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Explainer

HYDROGEN & THE GULF: CONTINUITY IN TRANSITION

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HOW FAR BACK DOES THE GULF'S HISTORY WITH HYDROGEN GO?

In December 1937, *The Oil and Gas Journal* described a Bahrain refinery operating two Dubbs process cracking units (systems that are used to produce gasoline and diesel fuel) and recovering gasoline fractions from their waste gas. The refinery had begun operating the previous year. Its equipment was designed to turn crude into marketable fuels, with hydrogen an incidental product of the cracking chemistry. The account documents the equipment and the gas stream without reporting its hydrogen content, placing the earliest chapter of the Gulf's history with the molecule inside the workings of the oil industry.

By the 1950s, hydrogen had a more deliberate role. Saudi Arabia commissioned a fluid hydroformer at Ras Tanura in 1955 and a diesel desulfurization unit two years later, while Bahrain began employing catalytic reforming (a process that produces high octane gasoline) in 1957. The hydrogen generated in these processes could support procedures such as sulfur removal. The molecule was becoming an industrial input that refineries produced, consumed, and managed within their boundaries.

Fertilizer production expanded that role when Kuwait opened an ammonia plant at Shuaiba in 1966, manufacturing hydrogen as an essential intermediate. Two years later, the same industrial estate gained what the trade press described as "the world's first all hydrogen refinery." It was also the region's first refinery built by a national company, and its first cargo sailed to Japan.

The rest of the region developed related industries: Saudi Arabia began urea production in 1970; Qatar established fertilizer production in the same period and subsequently built one of the world's largest production complexes; three Gulf states jointly established Gulf Petrochemical Industries Company (GPIC) in 1979; the United Arab Emirates (UAE) followed with what is now known as Fertiglobe in 1983; and Oman brought together Omani state ownership and Indian farmer cooperatives through the Oman India Fertiliser Company (OMIFCO). Hydrogen became embedded in ammonia and methanol production, refining, and other industrial processes, often reaching customers inside products with names carrying no mention of the molecule.

The Gulf therefore enters today's hydrogen market with decades of experience making and handling it. What it is being asked to build now extends that experience into new production routes, customers, and commercial arrangements.

WHAT HAS CHANGED AROUND THE MOLECULE?

Hydrogen is both a feedstock (used in the generation of industrial products) and an

energy carrier. Producing it requires energy to separate it from compounds such as water or natural gas. Its climate significance, therefore, depends on how it is made and what it replaces. A molecule produced with renewable electricity reduces emissions in an existing ammonia plant, or replaces part of the fossil feedstock used in steelmaking. Producing hydrogen through an emissions-intensive process, however, raises different considerations.

The molecule's appeal has repeatedly shifted with the balance between energy affordability, security of supply, and environmental protection: what is referred to as the energy trilemma. The balance between those priorities shaped three waves of hydrogen enthusiasm since the early 1970s. The first imagined an entire energy system supplied by nuclear power, with hydrogen carrying that energy to factories, homes, and vehicles. Fueled by the 1973 oil embargo, the fear of fossil resource depletion and pollution helped build the argument for such a system. Enthusiasm faded as fears of scarcity eased and nuclear expansion slowed. The second wave in the mid-1990s put vehicles at its center. Automakers, governments, and fuel-cell developers promised clean mobility, and hydrogen acquired political appeal as a route away from oil dependence. Vehicles appeared, but costs, limited refueling infrastructure, and competing technologies constrained adoption.

The third wave, gathering momentum in the late 2010s, made the production question more prominent. Expanding wind and solar generation offered a route to renewable hydrogen, while climate commitments created pressure to reduce emissions in industries difficult to electrify directly. Hydrogen's proposed role became more specific: an industrial feedstock, a means of storing and transporting renewable energy, and a fuel for selected applications within a wider energy system. Russia's invasion of Ukraine added security of supply to that agenda. Europe's ambition to produce 10 million tonnes of renewable hydrogen annually and import another 10 million by 2030 gave prospective producing countries, including those in the Gulf, a market around which to organize projects, partnerships, and export corridors, and helps explain why hydrogen suddenly became so prominent in regional energy strategies.

Even the renewable route has a far longer industrial history than the current debate suggests. The principle of water electrolysis (splitting water to hydrogen and oxygen) has been known for more than 230 years, and by around 1900, more than 400 industrial alkaline electrolyzers were operating worldwide. In 1929, a large-scale electrolysis hydrogen production plant was commissioned in Rjukan, Norway, using Norwegian hydropower to produce hydrogen for ammonia and fertilizer manufacturing. Electrolysis supported fertilizer manufacturing for decades before cheaper fossil-based production displaced much of the green hydrogen. Today's projects revisit that economic contest under different conditions: lower renewable electricity costs, pressure to reduce

emissions, and policies intended to create a market for cleaner production.

