



**Enablers to become
the hydrogen economy
superpower:**

Closing the hydrogen
capabilities gap in the GCC



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Introduction

At COP26, the 2021 United Nations climate change conference, over 190 countries agreed to finalize the outstanding elements of the Paris Agreement rulebook – a framework aimed at enabling ambitious and effective climate action with energy transition at the core of it. This paves the way towards limiting global warming to 1.5 degrees Celsius in the 21st century. To achieve this goal, both governments and private sector companies must be prepared with a set of no-regret and resilient strategies to face any future market scenario.

Amid this global energy transition, the GCC countries¹ have set ambitious agendas to increase the share of renewables in their energy mix, not only to meet the Paris Agreement targets on the one hand but also to prepare for the gradual decline in demand for fossil fuels from global markets.

However, GCC fiscal policy continues to be exposed to the heavy dependence of government revenues on volatile oil export revenues, as shown in Figure 1.

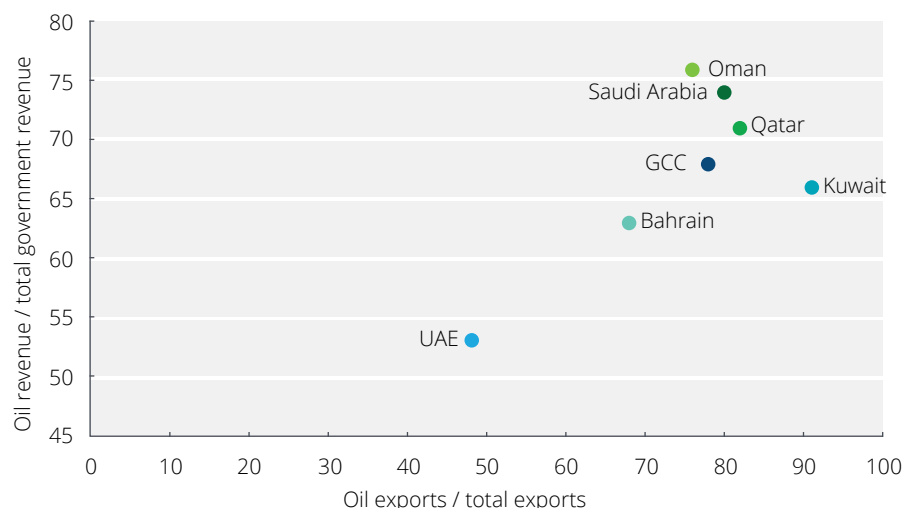


Figure 1: GCC countries oil exports and relevant revenues

The key role of hydrogen for the GCC in the future energy system

Although different initiatives to decarbonize and electrify energy sources are already being rolled out, one unleashed opportunity relates to leveraging green energy to generate alternative fuels that will power the energy-hungry sectors without producing CO₂, therefore achieving the zero-carbon emission goal. Among the various options,

hydrogen – blue hydrogen with carbon capture, utilization and storage (CCUS) in the short to mid-term, and green hydrogen in the longer-term - stands out as one of the more viable alternative fuels to achieve decarbonization, since after combustion it releases water instead of carbon dioxide. Because of its inherent properties, green hydrogen provides GCC countries with an opportunity to become the undisputed champions of the future hydrogen era.



The Kingdom of Saudi Arabia has pledged to cut carbon emissions to net-zero by 2060. Investments of up to US\$180 bn have been earmarked to support this, which will be achieved by a combination of cutting emissions and offsetting measures². At the core of its net-zero plans, the Kingdom seeks to become the de-facto supplier of hydrogen targeting to produce and export 4 million tons of hydrogen by 2030³.



The United Arab Emirates launched 'Energy Strategy 2050', which is considered the first unified energy strategy in the country that is based on supply and demand. The strategy aims to increase the contribution of clean energy in the total energy mix to 50% by 2050 and reduce the carbon footprint of power generation by 70%.³ The UAE reinforced its commitments to climate action through the Hydrogen Leadership Roadmap which targets a 25 percent market share in the key export markets⁴.



Oman's interim targets include the deployment of renewable energy and the deepening of energy efficiency actions, which are the pillars of its 2030 carbon control plan. This would enable Oman to slow the growth of greenhouse gas (GHG) emissions and reduce them by 7% by 2030.⁵ Oman has also established Oman's Hydrogen Alliance with the mission to diversify its fossil heavy energy mix to realize climate change commitments through shifting toward green hydrogen.⁶



Kuwait has pledged to cut its emissions by 7.4% below business-as-usual levels by 2035 in its revised Nationally Determined Contributions. This is well below the 45% cut in global greenhouse gas emissions set out in the Paris Agreement's 1.5 degrees Celsius warming goal.⁴



Qatar plans to combat climate change and reduce GHG to achieve a 25% reduction by 2030. For this purpose, a dedicated environment and climate change ministry was established in 2019 to address environmental and climate change issues.⁶



Bahrain aims to reach net-zero carbon emissions by 2060. To help tackle climate change and protect the environment⁷, Bahrain will adopt a circular carbon economy strengthened by various offsetting schemes including carbon-capture technology and afforestation.

Table 1: Energy transition agenda extract in the GCC

Why GCC countries can become key players in the green hydrogen economy

Green hydrogen is considered a critical component of the decarbonization agenda due to its natural abundance and environmental sustainability: it is produced through the electrolysis of water, using electricity produced from renewables. This production process implies that the full life cycle is close – if not equal – to neutral in terms of GHG emissions. In addition, the properties of hydrogen, such as high energy density and high convertibility to multiple forms for storage and transportation (e.g. liquid status), make it a

critical and high-impact element to enable the energy transition agenda.

