truly impactful event.

ENERGY EXECUTIVE CIRCLE

CONFERENCE

EUROPEAN UNION

GHSO EXPO

GHSO EXPO

MASTER CLASS

WOMEN IN FUTURE ENERGIES

CLOSING CEREMONY

Advario Oman: Future-focused bulk liquids logistics services provider


Bahjat Tuffaha

Advario Oman is a terminal operator providing bulk liquid logistics services to tenants at Sohar Port, as well as customers and traders from around the global energy sector.

In this Q&A, Bahjat Tuffaha, Advario Oman's General Manager, highlights the company's commitment to meeting the evolving requirements of its local and international customers in their energy transition.

What is Advario's vision to support Sohar Port's green hydrogen production goals, as well as the broader decarbonization strategy of its industrial tenants?

Advario has been present in Oman since 2006. During that time, we have always supported the needs of our customers in the area of storage and logistics of liquids and gases. We will do the same with regards to green hydrogen, and hydrogen carriers.

As a company, we have set ourselves the goal to be Net Zero by 2040, which aligns with Oman's 2040 Vision as well. So, we find ourselves working with each other on this journey. Recently, we joined the Sohar Net Zero Alliance comprising industrial and other tenants at the port, many of which are large emitters of greenhouse gases. Instead of all of the individual players undertaking their own decarbonization initiatives, Sohar Port decided to bring us all together to work collectively on decarbonizing our operations. This collective approach will help us achieve our goal within the limited time available for attaining Net Zero. As a first step, we started quantifying our GHG emissions, and we also came up with a list of capital investments necessary to switch to a greener energy source to power the terminal, which in our case will be solar. We are also taking steps to improve energy efficiency. We are still in the initial stages, but we are excited to be on our way on this journey.

Are you looking at repurposing your tankage and pipeline assets to cater to the energy transition anticipated in the coming decades?

As a service provider, our current services cater to the business needs of our customers from around the world, whether it relates to petroleum products, biofuels, chemicals, gases, and even some low carbon commodities. For example, we provide tankage services for handling ammonia elsewhere in the world. And as our customers switch to new energies as part of the energy transition, we will be ready for this change as well. Advario is ready to invest in making the change happen for our customers. We are there for our customers!

Can you please shed light on the inherent advantages that can be leveraged by Advario in driving the energy transition at Sohar Port?

As I mentioned earlier, we've been operating at Sohar Port for quite some time, so we have an understanding of the operating environment at an industrial port like Sohar, and in Oman in general. We have been meeting the liquid logistics requirements of our customers, such as providing liquid bulk handling, terminaling, storage, blending, and other such services to tenants and clients. Advario is not only positioned well in the local market, but we also have a global footprint as well. We can leverage this expertise, coupled with the capabilities of our central engineering team in Rotterdam, to support the transition.

Are you working with other green energy stakeholders in Oman and beyond in supporting the country's net zero goals?

We're always working with our customers and we are in continuous communication with them regarding their needs to transition to new energies. So when the time comes to support their transition, we will be ready to meet their requirements. It's an ongoing discussion with them that will never stop.

Any final thoughts?

Aside from our core focus on gases, chemicals, and sustainable fuels, Advario also has a target to become Net Zero by 2040. So I think we are the right partner for companies as they move ahead with their transition.

PLUG POWER: Helping Oman harness value from its green hydrogen sector

Plug Power, a global leader in comprehensive hydrogen solutions, is willing to leverage its considerable experience in driving value creation in Oman's emerging green hydrogen sector, says Rajesh Malhotra, General Manager and Operational Head – Plug Power (Oman).

In this Q&A-based interview, Rajesh shares his thoughts on how the US green energy tech firm can support Oman's clean energy aspirations:

What is Plug Power doing here at GHSO 2023?

Plug Power is delighted to have participated in GHSO 2023 for the 2nd successive year after 2022. Plug is doing pioneering work in product lines of Hydrogen Fuel Cells, Proton Exchange Membranes (PEM) based Water Electrolyzers, Storage and Liquefaction / Transportation of Hydrogen. You can see the two models of different capacity of Electrolyzers (5 MW for Pilot / small plants vs 10 MW Arrays for scaling up) being showcased at our display station. Plug Power's focus is on green hydrogen technology supported by its unique solutions and equipment. We are here to share the knowledge in this relatively new vertical. Infact I am happy to share with you, that we have been receiving many students / young engineers from Technical Universities / Industry who are quite inquisitive about this new segment of green hydrogen and the accompanied energy transition. This is a very good sign for inculcating / promoting ICV via human resources and prepare them for future.

