

ACCELERATING THE ENERGY TRANSITION THROUGH THE HYDROGEN ECONOMY



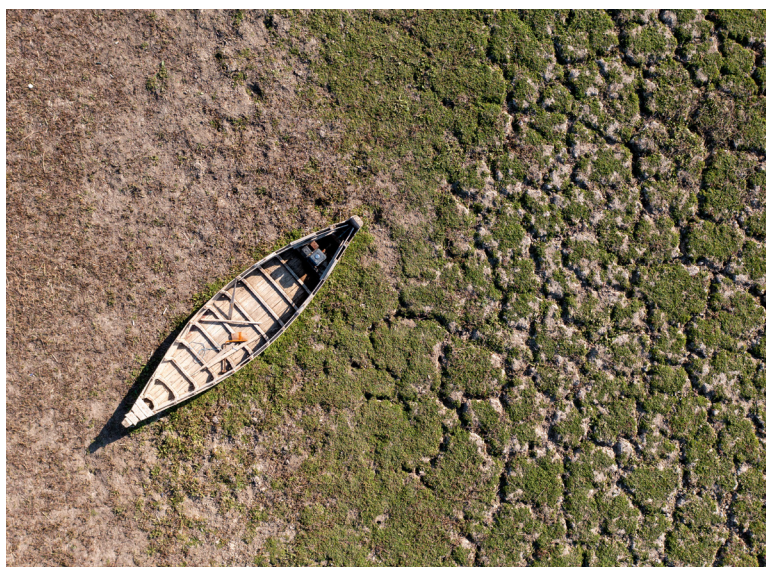
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Roundtable - Rotterdam

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Introduction

Hydrogen will form an essential element of the energy transition to a lower carbon future. Hydrogen technologies are being developed rapidly, projects are beginning to reach implementation and countries are setting out ambitious hydrogen strategies and forming partnerships in the race to deliver an effective solution to decarbonize hard-to-abate sectors such as heavy industries and transport.



“Climate change is not a region-specific challenge. It is something that is challenging all mankind. And it is high time that we all collectively and comprehensively approach this ever-threatening dilemma.”

As the world pursues ambitious but necessary carbon emissions targets, scaling up alternative energy sources and securing energy independence has never been more important. With this, we are seeing national hydrogen roadmaps and strategies published at speed. These vary on regional and country levels, based on national energy priorities, regulatory frameworks, infrastructure, and the maturity of R&D capabilities. But broadly speaking, the end goal is the same: create a clean, safe, and commercially viable global hydrogen economy.

The ambition is such with green hydrogen that over 45 countries have published (or are developing) national strategies, including the Netherlands, France, Portugal, and Canada. The UAE has recently published its own plan, as the country aspires to be one of the top producers globally by 2031. Additionally, supranational organizations such as the EU have hydrogen

strategies to stimulate supply and demand, and to build a robust pipeline of projects across the Union.

To realize hydrogen’s potential, smart and workable strategies are required. Ones that are developed with enablers in mind which account for the challenges public and private actors face – but can match our aspirations to be carbon neutral.

In January 2023, ADSW hosted the inaugural Green Hydrogen Summit which demonstrated Abu Dhabi’s vision to become a global hub for green hydrogen innovation and investment, while also providing a platform for experts from around the world to meet, exchange views, and progress the global hydrogen economy.

What was clear at the January summit is that businesses, policy makers and research



institutions need to continue to collaborate to create a clean, attractive, competitive, affordable, and achievable global hydrogen economy.

Building on this momentum, ADSW hosted a roundtable discussion at the World Hydrogen Summit in Rotterdam, Netherlands, about how we can unlock and maximize the opportunity for green hydrogen through public-private partnerships. Here are the key takeaways:

The Opportunity for the World's Most Abundant Element

Hydrogen, the world's most abundant element, has a higher energy density than other combustible energy sources. The distribution of hydrogen can be approached in a similar way to natural gas, making it suitable (to a degree) to existing infrastructure when it is adapted, particularly when it is blended with natural gas. When used directly, or in the form of derivatives, it can replace traditional energy sources with high emissions.

However, despite this promise, a global hydrogen economy has long been described as "nascent". This is due in part to the high costs of producing environmentally friendly green hydrogen and blue hydrogen. Other challenges and risks that need to be overcome include successfully scaling up production, demand creation,

pricing, standardization and certification of hydrogen, incentivizing trade and ensuring sufficient R&D advancements.