When it comes to the hydrogen market⁸, global production is expected to increase significantly to support the net-zero agenda⁹. From 90 million tons (MT) in 2021 with a total market value of ca. US\$315 bn, global hydrogen production is anticipated to increase to ca. 532 MT by 2050 with green hydrogen dominant among the different forms, and with a market value of ca. US\$798 bn. The turning point in terms of widespread adoption is forecast to occur in the year 2030, when production is estimated to reach 390 MT, as shown in Figure 2.

The hydrogen market global production is expected to increase significantly to support the net-zero agenda

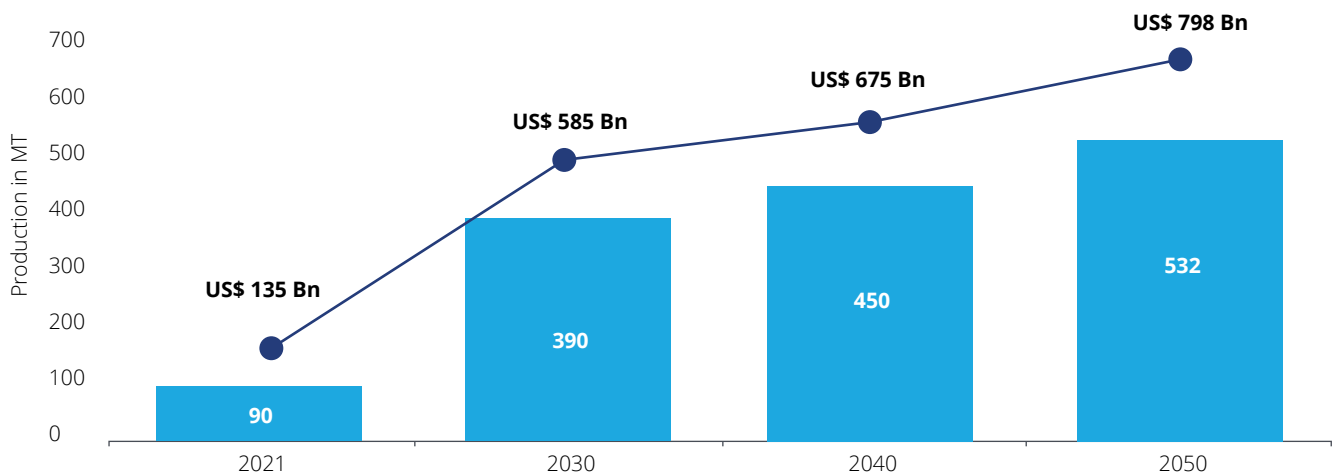


Figure 2: Net zero emissions global production (MT) and market value (US\$bn)

Besides being driven by the growing need to reach zero global emissions, the huge increase in green hydrogen demand is mainly accelerated by four different components illustrated in Figure 3.

1. Reduced levelized cost of hydrogen (LCOH) Production costs expected to significantly drop due to decreasing renewable electricity prices and CapEx as a result of technology improvements and production at scale; in addition, green hydrogen benefits from being carbon-free.	2. Market pressure on companies High pressure on large public and private companies due to increasing global awareness of the impact of CO2 emissions on climate change; several companies have announced their net-zero emissions strategy to be reached by 2050.
3. Higher funding availability Significant funds at the disposal of both private investors and governments with public funds to support the energy transition (e.g. investments in hydrogen infrastructure as part of COVID-19 recovery packages).	4. Increase in planet positive regulations Given the global concerns and awareness around the climate change challenge, policymakers and governments are developing policies and regulations to accelerate the long decarbonization process.

Figure 3: Main drivers of the green hydrogen increase

As already noted, green hydrogen production relies purely on renewables for the electrolysis process. However, while the availability of renewables represents a serious constraint for several governments, GCC countries are provided with a viable opportunity to become key players in the new hydrogen economy as they can rely on several competitive advantages:

1. The abundance of high-yield solar energy
2. Unlimited flat land to further develop energy-related infrastructure
3. Solid availability of funding and alignment with national diversification strategies
4. Potential to retrofit current fossil infrastructure for hydrogen operations and shipping that builds on existing routes
5. Central location vis a vis key energy demand markets (Europe, Japan, and South Korea)

If a solid value proposition and proper strategy execution are established, GCC countries will be well positioned to achieve cost leadership in the hydrogen economy as shown in Figure 4.