For the Gulf, this creates two connected, yet distinct, opportunities. Existing industries change how they obtain hydrogen, while new facilities produce hydrogen and derivatives for customers willing or required to pay for lower emissions. The distinction between those markets is consequential.

WHAT ARE HYDROGEN COLORS, AND WHICH IS THE GULF BUILDING?

Hydrogen colors are labels that help explain the molecule's production routes, an important consideration for businesses across all industries. Much of the Gulf's existing hydrogen is classified as gray, indicating production from fossil feedstocks without carbon capture. Blue hydrogen adds carbon capture and storage to fossil-based production. Qatar's project at Mesaieed and the UAE's Taziz development at Ruwais are examples of investment in low-carbon or blue ammonia, while Saudi Arabia is expanding its hydrogen business at Jubail, where Aramco acquired a half share in the Blue Hydrogen Industrial Gases Company (BHIG) in 2025. Their climate performance depends on the emissions of the whole production chain, including the scope and effectiveness of capture.

Green hydrogen uses renewable electricity – mainly solar and wind – to split water through electrolysis. Two prominent Gulf projects are targeting production in 2027. The first, Saudi Arabia's NEOM Green Hydrogen Company (NGHC), is designed to produce up to 600 tonnes of green hydrogen a day, converted into as much as 1.2 million tonnes of green ammonia annually. The second is ACME's first phase at Duqm in Oman, which is under construction for production scheduled in early 2027. A larger development pipeline sits behind them, including Oman's awarded hydrogen projects and Saudi Arabia's plans to build another green hydrogen and ammonia hub in Yanbu at double the size of the NEOM project.

White (or natural) hydrogen opens a different possibility: extracting hydrogen formed through geological processes. The Samail Ophiolite, extending across Oman and the northern UAE, has attracted interest because of the reactions between water and iron-rich rock. Commercial development remains uncertain, with Oman's Ministry of Energy and Minerals stating in June 2026 that the evaluation was preliminary and that no commercial licenses had yet been issued.

While the color labels help explain production routes, they cannot establish environmental performance on their own. Carbon intensity measures the greenhouse gas emissions associated with production, generally expressed as kilograms of carbon dioxide equivalent per kilogram of hydrogen. The result depends on upstream meth-

ane leakage, the electricity supply, how much carbon is captured across the facility, and the boundaries used for the assessment. Plant configuration and the treatment of associated products also affect the calculation.

A buyer therefore needs more than a color. In addition to emissions requirements helping determine the buyer and rules of purchase, production cost determines what a developer can offer in the first place. Both considerations lead to the same outcome: identifying the customer.

HOW MUCH OF THE EMERGING HYDROGEN MARKET ALREADY EXISTS?

Much of the market is already operating inside the refineries, ammonia plants, and methanol facilities that have used hydrogen for decades. These industries provide established demand, with factories, customers, and products already in place. Their transition depends on replacing an input while keeping the business around it viable. The continued demand for hydrogen in these existing processes therefore gives clean hydrogen a starting point, but securing a buyer willing to absorb the additional cost remains a separate task.

Gulf governments are also shaping that demand through policy decisions about which industries they bring onshore. Oman has linked gas allocation for new steel projects to a phased transition toward lower-carbon hydrogen, allowing facilities to start with natural gas and gradually increase hydrogen's role as a substitute over time. Meranti Green Steel's planned Duqm development illustrates the connection between hydrogen supply and the industries a country wants to attract. Gas allocation becomes a way to influence the future configuration of an industrial asset.

Export markets build on relationships the Gulf already has. Europe and the industrial economies of East and Southeast Asia have long purchased Gulf energy and feedstocks; their emerging requirements concern the emissions attached to those purchases. Europe's Carbon Border Adjustment Mechanism (CBAM) covers hydrogen, ammonia, and urea, bringing emissions accounting into existing Gulf trade as well as prospective clean hydrogen exports. The Gulf's first large green ammonia projects are entering this market through companies that already know its customers. NEOM's output is contracted to Air Products, a leading global hydrogen supplier, for 30 years, with chemical company Yara International providing an additional route to market. On the other hand, leading renewable energy company ACME has contracted its first phase to Yara directly.

Yara connects this emerging trade to the earlier history of renewable hydrogen, growing out of Norsk Hydro's fertilizer business. Today, it brings customer relationships,

shipping, and distribution to new Gulf production. The industrial market for hydrogen has survived successive waves of enthusiasm for the molecule because its products remained useful. Whether it can now sustain cleaner production depends on what customers can pay, what emissions rules require, and how much of the difference producers can close.

