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ARAB NEWS

The role of hydrogen in tackling climate change in MENA

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EXECUTIVE SUMMARY

Saudi Arabia will this month host a three-day event, focusing on sustainability, that includes the official launch of the Saudi Green Initiative and the Middle East Green Initiative, and the Youth Green Forum.

Running from Oct. 23 to 25 it will stress the need for more ambitious energy-transition efforts, both at the national and regional levels, given that the Middle East and North Africa is one of the regions most vulnerable to the effects of global warming. By 2050, temperatures in the region will be 4 degrees Celsius higher on average, with longer and more frequent heatwaves, and increases in wildfires, droughts and other extreme events.

Dialogue, consensus, and cooperation are therefore needed to develop large-scale solutions to climate change by mitigating the risks and adapting societies to a net-zero world by 2050, while also generating economic value.

One of the potential solutions that is increasingly occupying policy and economic spaces is hydrogen: green-hydrogen projects worth an estimated $42 billion are planned across the region. While hydrogen is already used in industrial sectors, such as petroleum refining or fertilizer production, if efficient methods of decarbonized hydrogen production can be developed the gas could play a significant role in the energy mix of a region still heavily reliant on fossil fuels.

Hydrogen is considered a disruptive innovation for oil-producing countries and for those rich in solar and wind resources on their path to net-zero emissions by 2050. It would help to create more-flexible power sectors that would otherwise be reliant on less-predictable renewable-energy sources in a carbon-constrained world.

A hydrogen sector would also draw on the historical know-how and skills of the hydrocarbons industry, thus safeguarding jobs while creating new ones in the growing industry itself and in research and development centers. Hydrogen expertise would also position these countries as key global suppliers and exporters.

Nevertheless, this glossy picture cannot be painted without reforming policy and economic sectors, and without addressing technical requirements. Most notably, interconnected electricity grids would be needed in the region to exploit the full potential of hydrogen, and should be a high priority on the agenda of the Middle East Green Initiative.

Joint efforts are necessary for the transition to be successful, and showcasing aligned strategies in November during COP26, the UN Climate Change Conference, will truly position the MENA states as reliable and leading partners in the fight against climate change.

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INTRODUCTION

Countries in the Middle East and North Africa have embarked on the transition from fossil-based to zero-carbon energy during the past decade[1], and the next 10 years should be decisive in terms of action plans to mitigate the effects of climate change. While the region's superiority in renewable energy, especially solar, is being exploited[2], hydrogen is a key tool to further enhance climate ambitions and decarbonize more deeply.

THE ISSUE: A REGION HIGHLY VULNERABLE TO CLIMATE CHANGE

Between 2030 and 2052, the Earth could become 1.5 C warmer, with the increase rising to 3 C by 2100[3]. The MENA region is already warmer on average and experiences very little rainfall compared with countries elsewhere, and global warming is accelerating this trend: by 2050, temperatures in the region will be 4 C higher[4].

However, the impact of global warming is not only about higher temperatures. The most recent UN report on climate change warns of a "Code Red" scenario[5] in which extreme weather events are expected to trigger massive population displacements because of heat-stress conditions that will be incompatible with human survival.

Green hydrogen certainly might offer MENA countries ways to move away from the fossil-fuel industry

In the Gulf, the combination of heat and relative humidity has the potential to be "deadly if the human body is unable to cool off through sweating[6]." Wildfires similar to the ones that occurred this summer in Lebanon and Turkey[7] are also becoming more frequent, while Oman and Iran recently experienced a wholly untypical cyclone, which claimed 13 lives[8].

Such events, and others, demonstrate just how fragile the region is from an environmental perspective. Add to that social, political and economic instability, population growth and a lack of interregional dialogue, and the picture for 2050 could be even gloomier than predicted.

Further, the region is still heavily reliant on fossil fuels in its energy mix, whether for power generation, mobility or industry[9]. Hydrocarbons remain a primary source of economic activity and revenue for Gulf states and other countries, and are the foundation of energy security for all states in the region.

Hence, the MENA region is also facing a societal challenge, requiring transformative shifts in ways of producing goods and services, consuming them and in living standards, to reduce its carbon footprint.

The world has embarked on a path to net-zero carbon emissions by 2050, and MENA countries have been at the center of discussions with the International Energy Agency[10], for instance, to ensure a fair energy transition, as oil-producing countries are poised to lose in the process.