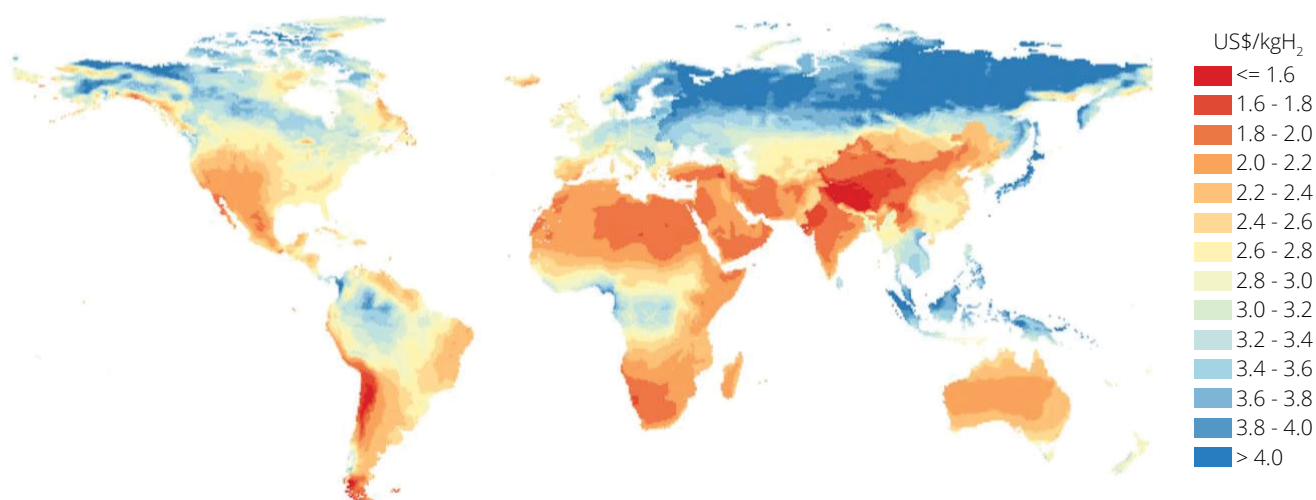


Figure 4: Hydrogen costs in the long-term¹⁰

In this context, GCC countries could become the key hydrogen suppliers globally: although green hydrogen is difficult to transport in a gaseous form because of its low density and high flammability, it can be converted to ammonia, LOHC, or LH₂ to offset such midstream and downstream-related issues. To leverage this opportunity, the Middle East region can already count on a highly effective export infrastructure that should be utilized as a strategic asset for export from the GCC on long-distance routes.

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Which are the key markets and relevant industries driving demand?

EU: All

- Energy importer
- Wants decarbonization and energy independence
- Green energy, technology subsidies and demand stimulation
- Leverage chemical and pipeline infrastructure

Saudi Arabia: Supply push

- Energy exporter
- Wants to create employment not dependent on fossil fuels
- Green hydrogen from solar and wind farms as feedstock for fertilizer
- Part of Vision 2030 program

China: Technology push

- Energy importer
- Most cost competitive technology (electrolyzers and fuel cells)
- Target of 1m FCEVs by 2030
- R&D grants, usage incentives

Japan: Demand pull

- Energy importer
- Wants to innovate in the transportation sector
- Focus on mobility and electricity production

Australia: Supply push

- Energy exporter
- Focus on blue hydrogen to export to Japan (e.g. hydrogen shipping project Kawasaki & Shell)

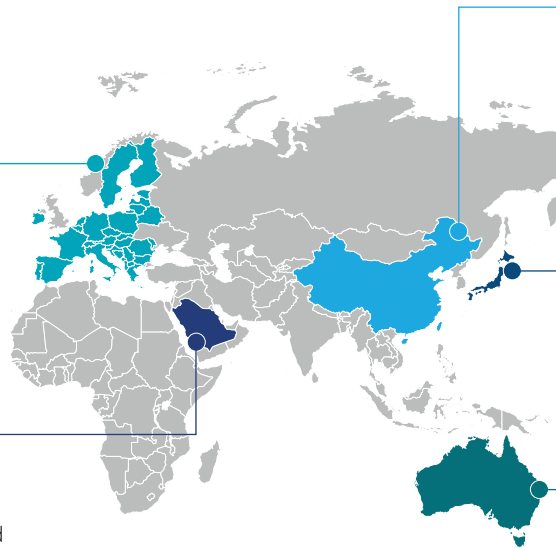


Figure 5: Hydrogen market and policies overview¹¹

¹¹ Monitor Deloitte Analysis

For the GCC to leverage the green hydrogen opportunity, it is essential to understand where its key markets lie. As seen in Figure 5, based on the availability of renewables and current hydrogen development, Europe and Asia-Pacific (but mostly Japan and South Korea) represent the two most viable markets for green hydrogen, while the GCC itself is well positioned as a solid exporter. Therefore, the GCC should focus on optimizing the configuration of midstream operations (shipping, port operations, storage and pipelines etc.) to cement their competitiveness for winning in the green hydrogen era.

In Europe and Asia-Pacific, the key sectors that will have high potential to drive demand for hydrogen are industry, mobility and power, as shown in Figure 6.

