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Charting National Hydrogen Strategies for Future Trade

Energy Research Paper

The Al-Attiyah Foundation

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As of June 2024, 61 national hydrogen strategies have been published, revealing diverse ambitions for future trade. However, progress on firm projects has been slow. Most countries aim to become hydrogen exporters, with only 12 planning to import, primarily in Asia and Europe. Key exporters include fossil fuel-rich nations transitioning to hydrogen, while new entrants focus on leveraging renewable energy potential. Many countries lack clear import and export projections highlighting uncertainties in matching supply and demand.

What market and contractual developments are emerging to unlock hydrogen production and trade? Which end-use cases are gaining favour, and which seem less likely to be successful? And who will be involved in the first wave of significant projects?

ENERGY RESEARCH PAPER

This research paper is part of a 12-month series published by the Al-Attiyah Foundation every year. Each in-depth research paper focuses on a current energy topic that is of interest to the Foundation's members and partners. The 12 technical papers are distributed to members, partners, and universities, as well as made available on the Foundation's website.

EXECUTIVE SUMMARY

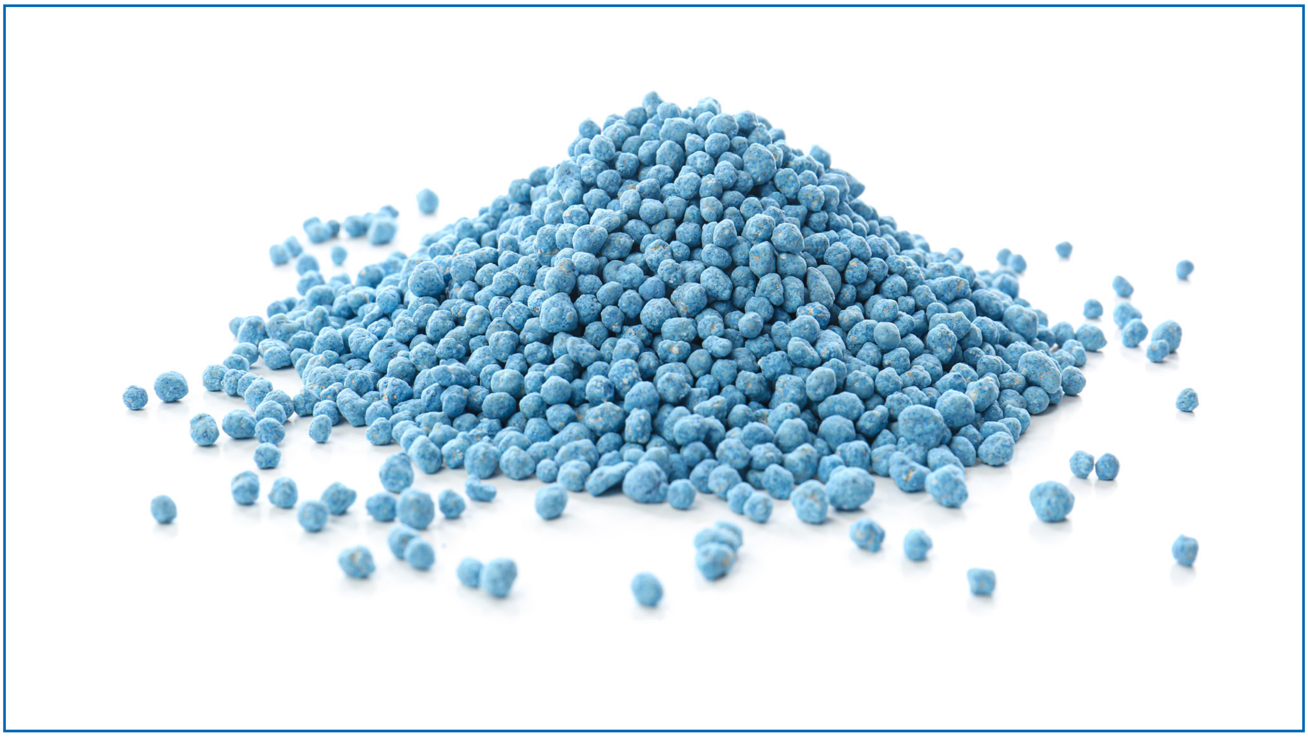
- Despite ambitious national strategies, hydrogen projects continue to face fundamental headwinds including high production and transport costs, weak offtake demand absent in a green premium and/or carbon price (particularly in MENA), policy uncertainty in the US, and growing trade barriers on Chinese cleantech. This underscores the gap between political ambition and commercial viability.
- Global hydrogen demand was estimated to increase to 99.5 Mt in 2024 (from 97 Mt in 2023) because of wider economic trends rather than the result of successful policy implementation, although the low-carbon hydrogen project pipeline reaching Final Investment Decision (FID) doubled to 3.4 Mt, predominantly green hydrogen (1.9 Mt).
- By mid-2024, 61 countries had formally published national hydrogen strategies, with additional jurisdictions establishing indicative targets
- Only 12 countries (primarily in Asia and Europe) have explicitly positioned themselves as low-carbon hydrogen importers; the majority of strategy-publishing nations aim to become exporters, either as fossil-fuel incumbents seeking to safeguard revenues or as new entrants monetising abundant renewable resources.
- The Gulf Cooperation Council (GCC) states exhibit the best balance of ambitious and realistic hydrogen strategies in the Middle East and North Africa region (MENA), underpinned by low-cost renewables, established hydrocarbon export infrastructure, relative policy coherence, and a stable investment climate.

- MENA strategies are progressively incorporating domestic offtake and industrial applications, catalysing the development of green-hydrogen-enabled manufacturing in sectors such as steel, aluminium, cement, and fertilisers.
- Deployment of low-carbon hydrogen in industrial applications is anticipated to reduce production costs, facilitate deep decarbonisation, and expand hydrogen's role in hard-to-abate sectors
- To remain effective, national hydrogen strategies require continuous revision, ensuring flexibility and alignment of local production with proximate demand centres to achieve competitive, low-emission hydrogen supply by 2030.

05 IMPLICATIONS FOR MENA ENERGY PRODUCERS

- MENA energy producers exhibit some of the region's most ambitious hydrogen strategies and should prioritise domestic demand development through 2030 to de-risk early-stage deployment
- Sustained investment in large-scale blue and green hydrogen is essential to capture post-2030 export opportunities while achieving cost reductions via economies of scale and technological learning.
- Early integration of hydrogen into industrial manufacturing can position MENA producers to capitalise on the growing global demand for low-carbon, "green" products.
- Innovation in high-emission industrial processes is critical; outperforming competitors on emissions intensity can unlock premium margins from hydrogen-embedded products.
- In the future, MENA producers have the potential to shape the evolution of hydrogen strategies by emphasising flexibility, ensuring policies avoid sector lock-in and support sustained industry growth.

MODEST GAINS OVER THE LAST 2 YEARS BUT MAJOR STAKES IN 2025 FOR HYDROGEN



Global hydrogen demand reached 97 Mt in 2023, an increase of 2.5% compared to 2022, primarily concentrated in the refining and chemical sectors, and principally covered by hydrogen produced from unabated fossil fuels[i]. Of this, low-carbon hydrogen accounted for less than 1 Mt[ii]. In 2024, global hydrogen demand was estimated to increase to 99.5 Mt[iii] as a consequence of wider economic trends rather than the result of successful policy implementation, with low-carbon hydrogen accounting for only 1% of all produced hydrogen[iv], with the vast majority being blue hydrogen. Green hydrogen accounted for 0.24% of the overall hydrogen produced[v].

The pipeline of low-carbon hydrogen projects reaching FID doubled from 1.7 Mt in 2023 to 3.4 Mt in 2024, of which 1.9 Mt consisted of electrolysis-based green hydrogen, with the remainder blue[vii]. Still, over 90% of the 49 Mt of announced low-carbon hydrogen projects by 2030 are still in the early stage or feasibility study stage[viii].

Most FIDs are located in North America and Europe, with the US hydrogen market further expected to consolidate its position as a blue-focussed one, driven by policy developments (such as continued support for the 45Q tax credit) and at least three large-scale blue hydrogen projects – the 0.86 Mt/y ExxonMobil Baytown, the 0.68 Mt/y Lake Charles Methanol II, and the 0.25 Mt/y Linde Beaumont – reaching FID in 2025, totalling over 1.7 Mt/y in capacity[ix]. However, the shortening of the 45V tax credit (for clean hydrogen) window from 2033 to 2028 has led ExxonMobil to warn of potential delays, highlighting how the rollback of incentives under Trump's fiscal package could undermine the sector's pathway to a commercially viable, market-driven business model[x]. In Europe, Air Liquide's 100 kt/y blue Hydrogen Project is slated to begin operations in 2026[xi].