As it stands, hydrogen is competing with oil, gas and other conventional energy resources, which means that off takers might be reluctant to adopt the market risk, which could ultimately commit them to paying higher-than-normal energy costs. And the current high electrolyzer costs mean project developers entering the market are taking on the risk of increasing their expenditure, potentially making early projects less competitive as economies of scale and new technologies develop.¹

The skepticism has since, however, given way to optimism and consensus, to the extent that industry experts and government

experts alike agree that hydrogen will be a key pillar of the world's move to net zero, and central to sustainable economies.

Eventually, hydrogen use could become commonplace in transportation, industry and power generation. Hydrogen producing nations could benefit from significant profits as the export market grows and they meet demand internationally. With this comes job creation, investment, and more clean energy.

The wide array of green hydrogen uses means demand could reach as much as

30 million tons per annum by 2030, with exponential growth prospects thereafter.²

Hydrogen is also appealing for governments because successfully launched strategies mean they can attract international businesses to relocate to their countries, particularly in hard-to-abate or energy-intensive sectors. But it is vital that hydrogen strategies are embedded in and aligned to broader decarbonization efforts.



"We need to triple renewable capacity by 2030 and increase it 6-fold by 2040. We need smart government regulation to incentivize and commercialize viable alternatives for high-emitting sectors, like hydrogen and carbon capture technologies."

COP28 President-Designate and Masdar Chairman, Dr. Sultan Al Jaber, at a Joint meeting of G7 Ministers of Climate, Energy and the Environment; April 2023

Assessing Hydrogen Strategies

When forming hydrogen strategies, there are a range of factors governments must consider and address. These include production and demand creation, achieving affordability, supporting the establishment of the required infrastructure, ensuring policies and regulations have an enabling affect, and the risks associated with driving technological and R&D development.

In assessing national strategies and roadmaps in 2021, KPMG evaluated the current frontrunners in the sector, categorizing their approaches.³

Key features of states hoping to lead the industry from a technological perspective included prioritizing talent development, R&D, and favorable legislation for hydrogen technologies. Those who targeted a hydrogen import economy were investing heavily in hydrogen value chain infrastructure, focusing

² <https://masdar.ae/en/Masdar-Clean-Energy/Green-Hydrogen>

³ <https://kpmg.com/xx/en/home/insights/2021/08/national-hydrogen-strategies.html>

on the transport sector, and setting targets for heavy industries.

States orienting themselves for hydrogen export economies were targeting budgeting for infrastructure development, and boosting R&D for large-scale production.

Most interestingly for the sake of this report, the key features of markets targeting all initiatives (import, export, and R&D) had large-scale investments planned, regulatory frameworks in development (or live), and public-private partnerships (PPPs) in the production of green hydrogen.



How Geography, Geopolitics, and Economics Shape National Hydrogen Strategies:

Security, affordability, sustainability and suitability. These are just some of the factors that nations evaluate when managing their energy mix, and these same principles apply in the context of green hydrogen. However, each government's priorities differ from country to country.

Nations may look to hydrogen to reduce reliance on oil and natural gas imports. China could look to hydrogen to improve air quality by decarbonizing transport. Other markets, including MENA and Australia, are targeting export-oriented projects.

As with other clean energy sources, such as offshore wind, geography has a big role to play in the production of green hydrogen. Markets in MENA, for example, have high potential for renewable power generally including pv, which lends itself to green hydrogen production through electrolysis.

How can Governments and Business Work Together on Green Hydrogen Production?

Developing a commercially viable national hydrogen market will require significant collaboration between public and private sectors. International collaboration will be critical to enable the development of thriving global hydrogen economy.

There are clear ways that the public and private sector can partner to develop competitive hydrogen sectors and supply chains. For example, there are already a range of funding initiatives and incentive mechanisms available, which can be utilized to coordinate hydrogen-related activities. In this context, the public sector acts as a vehicle that is accelerating the shift to the commercialization of green hydrogen projects.

However, businesses who are early movers require adequate assurances that risks they take on as early movers will not price them out of competition, and that they too will reap the benefits as economies of scale are achieved and costs are reduced. Mechanisms need to ensure innovation and progress are rewarded, and that those driving the change are not bound by contracts that are no longer competitive when global production ramps up. There is also an important job to be done in ensuring taxation and levy systems do not deter the public and customers from pursuing low-carbon energies.