The recent spike in oil and gas prices is a disincentive for these countries to move away rapidly from reliance on fossil fuels. Nevertheless, their climate ambitions have been renewed during recent meetings, such as the 2020 G20 summit, and the upcoming COP26 should be the moment of truth.

Setting aside the political discussions and negotiations, though, without disruptive innovation to match the drastic need to change, the goal of net zero will remain unattainable.

HYDROGEN'S POTENTIAL IN MENA: $42 BILLION[11] OF GREEN-HYDROGEN PROJECTS PLANNED

Boasting some of the world's largest solar projects and a burgeoning wind-power sector, the region is well known for its renewable-energy capabilities. In addition to being environmentally friendly, renewables offer energy security and inexpensive operating costs. However, focusing only on renewables without back-up methods of electricity generation could backfire when they do not yield enough power to match demand[12].

Climate change could increase further the variability in supply-and-demand dynamics; there might be a surge in cooling demand due to longer heatwaves, for instance. Traditional flexible power sources, such as coal or natural-gas plants, have been used to rapidly scale production but these are limited options in a carbon-constrained world. Some countries, such as the UAE, have turned to nuclear energy to guarantee baseload power, the minimum required by the grid, throughout the year. However, such programs represent a massive investment in time and cost, require extensive security procedures and place a strain on water resources.

Some countries have invested in Concentrated Solar Power, a photovoltaic system that can store energy using molten salt for up to seven hours. Morocco's Noor Ouarzazate plant is one example. But CSP comes at a higher cost than traditional photovoltaic systems and requires larger areas with specific climatic conditions[13].

The future of energy storage is therefore more often associated with the development of either electrochemical (batteries) or chemical (hydrogen) solutions. Batteries have shortcomings regarding, for example, long-term storage and the integration of large renewable plants into national grids.

As the share of renewable energy increases, the storage capacity of batteries currently on the market could be insufficient to address pronounced seasonal variability in renewable-energy output. In fact, to date the largest battery system in operation for large-scale renewables plants is a 300MW/1,200MWh system in the US, which has a four-hour discharging time[14]. Moreover, batteries do not allow for the electrification or decarbonization of hard-to-abate sectors such as the steel, cement or concrete industries[15].

The other storage option is hydrogen — but it is not an energy source, it is a carrier. This means that energy from renewables, fossil fuels or nuclear energy will be used to produce it. Hydrogen is a clean fuel, as its combustion only results in water vapor. It can be stored and distributed as a gas or as a liquid and this versatility allows its deployment to be context specific.

Currently, 98 percent of hydrogen production in the world uses fossil fuels — so-called "grey hydrogen" — by binding natural gas with carbon molecules using a steam reforming process that emits excess carbon dioxide and heat. For every ton of fossil-based hydrogen produced, 10 tons of CO_2 are emitted[16].

In contrast, when it is produced using renewable energy via electrolysis (the separation of di-hydrogen and oxygen atoms using electricity), "green hydrogen" is obtained. Green hydrogen is therefore the cleanest to produce and can become a substitute for fossil fuels in the transport sector, replacing hydrogen produced from fossil fuels in the industry or as a way to store electricity obtained from renewables. This is because 1 GW of electrolyser capacity yields between 40,000 and 100,000 tons of hydrogen a year, thus avoiding 400,000 to 1,000,000 tons of CO_2[17].

Other hydrogen-production options are being tested, such as "pink hydrogen," which is produced through electrolysis using electricity sourced from nuclear energy, or "blue hydrogen", which is grey hydrogen produced with a system that captures the greenhouse gas emitted and stores or sequesters it[18].

Currently, grey hydrogen is the cheapest version to produce, at an average cost of $1.50 a kilogram. Then comes blue at

> *Without disruptive innovation to match the drastic need to change, the goal of net zero will remain unattainable*

between $1.50 and $2.50 (based on a natural gas price of $1.10/MMBtu), and green at between $4.50 and $6[19].

Hydrogen might not be the final product, though; it can be bonded with nitrogen to produce ammonia, a liquid used in fertilizers. Why focus on ammonia, rather than pure green hydrogen? Ammonia has historically been at the core of fertilizer and refrigerant production, resulting in a robust supply chain and safety procedures for handling it. It is easier to liquefy than hydrogen, and therefore to transport over longer distances, and, as with hydrogen, the combustion of ammonia does not result in greenhouse gas emissions[20].