Figure 1 Global Hydrogen Demand, 2023 vs 2024, Mt/y [xvi]

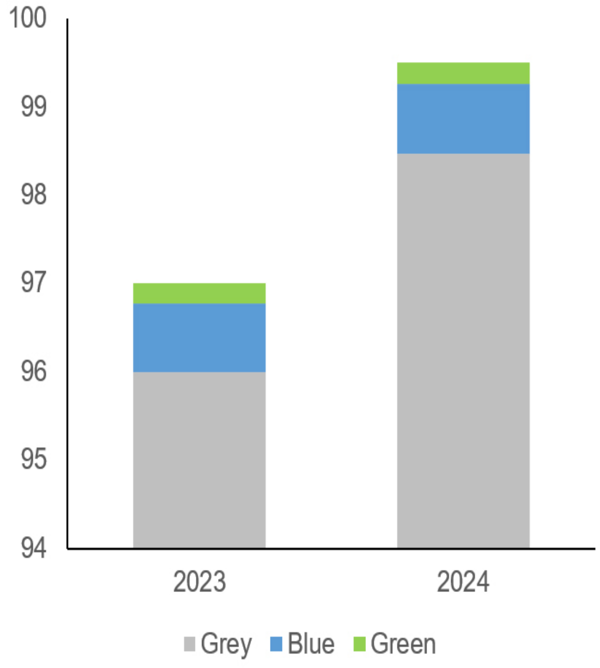
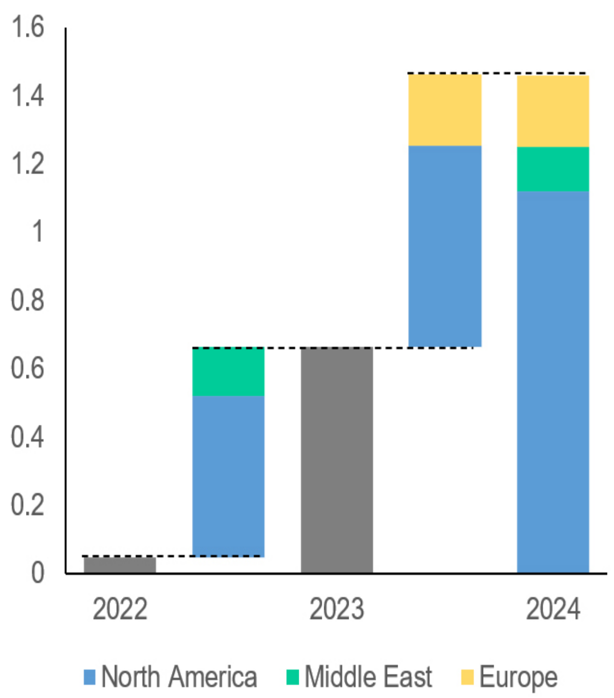


Figure 2 Blue hydrogen FIDs by Region, Mt/y [xiii]



Outside the US and Europe, the only notable upcoming blue hydrogen project is Qatar's 1.2 Mt/y QatarEnergy and QAFCO Blue Ammonia Project in Mesaieed Industrial City, also slated to begin operations in 2026. Inpex plans to begin production at a small 700 t/y blue hydrogen demonstration project in Japan this autumn[xii]. In the UAE, a 1 Mt/y blue ammonia project at the Ruwais Industrial Park under Fertiglobe is expected to be operational by 2027 and is currently under EPC.

FIDs are progressing at a slower pace than anticipated despite sustained momentum behind giga-scale developments (≥1 GW electrolyser capacity). To date, only 16 GW of green hydrogen capacity has achieved FID globally[xiv], led by flagship projects such as Saudi Arabia's NEOM Helios and India's Kakinada. Both projects combine secured offtake agreements, strong government backing, and favourable local conditions to drive down production costs and support long-term commercial viability.

NEOM, for instance, is underpinned by state-led strategic ambition and a 30-year offtake agreement with Air Products for 100% of production, providing revenue certainty despite concerns over high capital costs and perceived execution risk[xv]. However, this certainty is conditional as Air Products has so far resold just under 30% of its contracted volumes from the project – to TotalEnergies – and even that commitment could face potential risks if market demand does not materialise. Kakinada, meanwhile, leverages existing ammonia export infrastructure and targeted government subsidies to lower initial operating costs and mitigate early-stage commercial risk.

Key structural barriers persist, most notably a shortage of committed demand and bankable offtakers, compounded by the absence of meaningful carbon pricing mechanisms to incentivise large-scale hydrogen adoption.

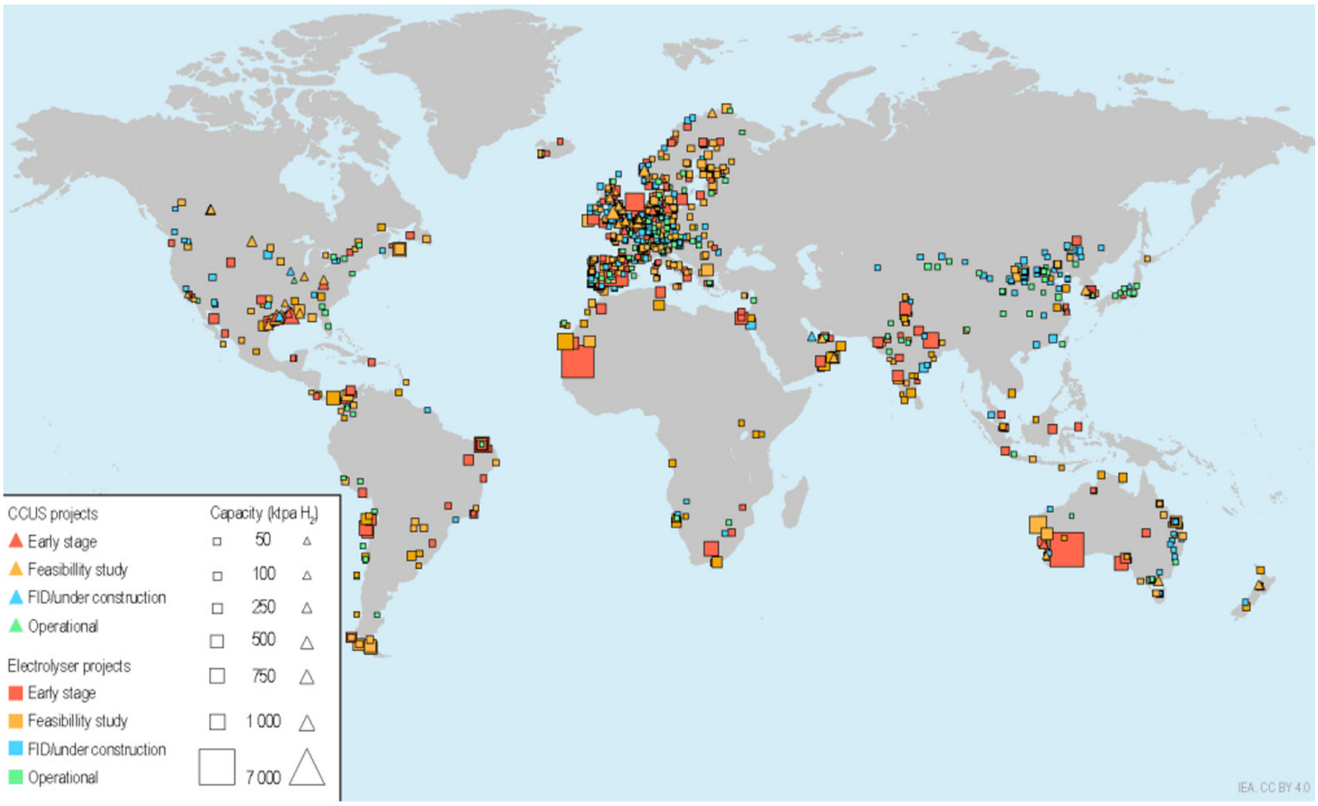
The limited willingness to pay a "green premium" further undermines project economics, while high transport costs erode competitiveness.

Moreover, offtakers are wary of the "first-mover disadvantage", seeking to avoid locking into higher risks and costs linked to immature infrastructure, elevated production expenses, and fast-evolving technologies – exposures that would leave them disadvantaged compared to later market entrants.

Additionally, regulatory uncertainties, macroeconomic pressures, and rising scepticism—particularly after abrupt US climate policy changes—have slowed progress over the past two years. Europe's struggles with securing large-scale FIDs for its green hydrogen projects, despite funding options like IPCEI1 available, has also impacted sentiment in other hydrogen-pursuing markets like the Middle East, since most technology and equipment is sourced from Europe, which can create a drag due to slow progress in innovation, upgrades, and applicability.

An additional factor contributing to the "global fatigue" around green hydrogen is competition for electricity supplies and investment from other rapidly growing industries, such as data centres, and long interconnection queues. Still, the Middle East is expected to lead the way in progress on green hydrogen this year and through 2030, a key reason for which is the absence of trade constraints on low-cost Chinese electrolysers, unlike the US and Europe.