Private-public partnerships can also unlock national hydrogen strategies and speed up its adoption worldwide by educating the public about its benefits and potential usages. A survey conducted in 2022 found that a lack of public

education was the “biggest problem stopping the world from using green hydrogen”, followed by cost; transportation and storage technology problems; a lack of financial interest from investors or companies; compliance and certification challenges; and a lack of demand.⁴

Educating and reassuring the public about the uses and safety of hydrogen, and its derivatives will form an important part of successfully executing national strategies. Public-private partnerships can educate industries and civil society about the benefits of hydrogen and kickstart the adoption of hydrogen initiatives and implementation of hydrogen projects.



Europe's Hydrogen Valleys

The European Commission (EC) previously operated the Fuel Cells and Hydrogen Joint Undertaking (FCH JU), which developed its relationship with Europe's fuel cell and hydrogen industry and research organizations.⁵ The goal of the partnership was to accelerate the market introduction of fuel cell and hydrogen energy technologies in Europe to make energy systems cleaner and contribute to the EU's Green Deal and Hydrogen Strategy.

The FCHJU was replaced by the Clean Hydrogen Joint Undertaking, which inherited FCH JU's portfolio with the aim of progressing the value chain in Europe for clean hydrogen.

These initiatives included huge investments in so-called Hydrogen Valleys, which are defined areas – cities, regions, or industrial centers – where hydrogen applications are accelerated across the entire value chain, including production, storage, and transportation.⁶

A key advantage of developing such integrated infrastructure is the sharing of costs across projects. This can have a significant impact on reducing the capital costs of hydrogen infrastructure development. The development of integrated hydrogen valleys also provides socioeconomic benefits for areas and communities – stimulating economic development and creating jobs.

In 2021, it was estimated that 50% of projects in hydrogen valleys were driven by the private sector. Extensive collaboration and dialogue with the public is critical to the prospects of such projects. Success of these initiatives relies on:



Availability of renewable energy



Local need for hydrogen



Commercial viability



Demand among off takers



Public support (public and policy makers)



Funding

⁵ <https://wayback.archive-it.org/12090/20220602144358/https://www.fch.europa.eu/>

⁶ https://www.clean-hydrogen.europa.eu/media/publications/hydrogen-valleys-insights-emerging-hydrogen-economies-around-world_en

The success of these valleys is already accelerating progress with hydrogen initiatives across Europe. For example, in Spain, which is a global hydrogen leader, you see projects like Lacq Hydrogen, which uses solar and electrolysis to reduce the cost of power. Spain's gas pipelines are also being adapted to export hydrogen to European and international markets.⁷



This shift represents similar changes in other countries that are adopting and investing in hydrogen – the economy is moving from highly localized and subsidized hydrogen projects, towards large-scale and commercially competitive hydrogen.

But there is still more to be done. Public and private actors need to collaborate by:

- Injecting public funds, while leveraging even greater investment from private-sector actors
- Deepening cooperation between public bodies and the industry, including research facilities and organizations, to drive project innovation
- Ensuring a predictable operating environment for industry
- Stimulating the establishment of a truly global hydrogen market, including infrastructure, production, and export and import mechanisms

Country Spotlight: The UAE

As part of the UAE Net Zero 2050 strategic initiative, the country is planning to be carbon neutral by 2050, making it the first MENA nation to do so. The UAE has spent over USD\$40bn on clean energy in the last 15 years, and it plans to invest over USD\$163bn by 2050.⁸

As part of this ambitious energy and economic diversification program, the UAE sees hydrogen playing a significant role in its energy transition. The UAE is well positioned to be a regional and global leader in low-carbon hydrogen, with its geographical location, climate and existing energy infrastructure and partnerships all key enablers of successful blue and green hydrogen sectors. In addition to a strong track record in delivering successful energy projects in partnership with the private sector, the UAE's stable political, financial, and regulatory systems will encourage long-term investments.⁹

Masdar, the UAE's clean energy pioneer, is testament to the UAE's vision for green hydrogen with a firm commitment to growing the global hydrogen economy.

