

AN OMAN DAILY OBSERVER SUPPLEMENT

THE CORRESPONDENT

ISSUE 1 | FEBRUARY | THE BUSINESS EDITION

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Why the Gulfs' oil
powers are betting
on clean energy

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A NEW CHAPTER WITH 'THE CORRESPONDENT'



Welcome to the first edition of The Correspondent — a monthly digital supplement published by the Oman Daily Observer. Through this magazine, we aim to feature a mix of thought-provoking essays, interviews, and stories that highlight the progress and preservation happening across the Sultanate of Oman covering different topics and industries.

It is our hope that this magazine becomes an important go-to for researchers and readers and helps expand our patron's understanding of issues and movements happening around them.

As a specialty supplement, every month, the topics will change focusing on the different aspects of our newspaper from local and international stories to business, to sports to lifestyle and culture.

In this edition, we focus on the ever-evolving landscape of business, examining the latest trends, strategies, and technologies that are shaping the future of the industry.

We invite you to join us on this journey and we hope that you will find the information collected here helpful.

Your feedback is also always welcome. If you have a think piece or analysis that you would like to share, please send your contributions through our email editor@omanobserver.om and include the the subject line: For the Correspondent.

Thank you, happy reading, and see you in our next editions.

ABDULLAH AL SHOUILY

Observer

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THE FUEL OF THE FUTURE

BY JÖRG HAAS

Green hydrogen is increasingly heralded as the best alternative to fossil fuels. But to prevent it from becoming another excuse for greenwashing, Western policymakers must work with their counterparts in the Global South to create an economically viable sector with strong environmental and social standards.

BERLIN – Green hydrogen is all the rage these days. During November's United Nations Climate Change Conference (COP27) in Egypt, German Chancellor Olaf Scholz announced that Germany will invest more than €4 billion (\$4.3 billion) in developing a market for it. In the United States, President Joe Biden's administration has made "clean" hydrogen a centerpiece of its Inflation Reduction Act, which provides subsidies for renewable energies. China, too, is so invested in electrolysis that some observers already fear that it will take over the market the same way it did with photovoltaic panels. And even corporations like the Australian mining giant Fortescue are betting on it becoming a multibillion-dollar industry.

When a technology is hyped to such an extent, many environmental activists tend to become nervous. Is "clean hydrogen" merely a way to greenwash so-called "blue" and "pink" hydrogen, generated from natural gas and nuclear energy, respectively? Is it an attempt to produce a magic technofix that vindicates absurd

excesses like space tourism and hypersonic flight, when the world's middle and upper classes should be shrinking their energy and resource consumption? Or is this the next stage of extractivism, appropriating low-income populations' land and water under the guise of fighting climate change?

The short answer to all these questions is yes. But that is neither inevitable nor the whole story. Yes, the green hydrogen dream could well develop into a nightmare if we do not get it right. Still, it is an indispensable building block of the global economy's transition from climate-destroying fossil fuels to sustainable models based on 100% renewable energies. It may be difficult to accept this ambiguity, but the urgent need to avert a climate catastrophe requires no less.

Given hydrogen's many potential applications, some leading experts estimate that it could power 20-30% of global energy consumption by mid-century. But that does not necessarily make it the most efficient choice.

Electric batteries, for example, require far fewer renewable kilowatt hours



per kilometer traveled to power cars and trucks than hydrogen fuel cells or e-fuels do. Similarly, using heat pumps is more efficient than converting gas boilers to hydrogen. Organic alternatives to nitrogen fertilizer should also be given much more consideration. But there are several critical sectors with few economically viable zero-carbon alternatives to green hydrogen and its derivatives, including long-distance shipping and aviation, chemicals, and steelmaking. Notwithstanding the hype, many industries will clearly need vast amounts of clean hydrogen to achieve net-zero emissions by 2050.

To illustrate the scale of the challenge, Bloomberg New Energy Finance founder Michael Liebreich recently estimated that just replacing today's "dirty" hydrogen – produced from fossil fuels – would require 143% of the wind and solar energy the world currently has. Several countries in the Global South have been blessed with world-class solar and wind potential, enabling them to produce green hydrogen at very low cost. Some, like Namibia, have built their industrial development strategy around this competitive advantage. But how could international trade in green hydrogen and its derivatives become a pathway

to prosperity? And how can developing countries avoid the green extractivism trap and ensure that trade is fair and sustainable?

A series of consultations and studies in Chile, Argentina, Brazil, Colombia, South Africa, Morocco, and Tunisia have explored these questions at length. A new report by the Heinrich Böll Foundation and Bread for the World synthesizes their findings and highlights the need to do no harm. To prevent the green hydrogen dream from becoming a nightmare, we must develop the sector with territorial planning, and clear standards and policies, as well as uphold local communities' right to prior informed consent. To deliver on the promise of post-fossil development and foster sustainable economies, governments must devise ambitious and realistic industrial strategies. And these strategies must be embedded in a systemic approach to sustainable development and the energy transition. Moreover, we need to consider how hydrogen is used – not just who can pay for it.

None of this will happen by itself. Achieving a sustainable future is a political choice that requires leadership and cooperation. Several countries could help make fair and sustainable

trade in green hydrogen a reality.

Namibia, Chile, Colombia, and now (under President Luiz Inácio Lula da Silva) Brazil, for example, have the right political conditions for balancing green-hydrogen production with strong environmental and social standards.

Over time, Argentina and South Africa could join this list and become producer countries. As a prospective major importer and consumer of green hydrogen, Germany would need to form partnerships with producing countries, based on strong environmental and social standards. And given its progressive government, it can be expected to engage with its long-term partners not just as resource providers, but as fellow travelers on the journey toward sustainable, inclusive prosperity. To that end, Germany and other energy importers must also support exporting countries in their efforts to localize value creation.

In this way, the emerging international trade in green hydrogen could become a harbinger of a new, equitable trading relationship between the Global North and South. That is a future worth fighting for, and renewable energy holds the key.

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HYDROGEN-POWERED GREEN FUTURE AWAITS OMAN

BY CONRAD PRABHU

Transformational change: The next big milestone on Oman's fast-paced decarbonisation journey is slated around the end of April when Hydrom announces the winners of its inaugural round of auctions of land blocks earmarked for large-scale green hydrogen projects.