Figure 3 Map of Announced Low-Emissions Hydrogen Production Projects, 2024[xvi]



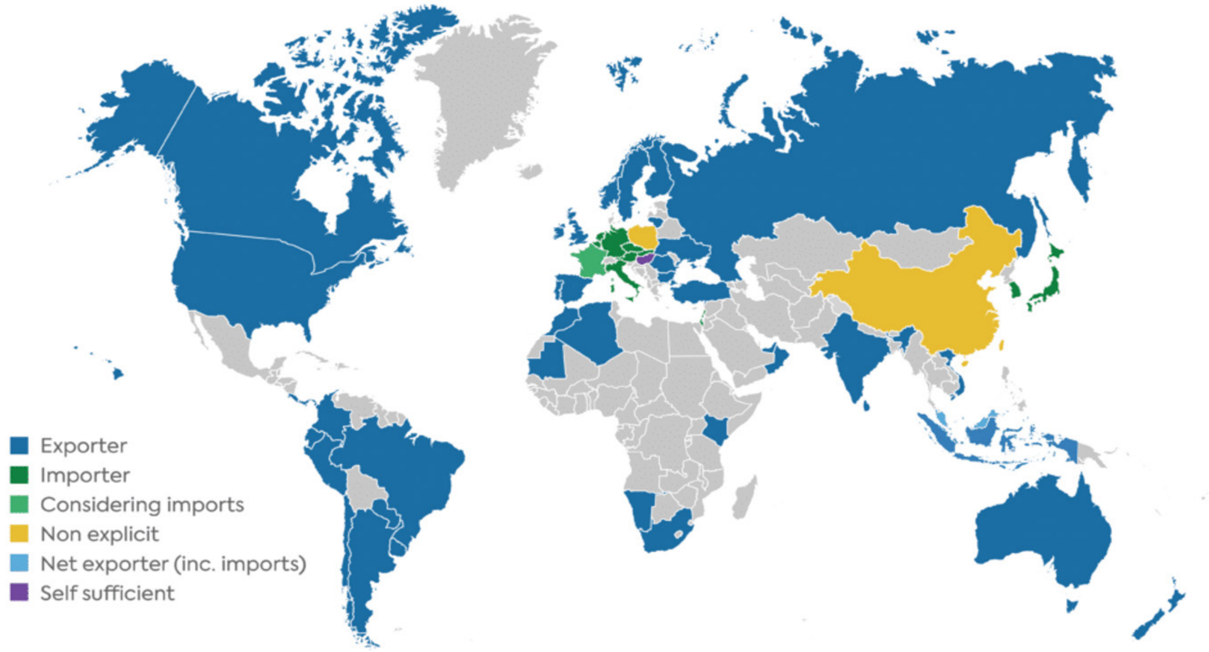
1 – IPCIE: Integrated Important Project of Common European Interest

As of June 2024, 61 national hydrogen strategies and roadmaps have been released worldwide, with many additional countries setting indicative targets. Several early movers, including Germany, France, and Japan, have already updated their strategies to reflect evolving market conditions. These strategies typically define the country's intended position within future hydrogen trade flows, whether as a net importer or exporter, along with the preferred transport medium (e.g., LOHC, ammonia), and the expected economic value, market share, and competitive advantages to be captured.

Analysis indicates that only twelve countries have committed to a low-carbon hydrogen importer role[xvii]. These are concentrated in Asia (Japan, South Korea, Singapore) and Europe (Austria, Belgium, Czech Republic, Germany, Italy, Luxembourg, Slovakia, Netherlands), with France signalling potential interest but no formal commitment. The importer profile largely mirrors today's fossil fuel and LNG trade dependencies. Some, such as Belgium, Italy, and the Netherlands, also aim to position themselves as hydrogen trading hubs serving not only domestic demand but also the wider industrial heartlands of Europe. This hub-and-spoke model could be pivotal: if Europe fails to secure reliable hydrogen supply and distribution through these nodes, it faces a stark choice, either fall short of medium-term climate goals in hard-to-abate sectors such as industry, aviation, and shipping, or lean heavily on Carbon Capture, Utilisation and Storage (CCUS), which, while advancing, is unlikely to scale quickly enough. In practice, the success of European hydrogen hubs will determine whether the region sustains its industrial base under a decarbonisation pathway, or risks contraction and relocation of energy-intensive sectors abroad.

By contrast, several major economies have yet to define a clear trade stance. Notably, China's national and provincial-level hydrogen strategies make no reference to imports, representing a material uncertainty for global hydrogen market projections given its scale of current fossil fuel demand.

Figure 4 National Hydrogen Strategies by Trade Status[xviii]



Hungary stands out for targeting hydrogen self-sufficiency, although a substantial portion of its projected low-carbon hydrogen production in 2040–2050 will depend on imported natural gas.

Most countries with published hydrogen strategies intend to become exporters. This cohort can be divided into two broad categories: established fossil fuel exporters pivoting to hydrogen to safeguard export revenues, and new market entrants seeking to monetise abundant renewable resources. The first group encompasses Middle Eastern producers (UAE, Saudi Arabia2, Oman, Egypt3, and Algeria) and other major fossil fuel suppliers (Australia, US, Russia, Indonesia, Norway, South Africa, Ecuador). While some – such as the UAE, Saudi Arabia, and the US – are pursuing a hybrid pathway involving both renewable hydrogen and gas-based hydrogen with CCUS, others (Oman, Egypt, South Africa, Mauritania) are focussed solely on renewable-derived exports.

The second group includes countries without a legacy of large-scale energy exports but with significant renewable potential. Examples include African states (Morocco, Mauritania, Kenya, Namibia), Latin American producers (Chile, Paraguay, Uruguay), Asian markets (such as India), and European nations (Spain, Portugal, Türkiye, and Nordic countries (excluding Norway)). Despite the EU's stated objective of becoming a net importing region, ten of its member states have nonetheless set export-oriented hydrogen ambitions.

Beyond direct economic gains, such as revenue generation, employment creation, and industrial development, many prospective hydrogen exporters view the sector as a lever to attract foreign direct investment and

2 – Saudi Arabia has not yet published a standalone hydrogen strategy document, but hydrogen is explicitly emphasised in its Vision 2030 and Circular Carbon Economy Policy Frameworks

3 – Egypt's National Hydrogen Strategy is not public

advance broader economic diversification agendas. Clean hydrogen derivatives are also positioned to substitute imports of fossil-fuel-based methanol and ammonia, supporting both decarbonisation and trade balance improvement.

Several exporting nations are pursuing a dual-track strategy, building domestic hydrogen demand in parallel with export capacity. India, for example, expects that the expansion of export markets will generate positive spillover effects for domestic production. In markets such as Kenya, Canada, the US, the UAE, Türkiye, and Ecuador, early-stage deployment appears weighted toward domestic use (whether in timing, volumes, or both) although in the US case, hydrogen is also seen as a tool to bolster the energy security of allied nations.

Conversely, some countries place clear priority on export-led growth. Argentina intends to export 4 Mt of hydrogen annually by 2050, representing 80% of planned output, while South Africa has adopted a similarly export-oriented posture. Several of the Middle East countries are similarly pursuing export-oriented hydrogen development, including Oman, Saudi Arabia, Egypt, and Morocco, although in the case of the two GCC countries, there are signs of a strategic pivot toward the UAE model, in which export ambitions are complemented by deliberate efforts to cultivate domestic offtake.

4 – Converted to Mt/y from 30 TWh utilising hydrogen conversion factor of 1 kgH2 = 33.33 kWh of usable energy, therefore 1 MtH2 = 33 TWh

5 – Converted to Mt/y from 307 TWh utilising hydrogen conversion factor of 1 kgH2 = 33.33 kWh of usable energy, therefore 1 MtH2 = 33 TWh

6 – Converted to Mt/y from 2 GW of electrolyser capacity utilising an assumed 60% capacity factor and a specific electricity consumption rate of 46 kWh/kgH2 (PEM average)

7 – Converted to Mt/y from >5 GW of electrolyser capacity utilising an assumed 60% capacity factor and a specific electricity consumption rate of 46 kWh/kgH2 (PEM average)

8 – Converted to Mt/y from 70 GW of electrolyser capacity utilising an assumed 60% capacity factor and a specific electricity consumption rate of 46 kWh/kgH2 (PEM average)

9 – Converted to Mt/y from 25 GW of electrolyser capacity utilising an assumed 60% capacity factor and a specific electricity consumption rate of 46 kWh/kgH2 (PEM average)

10 – Converted to Mt/y from 1-3 GW of electrolyser capacity utilising an assumed 60% capacity factor and a specific electricity consumption rate of 46 kWh/kgH2 (PEM average)