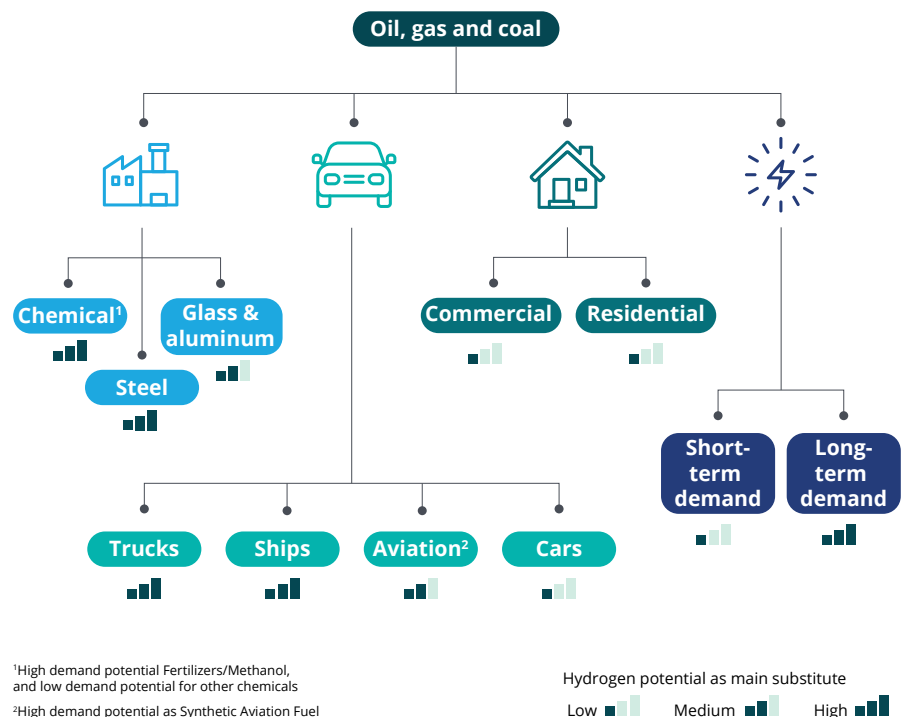




Figure 6: Substitution opportunities for Hydrogen

- **Chemicals:** Chemical feedstock related demand is set to increase from 44 MT/year in 2021 to 57 MT/year by 2030 as demand for ammonia and methanol surges: this represents an opportunity for green hydrogen, which has a competitive cost base¹², as shown in Figure 7.

- **Steel:** Without policy intervention, demand for dedicated hydrogen production in steelmaking is expected to grow from the current level of 4 MT/year to 46 MT/year by 2050, representing an increase of approximately %1150. As a result, industrial heat is a potential sector in which green hydrogen could thrive due to its cost competitiveness in the long term¹⁴, although significant investments to offset production costs are required.

- **Mobility:** Hydrogen offers the opportunity to decarbonize mobility, especially freight mobility including trucks and buses, shipping, aviation, and specialist equipment.

-  Trucks: Hydrogen-powered trucks could be highly competitive in road freight, which is characterized by long-distances and cross-border journeys. Since trucks are responsible for a significant share of road transport GHG emissions, hydrogen could be the ideal element for decarbonizing road freight operations¹⁵.

-  Maritime: Maritime freight activity is set to grow by around 45% by 2030. Hydrogen and ammonia represent solid solutions for both national action on domestic shipping and meeting the International Maritime Organization (IMO) Greenhouse Gas Reduction Strategy¹⁶. The main drawback of hydrogen/ammonia is that, due to their low density, cargo volume would be

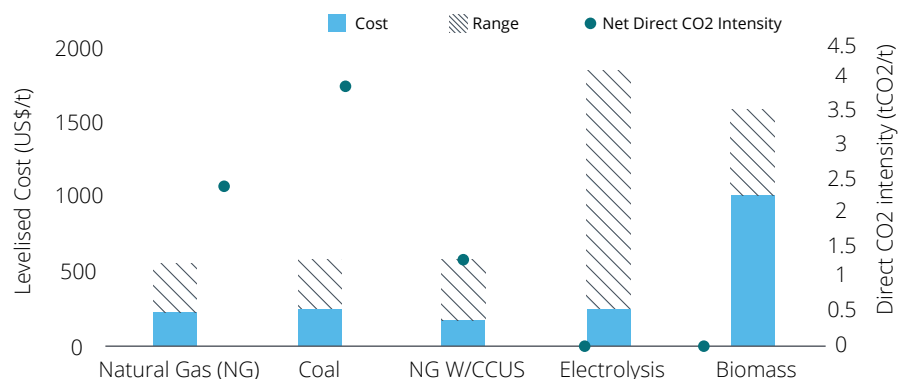




Figure 7: Costs and CO2 intensities for greenfield ammonia and methanol production¹³

lost at the expense of storage.

some metals.

-  Aviation: Large storage volume and aircraft redesign would be needed to accommodate pure hydrogen, making power-to-liquid and biofuels more attractive options for this industry. However, these are four to six times more expensive than the currently used kerosene.

-  Passenger vehicles: The global car stock is expected to grow, and hydrogen can capture part of this market. The short refueling time and zero tailpipe emissions make hydrogen an efficient fuel in niche markets if the initial rise in fuel costs and large electricity consumption is offset¹⁷.

- **Buildings:** Green hydrogen is less likely to be adopted within the built environment sector for the following reasons:

- Hydrogen achieves relatively lower radiation heat than other fuels
- Hydrogen-powered burners may need to be redesigned to use hydrogen
- Hydrogen causes corrosion and brittleness when in contact with

The GCC should focus on optimizing the configuration of midstream operations to cement their competitiveness for winning in the green hydrogen era

What type of investment is required to achieve leadership in the hydrogen era?

Just as GCC countries hold a key position in the oil industry, they could also become leaders in the hydrogen era. To fully seize the opportunity related to the hydrogen market and its potential, three different scenarios have been considered for the GCC, with penetration rates of 10%, 20%, and 30% representing the conservative, intermediate and aggressive scenarios respectively, as shown in Figure 8.

There is a significant market opportunity for GCC countries for each of the considered scenarios with a potential to capture a market size¹⁸ that ranges between US\$79.5 bn (conservative scenario) and US\$239.4 bn (aggressive scenario) in 2050.

Over the next few decades, the cost of producing green hydrogen is expected to decrease as a result of significant operating cost reductions due to economies of scale and technological improvements. Although operating costs will potentially shrink,

the investments required to support the energy transition will be considerable, although they will pay off in the long-term.