The transportation advantages open up the potential for shipping it internationally from low-cost production sites to locations with high demand for hydrogen. Indeed, the strategic locations of some MENA countries will position them as major exporters to European markets. Moreover, ammonia can serve as long-term seasonal storage as it has a higher volume, resulting in lower energy losses.

The MENA region has a clear economic advantage in producing green hydrogen. Cost variations in the production of hydrogen are linked to initial investment in electrolysers and, most importantly, electricity prices: When the cost of generating power is lower, the cost of producing hydrogen is lower.

Currently, grey hydrogen is the cheapest version to produce worldwide — except in the Middle East and North Africa. Because countries in this region have some of the best solar irradiation in the world[21], solar-energy projects can achieve record-low costs.

In April 2021 in Saudi Arabia, for example, the 600MW Shuaibah solar plant was awarded a world record low purchase-agreement price for solar of $1.04 cents/kWh[22]; in 2020 the previous record holder was Abu Dhabi's 2GW Al-Dhafra project, at $1.35 cents/kWh.

This easily positions green-hydrogen production costs on a par with grey at $1.50/kg by 2030, when most projects in the region will be completed, which is the current production cost for grey hydrogen without carbon taxes[23]. The price in the region in 2030 should also be below the expected $2-$3/kg world average for green-hydrogen production.

Other technical considerations that are reassuring for several MENA countries concern the storage of hydrogen. The most common option is in a liquid state, as ammonia, at an average cost of $2.83/kg. But at $1.90/kg, storage in depleted gas fields is also a relatively cheap option, and represents an opportunity for countries in which fields are drying up[24].

The region has embarked on a path toward climate neutrality by 2050 supported by great potential

Moreover, the historical know-how acquired by oil and gas producers can be reemployed in the hydrogen business, as the gas is widely used in industrial processes such as petroleum refining or methanol production. In this respect, blue hydrogen represents one such opportunity to repurpose hydrocarbon skills and resources while mitigating emissions.

Blue hydrogen is obtained mainly from natural gas, using a system known as Carbon Capture, Utilization and Sequestration to capture the CO2 emitted during production. Saudi Aramco is a clear leader in this field. In September 2020, Aramco produced and shipped 40 tons of blue ammonia[25] from Saudi Arabia to Japan, destined for zero-carbon power generation, in a first-of-its-kind demonstration of new supply-chain dynamics at the heart of the energy transition. Therefore, with the acquisition of a 70 percent stake in Saudi Basic Industries Corporation last year, Saudi Arabia is transforming its asset base and becoming the third-largest exporter of ammonia in the world.

The region has embarked on a path toward climate neutrality by 2050, supported by great potential, clear ambition and an impressive array of green-hydrogen projects worth $42 billion.

The most impressive of these is on the Red Sea coast, where Saudi Arabia is building NEOM, an ultramodern smart city expected to open by 2025. NEOM, which promises to transform the Kingdom into a global hub for innovation and industry, is the country's driver for an oil-free future.

In the Tabuk province where it is situated, the climate is on average 10 C cooler than in other Gulf Cooperation Council countries, and the megaproject has been designed to run 100 percent on solar and wind energy. A total of $500 billion will be spent to build the city on an area of land as large as Belgium, in the process mobilizing international interest and investment, especially in the green-hydrogen field.