11 – Converted to Mt/y from 4-6 GW of electrolyser capacity utilising an assumed 60% capacity factor and a specific electricity consumption rate of 46 kWh/kgH2 (PEM average)

12 – Converted to Mt/y from 12 GW of electrolyser capacity utilising an assumed 60% capacity factor and a specific electricity consumption rate of 46 kWh/kgH2 (PEM average)

Table 1 Summary Table of National Hydrogen Strategies of Major Upcoming Hydrogen Exporters

Country	Strategy Release Date	Hydrogen Production Targets, Mt/y						Focus	
		2030		2040		2050			
		Blue	Green	Blue	Green	Blue	Green	Domestic	Export
UAE	July 2023	0.4 (2031)	1 (2031)	3.75	3.37	7.07	7.07	√√√	√√√
Oman	May 2024	x	1-1.5	x	3.75	x	7.5-8.5	√	√√√
Algeria	March 2023	x	x	>0.3	0.9-1.2	>0.3	>1.2	√√√	√√
Morocco	September 2021	x	0.91[4]	x	x	x	9.3[5]	√	√√√
Mauritania	September [illegible]	x	x	x	x	8.1	12	√	√√√
Türkiye	January 2023	x	0.228[6]	x	>0.571[7]	x	~7.99[8] (2053)	√√	√√√
Australia	November 2019	x	0.5 – 1.5	x	5 – 12	x	15 – 30	√	√√√
Canada	December 2020	x	x	x	x	x	x	√√√	√√
Chile	November 2020	x	2.86[9]	x	x	x	x	√	√√
Colombia	September 2021	0.0005	0.114 – 0.343[10]	x	x	x	x	√	√
Denmark	December 2021	x	0.457 – 0.686[11]	x	x	x	x	√√ √	√√ √
India	January 2023	x	5	x	x	x	x	√√	√ √√
Norway	June 2020	x	x	x	x	x	x	√√	√√
Spain	October 2020	x	1.37[12]	x	x	x	x	√	√√
Paraguay	June 2021	x	0.09	x	x	x	x	√	√
US	June 2023	7.5	2.5	15	5	37.5	12.5	√√ √	√√ √

13 MENA COUNTRIES AND THEIR AMBITIOUS TARGETS

The Middle East countries have the most ambitious hydrogen targets to 2050. Despite not yet having published standalone hydrogen strategies of their own, Saudi Arabia and Egypt also share similar ambitious production targets; in the case of Saudi Arabia, the country is targeting 0.97 Mt/y of green and 1.93 Mt/y of blue hydrogen by 2030 and 1 Mt/y of green and 3 Mt/y of blue hydrogen by 2035, while Egypt is targeting 3.2 Mt/y of green hydrogen by 2030.

One of the principal reasons for the Middle East – especially the GCC countries – having such ambitious plans is its abundant renewable energy potential.

These countries enjoy low costs of solar power because of their high insolation, large areas of available land with little competing use13, political and economic stability and financial wealth leading to low cost of capital, the ease of permitting, the near-absence of trade barriers such as import tariffs, and large project sizes which maximise economies of scale[xix] This has been augmented by a growing body of experience in executing these large projects, and the adoption of the latest technologies such as bifacial panels14. This low cost also applies to wind power in areas with good resources, notably Oman and north-western Saudi Arabia.

13 – This does not apply to Bahrain

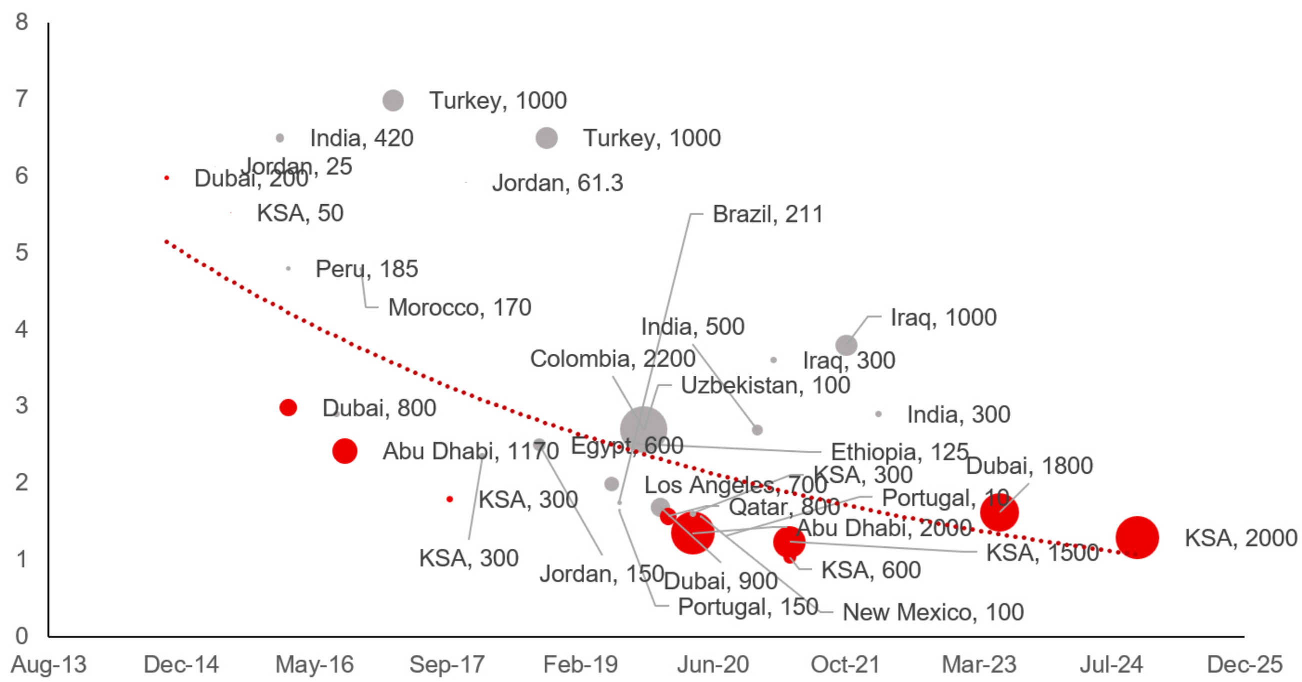
14 – Some studies suggest that in extreme desert conditions, the front side discolouration of bifacial panels can cause a degradation of 1.3-1.88% per year compared to the back side (0.39-0.79% per year), which could impact the operational lifespan of bifacial panels, but these studies acknowledge the limitations and several critical gaps in assessing their degradation, including the lack of comparative studies focussing on fixed, 1-axis, and 2-axis bifacial PV systems, their performance under identical environmental conditions, and high fragmentation in scientific literature regarding assumptions, methodologies, and performance metrics

Authorities awarded projects from 2020 onwards at around US Cents 1.3–1.5/kWh. Saudi Arabia's 600 MW Shuaibah solar PV project was awarded in April 2021 at US Cents 1.04/kWh, then a world record[xx], while the most recent round, in October 2024, attracted a bid of US Cents 1.29/kWh for the 2 GW Al Sadawi PV project[xxi]. In the UAE Masdar reached financial close on the 1.8 GW Phase 6 of the Mohammed bin Rashid Al Maktoum Solar Park – the largest single-site solar project in the world – at a bid price of US Cents 1.6/kWh in February 2024[xxii]. A team led by EDF Renewables and Korea Western Power for the 1.5 GW Al Ajban Solar PV in Abu Dhabi submitted a winning bid of US Cents 1.41/kWh in July 2023, and was awarded the project in February 2024[xxiii]. The combination of solar power with batteries results in costs for steady power supply of around US Cents 5-6/kWh, as in the project announced by Abu Dhabi's Masdar in January 2025, for 5.2 GW of solar power twinned with 19 GWh of battery storage, at a cost of US$ 6 B, giving at least 1 GW of continuous supply[xxiv].

Wind resources are less evenly distributed, but parts of the GCC have good wind conditions. The 416 MW Dumat Al Jandal wind farm in Saudi Arabia was awarded in 2019 for US Cents 1.99/kWh[xxv].

The massive scale-up of renewable energy in the last few years is slated to expand further in the coming years to meet green hydrogen production targets. Saudi Arabia is targeting 130 GW of renewable energy capacity by 2030[xxvii] from 4.7 GW today[xxviii], while the UAE is better than on-track to surpass 19.8 GW of clean energy capacity by 2030[xxix], with forecasts pegging a long-term renewable capacity of nearly 200 GW by 2050[xxx]. Oman's targeted 8.5 Mt/y of renewables-based hydrogen capacity by 2050[xxxi] suggests a hydrogen-dedicated renewables capacity of nearly 185 GW[xxxii].