What is the current cost of producing green hydrogen compared to other energy sources?

This is a very geography-specific question, but an important one, nonetheless at the present time. Still, it's been difficult to make a comparison between the two: The cost of fossil fuel based energy sources is very evident, because we have access to these energy sources for a long time now. In the case of green hydrogen however, there are multiple factors that come into play, chiefly the abundance of renewable resources, coupled with the availability of competitive and abundant land space & high drive. The Sultanate of Oman, as highlighted by a recent IEA report, with an incentivized support, is well-positioned to achieve a very competitive levelized cost of hydrogen production expected to be lesser than that in European / Asian markets by 2030. This makes it very exciting for Oman to be considered as a green hydrogen production hub for both Exports & domestic consumption.

How can Oman make green hydrogen production more cost-effective?

Again, several factors come into play. As I said, Oman is not only blessed with sun and wind resources throughout the year, but also vast available land and the political will to make this new industry happen. This is also evident from the steps taken by the government to, for example, auction of large land blocks, bringing in overseas investment and highly experienced developers, have announced certain tax benefits,

local industry support and so on. All these measures coupled with incentivizing carbon reduction will help support the long-term growth of this industry to achieve volumes. So the Industry will remain positive about the outlook for cost-effective green hydrogen production in Oman.

What is the current global demand for green hydrogen, and in which sectors is this demand more prominent?

Before we delve into the current demand for green hydrogen, let's focus on current hydrogen demand per se: A high level estimate mentions this to be about 95 megatons, which is sourced almost entirely from fossil fuel, and hence called 'grey hydrogen' in the current spectrum of hydrogen colors. But then, hydrogen consumption volumes are expected to exponentially grow as new applications for hydrogen use are coming into play. Mobility is one such good example. According to high level projections, global demand for green hydrogen is estimated at around 25 million tons by 2030. So will be better for the world if we can speed up the development of this industry to achieve the set goals faster.

What investment opportunities exist in Oman's green hydrogen sector?

Green hydrogen is anticipated to gradually but considerably replace / augment fossil fuels that presently account for a major portion of national revenues. Now as the energy transition takes hold, a whole new green hydrogen value chain and ecosystem is expected to emerge around this nascent sector. To this end, Oman has already set ambitious and aggressive targets to become one among the biggest producers and exporters of green hydrogen in the GCC. And in addition to the anchor mega projects currently under early development with large anticipated foreign investments, there can be also a focus on localizing the vast array of manufacturing opportunities that emerge when one looks at the input requirements of these green hydrogen investments. These opportunities relate to, among others, the manufacture / assembly / testing of components for various capital equipment for Solar / Wind farms, Electrolyzers & Fuel cells, local consultancy, Construction, training and manpower development, maintenance services. Indeed, a whole gamut of opportunities open-up across this new sector.

What is the ROI for green hydrogen in comparison with conventional energy sources?

This is a bit like comparing apples to oranges. From a purely commercial standpoint, ROI on conventional energy sources, like fossil fuels, will be high, primarily because technologies and applications have matured over the past century of its use. But we now are aware of a significant environmental and human cost associated with continued fossil fuel use. If this negative impact is mitigated by, for example, carbon tax, etc such as on verge of introduction in Europe and / or the Industry is incentivized such as in USA, the gross benefits associated with green hydrogen both in quality and quantity will easily surpass the conventional energy. So, calculating ROI in traditional way is not the correct barometer here & hence alone should not be a determinant in investing in clean energies like green hydrogen. Future economies of scale are likely to easily justify the current early investments.

Can you share some successful case studies or pilot projects in the green hydrogen sector that have shown promising ROI?