A CRITICAL MILESTONE in Oman's nascent green hydrogen journey was marked on February 26, 2023 when His Majesty Sultan Haitham bin Tarik issued Royal Decree 10/2023 effectively laying the bedrock of a new regulatory framework governing the development of large-scale renewables and green hydrogen projects in the Sultanate of Oman.

In essence, the Royal Decree empowers Hydrogen Oman (Hydrom), an independent entity regulated by the Ministry of Energy and Minerals, to exercise its broad mandate in overseeing the delivery of the Omani government's vision for a green hydrogen industry to power the nation's future decarbonized economy.

As part of that remit, Hydrom has been tasked with master planning the sector, delineating government-owned land areas for green energy projects,



structuring associated large-scale green hydrogen projects, managing the process for their allocation to developers and overseeing their execution as well as facilitating the development of common infrastructure, connected ecosystem industries and hubs.

Given the complete novelty of the new economic industry in question, the Ministry of Energy and Minerals has also been mandated to draft supporting guidelines to underpin and nurture the growth of this industry sustainably and in line with Oman's Vision 2040 priorities.

Royal Decree 10/2023 delivers on a pledge by authorities, articulated during the Green Hydrogen Summit Oman 2022 forum held last December, that foundational legislation identifying the powers and prerogatives of key stakeholders in the green energy

space, notably the Ministry and Hydrom, would be issued before the end of the first quarter of this year.

The Ministry is expected to follow suit with Executive Regulations that will provide further clarity on the finer legal, transactional and policy specifics encompassing all aspects of this emerging industry. Together, the two frameworks provide robust legal comfort to foreign investors taking the plunge into Oman's promising green hydrogen sector, say experts.

The next big milestone on Oman's fast-paced decarbonisation journey is slated around the end of April when Hydrom announces the winners of its inaugural round of auctions of land blocks earmarked for large-scale green hydrogen projects. Up for grabs in this round is a pair of blocks each of about 320 sq kilometres in the Wilayat of Duqm in Al Wus'at Governorate.

International investor interest in Oman's green hydrogen programme has been strong, with as many as 180 parties having registered their particulars on Hydrom's platform as of mid-January 2023. Of this number, more than 50 companies had collected a Request for Qualifications (RfQ) document, affirming their intent to participate in the auction process. An unspecified number have also since passed the qualification stage and are now actively working to put together their final offers – a response Hydrom has characterized as “encouraging and in line with initial expectations”.

The competitive auctioning process itself is subject to a compressed timeline – in part to harness a groundswell of investor interest in Oman's green hydrogen industry, but also to position the Sultanate among the global frontrunners in this





emerging sector. The deadline for the submission of firm proposals against the blocks on offer was recently extended to March 15, 2023. Offers will be evaluated against different criteria, such as project concept and feasibility, financial viability or bidders' credentials.

The auction process has garnered global interest not least for the path-breaking approach adopted by Oman to attract international investors to bid for parcels of renewable resource-rich acreage via a transparent competitive tender process.

The winning consortium will secure long-term leases to sizable tracts of land to develop integrated projects covering the full green hydrogen value chain, encompassing solar and wind farms (upstream), production of green hydrogen through electrolysis (midstream) and a green energy end-product comprising either hydrogen, ammonia or derivative for domestic consumption or export.

Project implementation is envisioned in three distinct phases, encompassing Development, Construction and Production. During the development phase, spanning roughly three and a half years, the successful developer will start working on assessing the area's solar and wind resources, embarking on their feasibility study, assessing permitting and bankability requirements and so on. Incentives have been incorporated into the

process to encourage developers to move through the phases on to production.

Further, to incentivize the expeditious delivery of the development and construction phases, Hydrom has slashed land fees for the allocated block to just 20 per cent of the stipulated levy during the development phase.

The fee is completely waived during the construction phase, ensuring sizable savings for the developer.

A second bid round targeting the auction of up to four additional land blocks, located in Thamrait (Dhofar Governorate), gets underway immediately after the award of the first round. These additional blocks are slated to be awarded before the end of 2023 with the goal of enabling the aggregate national production of at least 1 million tonnes per annum of green hydrogen annually starting from 2030. This targeted output, will necessitate investments to tune of around \$30 billion primarily in installing around 20 gigawatts of renewable capacity and 10 gigawatts of electrolyzer capacity by 2030.

With a total of around seven years allotted for the development and construction phases, the first output



of green hydrogen or its derivatives from the Round 1 blocks in Duqm is anticipated in 2030. And as successive blocks are awarded and developed, production is projected to rise to between 3.25-3.75 million tonnes per year in 2040 before climbing to a peak of 7.5-8.5 million tonnes per year by 2050.

A subsidiary of Energy Development Oman (EDO), Hydrom's mandate includes the delineation of government-owned land areas and the structuring of associated large-scale world-class green hydrogen projects, managing the process for their allocation to developers as well as facilitating the development of common infrastructure and connected ecosystems in industries and hubs in close collaboration with the Public Authority for Special Economic Zones and Free Zones (OPAZ).



OPPORTUNITY OMAN: GREEN HYDROGEN

THERE IS AN increased consensus around the world that focused steps need to be taken to reduce global warming to levels less than 2° C and, if possible, to cap it at 1.5° C higher than pre-industrial levels. Various countries have pledged their nationally determined contributions to ensure energy transition and reduce emissions. In addition, most large economies have committed to net zero targets. Transitioning to Green Hydrogen and Green Ammonia is one of the practical solutions, both of which have been gaining a lot of momentum lately, driven by the need to meet sustainable development goals (SDGs), reduce carbon emissions, and address the climate challenge overall. The main advantage of green hydrogen is that it can generate massive energy with zero emissions of harmful gases. Green hydrogen is also an explosive chemical, meaning it is a source of energy, which qualifies it to achieve the goal of replacing more than 10 billion barrels of oil from global energy consumption within the year 2050.