Figure 5 Levelised cost of solar PV power from competitive bids (GCC cases in red)[xxvi]

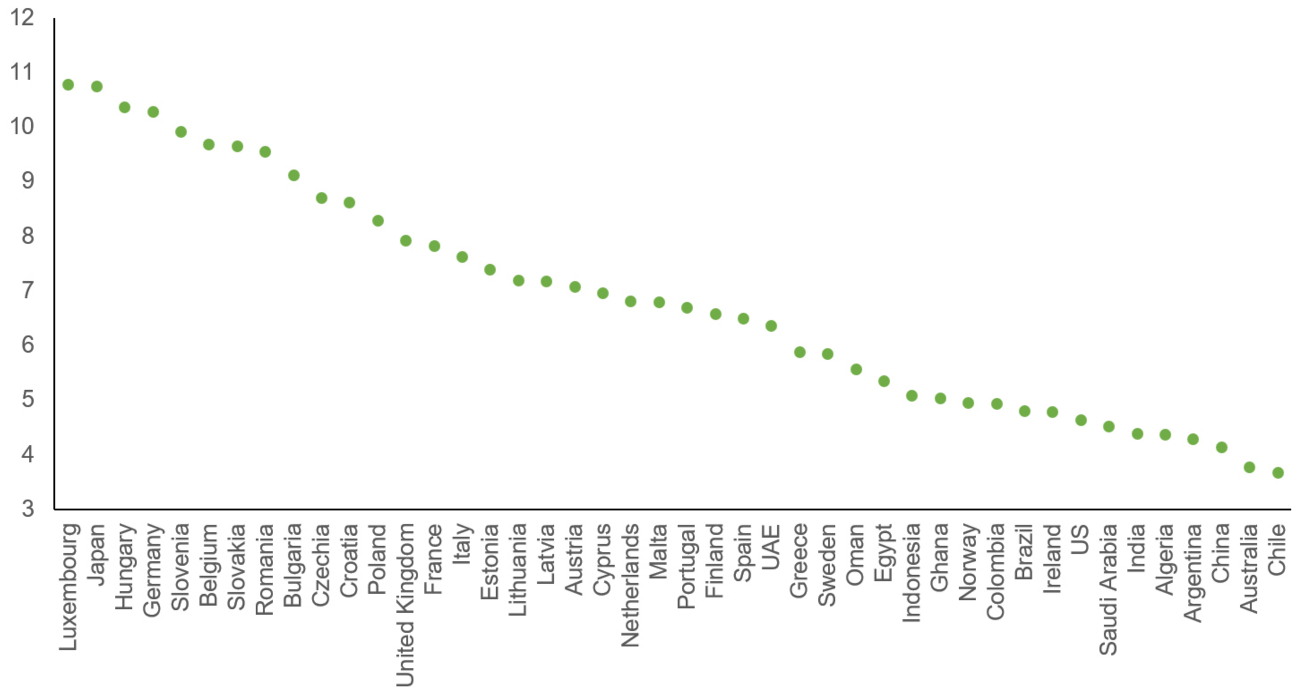


Low Levelised Cost of Electricity (LCOEs), therefore, present a structural cost advantage to hydrogen competitiveness.

The UAE's Fertiglobe was awarded a tender in July 2024 to supply 259 kt/y of green ammonia produced in Egypt to Europe at €1000/tH2 (or €1/kgH2), including delivery, or €811/tH2 net[xxxiii], equalling to about US$ 5.4/kgH2 for the underlying green hydrogen content. The initial price signal indicates substantial potential for achieving more competitive prices in the near future, particularly if volumes are lifted from the GCC countries that have much lower costs of capital compared to Egypt. Current green hydrogen costs range from US$ 4.28/kgH2 in Saudi Arabia, US$ 5.22/kgH2 in Oman, to US$ 6.07/kgH2 in the UAE for electrolysis via an alkaline electrolyser[xxxiv]. PEM electrolysis yields slightly more expensive hydrogen, at about US$ 4.78/kgH2 in Saudi Arabia, US$ 5.93/kgH2 in Oman, and US$ 6.67/kgH2 in the UAE[xxxv].

Interestingly, Abu Dhabi-based Ocior Energy secured a bid in July 2025 to supply 5 kt/y of green hydrogen from a captive green hydrogen plant to Hindustan Petroleum Corporation Limited's (HPCL) Vishakhapatnam Refinery in Andhra Pradesh at Indian Rupee 328/kgH2, i.e. US$ 3.8/kgH2 excluding goods and service tax (GST)[xxxvi]. Similarly, Noida-based Jakson Green, the energy transition platform of infrastructure and renewable major, Jakson Group, won an 85 kt/y green ammonia supply auction for Indian Rupee 50.75/kgNH3 in August 2025[xxxvii], translating to about US$ 3.29/kgH2[15]. This low cost for Indian green hydrogen is due to cheap labour offsetting higher capital costs and the proximity of the offtake, but would

Figure 6 Green hydrogen estimated production costs by region, US$/kgH2[xxxix]



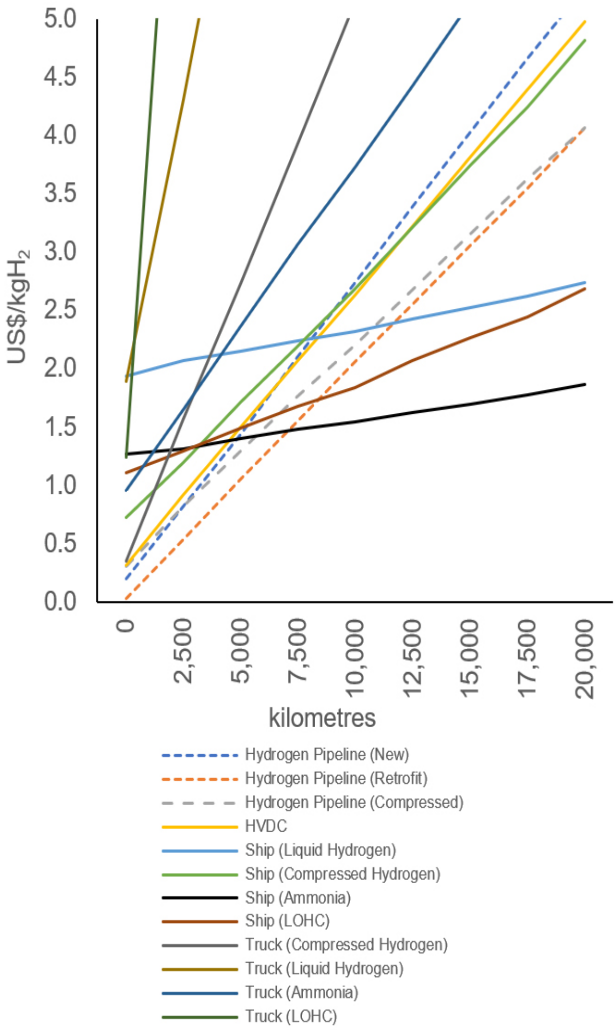
15.- Converted to US$/kgH2 at US$ conversion rate of 87.37 per US$, and an NH3 to H2 conversion of 1kgNH3 = 0.17647 kgH2 (since 2 NH2 --> N2 + 3 H2 ==> 6/34 by mass) be much higher for longer distances and/or export, despite interstate transmission system charges being waived for 25 years for projects commissioned on or before December 31, 2030[xxxviii].

Developers can readily utilise this for hydrogen. Decades of investment in LNG terminals, petrochemical complexes, and port logistics provide a transferable foundation for hydrogen carriers such as ammonia or liquid organic hydrogen carriers (LOHCs), while gas-fired power plants, hydrogen-producing and -using facilities – such as ammonia plants, refineries, petrochemical plants, and industry provide potential for domestic offtake. Industrial and port clusters offer the potential for hubs, akin to the popular European concept of "hydrogen valleys".

These countries also benefit from shorter shipping distances to Europe, particularly Saudi Arabia via the Red Sea. Still, Saudi Arabia's natural gas infrastructure (particularly LNG terminals) is relatively less extensive compared to the UAE and Oman who are large LNG exporters, posing both challenges and opportunities for its hydrogen endeavours[xl].

Despite the absence of pipeline transport options currently, pipeline export could potentially be the cheapest option for distances less than 7,500 kilometres, making GCC hydrogen exports via pipeline to Europe an economically attractive option. A study conducted in 2023 suggests the feasibility of such a cost-effective pipeline originating in the GCC before crossing Saudi Arabia and Egypt to enter Europe via the Mediterranean and then scatter across Central European countries[xli]. For far out destinations like the Asia Pacific, shipping hydrogen as ammonia is the most cost-effective method of delivery.

Figure 7 Cost of Hydrogen Delivery by Distribution Method[xlii]



Thirdly, the centralised governance structures of GCC states allow for policy coherence and rapid execution, particularly in aligning national hydrogen ambitions with broader economic development agendas. This allows for lower financing costs and the establishment of industrial bases for hydrogen derivatives (e.g., ammonia, synthetic fuels, green steel). Key industrial zones – such as Saudi Arabia's NEOM, the UAE's Ta'ziz, and Oman's Duqm – are therefore well positioned to become global hubs for hydrogen production and exports.