- In 2022, ADNOC and TAQA completed a transaction that saw them take stakes in Masdar alongside Mubadala, the UAE's sovereign wealth fund. Under this new shareholder structure, Masdar is targeting global production of 1 million tonnes of green hydrogen by 2030.
- Masdar has been a pioneer in Renewables since its foundation in 2006 and has been exploring green hydrogen production ever since.
- Masdar is active in more than 40 countries across 6 continents and has invested, or committed, in worldwide projects with a value of more than US\$30 billion.



⁸ <https://solarquarter.com/2023/03/07/uae-to-publish-national-hydrogen-strategy-in-april/#:~:text=Al%20Olama%20stated%20that%20it,hydrogen%20per%20year%20by%202050.&text=Alhanea%20reports%20that%20the%20UAE,invest%20%24163%20billion%20by%202050.>

⁹ <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/national-hydrogen-strategy#:~:text=The%20strategy%20will%20help%20accelerate,15%20mtpa%20by%202050.>
<https://carboncredits.com/uae-will-invest-54b-in-renewable-as-part-of-net-zero-goal-2050/>

Country Spotlight: The Netherlands

The Netherlands is pushing with ambitions to be Europe's hydrogen hub and, through its national strategy, Nationaal Waterstof Programma, the country is pushing ahead with several projects and initiatives to scale up production and use of low-carbon hydrogen.¹⁰

Through a network of innovation centers and testing facilities, the Netherlands is scaling technologies, while developing its logistics infrastructure for the transport of green hydrogen. The country now has more than 1000km of hydrogen pipelines, and its natural gas grid is being retrofitted to transport hydrogen. Plans and developments at the ports of Rotterdam and Amsterdam ensure that they will be key entry points not only to the Netherlands but to Europe overall.

The Netherlands' hydrogen strategy centers around collaboration between knowledge institutions, governments, and the business community. The strength of its approach has seen the emergence of a business consortium, NorthH2, involving Shell, RWE, Groningen Seaports, Equinor & Gasunie, who are coming together to develop Europe's largest green hydrogen project which covers all aspects of the hydrogen value chain.

Moreover, the Netherlands is home to Faraday open innovation laboratory, a leading hydrogen research facility that operates as part of the Netherlands Organization for Applied Scientific Research. The site is a center that drives the optimization and scaling up of electrolysis technologies that are key to unlocking the clean hydrogen economy.¹¹



¹⁰ <https://investinholland.com/news/the-netherlands-fueling-a-green-hydrogen-future/>

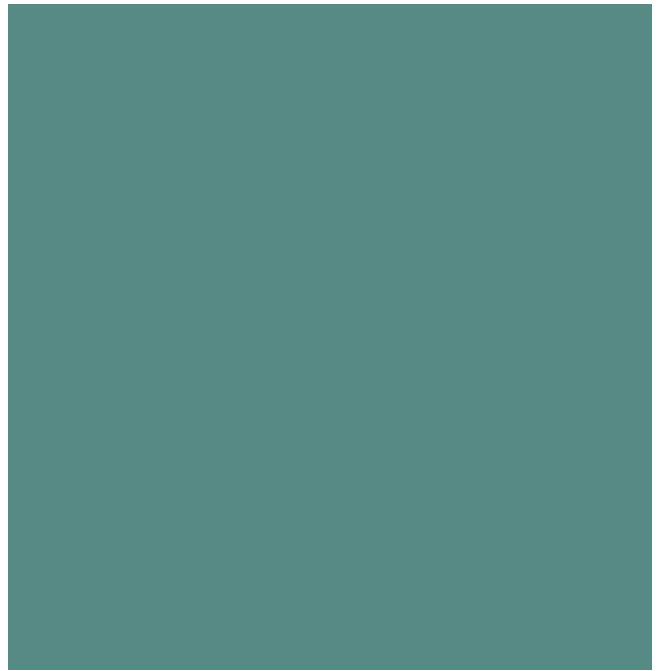
10 ¹¹ <https://www.prnewswire.com/news-releases/a-green-hydrogen-future-is-accelerating-in-the-netherlands-301816703.html>

Country Spotlight: The USA

A recent example of efforts to spur private hydrogen investment is the US Inflation Reduction Act (IRA), which is seeing energy businesses consider expanding their footprint in the States, by providing a favorable environment for renewable energy and hydrogen capacity. And it is the long-term predictability of the subsidies on offer that makes the US market so attractive in this context.