With capital investments expected to increase over the coming decades, the capital expenditure for producing 1 MT of green hydrogen and its derivatives such as ammonia will drastically decline due to efficiency improvements in the three key cost components among others, as shown in Figure 9.¹⁹

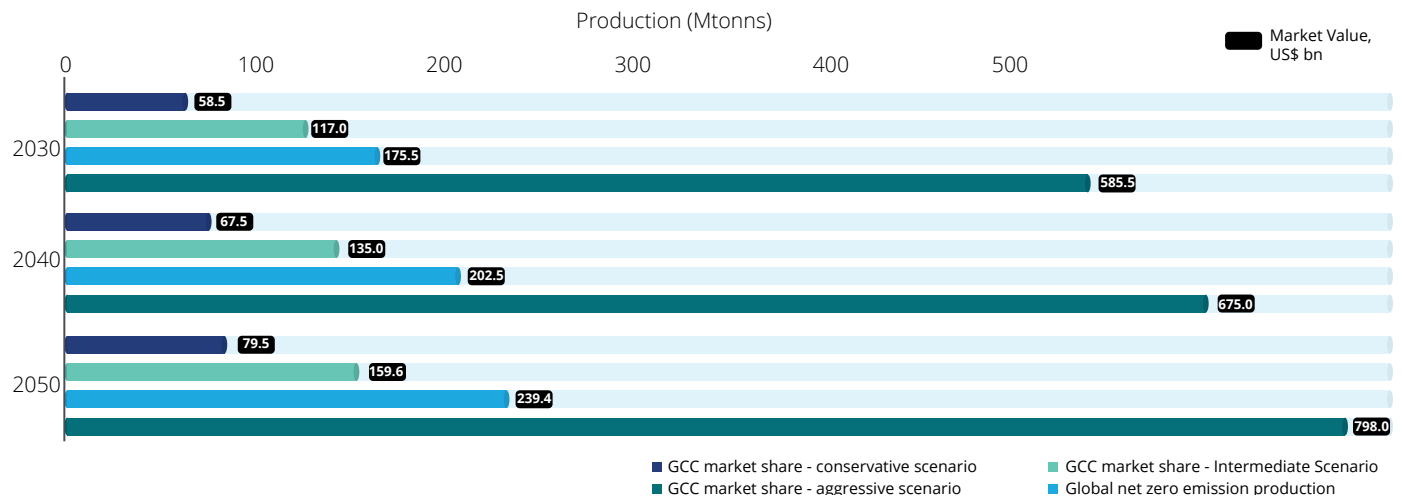


Figure 8: Net Zero Emissions Hydrogen Production (Mtonns) and Market Value (USDBn)

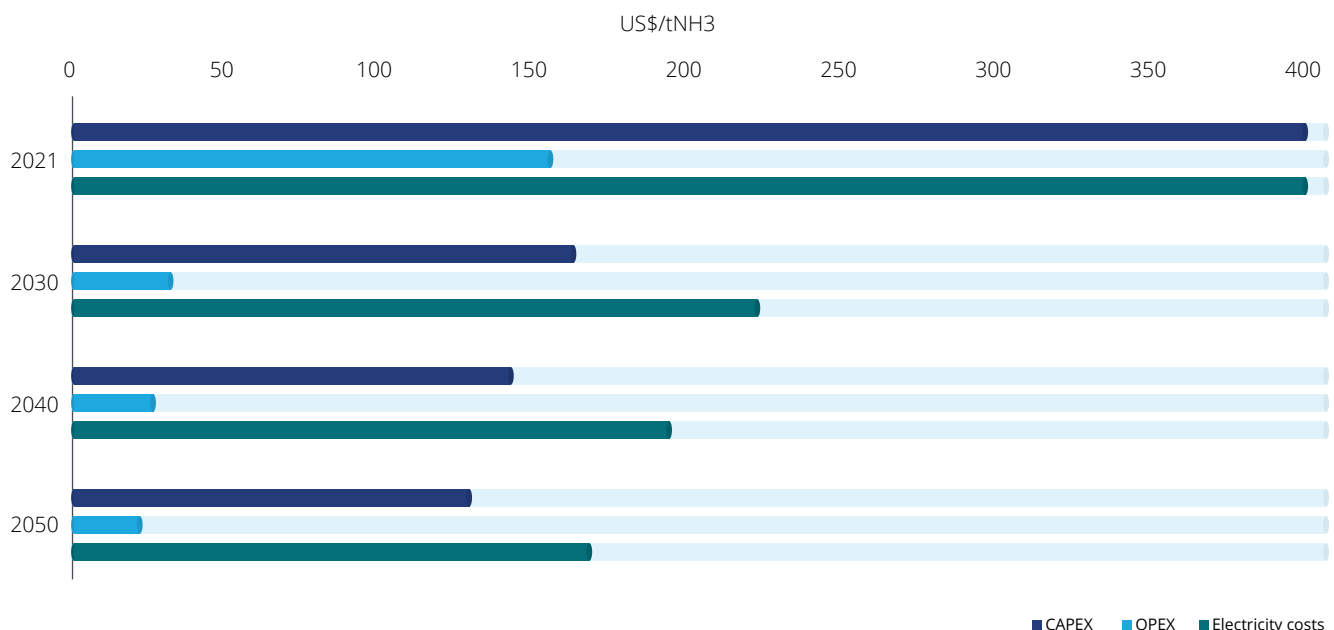


Figure 9: Total CAPEX per 1 MT (US\$bn)

As the GCC bloc embarks on a journey to become one of the main green hydrogen exporters, considerable investments towards net-zero projects are crucial. Currently active projects (see below) indicate that GCC countries are moving in the right direction. However, a greater level of scale is still necessary.