This advantage persists despite underlying strategic rivalries among Middle Eastern states, each seeking to position itself as a hydrogen leader. Most GCC countries are pursuing broadly similar hydrogen development models, reflecting common structural advantages: abundant resources, strong infrastructure potential, and centralised socio-political systems. In contrast, EU policy-making on hydrogen has been challenged by the bloc's heterogeneity and structural disparities, with member states having starkly diverging starting points, priorities, geographies, renewable endowments, and other competitive advantages, contributing to conflicts of interest and creating friction, further complicating consensus-building and slowing coordinated action[xliii].

Similarly, the United States faces its own structural challenges in advancing a coherent hydrogen strategy. Policy development is constrained by political divisions over the relative prioritisation of hydrogen production pathways and the trade-offs between economic competitiveness and climate objectives. The federal landscape is further fragmented by significant regional disparities in energy resources and industrial priorities, alongside contentious debates over tax credit allocation, tariffs on clean-tech equipment imports, and fluctuating levels of federal support. These factors introduce uncertainty for investors and hinder the establishment of a unified national approach, in stark contrast to the policy coherence achievable in GCC states.

Fourth, the region has an established status as an energy and international business hub, the UAE and Saudi Arabia perhaps more so than the others. The region has strong relationships with energy customers over many decades and has an established reputation as a reliable supplier.

Most of the world's leading international oil companies (IOCs), including Shell, TotalEnergies, BP, ExxonMobil, ENI, Occidental, CNPC, CNOOC, ONGC, INPEX, Mitsui, PTTEP, GS Energy, KNOC, Lukoil and others, have an equity presence in the oil and gas sector as partners of national oil companies (in the UAE and Oman). Large sovereign wealth funds like Saudi Arabia's PIF, the UAE's ADIA, ADQ, Mubadala, and Taqa (as well as clean energy vehicle Masdar), and Oman's OQ have international energy businesses in oil, gas, power, and renewables, including hydrogen.

Saudi Arabia's PIF established a new entity – Energy Solutions Company, a wholly-owned subsidiary of the PIF – in October 2024 to invest an estimated US$ 10 B in the production of green hydrogen[xliv]. Its current mandate seems to suggest that investment will have a domestic focus, but could expand in the future to include international projects. The UAE's Masdar has already made strides in international hydrogen investments, for example, through the acquisition of European clean energy platform TERNA Energy, the largest investor in the renewables energy sector in Greece[xlv], and strategic framework agreements with Hy24 – the world's largest clean hydrogen pure-play investor – and VERBUND – Austria's leading energy company – to explore and enable large-scale green hydrogen production projects across Europe, the Americas, Asia Pacific and MENA[xlvi], and Spain[xlvii], respectively. Oman's OQ, meanwhile, has shares in energy companies such as South Korea's clean energy company GS EPS and Spanish gas company Saggas[xlviii].

MENA HYDROGEN STRATEGIES ARE EVOLVING TO INCLUDE DOMESTIC OFFTAKE

In a new sector like hydrogen, it is natural to have an attrition rate where the business case simply isn't strong enough, but this is not the case for the GCC countries, where hydrogen projects are some of the highest credibility ones, thanks to the low-cost and low-carbon resource base they are based on. This makes them best placed to meet emissions standards in Europe, Japan, China, and elsewhere at the least possible cost.

These projects also have strong government backing, while European projects have struggled to secure large-scale FIDs despite the availability of funding options like IPCEI support. The US, focussing on blue hydrogen, further complicates the global landscape for green hydrogen, keeping it in the backseat there. This makes the GCC region a standout in terms of large-scale, effectively-planned green hydrogen projects, since they have the advantage of being snapped-up for domestic use if export commitments do not materialise soon enough or not at all, thus helping these countries meet their ambitious national decarbonisation goals.

The focus on industrial applications for low-carbon hydrogen will reduce costs for green hydrogen integration into core sectors of these countries' economies like steel, aluminium, cement and fertilisers, making industrial decarbonisation more viable and expanding hydrogen's role in hard-to-abate sectors more generally.

Such efforts will also facilitate a more integrated hydrogen market, creating stronger supply chains and improving market liquidity, by, for example, establishing reliable supply lines, introducing higher competition and easier cross-border transactions, boosting collaboration and standardisation, and increased capital flows.

Major industrial sectors such as steel and aluminium will require increasingly large volumes of hydrogen to abate their emissions and affix a green premium to low-carbon hydrogen-embedded products. For example, green steel could require 19% of the total EU policy target for domestic renewable hydrogen production, i.e. 1.7 Mt/y by 2030, increasing to 1.9 Mt/y by 2045[xlix]. However, with only 3 GW (or about 343 kt) of renewable hydrogen production projects having started construction or reached FID at the end of 2023, the EU is seriously behind its 10 Mt/y of domestic production capacity by 2030[l]. This increases the focus on imports, especially in the near- to medium-term as the bloc ups its own production, which still won't be sufficient to meet all local demand.

The GCC is already pursuing developments to meet future green industrial demand. Brazilian mining giant Vale signing a land reservation agreement with the Royal Jubail and Yanbu Commission in January 2025 to build a 12 Mt/y green steel facility in Ras Al-Khair to supply high-quality iron ore and contribute to the development of the regional green steelmaking ecosystem[li]. The project will supply iron ore agglomerates (primarily briquettes) for Indian steel group Essar's US$ 4.5 B, 4/Mt/y integrated steel plant also in Ras Al-Khair[lii]. Essar will develop renewable energy generation and storage solutions along with solar PV firm Desert Technologies for use at its project which is set to start production in 2027[liii]. Produced green steel will be used domestically as well as exported, helping meet CBAM requirements if sent to the EU.

Vulcan Green Steel, sister company of Jindal Shadeed Iron and Steel under the Vulcan International Holding Company (which is part of India's Jindal Group)[liv], meanwhile, is constructing its 5 Mt/y green steel mill at Oman's Arabian Sea Port of Duqm, and has signed a binding agreement with Czech company Vitkovice Steel for 1 Mt/y of green steel supply from the project when it comes into operation in 2027[lv]. This produced steel could meet CBAM requirements even if relying solely on operational efficiency gains, renewable power, and technology expansion to reduce emissions[lvi].

While current activity has been heavily focussed on production and processing, attention is now shifting towards relatively underdeveloped segments – particularly transmission, storage, and distribution – which are essential to building globally competitive hydrogen ecosystems.

The UAE, for instance, is actively promoting advanced transmission and storage technologies, electrolyser assembly and subcomponent localisation (with emphasis on efficiency, material substitution, and emissions intensity), and integrated renewable infrastructure[lvii]. Its innovation ecosystem, bolstered by strong institutional support (e.g., Masdar and national R&D initiatives), has enabled it to target both low- Technology Readiness Level (TRL) research and higher-TRL demonstration opportunities, particularly within storage and distribution.

Saudi Arabia, meanwhile, has taken a large-scale, centralised approach by anchoring its hydrogen strategy around flagship projects like NEOM, while signalling a growing interest in ecosystem localisation and manufacturing partnerships that support critical technologies such as electrolysers, pressure vessels, and system integration. The emphasis here is more on attracting global players to co-develop essential midstream infrastructure and scale domestic supply chain capabilities, consistent with its broader industrialisation goals under Vision 2030. For example, it has taken proactive steps by signing an MoU with India to ensure reliable and resilient supply chains for materials utilised in low-carbon hydrogen, including for electrolysers[lviii].

Oman has positioned itself as a flexible and open platform for international investment and technology partnerships, especially in project development and EPC services. It offers fewer barriers to entry and attractive regulatory conditions for firms aiming to capitalise on an emerging, less saturated midstream landscape. All three countries are increasingly viewing supply chain optimisation – including logistics, smart grid integration, material recycling, and circularity – as a crucial competitive domain in which they can partner with international firms to set future standards.

Stakeholders are not confining their efforts solely to technology adoption. Hydrogen innovation activity is being strategically cultivated across the entire innovation cycle, from basic and applied research to deployment at scale, especially in the UAE and, to a lesser extent, in Oman. In the UAE, this manifests in both patent activity and government-supported research clusters focussed on emerging sub-sectors like hydrogen storage and materials science. Saudi Arabia, while slower in terms of domestic research infrastructure, is investing in strategic technology acquisition and in partnerships with global OEMs to localise critical components and embed technological know-how.