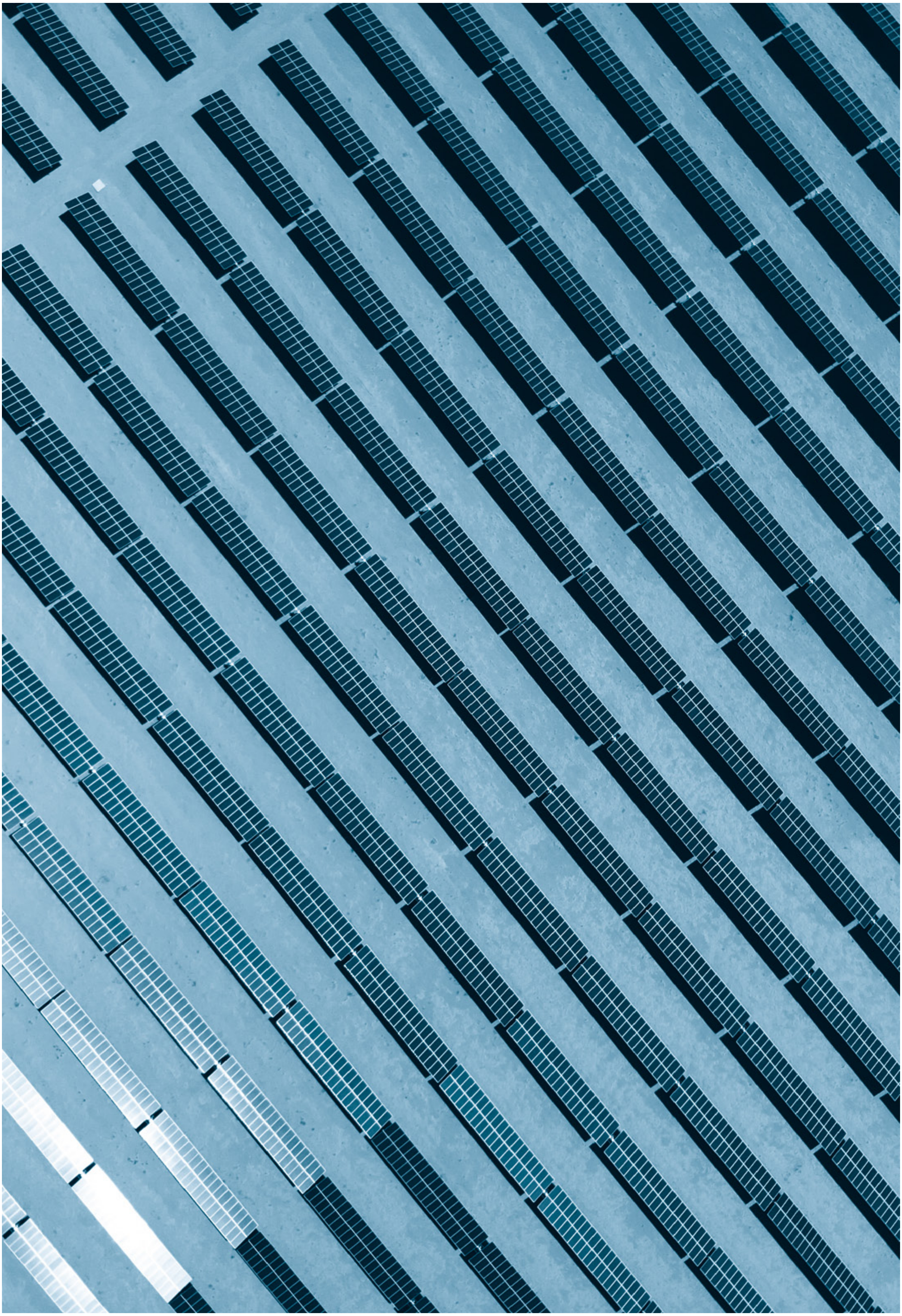
NEOM has a production target of 1.2 million tonnes of ammonia a year, which would make it the world's largest producer, thanks to a 4 GW planned capacity of renewables and plans to join the ranks of the top ammonia exporters to Europe[26].

In Oman, meanwhile, an international consortium was formed in May to develop a $30 billion green-hydrogen project. Powered by 25 GW of solar and wind energy, when at full capacity, by 2038, 1.8 million tonnes of hydrogen and up to 10 million tonnes of green ammonia will be produced annually, mainly for export to Asian and European markets.

THE HYDROGEN RAINBOW

Hydrogen type	Production method	How globally widespread?	Global production cost
Grey hydrogen	Binding natural gas with carbon molecules using the steam reforming method, emitting excess CO2 and heat. Black and brown hydrogen refer to the same process, using coal or lignite.	98 percent	2020: $0.70–$2.20/kg, average $1.50/kg 2030: $3–$5/kg
Turquoise hydrogen ("low-carbon")	Similar to grey but a lower-carbon method because it is produced by methane pyrolysis, using high-temperature heat. There are concerns about methane leaks however.	Not proven at scale	
Blue hydrogen ("low-carbon")	Blue hydrogen is produced in the same way as grey, except the CO2 emissions are captured and sequestered or stored (known as CCS technology).	1 percent	2020, natural gas: $1.50–$2.50/kg 2030: $1.50–$2.90/kg
Green hydrogen ("renewable" or "clean")	Electrolysis: water molecules are split into hydrogen and oxygen, using renewables to power the process.	1 percent	2020: $4.50–$6/kg 2030: $1.50/kg in MENA, $2–$3/kg world average.
Yellow hydrogen ("renewable" or "clean")	Similar to green, this employs the electrolysis method but using only solar energy.	Difficult to separate from green	
Pink hydrogen ("clean")	Similar to green, this employs the electrolysis method but using only nuclear energy.	Experimental, very new	

Sources: Bloomberg New Energy Finance, 2020; Hydrogen Council, 2021; IEA, 2019.