Oman aims to become one of the world's leading green hydrogen hubs. Several fundamental components, such as the abundance of land, high sun radiation and good winds, large coastal areas and proximity to energy markets, support the focus on green hydrogen in Oman. Equally, Oman's vision 2040 sets a clear road map and focuses on diversification and renewable energy. In fact, Oman is taking a progressive



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role and has recently signed several green hydrogen projects; in Duqm, Salalah and Sohar. The investment ticket for each hydrogen project is enormous, and when these projects materialize, they will indeed have a significant impact on the economy and investment landscape.

To unlock the green hydrogen potential Oman is seeking to attract sizable foreign direct investments to the sector. The Ministry of Energy and Minerals is carefully working to unify efforts with other parties concerned with investment and developing appropriate policies, legal and regulatory frameworks as well as basic studies for this sector. There are preconditions for the green hydrogen agenda and projects to move forward and become successful such as access to finance, infrastructure, technology, enabling legislative framework and aggregating industry demand locally and internationally through export.

Finally, Green hydrogen provides ample opportunities for local companies who would like to diversify and adventure to this new sphere in downstream, midstream and upstream for instance, by manufacturing solar panels, wind plates as well as providing services to companies in production and those in different phases of the green hydrogen project. In essence, in Oman our ambition is high, our commitment is deep, and we have all that it takes to become one of the world's leading green hydrogen hubs.



ALENA DIQUE
FOUNDER, ESG MIDDLE EAST INSIGHTS

Alena Dique is listed as one of the Top 100 Successful Women in Oman and amongst the Top 10 National Gamechangers of the Sultanate. She is the author of Sustainable Governance part of the Omani Corporate Governance Guide. A Sustainable Development and Energy Transition Consultant (Oman and UAE) by profession with a degree in Quantitative Statistics, she holds a Scholastic award and MBA from University of Wales.

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HYDROGEN MARKETS IN OMAN

HYDROGEN IS A clean and renewable source of energy that is gaining popularity in the world as countries try to reduce their dependency on fossil fuels. The hydrogen market in Oman is relatively new but has the potential to play a significant role in the country's energy mix in the future.

Oman plans to produce a million tons of green hydrogen by 2030 and has set up a state-owned company, Hydrom as part of its plan to achieve net-zero carbon emissions by 2050. The country has ambitious plans to increase its use of renewable energy setting a target of generating 10% energy from renewable sources by 2025, hydrogen being a key component of these plans.

Looking on the demand side, while the transportation sector is expected to be the main market using hydrogen fuel cell vehicles, there will emerge a growing industrial market, for hydrogen to be used as a feedstock to produce chemicals, such as ammonia and methanol. At present, there are few hydrogen refueling stations in the country, which makes it difficult to use hydrogen as a fuel for transportation thus making it difficult for consumers to switch to hydrogen-powered vehicles and with the increased used of hydrogen as a feedstock, manufacturers can reduce dependence on traditional fossil fuels and lower carbon footprint. Oman has earmarked two blocks in the southern port city of Duqm and another four blocks in Salalah to be tendered for the development of green hydrogen projects.

Another challenge is the high cost of production, transportation, and storage. Majority of hydrogen (blue hydrogen) produced is from natural gas, which is a fossil fuel making hydrogen relatively expensive compared to other sources of energy. Hydrogen is mostly transported by trucks, which is less efficient and more expensive than pipelines. However, as technology advances and renewable sources of energy are used to produce hydrogen, it is likely that the cost of production will decrease, making it more accessible to consumers. Green Energy Oman (GEO) is a promising clean fuels hub sited in the southern region of Oman in



Al Wushta and Dhofar governorates to utilize Oman's natural resources of wind and sun to turn seawater into green fuels: hydrogen, ammonia, methanol, and synthetic fuels. Additionally, the project has potential to supply the local economy with cheap clean power.

Oman's hydrogen market is expected to grow significantly in the coming years. The country overlooked by waterbodies has a large amount of sunshine and high temperatures, which makes it an ideal location for producing hydrogen. Additionally, the increased efforts to welcome foreign experts and knowledge sharing to develop the green hydrogen market, is a positive sign for the future of this industry. As the comprehensive infrastructure for hydrogen production and distribution keeps maturing, it is likely that with the right policies and investments, the Sultanates hydrogen market will play a significant role in the country's energy mix, help reduce its dependence on fossil fuels and be sustainable in the long term.

WAVE ENERGY: AN ECO-FRIENDLY POWER SOURCE

WAVE ENERGY is a dynamic and simple source of clean, renewable energy that has the potential to provide significant benefits to Oman. With its long coastline along the Arabian Sea and the Gulf of Oman, the country is well-positioned to harness the power of ocean waves for electricity.

Wave energy is generated by the motion of ocean waves, which is created by winds and other meteorological conditions. The energy in ocean waves is considerable, with the potential to generate large amounts of electricity if harnessed correctly. Unlike other forms of renewable energy, such as solar or wind, wave energy is more constant and predictable, making it a reliable source of energy for communities and countries that depend on it. Wave power plants are also much more space-efficient,

energy to coastal communities, making it a valuable source of energy for rural and remote areas. Additionally, wave energy devices can be designed to have a low environmental impact, and can even be used to enhance the biodiversity of coastal ecosystems.

Uses of this relatively unobtrusive source of energy – they can be co-located with offshore windfarms - for direct maritime and land benefit are multifold and examples include: fish farms, surveillance installations, desalination units, maritime charging points, coastal industry, ports, and can be off grid or linked into local and national grids.

The EU has committed to a renewable energy target of 32% by 2030 and by 2050 10% of all renewables can be provided by wave energy. The Norwegian tech-company Havkraft



MATT MINSHALL



being up to 50 times less space-consuming than solar plants.

Oman is also committed to reducing its dependence on fossil fuels and increasing the use of renewable energy sources, which makes wave energy an attractive option. By developing wave energy projects, Oman can tap into the potential of this renewable energy source and contribute to its energy security while reducing its carbon footprint.