Table 2 Recent Hydrogen Market Opportunities Development in the UAE, Saudi Arabia, and Oman[lix]

Country	Entity	Opportunity	Details	Year
UAE	Masdar – Daimler[lx]	Hydrogen Transport	MoU to export liquid green hydrogen from Abu Dhabi to Europe by 2030, supporting Daimler Truck's CO_2-neutral fleet target by 2039	January 2024
	ADNOC – POSCO[lxi]	Hydrogen Infrastructure	Joint development of blue hydrogen infrastructure at POSCO's Gwangyang LNG Terminal with operations starting in 2029, integrating CCUS for certification	February 2024
	ADDED and HYCAP[lxii]	Industrial Hydrogen	MoU to develop hydrogen and renewable energy complex in Abu Dhabi, including hydrogen storage, transport, electrolyser manufacturing, and fuel cell production	February 2024
	Masdar – TotalEnergies[lxiii]	Hydrogen to Methanol to SAF	Agreement to assess viability of commercial green hydrogen to methanol to SAF project	August 2024
	ARMS – Pure Hydrogen[lxiv]	Hydrogen Transport	Partnership to introduce hydrogen fuel cell commercial vehicles in the UAE by 2025	September 2024
	Ardian – Masdar – PIF[lxv]	Hydrogen Collaboration	Co-investments in green hydrogen projects with Masdar in Abu Dhabi and plans to collaborate with PIF on joint ventures in Saudi Arabia	October 2024
	Masdar and Norway[lxvi]	Hydrogen Infrastructure	Agreements with Equinor and others to develop green hydrogen infrastructure in Europe, targeting hard-to-abate sectors	October 2024
	UAE and EU[lxvii]	Free Trade Agreement	Formal negotiations for a free trade agreement, with green hydrogen, renewable energy, and critical raw materials identified as key pillars	April 2025
	Masdar – EnBW[lxviii]	Hydrogen Systems	MoU to explore the development of energy storage systems, offshore wind, and green hydrogen across	July 2025
Oman	Greenzo Energy[lxix]	Electrolyser Supply	Supply a 1 MW alkaline electrolyser to produce 400 units of electricity per hour using green hydrogen for Oman's airport	March 2024
	Shuangliang Hydrogen[lxx]	Hydrogen Systems	Supply of green hydrogen production systems for the 300 kt/y ACME ammonia project in Oman, with completion by 2025	December 2024
	Hydrom and Belgium[lxxi]	Hydrogen Cooperation	MoU to advance green hydrogen projects, focusing on joint research, industrial partnerships, and regulatory frameworks for hydrogen import and distribution	December 2024
	Wisdom Motor & OIA[lxxii]	Hydrogen Transport	Agreement to explore local hydrogen vehicle manufacturing in Oman	January 2025
	Oman and Turkey[lxxiii]	Hydrogen Collaboration	MoU to collaborate in the oil and gas sector, LNG trade, as well as renewables, energy efficiency, alternative fuels, green hydrogen and carbon capture technologies	July 2025
Saudi Arabia	Saudi Arabia and India[lxxiv]	Hydrogen Supply Chains	MoU to ensure reliable and resilient supply chains for materials utilised in low-carbon hydrogen, including for electrolysers	September 2023
	Ardian – Masdar – PIF[lxxv]	Hydrogen Collaboration	Co-investments in green hydrogen projects with Masdar in Abu Dhabi and plans to collaborate with PIF on joint ventures in Saudi Arabia	October 2024
	ACWA Power – Danantara Indonesia[lxxvi]	Hydrogen Partnership	MoU to formalise the exploration of investments in renewable energy generation, CCGTs, green hydrogen and water desalination in Indonesia	July 2025

But they require continuous updates to remain liquid and flexible, and avoid becoming locked in and thereby constraining the growth of the industry. Most countries with hydrogen strategies see the next half decade until 2030 as a period of technology piloting and the construction of first large-scale hydrogen production facilities. In parallel, expected demand to 2030 is relatively low and limited to a few specific applications in industry and transport.

Targets and objectives beyond 2030 are interestingly stated in only the GCC countries' strategies and in the case of the UAE, are more detail-oriented in their long-term vision of the future hydrogen economy. Other global players tend to describe only a high-level overview of an expected hydrogen economy in their strategies.

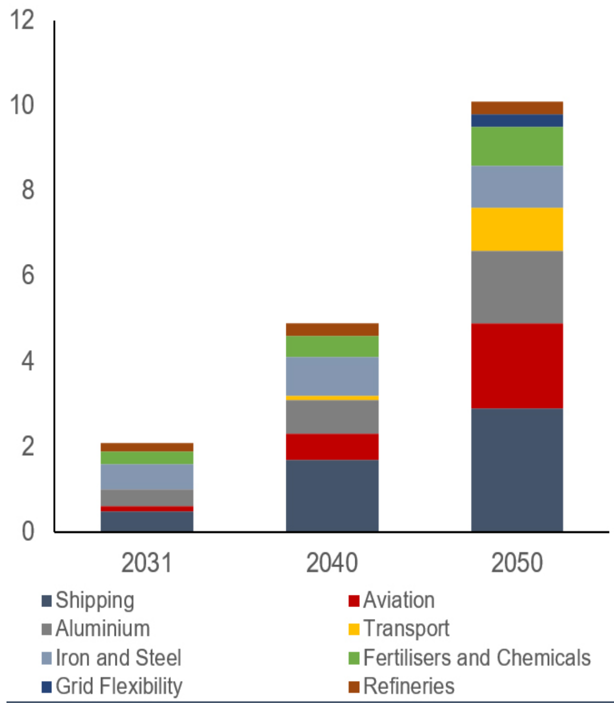
Though all strategies are motivated by national commitments to emission reductions and efforts to keep global warming below 1.5°C, their ambitions are more focussed on what is needed over the next decade to lay the groundwork for the emergence of the hydrogen economy after 2030. Especially for exporters, the analysis of long-distance maritime transport options of hydrogen is highlighted predominantly in their strategies, despite boundary conditions and the economics for global hydrogen trade flow still being highly uncertain.

Therefore, for the next five years, the emphasis in national hydrogen strategies should primarily be on how local hydrogen demand can be met with local production by connecting demand centres with the closest available sources for competitive low-emission hydrogen. This is well pronounced in the GCC, where the UAE has already demonstrated advanced potential in hydrogen integration through initiatives such as the production of low-carbon steel and aluminium and the establishment of regulatory frameworks that support green manufacturing. Saudi Arabia's large-scale industrial base and petrochemical capacity present opportunities to integrate hydrogen across energy-intensive sectors, particularly where existing infrastructure can be leveraged to facilitate uptake. Oman, while at an earlier stage of industrial hydrogen deployment, is building strategic partnerships to align industrialisation with its hydrogen ambitions, particularly through special economic zones and value chain localisation initiatives.

These differentiated capabilities will shape the structure and pace of domestic offtake across the region, with the UAE positioned to move early on niche, high-value products; Saudi Arabia favouring scale through integration with its broader industrial and energy portfolio; and Oman seeking to align industrial policy with hydrogen development from the outset.

Note that GCC countries have so far made limited announcements regarding clean hydrogen offtake in their oil refining sectors, despite this representing a relatively low-cost opportunity for decarbonisation, that has been actively taken up in Europe. This is likely driven by several interrelated factors. First, the majority of refinery output is export-oriented, meaning that Scope 1 and 2 emissions are effectively "exported" to consuming countries; committing to refinery decarbonisation could imply internalising costs that competitors in Asia are not yet incurring, particularly in the absence of a regional carbon pricing framework. Second, substituting conventional refinery hydrogen with blue or green hydrogen may be perceived as defensive decarbonisation, offering limited strategic upside.

Figure 8 The UAE's Low-Carbon Hydrogen Sectoral Demand From 2031 to 2050, Mt/y[lxxvii]



Finally, the political and signalling value of large-scale electrolyser projects (such as 2 GW desert-based megaprojects) may outweigh incremental refinery retrofits, providing a more visible demonstration of climate ambition and technological leadership.

An integrated domestic market for low-carbon hydrogen also supports the emergence of more liquid and efficient supply chains. As hydrogen uptake expands within domestic industries, it fosters supply security, economies of scale, and increased confidence for investors. In parallel, this promotes harmonisation and interoperability across borders, encouraging inter and intra-regional collaboration and laying the groundwork for broader international hydrogen trade.

Such efforts can also catalyse strategic engagement with international partners.

Many current stakeholders in GCC hydrogen projects, including leading EPC contractors, OEMs, and technology providers from Europe, Asia, and North America, are well-placed to deepen their involvement by extending services into domestic value chains. Firms such as Siemens, Air Liquide, Haldor Topsoe, Thyssenkrupp, Johnson Matthey, and others have existing technical exposure to projects in the region and could leverage this to support industrial integration and infrastructure deployment.

For these companies, a stronger domestic hydrogen ecosystem offers several incentives: access to low-cost energy inputs, opportunities to co-develop policy and regulatory frameworks, participation in export-oriented manufacturing hubs, and a stable base of industrial customers aligned with the region's strategic decarbonisation agenda. These partnerships also align with national visions for economic diversification, localisation of supply chains, and high-skilled job creation – key policy priorities for the GCC.