- **Saudi Arabia (ongoing):** A large-scale hydrogen plant powered by 4 gigawatts of wind and solar power is set to be built in NEOM²⁰ – a planned smart city located in northwestern Saudi Arabia. The completed facility will produce 650 tons of green hydrogen daily. Air Products, the U.S. industrial gas giant, will be the distributor.

- **Oman (announced):** The Hyport® Duqm Green Hydrogen Project plans for a 500-250 megawatt electrolyzer powered by solar and wind (Deme Group, 2020). In addition, Sohar Port aspires to become the Middle East's first green hydrogen generation hub powered by gigawatts of solar energy.

- **United Arab Emirates (ongoing):** As the host of COP28, the United Arab Emirates is focusing on economic opportunities in climate action, which include piloting the region's first solar-powered green hydrogen plant through public-private partnerships between Siemens Energy, the Dubai Electricity and Water Authority (DEWA) and Expo 2020. In addition, the Ministry of Energy and Infrastructure launched the UAE Hydrogen Technical Committee in 2020, which brings together the key stakeholders who will be able to shape the future of hydrogen in the UAE. Moreover, under the umbrella of Dii Desert Energy, the MENA Hydrogen Alliance²¹ is bringing together private and public sector actors and academia to kick-start a (green) hydrogen economy based on low-cost value chains for green molecules in the region and beyond.

Although these are trendsetting projects among GCC countries, when compared to the top five countries active within green hydrogen development, the GCC region is still forecast to have a significant gap in terms of green hydrogen capacity development by 2025, as shown in Figure 10.

To offset the risk of being left behind, GCC countries need to consolidate a common

green hydrogen strategy and leverage their net-zero commitment as well as their leadership position in the energy markets internationally, which is set to be enhanced by milestones such as COP27 and COP28, due to take place in the region.

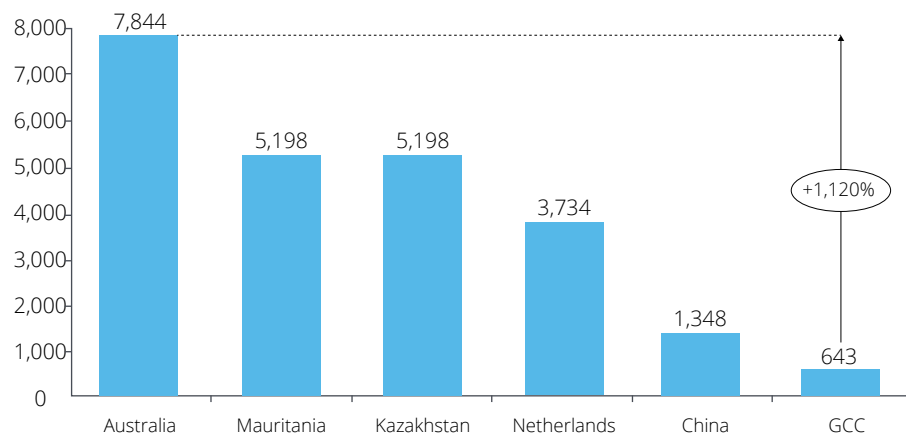


Figure 10: Capacity available by 2025 considered active projects (Kt H2/y): GCC vs. top 5 countries worldwide

As the GCC bloc embarks on a journey to become one of the main green hydrogen exporters, considerable investments towards net-zero projects are crucial.

Where should the value chain focus be to ensure long-term cost leadership in the hydrogen era?

The green hydrogen value chain, as shown in Figure 11, comprises three areas:

- **Upstream:** green hydrogen is produced from renewables:
 - Renewable generation: Electricity is generated from renewables
 - Electrolysis: Electricity is converted into green hydrogen through electrolyzers
- **Midstream:** Green hydrogen is converted and transported via the selected carrier
- **Downstream:** Green hydrogen is then delivered according to the sector / application

We have identified three key areas of focus for the GCC countries, based on the impact on the landed cost and opportunity to

achieve efficiency gains, in order of priority as shown below:

- **Conversion and reconversion of hydrogen:** Although there are different methods to supply green hydrogen, conversion to liquid ammonia is the most preferable. This is due to three main reasons:
 - **Synthesis know-how:** Ammonia synthesis is a widely known process
 - **Infrastructure maturity:** The infrastructure to store and supply ammonia already exists and it is widespread
 - **Quantity of hydrogen carried:** Liquid ammonia can contain more hydrogen by volume in respect to other hydrogen transportation methods

Although unlocking the potential and leveraging the oil and gas supremacy in the

midstream operations is one of the critical enablers for the GCC to substantiate its leadership position in the hydrogen era, reducing costs in the conversion and reconversion process through technological breakthroughs in the product creation to produce ammonia remains to be unlocked.

- **Electrolysis:** We have identified three opportunities for GCC countries as shown below:

- **Reducing the cost of production:** Although electrolysis technology (alkaline and polymer electrolyte membrane) is mature, reducing the cost of materials and automating processes could significantly decrease the capital required. Moreover, GCC countries could capitalize on the existing supply of electrolysis components (e.g., compressors, pumps, gas analytics) to further decrease production costs.