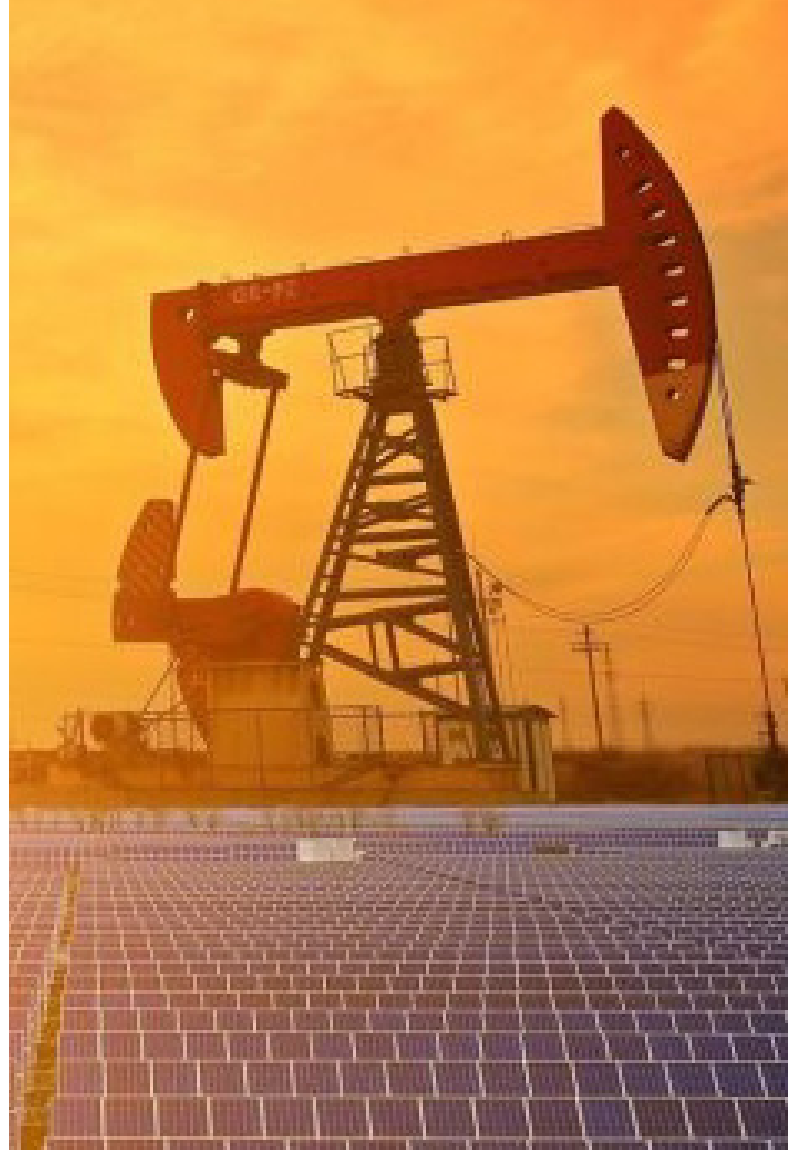
There are several different types of wave energy conversion methods, and the oscillating water column (OWC) is the most efficient and reliable solution for nearshore power production. One of the key benefits is that electricity can be generated close to the coast, reducing the need for expensive and environmentally damaging transmission lines. This means that wave energy projects can provide clean, renewable

– literally translated to Ocean Power or Kuwat Al-Bahriya (القوة البحرية) - provides a unique modular OWC-system where the powerplants are fitted to capture a broad range of wave-frequencies at any nearshore site. They are providing direct power to fish farms in support of government policy in a manner which can dramatically improve the industry. This offers the dual benefit of providing an eco-friendly power source while providing a boost to the economy.

For Oman wave energy is a promising source of clean, renewable energy that has the potential to provide significant benefits. By developing wave energy projects, Oman can contribute to its energy security, reduce its carbon footprint, and provide clean energy to its communities in direct support of the Oman 2040 Vision.

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Project

OMAN: A MAJOR OIL PLAYER WITH GREAT ASPIRATIONS



BY MARYAM AL NOFLI

Over the past centuries, the Sultanate of Oman has sought to consolidate and strengthen its economy by harnessing its various resources. Oil and gas have become the mainstay of the economies of the Gulf countries, including Oman. Since the oil and gas sector accounts for a large portion of Oman's economic growth and government revenue, changes in the sector can have a significant impact on the Sultanate's overall progress.

THE SULTANATE OF

Oman is in the southeast corner of the Arabian Peninsula. It has a strategic location and a variety of landscapes that make it rich on the outside and inside. It is bursting with enormous human and natural resources, and internally, it contains innumerable amounts of oil, gas, and mineral treasures.

Oman is the only GCC member located outside of the Persian Gulf, and it is near the Strait of Hormuz. One-fifth of the world's oil production and liquefied gas transit through the Strait of Hormuz, which is strategically located at the entrance to the Arabian Gulf and between the Arabian Gulf and the Indian Ocean. It is also the world's oldest and most significant maritime commerce route. Oman's hydrocarbon reserves are lower than those of its neighbours, yet oil and gas are nonetheless vital to the country's economy.

Oman has made infrastructure investments in an effort to take advantage of its advantageous location and establish itself as a hub for global logistics. The Oman Vision 2040 will continue to place a significant emphasis on diversification, privatisation and Omanisation in order to fulfil its short- and long-term strategic development goals.

Over the past centuries, the Sultanate of Oman has sought to consolidate and strengthen its economy by harnessing its various resources. Oil and gas have become the mainstay of the economies of the Gulf countries, including Oman. Since the oil and gas sector accounts for a large portion of Oman's economic growth and government revenue, changes in the sector can have a significant impact on the Sultanate's overall progress.

The Ministry of Energy and Minerals of Oman has made significant



efforts to achieve various goals connected to developing and improving the performance of the oil and gas sectors. Despite recent progress in diversification initiatives, hydrocarbons activity continues to attract a sizable portion of local and international investment, and this pattern is expected to continue for some time.

SULTANATE OF OMAN OIL EXPLORATION

The Sultanate of Oman faced numerous obstacles and challenges during the discovery and extraction of crude oil reservoirs. Irish geologist, George Martin Lees, began looking for oil in the Sultanate of Oman in 1925, under the rule of Sultan Taimur bin Faisal, after surveying the region from the north of the country to the southeast coast of the Arabian Peninsula to the Dhofar Governorate. George worked with D'Arcy, which received a mining licence for a two-year renewable period. Although the primary motivation for founding the parent firm "Anglo-Persian" was oil exploration in Iran, D'Arcy was created as a subsidiary of the Anglo-Persian Oil Company (currently British BP) exclusively for crude

exploration in Oman, and due to the difficult geological nature and the unstable political situation in the Arabian Peninsula and its inability to find oil, it withdrew in 1928.