Moreover, the presence of globally influential national champions such as ADNOC, Aramco, and OQ provides a unique platform for scaling pilot projects, mobilising capital, and anchoring demand through long-term offtake. In turn, international firms gain access to commercially credible counterparties, enabling the deployment of advanced hydrogen technologies in a region well-positioned to become a major hub for the global hydrogen economy.

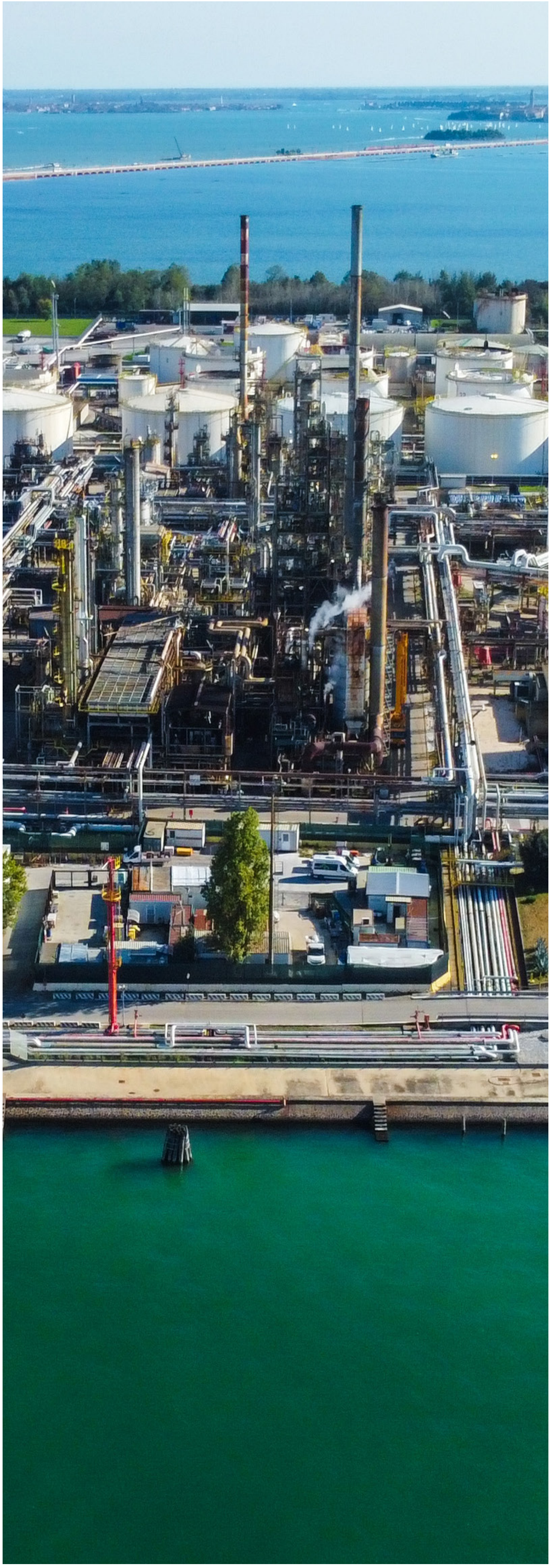


Table 3 Pipeline of GCC Hydrogen Projects Targeted Towards Domestic End-Use Sectors

Country	Sector	Low-Carbon Hydrogen Domestic Use
UAE	Iron & Steel	• Blue steel via the Al Reyadah CCUS Facility since 2016 that converts hydrogen into blue hydrogen[lxxviii] • 2.1 MW pilot project between EMSTEEL and Masdar to produce green steel using green hydrogen to extract iron from iron ore[lxxix]
	Power Generation	• 0.2 kt/y green hydrogen pilot project at the Mohammed bin Rashid Al Maktoum Solar Park, implemented by DEWA in collaboration with Siemens Energy[lxxx] • 6.6 kt/y waste-to-green hydrogen project by BEEAH, Chinook Hydrogen, and Air Water Gas Solutions by Q2 2027[lxxxi]
	Fertilisers	• 200 MW green hydrogen facility by Masdar and ENGIE to supply Fertiglobe's ammonia production plants in Ruwais for Fertiglobe's decarbonisation[lxxxii]
	Aviation	• Masdar and TotalEnergies 1 kt/y green hydrogen to methanol to SAF facility in Abu Dhabi by 2030[lxxxiii]
Saudi Arabia	Mobility	• ENOWA and Extreme E collaboration to utilise green hydrogen fuel cell technology in Saudi Arabia for mobility[lxxxiv]
Oman	Iron & Steel	by Jindal Shadeed Iron & Steel for 5 Mt/y green steel production in Oman[lxxxv] • 200 kt/y green hydrogen project by Amnah, a consortium including Copenhagen Infrastructure Partners, Blue Power Partners, and Al Khadra, for green steel[lxxxvi]
	Aviation	• Madayn and H2 Industries MoU for a 67 kt/y waste-to-hydrogen plant for either synthetic diesel or SAF[lxxxvii]

National hydrogen strategies today show broad convergence around climate-driven objectives but striking differences in trade positioning, governance models, and execution capacity. The Middle East – particularly the GCC – emerges as one of the most ambitious regions globally, with strategies closely tied to economic diversification agendas, industrial base development, and global energy leadership. Oman, Saudi Arabia, and the UAE are advancing export-oriented hydrogen industries while increasingly emulating the UAE's dual-track model of building domestic offtake alongside exports.

Most national strategies globally, including those in the Middle East, prioritise near-term technology development and first commercial-scale deployment, underpinned by R&D funding, innovation incentives, and early regulatory measures such as certification systems. Yet, few articulate a coherent long-term vision for integrating hydrogen into national and cross-border energy systems. Without this, scaling beyond 2030 could be constrained by gaps in infrastructure, trade rules, and market integration.

For the 2030 horizon, Middle Eastern strategies will need to ensure domestic hydrogen demand is met through competitive local production while securing global market share. The GCC's centralised governance, policy coherence, and industrial clusters (such as NEOM, Ta'ziz, and Duqm) offer structural advantages that contrast sharply with the policy fragmentation hampering progress in the EU and US.

To remain global frontrunners, the region must move beyond aspirational targets to detailed, actionable roadmaps. This requires sustained collaboration between governments, industry, and academia to close regulatory gaps, address infrastructure bottlenecks, and position the Middle East as both a leading producer and a strategic trading hub for low-emission hydrogen.

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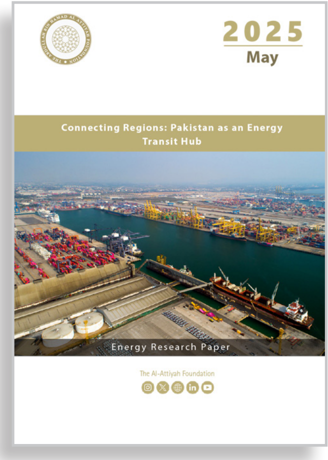

May – 2025

Connecting Regions: Pakistan as an Energy Transit Hub

Pakistan, one of the largest markets around the Arabian Sea periphery, has the potential to become an energy transit country linking the Middle East, Central Asia, and South Asia. However, numerous economic, infrastructure, political and security obstacles hinder reliability and security of supply through Pakistan.

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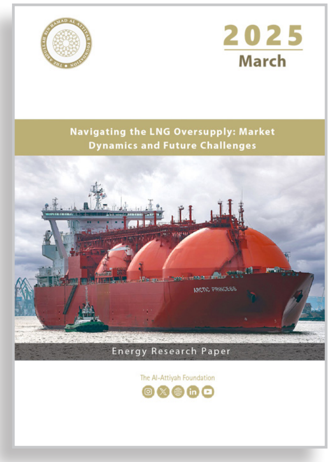

March – 2025

Navigating the LNG Oversupply: Market Dynamics and Future Challenges

Global LNG markets are expected to enter a phase of oversupply in the later part of this decade due to moderate demand growth and a significant influx of new export capacity.

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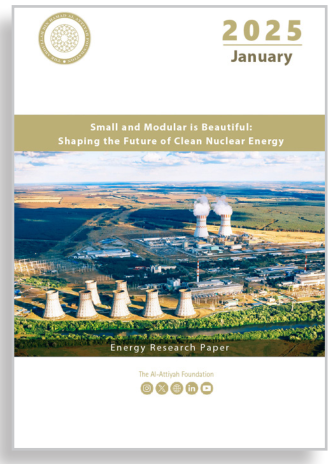

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Small and Modular is Beautiful: Shaping the Future of Clean Nuclear Energy

Building on the success of COP28 in Dubai and the first Nuclear Energy Summit in Brussels, global momentum for nuclear energy is accelerating. The latest International Atomic Energy Agency (IAEA) projections highlight growing recognition of nuclear power as a clean and secure energy source.

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