Solar panels field (solar cell) from above. Alternative energy, ecology power conservation concept. Aerial view.
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The project, which will position the sultanate as one of the world's top producers of green hydrogen, is part of the larger Oman 2040 vision for energy and economic diversification. It is also part of Oman's National Hydrogen Alliance, Hy-Fly[27], which brings together 13 institutions working to support and facilitate the production and transport of clean hydrogen for local use and export.

Morocco's green-hydrogen strategy means it is also a potentially significant player in the field. With 40 percent of the country's total electricity production coming from renewables in 2021, the country is aiming for 52 percent by 2030 and 100 percent by 2050, which means it will need to explore non-fossil storage options.

The nation has therefore been setting up favorable conditions to attract global investment and foster research and development, and is building international strategic partnerships. For example, the National Hydrogen Commission was set up in July 2020 to establish a road map and facilitate dialogue with Portugal and Germany.

Green hydrogen will also be essential in the efforts to decarbonize Morocco's fertilizer and cement industries, which are responsible for all of the country's emissions from manufacturing — 16 million tons of CO2 equivalent[28]. It will also be needed to contribute to other countries' decarbonization strategies, as it is expected to meet 4 percent of the global demand for hydrogen[29].

The €865 million ($1 billion) HEVO Ammonia Morocco, the leading project attracting global investment, aims to produce 31,850 tonnes of green hydrogen and 183,650 tonnes of ammonia a year. More projects are expected to be announced soon.

Last but not least, green hydrogen is in the spotlight at Expo 2020 Dubai[30]. The Dubai Electricity and Water Authority, Emirates National Oil Company and Siemens Energy launched the first industrial-scale green-hydrogen pilot project in MENA powered by solar energy. With 5 GW of solar capacity, producing 20.5 kg of hydrogen an hour (179,580 kg a year), it is expected to store the electricity to power the Expo's facilities. The aim of this project is to reaffirm the UAE's commitment to developing a local hydrogen economy, with research and development facilities[31].

THE WAY FORWARD

Green hydrogen certainly might offer MENA countries ways to move away from the fossil-fuel industry while decarbonizing their industrial sectors, creating jobs, and attracting global capital. Nevertheless, creating a green-hydrogen economy requires upgraded electrical infrastructure and new systems for hydrogen production to be built[32]. This includes, for example, the repurposing of transnational natural-gas pipelines to allow the injection of pure hydrogen, as well as appropriate upgrades to avoid overloading existing transmission lines as more renewables and electrolysers are connected.

In this sense, cooperation between states is essential not only in terms of research, innovation and funding, but also to build the interconnected energy system of tomorrow and advance jointly in the transition.

Investing in regional grids and electricity interconnectors between countries can contribute to resolving storage and flexibility challenges and avoid overinvestment in electrolyser capacity.

By connecting the UAE to Saudi Arabia, for example, an excess of electricity in one can be diverted to meet a surge in demand in the other. Another advantage is that countries such as Lebanon or Tunisia, which unlike Egypt, Saudi Arabia or Morocco do not have the space to develop large wind or solar complexes but are still embarking on an energy transition, can be added to an international grid.

While some interconnectors are already in place between countries in the region — including Saudi Arabia and Egypt, and the Maghreb interconnection — plans to include other Arab countries are being discussed[33].

All of these projects need a strong push, a consensus between states that the UN hoped to achieve with the latest report from the Intergovernmental Panel on Climate Change. UN Secretary-General Antonio Guterres said the report should serve as a "wake-up call" and sounds the "death knell" for coal, oil and gas, which are destroying the planet[34].

This is where the Middle East Green Initiative should play a role. This month in Riyadh, Saudi Arabia will host a three-day event focusing on sustainability as the nation takes the lead in the climate effort in the region in the most inclusive and ambitious way possible.

Firstly, the launch of the Saudi Green Initiative will set out the Kingdom's road map for climate action, which will transform the ambitions of the Saudi Vision 2030 blueprint for the Kingdom's future into concrete projects.

The wider Middle East Green Initiative should then become a catalyst for a consensus on climate action in the region, encouraging all countries to work together to scale up and unify their climate commitments ahead of COP26 in Glasgow, Scotland, in November.

FOOTNOTES

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