In 1937, an oil exploration concession was granted to the 'Oil Concessions Company Limited,' which entrusted the concession to the Oman Oil Company and Dhofar during the reign of Sultan Said bin Taimur, and the operations did not reveal the presence of oil. In 1951, the Dhofar concession was terminated, the name of the company was changed to Petroleum Development Oman Limited, and a second exploration concession was awarded to the "City Service" American company, which had worked for the Dhofar City Services Company, which included a franchise in the Dhofar Governorate.

Oman used alternative methods of exploration, such as seismic surveys, and as the security situation improved, the nation ultimately found oil resources. It was reported that oil had been discovered in the fields of Jebal and Natah in commercial amounts in 1962, and the Fahud field in commercial proportions two years later.

In 1966, a significant crude oil pipeline between the Fahud field and Mina al-Fahal was built. On board, the Japanese tanker Moss Prince, the first shipment, which contained 543.8 thousand barrels and cost \$1.42 per barrel, was exported in 1967. In 1970, the average daily production of crude oil was 332,000 barrels.

The Sultanate's government acquired a 25% stake in Petroleum Development Oman (PDO) in 1973, increasing it to 60% a year later. In 1980, a Royal Order was issued to alter PDO's legal form to that of an Omani limited liability corporation, and in 1982, work at the Al Fahal port's Oman Oil Refinery got underway. In 1996, the government-owned Oman Oil Company was established to invest in the energy sector inside and outside the Sultanate, and the average level of crude oil production in 2001 reached 956,000 barrels per day (bpd) produced from 2,546 wells. The Sohar refinery began its production in 2006, and in 2007 the two refineries were merged by royal decree under the name of Oman Refineries and Petrochemical Company.

The average daily production of crude oil and oil condensate was

OMAN ASPIRATIONS



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around 955,000 barrels per day at the end of December 2016. The Sultanate reduced its oil production by 45,000 barrels per day (bpd) in January 2017 after Opec signed a deal with independent producers that were not members of Opec. 2020 saw the signing of four new oil contracts, the first of which was for the 9,546 square kilometre No. 12 Concession Area with the Thai business (PTITIP) and the French corporation Total Exploration and Production. For the 4,557 square kilometres of concession area No. 58, Tethys Oil Co. signed the second agreement. For concession area No. 36, IUG Resources signed the third agreement. For concession area No. 70, Maha Energy signed the fourth agreement.

Oman is now the Middle East's largest oil producer outside of Opec, with approximately 150 oil and gas fields. The majority of which are small, more complex, and expensive compared to their counterparts in other Gulf countries. Even though Oman relies on fossil fuels, it did not join Opec. Instead, it joined the Opec + alliance, which also has some crude producers that are not in Opec.

OMAN'S OIL PRODUCTION

Oman complies with Opec+ regulations despite having the ability to produce up to

a million barrels of crude oil and condensates per day. Oman's oil reserves are primarily made up of heavy crude, and China is its main export destination. 30% of Oman's GDP is derived from the oil and gas sector, which also provides the government of Oman with 70% of its annual budget through taxation and joint ownership of some of the more productive fields.

The Sultanate of Oman's oil output made a stunning recovery in 2022 following the record production cuts implemented by OPEC+ starting in mid-2020 as a result of the Corona crisis that rattled the world's energy markets.

During the first half of last year (2022), Oman's oil sector saw an increase in production and exports of that fossil fuel as the nation continued to profit from rising worldwide market prices. During the first half

of the year, Oman's output of crude oil and condensate grew by 10% compared to the same period last year (2022). Oman's crude oil reserves, according to the Ministry of Energy and Minerals (MEM), were estimated to be 5.2 billion barrels in June 2022. Additionally, according to MEM, new oil finds will raise Oman's production by 50,000 to 100,000 barrels over the course of the following two to three years.

The sector suffered greatly from the 2020 oil price decline, but it has recovered as oil prices have risen above pre-pandemic levels. Oman's Ministry of Energy and Minerals previously cited adherence to the Opec+ alliance pact to achieve a balance between supply and demand on a global scale as the reason for the Sultanate's decreased oil production. The nation took part in the Opec+ alliance deal, which was made public

in the middle of 2020, and lowered oil supplies by a record 9.7 million barrels per day in order to balance out the world markets after the effects of the pandemic. However, the alliance decided to gradually reduce the cuts with economic recovery until they were completed in August 2022.

Based on typical oil prices of \$50 per barrel, Oman's government budget estimates \$27.6 billion in revenue, with oil accounting for 42% of total revenue. The government recorded revenues of \$17.4 billion (and a \$2 billion surplus) in the first half of 2022 based on an average oil price of \$87 per barrel, and it is on track to produce its first annual surplus in ten years. Notably, the Sultanate of Oman increased its production volume from 0.957 million barrels per day in 2020 to 0.964 million barrels per day in 2021, placing it eighth among the top oil-producing Arab nations.





HYDROGEN ON TRACK TO REPLACE DIESEL LOCOMOTIVES

BY PAUL DAY

Hydrogen will likely replace diesel-powered railway locomotives wherever full electrification is difficult or too expensive as it offers an emission-free, quiet alternative that can be economically competitive, say developers.