WHAT MAKES HYDROGEN WORTH BUILDING IN THE GULF?

The Gulf's interest in hydrogen combines export earnings, domestic resource management, and industrial diversification. Hydrogen offers a way to use renewable resources to support new manufacturing, reduce some industries' dependence on gas, and preserve access to markets that introduce tighter emissions requirements. These objectives reinforce one another, although their relative importance differs across countries and projects.

Electricity is a major component of green hydrogen's cost, giving locations with strong renewable resources an advantage. The Gulf combines those resources with ports, industrial land, and experience delivering large energy projects. Financing is equally consequential; the cost of capital changes the price a plant must recover over its operating life and, therefore, the price at which its products can compete.

Comparisons need to take these conditions into account, because a modeled production cost at a Gulf plant will be different from a delivered price in Europe or Asia, which includes conversion and transport. Comparing a future Gulf project with an existing European facility also introduces differences in timing, scale, and financing. The region's advantages are substantial, but the commercial result remains specific to each individual project and its destination.

Domestic use changes that calculation. Renewable hydrogen that replaces gas-derived hydrogen frees gas for export or other uses. It also carries the value of whatever industry it attracts, whether steelmaking, fertilizer, or other manufacturing. Both routes belong to a longer Gulf effort to retain more value from its resources, an ambition that predates the current energy transition.

WHERE WILL THE VALUE OF BUILDING HYDROGEN IN THE GULF ACCUMULATE?

During the 1930s, Shaikh Hamad bin Isa Al Khalifa advocated for the refining of oil in Bahrain and sought positions of responsibility for Bahrainis in the process. The country's refinery, built by the Bahrain Petroleum Company (Bapco), subsequently

opened in 1936, with a formal apprenticeship training scheme being established in 1955. These milestones show how securing an industrial facility and developing a formal workforce pipeline can proceed on different timetables. They also place today's localization questions within a much older debate about what resource development should deliver at home.

The answer depends on which parts of the industry countries develop. Engineering and maintenance provide work that continues after construction; component manufacturing connects local suppliers to successive projects; and research and technology development create capabilities that can serve markets abroad. Industries consuming hydrogen add another layer of value through their downstream products. Research on hydrogen's emerging value chains warns that export projects can become industrial enclaves, with domestic participation confined to temporary construction and relatively low-value services. Building connections between foreign investors, domestic suppliers, and research institutions requires deliberate policy and firms capable of absorbing the knowledge.

The first green hydrogen developments illustrate a starting point. NEOM uses German electrolyzer technology and Chinese wind turbines, while Chinese suppliers are delivering electrolyzers to Omani projects. Hosting a production plant does not by itself create domestic capability in engineering, component manufacturing, or technology ownership. Construction and operations generate local activity, but higher-value capabilities may remain with international suppliers unless they are deliberately transferred or developed. The scale of procurement gives Gulf countries an opportunity to negotiate training, supplier qualification, local servicing, and localization commitments while an industry is still taking shape.

Manufacturing and investment are beginning to address different parts of that opportunity. Oman's Sohar polysilicon development connects renewable deployment to production of an essential solar material and is deemed the largest polysilicon manufacturing facility outside of China. In the UAE, the Abu Dhabi National Oil Company (ADNOC) announced a collaboration agreement to develop domestic electrolyzer manufacturing to produce green hydrogen. The agreement's industrial value will depend on manufacturing activities and skills ultimately located in the country.

Equity investment provides another route. Saudi Arabia's sovereign wealth fund, the Public Investment Fund (PIF), holds 6% of electrolysis technologies provider thyssenkrupp nucera, while an arm of Oman Investment Authority participated in electrolyzer manufacturer Hysata's investment round. Such holdings give Gulf investors an economic interest in the companies developing electrolyzer technology. Translating interest into domestic capability still requires arrangements for value capture. Share ownership, local assembly, and the ability to design a component are different achievements,

each with different implications for where future value accumulates.

Governments therefore need to judge projects over their operating lives: whether engineers advance into technical leadership, suppliers win repeat business, and domestic firms acquire capabilities that survive beyond a single construction contract. The same long-term view applies to industries consuming hydrogen. A fertilizer plant creates employment opportunity and export revenue, but the production relationships surrounding it can eventually become part of another country's food security.

WHY IS HYDROGEN RELEVANT TO FOOD SECURITY?

Ammonia production represented roughly a third of global hydrogen demand in 2025, with most of the ammonia used to make fertilizer. The Middle East's importance becomes particularly clear in trade: the International Energy Agency (IEA) puts the region's share at more than 25% of internationally traded ammonia and almost 40% of traded urea. The connection between hydrogen and food security therefore runs through an established industrial system on which agricultural economies already depend.