If you will check out our website (www.plugpower.com), you will see that Plug Power has been able to demonstrate the success of its technologies and solutions across the world. Two examples that come to my mind in the Middle East pertains to a 15 MW pilot plant commissioned / operating in Egypt and another one under construction in Portugal. This 100 MW plant – although dubbed as a 'pilot' only by the client – is poised to produce Sustainable Aviation Fuel (SAF) based on green hydrogen. The client, as an early mover in this field, is pressing ahead with its implementation with a plan to ramp up capacity in very near future. Plug is the designer, engineer, manufacturer, supplier and commissioner of the PEM based Electrolyzers in these projects.

What are the in-country value enablers for the green hydrogen value chain in Oman and how is Plug Power supporting this key goal?

The investment opportunities available across this emerging industry are bountiful from the ICV standpoint. As a nascent sector, it opens up a great deal of opportunity to, for example, start manufacturing components here for the capital equipment required by the industry, carry out the assembly and fabrication activities locally, the testing, maintenance services, manpower development, training, and so on.

Plug Power understands ICV and it's importance to the nation very well. Gladly it was previously involved in a contract to fabricate gas well hookup skids in Oman. Awarded to our Dutch-headquartered Frames' operations in 2021 (before Plug Power took over Frames), this long-term multimillion dollar contract was eventually executed by our Oman team. The skids were fabricated / assembled / tested / installed in various Gas fields in Oman with Omani man-power and using Oman sourced materials to the maximum extent possible. This has given Plug Power a considerable & valuable experience in the ICV space and is willing to leverage this expertise to support similar value creation in the Green hydrogen vertical also; in line with Oman's strategic goals.

Oman's journey towards sustainability and energy independence hinges on its ability to harness and store renewable energy efficiently.

Takhzeen: Pioneering Sustainable Energy Storage Solutions for Oman's Future

In a world increasingly focused on sustainability and environmental responsibility, Oman stands poised at the forefront of innovation and progress. As the nation charts its course towards a greener, more prosperous future, the need for cutting-edge energy solutions becomes increasingly apparent. Enter Takhzeen, a 100% subsidiary of ONEIC, dedicated to advancing energy systems for a sustainable and prosperous Oman.

Inauguration at the Green Hydrogen Summit Oman 2023

The journey of Takhzeen began with a significant milestone – its inauguration during the prestigious Green Hydrogen Summit Oman 2023. Against the backdrop of this forward-thinking event, Takhzeen emerged as a beacon of hope, promising to revolutionize the energy landscape of the Sultanate. The inauguration was marked by the signing of crucial agreements with Energy Dome, one of the most revolutionary technologies in the field. These agreements were signed in the presence of His Excellency Salim Al Aufi, the esteemed Minister of Energy and Minerals of the Sultanate of Oman, signaling a strong commitment to innovation and sustainability.

Vision and Mission: Driving Sustainable Progress

At the core of Takhzeen's ethos lies a powerful vision: advancing energy systems for a sustainable and prosperous future. Guided by this vision, our mission is clear – to provide cutting-edge energy storage solutions that pave the way towards a greener, more sustainable Oman. We understand the urgent need for action, and we are committed to supplying the Sultanate with the latest sustainable energy storage solutions to support national energy objectives and achieve net-zero emissions.

Why Oman Needs Long Duration Energy Storage Solutions

Oman's journey towards sustainability and energy independence hinges on its ability to harness and store renewable energy efficiently. Long duration energy storage solutions play a pivotal role in this endeavor by bridging the gap between energy production and consumption. As Oman continues to invest in renewable energy sources such as solar and wind, the need for reliable and scalable storage solutions becomes increasingly critical. Long duration energy storage not only ensures grid stability and resilience but also unlocks the full potential of renewable energy resources, enabling Oman to reduce its reliance on fossil fuels and embrace a cleaner, more sustainable future.

Against the backdrop of this forward-thinking event, Takhzeen emerged as a beacon of hope, promising to revolutionize the energy landscape of the Sultanate.