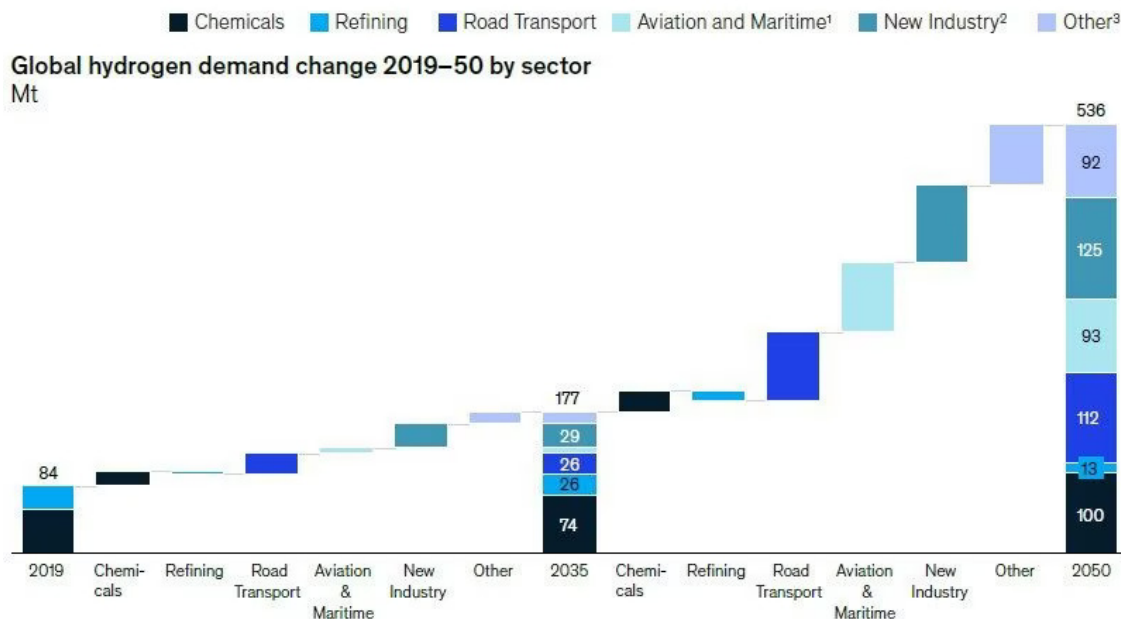
This summer, Alstom announced the creation of the first fully hydrogen-fueled passenger train route in Bremervorde, Lower Saxony, Germany with 14, two-car Coradia iLint vehicles equipped with fuel cell propulsion. They will replace 15 diesel-powered trains currently running on the line.

The trains, which have a hydrogen tank with a range of 1,000 kilometers and a maximum speed of 140 km/h, will be fueled daily at a Linde hydrogen filling station. One kilogram of hydrogen replaces around 4.5 litres of diesel fuel, says Alstom.

"As a pioneer in hydrogen powered trains, we are building the foundation for the future industry. Coradia iLint is an illustration of a historic step towards sustainable mobility since it is the first passenger train in the world powered by hydrogen and is now in commercial service in Germany," says Vice President of Regional Rolling Stock Platform at Alstom Brahim Soua.

Alstom presented the Coradia iLint for the first time at InnoTrans 2016 in Berlin before the trains entered into commercial service in

GLOBAL HYDROGEN DEMAND CHANGE 2019-50 BY SECTOR



Germany in 2018.

The company currently has three other contracts for hydrogen fuel cell powered regional trains including another in Germany servicing the Frankfurt metropolitan area with 27 Coradia iLint commuter trains.

In Italy, Alstom is building six Coradia Steam hydrogen trains in the Lombardy region, with the option for eight more, and in France the company will supply 12 Coradia Polyvent hydrogen trains shared across four French regions.

“Alstom’s ambition is to contribute to the decarbonization of railways by deploying its emission free solutions, hydrogen in particular. Several discussions are progressing for hydrogen applications not only in Europe, but also in North America and Middle east,” says Soua.

“For short range, battery trains should fit the need, and for applications where the range is key, hydrogen is the best solution.”

However, Soua notes that a central goal for the company is to make the hydrogen ecosystem more competitive.

According to Alstom, the hydrogen fleet becomes a more favorable business case after nearly 15 years thanks to the lower maintenance costs and despite hydrogen trains needing a 30%

higher investment than diesel.

A lack of refueling infrastructure is also a major hurdle for the adoption of the technology and Alstom has signed multiple active partnership agreements which focus on the infrastructure for production, transportation, and management of refueling stations, including two consortiums in Germany, with Linde and with Infraser, in Italy with Snam, and in France with Engie.

GLOBAL HYDROGEN DEMAND CHANGE 2019-50 BY SECTOR

1. Aviation and maritime include direct use of hydrogen and hydrogen-derived synfuels including kerosene, diesel, methanol, gasoline, and ammonia. The category also includes some hydrogen-derived synfuels in road transport 2. New industry includes all new uses of hydrogen in Industrial processes, eg, iron and steel production, whereas chemicals and refining are traditional hydrogen uses 3. Other includes buildings and electricity generation Source: McKinsey Energy Insights Global Energy Perspective 2022

FILLING THE TANK

Refueling infrastructure is key

to the success of any hydrogen transportation solution, and Linde inaugurated the world’s first hydrogen refueling system for passenger trains, with 64, 500-bar high pressure storage tanks and a total capacity of around 1,600 kg of hydrogen a day, as part of the Bremervorde project.

Linde operates the world’s first high-purity hydrogen storage cavern plus pipeline networks of around 1,000 km worldwide, and has installed 200 hydrogen fueling stations and over 80 hydrogen electrolysis plants worldwide.

The Bremervorde trains run along a single 123 km track, so the single refueling site avoids transporting hydrogen to multiple locations.

“It’s almost like a back-to-base set up. You can build one big station and fuel the trains in one spot, so you don’t have to build multiple fueling sites,” says Vice President of clean energy at Linde David Burns.

“Even though it’s the biggest fueling station in Europe, we were able to site it so we could fuel the trains in a reasonable amount of time and fuel them back-to-back as well, so we don’t have to wait between fueling, which is key. We’re looking at this as a good model for similar suburban rail networks going forward.”



In Europe, many suburban commuter train networks use diesel and as such would be good candidates for conversion to hydrogen, a lower cost option than electrification.

Diesel trains in the United States meanwhile are often long-distance freight trains, which pose different logistical challenges when it comes to refueling.

"In the United States, (freight trains) tend to have multiple engines, so you need to be able to get enough hydrogen on board to be able to go long distance and haul from 50 to 100 rail cars. In terms of hydrogen demand it'll be much larger," says Burns.

"We are working on potential solutions for this. For example, do we have to look at liquid hydrogen on board and not gas?"