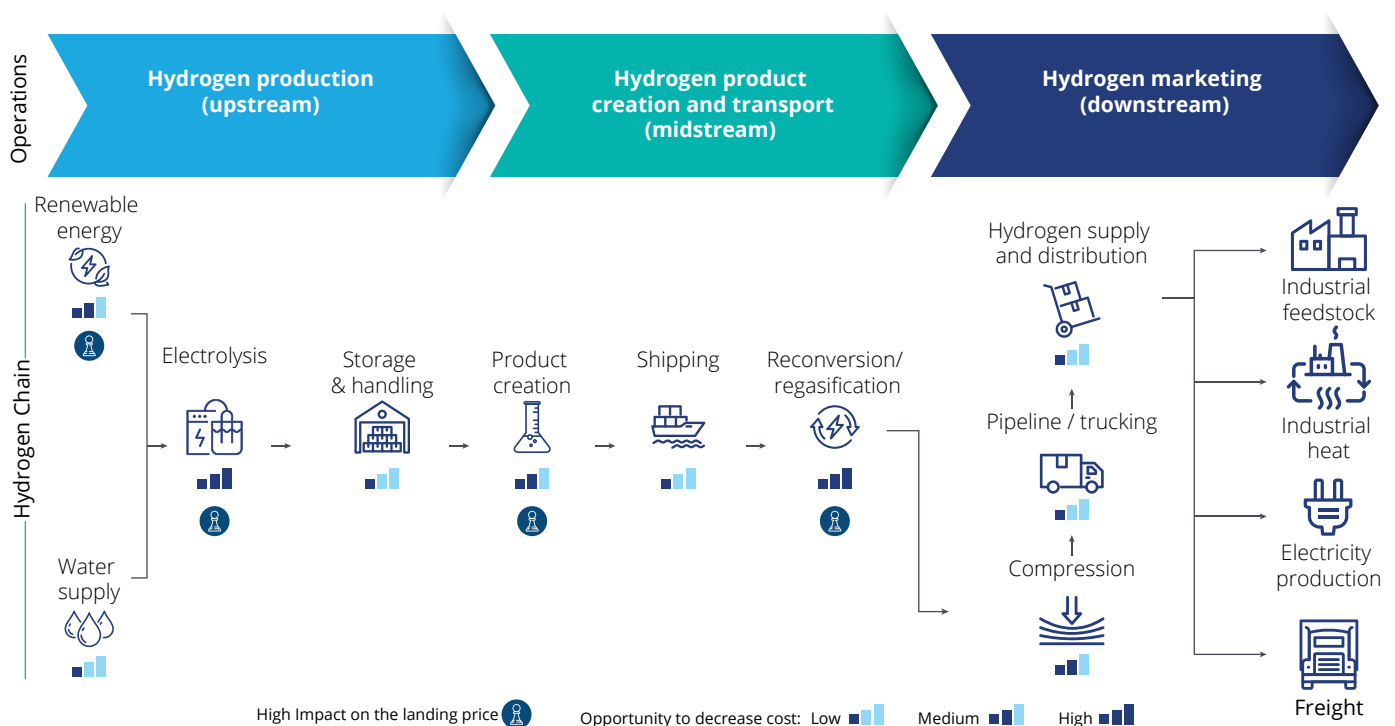


Figure 11: Renewable energy value chain and hydrogen role

- **Leveraging the oil and gas legacy:** To establish large-scale electrolysis plants at required quality standards, GCC countries could leverage expertise gained from the oil and gas sector to build and improve efficiency.
- **Investment attraction:** investments are being channelled into green hydrogen companies, leading to a rally of valuations for those companies with solid growth potential (in some cases with +50% multiples). The GCC countries can seize this opportunity by setting up new companies or localize promising ones to attract early on the foreign direct and local investments required to become a supplier for hydrogen technologies and products for both domestic use and global markets.

- **Renewables energy:** Leveraging photovoltaics (PV) and wind potential, GCC countries would be able to generate high volumes of renewable energy at a relatively low cost. Moreover, engineering and design activities related to renewables generation could be localized in the long term.

The road ahead to accelerate green hydrogen development within the GCC

The national and supranational government strategies are critical components to drive the energy transition strategy. In the last few years, increasingly after the 2020 Paris Agreement and in light of COP26, many governments are developing energy-related policies and regulations that will boost their carbon-free transition and facilitate the change for energy companies.

On a global level, national long-term energy strategies aim at determining the most efficient way for low-emission power sources to support the decarbonization process, gathering stakeholders' investments, and facilitating collaboration among private and public entities to generate synergies. These energy-related policies are based on each country's priorities and constraints (e.g., renewables availability, technology), as needs differ among countries.

When it comes to designing comprehensive policy frameworks to facilitate the ambitious program of adopting green hydrogen across the entire energy system, the GCC countries need to consider three key areas, as shown in Figure 12.