The IRA introduced the 45V Hydrogen Production Tax Credit, which allocates projects under construction before 2033 a tax credit for a decade for every kilo of clean hydrogen produced.¹² This credit arrives as the Energy Department is also progressing with plans for another program to scale up hydrogen production locally, having announced in 2022 that it will invest USD\$7 billion to establish seven regional hydrogen hubs.¹³

This is a prime example of the public sector creating an attractive investment environment that helps early movers to manage the long-term risks associated with entering new markets and developing hydrogen production capacities. Businesses can invest safe in the knowledge they're entering a predictable subsidy and tax environment.



¹² <https://news.bloombergtax.com/daily-tax-report/the-new-clean-hydrogen-production-tax-credit-explained>

11 ¹³ <https://news.bloomberglaw.com/environment-and-energy/white-house-launches-generational-7-billion-hydrogen-hub-plan>

Role of Public-Private Partnerships in Realizing National Hydrogen Strategies

National governments will be key enablers of the development of successful hydrogen initiatives, laying the groundwork and creating favorable environments for the private sector to operate. It is imperative that governments and regulators work closely with the private sector to ensure that policies establish a viable commercial model for developing hydrogen projects.

For countries with ambitions to produce hydrogen, the role of the enabler will include ensuring that there are sufficient assurances that hydrogen will be commercially viable and there is guaranteed offtakes. It is vital, therefore, that governments establish a market for hydrogen, in addition to facilitating the development of sustainable supply chains.

This requires governments and other public-sector actors to look at the entire value chain and not adopt a project financing approach. The rationale for this is simple: the success of the global hydrogen economy is dependent on the chain as a whole, which is linked across projects, markets, and regions.

A vital enabler of a thriving hydrogen market is adequate hydrogen offtake agreements, known as hydrogen purchase agreements. Broadly speaking, these can take two forms: a tolling model or a sale-and-purchase model.¹⁴ Under the former, a green hydrogen customer could provide the electricity and water, and the role of the project operator is to process the electrolysis. According to the latter, the facility operator would produce hydrogen end to end – including generating the renewable energy

required and supplying the raw materials – which is then sold to the customer.

Given the hydrogen economy is relatively new, and growing rapidly, it is important that risk is shared between public and private actors. It is important that governments and the private sector work together to provide incentives to stimulate demand for clean hydrogen and address the investment risks of first movers. Developing policies that create sustainable markets for clean hydrogen will be key to encourage investments from suppliers, distributors, and users. This will support scaling up of the supply chain chains, critical to driving down costs and stimulating demand.

To address the investment risks of first movers, critical to kickstarting the growth of viable hydrogen market, targeted and time-limited loans, guarantees and other incentives can encourage the private sector to invest and take



on more risk. It is critical that governments and the private sector work together to ensure regulations are not a barrier to hydrogen development.

To facilitate a predictable market for purchasers and producers, governments also need to ensure clear methodology for end customers to feel secure knowing that the hydrogen they are purchasing is green, define the emissions saving, and verify the energy used during electrolysis is clean or renewable. According to the IEA, the successful development of hydrogen markets will require relevant standardization bodies to develop international standards to remove and reduce current regulatory barriers. The development of common international standards, from equipment and safety standards, will encourage and accelerate the development of hydrogen trade.

Standardizing clean hydrogen certification, with governments agreeing a global reference point, will go a long way to ensure the mutual recognition of national standards. This is particularly important when hydrogen economies begin to mature in new markets, ensuring interoperability, compatibility of end-use processes, safety, and environmental integrity to support the development of infrastructure.

Moreover, collaboration between the public and private sector will be important to support funding and grants for research and academic institutions – organizations that will play a key part in driving the growth of a global hydrogen market. In addition to developing new technologies which will drive down the cost of green hydrogen, academic institutions will play a key part in facilitating dialogue, exchanging best practices, and responding to challenges – all of which will be important parts of enabling countries to develop



their own national hydrogen strategies and define a model for regional and international trade.

In conclusion, hydrogen can play an important role in allowing countries to meet net-zero targets and mitigate the impact of climate challenge. While green hydrogen offers great promise to solve some of the energy transition's biggest obstacles, there are significant challenges across the entire hydrogen value chain that must be addressed to drive down the cost of green hydrogen production and enable the development of sustainable supply chains and a thriving global hydrogen trade.