Liquid hydrogen has been used for many years as fuel for rocket applications by NASA and, given

its high energy density, can be used to optimize the supply chain as demand grows.

With a single truck able to deliver 5 tons of liquid hydrogen at a time, Burns sees liquification being key for a distribution network going forward.

GOING GREEN

The trains in the Bremervorde project are, in themselves, emission free, but the hydrogen to power them is currently by-product sourced from local industrial processes.

Linde says its refueling system has been specifically designed and constructed with the ability to integrate future on-site green hydrogen generation.

In January, the company announced it had signed an agreement with Yara for the construction and delivery of a 24 MW green hydrogen plant, the

second of such plants with the first currently being built at Linde's Leuna Chemical Complex in Germany.

The proton exchange membrane (PEM) based electrolyser will have a capacity of around 10,000 kg a day, says Linde.

"That's the site (Leuna) we will be using initially to supply a ferry in Norway that's going to be using green hydrogen. In the longer term, as demand grows across Germany, we'll be building other sources of green hydrogen production closer to demand," says Burns. — Reuters

The author, based in Toronto, Canada, writes about nuclear power and hydrogen.

GREEN HYDROGEN: A HYPE OR REALITY IN THE ENERGY TRANSITION?

ENERGY TRANSITION is a big buzzword, and many countries are at the crossroad of making some important decisions to achieve net zero, invariably by 2050. Oman is on a historic journey on the energy transition path with the recent establishment of a Directorate of Renewable Energy & Hydrogen. This is further been reinforced with the creation of Hydrom, which acts as an orchestrator of the green hydrogen

tender & auctioning of land with award planned at end of Q1 2023. The hype and fanfare of hydrogen in Oman seems to be a reality and is being fast tracked. Green hydrogen is indeed being weaved into the energy fabric of Oman.

The reality is more evident with Oman hydrogen demand, echoed by the government, as indicated in the table below:

Year	Green Hydrogen production	Electrolyser Capacity	Renewable Capacity
2030	1 mtpa	10 GW	20 GW
2040	3.5 mtpa	40 GW	75 GW
2050	8 mtpa	100 GW	185 GW

Source: Hydrogen R&D Roadmap workshop, Hydrom

At this juncture we need to cross over some hurdles or perceived barriers to ensure the transition path is smooth, cost effective and sustainable. Oil and gas resources has historically been the main GDP contributors in Oman and will continue play a pivotal role. However, we need to abide to the Paris protocol and reduce our CO2 emission. The sustainability and environment vectors are key ingredients coupled with energy efficiency, technology and not limited to, are key drivers to trigger a green hydrogen economy.

In a recent workshop conducted on February 1, 2023 on developing R&D roadmap for Oman's hydrogen value chain was indeed a step in the right direction. It was a platform where academia, industry and the government brainstormed and challenged on key topics on the technical and socio-economic pivots. The workshop provided a good funnel and grounding to push green hydrogen in the context of Oman trying to be a fast mover. The focus of the hydrogen value chain was divided into 3 interlinked scopes — production, handling and end use. This in itself is complex and cannot fully be covered. Albeit it shows the importance of getting every facet, barriers and solutions on the table for the relevant stakeholders to contribute and make the value chain successful and fit for purpose.

On the onset, the workshop took a "thermometer reading" with perceived barriers to a cost-effective production of green hydrogen. The list includes renewable and high technology cost, electrolyser system process cost, policies, regulation and securing offtake. These barriers become opportunities and the work is already on the anvil to encourage investors with an anticipated policies and national energy strategy to be released soon. Additionally,

R&D topics were requested from participants to find Oman's top priorities. To this end, it was suggested to research on full scale electrolyser demonstrator, study on the value chain blue and green hydrogen, improve safety on Liquid Organic Vessel Carriers (LOHC), materials as input for electrolyzers, compatibility of water for electrolyser and study of having an optimal mix for renewables (energy mix). This list was quite extensive and only a few will progress to the research stage. At high level, the participants looked at pricing, technology, resources, safety/reliability, infrastructure and efficiency of energy conversion as R&D studies to be done.

It is worth noting that social aspects and in-country value for hydrogen production was discussed. It was emphasized the importance of raising awareness of hydrogen. Currently there is some lack of knowledge in this area. A higher level of training and upskilling is required. This was targeted for vocational, education and higher education to increase knowledge, provide relevant syllabus, encourage innovation and possibility of having a Centre of Excellence.

In summary, Oman is at the crossroad of the energy transition and hydrogen whether blue or green, will play a crucial role in the country, with key projects coming online from 2030. The challenge is on key players to do their part and bring a sustainable hydrogen value chain. The government, industry, academia and investors need to unite and tap into Oman's unique benefits of having abundant solar energy, wind, land and other resources. Indeed, the right policies and regulations will be fundamental to jump-start green hydrogen and contribute to the energy transition. I think hydrogen is becoming a reality in the energy transition and the question is food for thought.



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CLEAN ENERGY IN THE MIDDLE EAST

WHY THE GULF'S OIL POWERS ARE BETTING ON CLEAN ENERGY

Aramco, ADNOC and others are placing
multidollar-billion wagers on the energy transition



The United Arab Emirates sits on a rich fossil bounty. ADNOC, the national oil company, is one of the world's top hydrocarbon producers. Two months ago the UAE hosted some 140,000 delegates at the planet's largest oil-and-gas jamboree. Against the backdrop of the worst energy crisis in decades, you might have expected much gloating about how the Persian Gulf's carbon-spewing exports helped avert a bigger shock. That made the keynote address by Sultan Al Jaber, the UAE's minister of industry, all the more remarkable. Mr Al Jaber repeatedly highlighted the importance

cut emissions by a quarter by 2030 relative to a scenario that assumes business as usual. All of the Gulf countries have signed the Global Methane Pledge, which commits them to reduce emissions of that potent greenhouse gas. The UAE will even host the annual UN climate summit in 2023.

Some suspect this is greenwash: all soothing noises and toothless targets after years of denying climate science and obstructing efforts to tackle global warming. On this view, the Gulf's governments are too reliant on the revenues generated by the national energy firms — which account for a big

world's biggest energy firms go technologically and strategically, their state-run peers often follow.