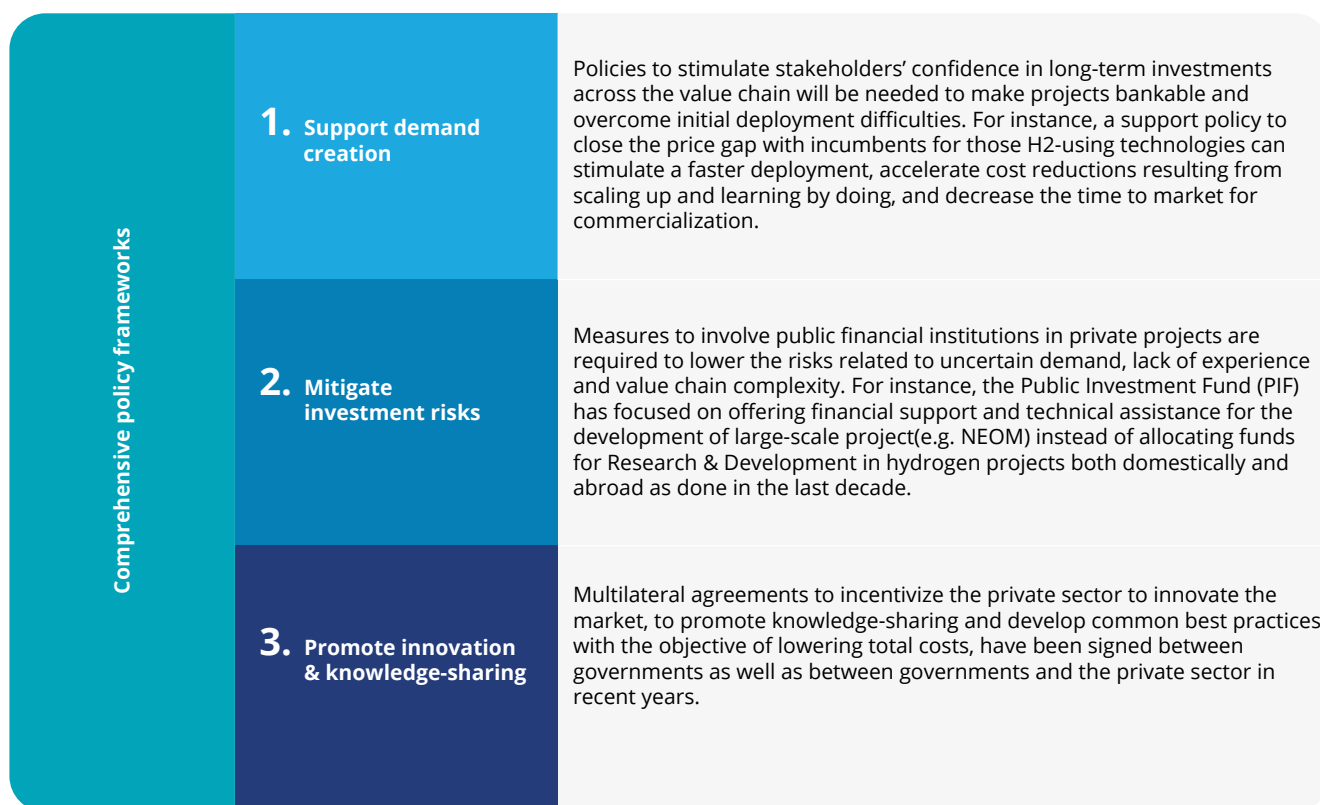


Figure 12: Comprehensive policy frameworks

To stimulate investment in the hydrogen market, GCC governments should also leverage three additional measures, as shown in Figure 13, in line with their overall energy policy agendas.

In addition to setting energy-related regulations based on the actual needs and specific conditions, GCC countries have the opportunity to design an integrated energy vision that takes into account each contributor's ambitions, driven by the shared view of shaping a zero-emissions future. With these efforts guided by

domestic and bloc-wide approaches, the GCC will have a consolidated, integrated and connected role in the energy transition era, from a global standpoint.

To pave the way, the GCC is required to reduce domestic oil and gas and fiscal dependency by integrating green hydrogen in long-term strategies through a set of industrial and market initiatives. Moreover, to become leaders in the green hydrogen market, it is essential for the energy vision to encompass a set of

initiatives to increase the production of renewables, to localize hydrogen research and technologies, and to focus on solid midstream operations. With the right and timely choices, GCC countries will have the possibility to become the undisputed champions of both the fossil and hydrogen markets and trusted suppliers to energy importers across the world.

Blending obligations	Innovation budgets	Market instruments
<ul style="list-style-type: none"> Blending obligation for suppliers to deliver a certain share of hydrogen in natural gas (~5 - 15%) Minor investments required and significant market effect through the creation of additional demand for hydrogen Insufficient to create a big market and possible hydrogen devaluation by blending a high premium product with a commodity product 	<ul style="list-style-type: none"> Funding programs for demonstration projects (e.g. an innovation fund) to support investments Reduction of risks for banks and acceleration of R&D efforts with the aim of boosting economic growth towards climate announcements Financing limited to one-offs and commercial parties stimulated to fulfill funding requirements even if not strategically relevant to the project 	<ul style="list-style-type: none"> Market instruments (e.g. increase of carbon taxes) to support hydrogen market creation Provision of financial support and creation of market demand through the introduction of new binding rules Hydrogen not yet commercial for market funding and market instruments not designed for energy carriers

Figure 13: Key levers for boosting investments in the hydrogen economy

With the right and timely choices, GCC countries will have the possibility to become the undisputed champions of both the fossil and hydrogen markets and trusted suppliers to energy importers across the world.

Contacts



Bart Cornelissen

**Partner Strategy, Monitor Deloitte,
Middle East**

**Energy, Resources & Industrials
Leader, Deloitte Middle East**

bpcornelissen@deloitte.com



Yousef Iskandarani

**Senior Strategy Manager, Monitor
Deloitte, Middle East**

yoiskandarani@deloitte.com



Robin Butteriss

**Partner, Corporate Finance Advisory,
Deloitte Middle East**

robutteriss@deloitte.com

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- . Giulio di Nocera - Consultant, Monitor Deloitte, Italy
- . Lorenzo Giudici - Associate, Monitor Deloitte, Italy
- . Michal Arament – Director, Monitor Deloitte, Netherlands
- . Leong, David – Associate Director, Corporate Finance Advisory, Deloitte Middle East



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