The 2026 US-Iran conflict disrupted several parts of that system simultaneously. The IEA records that the Qatar Fertiliser Company (QAFCO) paused production at its Mesaieed complex, while gas shortages forced Bangladesh to suspend four of its five urea plants in March. Producers in India and several European countries also reduced or interrupted operations. Importing countries faced exposure from both the fertilizer they purchased and the gas they needed to manufacture it themselves. Domestic fertilizer plants offered limited protection when their feedstock depended on the same disrupted trade routes which transport the complete product. The consequences extended into planting schedules and fertilizer application, where reduced use can damage yields.

OMIFCO shows how these dependencies can be organized into a lasting partnership. At Sur, Omani state ownership sits alongside two Indian farmer cooperatives, connecting fertilizer production directly to the agricultural economy it serves. India's relationship with the plant extends beyond purchasing its output: institutions representing its farmers share in its ownership. For future hydrogen trade, this arrangement raises a larger question about whether importing countries will simply buy cleaner products or invest alongside producers in the industries supplying them.

Renewable hydrogen offers one way to reduce dependence on imported gas for fertilizer production, although it introduces its own requirements for reliable electricity, equipment, and infrastructure. Higher gas prices can improve its relative economics,

but the issue is that low-emissions production cannot expand quickly enough to relieve immediate crises. The strategic opportunity lies in the next generation of industrial assets: whether they broaden the sources and routes on which essential production depends and whether their contracts remain adaptable through changes in energy prices.

For Gulf producers, the terms of the hydrogen discussion broaden. Buyers need confidence in emissions performance and price, but also in the continuity of supplies that support factories and farms. The region brings production experience, infrastructure, and established commercial relationships to those negotiations. Turning these advantages into lasting value requires industrial policy at home and a clearer position abroad on market access, supply commitments, and the rules under which hydrogen's products will be accepted.

IS THERE A UNIFIED GULF POSITION ON HYDROGEN?

The Gulf has developed hydrogen through national programs, project agreements, and bilateral relationships. A comparable collective position on the rules governing the emerging trade is less visible, even though developers across the region share many of the same questions about eligibility, certification, and the durability of demand.

The Middle East is "home to some of the largest committed individual hydrogen projects in the world." Around $11 billion is committed across 15 projects representing roughly 500,000 tonnes of annual production capacity. Projects in the Gulf account for the largest share and represented half of the capital attached to projects entering FEED globally this year. FEED stands for front-end engineering and design and refers to the stage where a project enters the detailed engineering phase in which the design, cost, and schedule are established ahead of a final investment decision; Yanbu alone represents more than $3 billion. The concentration of investment shows that the region can finance and build at scale. It also raises the following question: whether its national projects can become a collective position in the markets that will determine their value.

The European debate over renewable hydrogen requirements makes arriving at such a collective position more difficult. Developers have designed projects around rules that European Union (EU) member states are pushing to change; a European Commission document leaked in September 2026 proposes replacing binding national targets with a post-2030 indicative goal of eight million tonnes a year. Any proposed revision needs to be distinguished from adopted policy, but the uncertainty itself affects decisions: investors must judge whether a project designed to qualify today will retain its value

under tomorrow's framework.

A Gulf approach could focus on concrete shared interests, with producers coordinating technical positions on certification, seeking recognition of credible emissions measurement, and arguing for predictable treatment of projects already committed under existing rules. Acceptance in an importing market would still require agreement with the respective market's authorities, but regional coordination would give those negotiations a clearer foundation.

The case for cooperation follows the water–energy–food nexus framework, where decisions about a single commodity shape industrial development, agricultural supply, and foreign relations at the same time. Hydrogen makes those connections visible because its value depends on the products, infrastructure, and institutions built around it.

The renewed attention on hydrogen, then, is not about the molecule. It is about what buyers have newly decided to pay for, how they intend to verify it, and whom they will trust to deliver it when a route closes. The Gulf meets this shift with the deepest operating experience of any producing region but with the least developed collective position. Both this experience and lack of collective position will be tested on a short timetable; the projects entering production in 2027 will show whether the region can deliver, and Europe's revision of its hydrogen rules will show whether the region can negotiate.

About the Author



Rumaitha Al Busaidi is a leading voice in Oman's green hydrogen sector, whose work focuses on the Water, Energy, and Food (WEF) Nexus as a foreign policy and sustainability framework for the Gulf. In April 2025, she helped launch the world's first liquid hydrogen corridor for Oman, alongside His Majesty the Sultan and the King of the Netherlands. A graduate of both the Harvard Kennedy School & the University of Oxford, she has been recognized by the BBC 100 Women list, Reuters Top 25 Women in Climate, and Fast Company's Most Creative People in Business.

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