The Gulf oil champions' approach rests on two pillars. The first is deep brown: it involves doubling down on oil and gas. Bolstered by high crude prices, the region's energy firms are investing heavily to expand output. Aramco's capital expenditure in 2022 will come to \$40bn-50bn. It is promising even bigger sums in the next few years, as it aims to lift its oil-production capability from roughly 12m barrels per day (b/d) to 13m by 2027. ADNOC will spend \$150bn on capital projects by 2027 with the goal of boosting



of greening this brownest of industries. "ADNOC is making today's energy cleaner while investing in the clean energies of tomorrow," he intoned.

In the past, the grandees of the Gulf's energy industry limited themselves to defending fossil fuels. Now many, like Mr Al Jaber, profess a commitment to decarbonisation. Saudi Arabia and Kuwait have announced targets of net-zero emissions of greenhouse gases by 2060. The UAE and Oman say they will get there by 2050. Qatar has no net-zero target, but it will

share of state budgets — to be serious about decarbonisation. Yet an examination of the leading companies' investment plans reveals a genuine — and in some cases rather large — bet on green technologies.

This is worth scrutinising, because the firms behind the effort matter beyond their region. National energy companies in other parts of the world look to the Gulf behemoths, and especially to ADNOC and Saudi Aramco, the Arab kingdom's oil colossus, as examples to emulate. Where two of the

capacity from roughly 4m to 5m b/d. Qatar Energy will plough \$80bn between 2021 and 2025 into expanding production of liquefied pure gasoline (LNG) by two-thirds by 2027.

For most energy firms, doubling down on fossil fuels during the transition to a carbon-constrained world would be financial folly. Every national oil company in the world "wants to be the last one standing", observes Patrick Heller of the Natural Resource Governance Institute, an American NGO. Naturally, "not all of them can



be.” The Gulf giants, with their vast, low-cost reserves, are the likeliest to prevail. As such, their huge investments in new production could pay off, Mr Heller thinks, “even if global demand declines dramatically in the years to come”.

Oilmen betting on oil is nothing new. But the Gulf giants’ newest wagers suggest they not have their heads within the sand about the future of oil demand. They are keenly aware that their best customers in the developed

world are going to crack down on carbon emissions, argues Mariam Al-Shamma of S&P Global, a research firm. Policies just like the EU’s carbon border tax, the details of which member states approved on December 18th, are a sign of things to come. “To be the last producer standing, you need more than just the lowest cost,” Ms Al-Shamma says. To ensure their longevity, the Gulf’s oil champions also intend to be the cleanest producers of fossil

fuels.

They enjoy a natural advantage. Their hydrocarbon reserves are among the least carbon-intensive to extract. The Emiratis and the Saudis have also made an effort to reduce this carbon intensity further with high operational efficiency and low gas flaring, notes Olga Savenkova of Rystad Energy, a research firm. ADNOC is spending \$3.6bn on subsea power cables and other kit to replace natural gas burned



at its offshore facilities with clean energy from onshore. This is both green and potentially, good business. Ms Al-Shamma reckons that grades of crude made with fewer emissions will fetch a premium, a trend already seen in the LNG market.

The second pillar of the Gulf's technique is more intriguing. It involves investing a part of today's fossil windfall in the clean-energy technologies of tomorrow. The region's governments are making some of the world's biggest bets on carbon capture and storage, renewables and hydrogen. "A wave of low-carbon projects is building in the Middle East,"

marvels one analyst.

"Saudi Arabia holds major advantages in decarbonisation," says Jim Krane of Rice University in Texas. He points to vast tracts of empty, sunny land with a geology tailor-made for storing carbon emitted in adjacent industrial areas. Aramco plans to develop capability to capture, store and utilise 11m tonnes of carbon dioxide a year, and to install 12 gigawatts (GW) of wind and solar power by 2035.

Overall, Saudi Arabia aims to build 54GW of renewable capacity by 2032. Not to be outdone, the UAE is eyeing 100GW of renewable-energy capacity by 2030, at home and abroad, up from a cumulative investment in 15GW-worth in 2021. That would make Masdar, a state-controlled clean-energy outfit in which ADNOC has a stake, the world's second-biggest developer of clean energy. It recently bought a British firm developing energy-storage technology.

The Gulf's greatest green bets concern hydrogen. If it is made using renewables as opposed to natural gas, hydrogen is a clean fuel. Investments in the needed infrastructure are proliferating the world over, from Gujarat to Texas. In 2021 the UAE inaugurated its region's first such "green hydrogen" plant. ACWA Power, a Saudi utility, has almost completed financing for a \$5bn green-hydrogen project. Oman, whose oil reserves are smaller and costlier to exploit than these of its bigger neighbours, is talking of a \$30bn funding in what could be the world's largest hydrogen plant. It has launched a state-owned

hydrogen entity to supply green-hydrogen projects concessions in its special economic zones.

The Saudis and Emiratis are also looking abroad. Masdar is investing in a \$10bn hydrogen venture in Egypt; developing 4GW of green-hydrogen and renewables projects in Azerbaijan; and has invested in a firm working on green hydrogen in northern England. ACWA Power is eyeing multibillion-dollar green-hydrogen projects in Egypt, South Africa and Thailand. By 2030 both the UAE and Saudi Arabia want to control a quarter or more of the global export marketplace for clean hydrogen.

Ben Cahill of the Centre for Strategic and Worldwide Research, a think-tank, sees the two countries moving aggressively on hydrogen and ammonia (which can serve as a less fiddly medium to transport the gas). They want to acquire first-mover advantage by securing deals with buyers from Asia and Europe. Qatar is spending greater than \$1bn on a plant to make "blue ammonia" from natural gas. It is scheduled to open in 2026. If the hydrogen economy takes off, estimates Roland Berger, a consultancy, it could produce between \$120bn and \$200bn in annual revenues for Gulf countries by 2050. That is far less than they now make from oil and gas; Aramco alone had sales of more than \$300bn within the first half of 2022. But it is serious money —and, given the real risk of an end to the oil bonanza, suggests that the Gulf's green efforts ought to be taken seriously.

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