Building Tomorrow Together

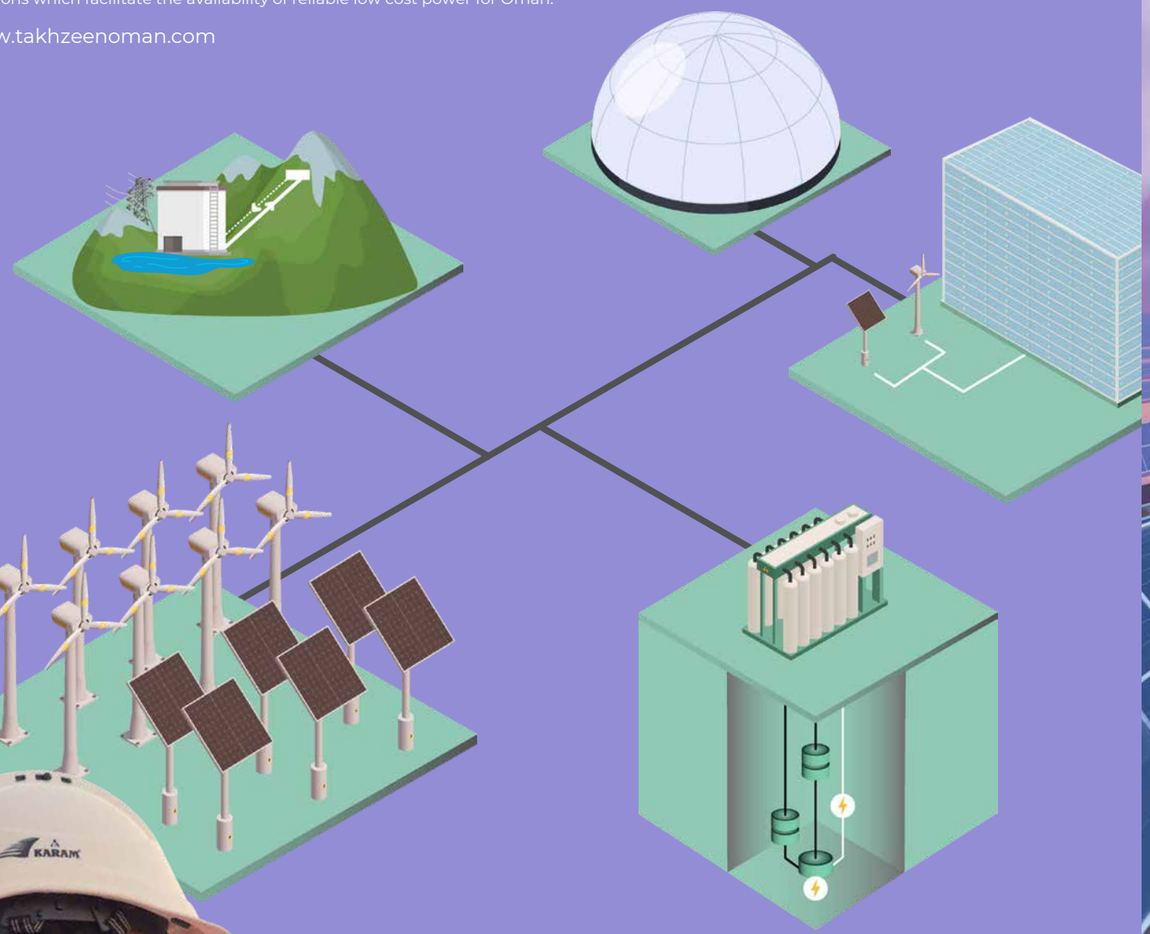
At Takhzeen, we believe that people are at the heart of what we do. We are not just a company; we are a family united by a shared vision of driving progress and sustainability in Oman. Through collaboration, innovation, and unwavering dedication, we are building tomorrow together – a tomorrow where energy is synonymous with sustainability, and prosperity knows no bounds.

Takhzeen is more than a provider of energy storage solutions – it is a catalyst for change, a champion of sustainability, and a driving force behind Oman's journey towards a brighter, greener future. As we forge ahead on this path of progress, Takhzeen remains steadfast in its commitment to powering Oman's sustainable transformation.

In Oman we're blessed with abundant wind and solar

If just 5% of the Middle East's desert was used to generate wind and solar power it could meet the annual electricity demands of the entire world. The key enabler is efficient energy storage. Takhzeen provide sustainable energy solutions which facilitate the availability of reliable low cost power for Oman.

www.takhzeenoman.com



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Takhzeen
Energy storage for a sustainable world

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OUR EVENTS

GHS Global Hydrogen Summit

CCUS Forum

GREEN HYDROGEN SUMMIT OMAN

eec energy executive circle

CSEW Cairo Sustainable Energy Week

WiFE Women in Future Energies

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