Hydrogen will form a key part of discussions at COP28, with collaboration between governments, policymakers and energy and industrial leaders crucial to laying the foundations for global hydrogen trade. Consensus on standardization and what a low-carbon hydrogen market looks will form the starting point of mapping out the future for low-carbon hydrogen. Establishing adequate policies and incentives, supported by a removal of current regulatory barriers, will be another area that policymakers and industry leaders must collectively address if hydrogen plans are to reach implementation.

While hydrogen infrastructure is developing rapidly, public-private partnerships will be vital to ensure planning is integrated. And as an enabler, the public sector needs to create an investment-friendly environment to support players in the hydrogen economy, including producers, pipeline operators, storage project operators and off takers.

National hydrogen strategies must navigate the challenges we have today, balanced against the aspirations we have for tomorrow. And public-private partnerships will remain firmly at the center of this nexus.

The Role for Ports

We recently spoke to major port operators, who outlined their central role in facilitating and stimulating the hydrogen economy. This includes:

- Leading decarbonization across maritime by encouraging the use of green hydrogen in port operations as well as in vessel fuels
- Cooperating with the private and public sector to facilitate the export and import of hydrogen
- Supporting other elements in the hydrogen value chain, including production and distribution

With ports handling a large share of trade globally, there is huge opportunity for collaboration and partnerships to not only decarbonize the maritime sector itself, but for ports to also operate as a key facilitator of hydrogen trade and transport.

For example, the Port of Rotterdam plays an important role in Europe's hydrogen economy, including production and import of hydrogen, demonstrating its commitment to become an international hydrogen hub.

Participants

H.E. Sharif Salim Alolama, Undersecretary for Energy & Petroleum Affairs,
Ministry of Energy and Infrastructure, UAE

Deepak Sakaria, Energy Transition Expert, Undersecretary for Energy &
Petroleum Affairs Office, Ministry of Energy and Infrastructure, UAE

Ruud Kempener, Cabinet Member, Cabinet of the Commissioner for Energy,
European Commission

Han Feenstra, Programme Manager Hydrogen, Ministry of Economic Affairs
and Climate Policy, Netherlands

Harley Higgins-Watson, Hydrogen and Renewable Energy Lead, COP28

Dr. Faye Al Hersh, Head of Business Development - UAE, Green Hydrogen,
Masdar

Nizam Salem, Director, Projects Development and Execution, Masdar

Dr Nikunj Gupta, Vice President, New Energies Technical & Projects, ADNOC

Ali Aljefri, Advisor, Technical Hydrogen Studies Division, ADNOC

Eduard de Visser, Director Strategy & Innovation, Port of Amsterdam

Prof. Dr. Christopher Hebling, Director Division Hydrogen Technologies,
Fraunhofer Institute for Solar Energy Systems

David Burns, VP Clean Energy, Linde plc

Hamead Ahrary, Director Hydrogen, Verbund

Erik van der Heijden, Senior Business Manager Hydrogen, Port of Rotterdam

Daria Nochevnik, Director for Policy and Partnerships, Hydrogen Council

Prof Phil Hart, Chief Researcher, Renewable and Sustainable Research Center

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Abu Dhabi Sustainability Week (ADSW) is a global initiative championed by the UAE and its clean energy powerhouse Masdar to accelerate sustainable development and advance economic, social and environmental progress.

Established in 2008, ADSW provides a global platform for all who have a stake in the future of our planet. ADSW brings together leaders from across governments, the private sector and civil society, to discuss and engage on bold climate action and the innovations that will ensure a sustainable world for future generations.

ADSW is not only a premier convenor for global dialogue, but a catalyst for concrete results, providing multi-stakeholder platforms where thought leadership can evolve into thoughtful action.



Abu Dhabi Future Energy Company (Masdar) is the UAE's clean energy champion and one of the largest companies of its kind in the world, advancing the development and deployment of renewable energy and green hydrogen technologies to address global sustainability challenges.

Established in 2006, Masdar is today active in over 40 countries, helping them to achieve their clean energy objectives and advance sustainable development. Masdar is jointly owned by Abu Dhabi National Oil Company (ADNOC), Mubadala Investment Company (Mubadala), and Abu Dhabi National Energy Company (TAQA), and under this ownership the company is targeting a renewable energy portfolio capacity of at least 100 gigawatts (GW) by 2030 and an annual green hydrogen production capacity of up to 1 million tons by the same year.



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For more information

General enquires: contactus@adsw.ae

Media enquires: media@adsw.ae

