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Green Hydrogen Opportunities for the Gulf Region

Sustainability Research Paper

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Green hydrogen can help decarbonise hard-to-abate sectors like refinery, steel and heavy duty transport and the chemical industry. The Gulf region is well positioned to establish itself as a hydrogen hub as it has cheap and abundant renewable energy resources and is located in the vicinity of major hydrogen consumption centres like Europe and Asia. What risks does a massive uptake of green hydrogen pose to the region? What is green hydrogen and what is its current and future contribution to a sustainable global development? Which hydrogen policy frameworks are currently existing in the Gulf region?

SUSTAINABILITY 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 sustainability 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.

- Green hydrogen can help decarbonise hard-to-abate sectors like refinery, steel and heavy duty transport and the chemical industry.
- Today's hydrogen demand is forecasted to grow five-fold until 2050 which opens significant economic opportunities for renewable energy rich regions like the Gulf countries.
- The Gulf region is well positioned to establish itself as a hydrogen hub due to various reasons:
    - o It has cheap and abundant renewable energy resources.
    - o It is geographically well located in the vicinity of major hydrogen consumption centres like Europe and Asia.
    - o It has the experience and infrastructure as well as the financial means to develop large-sale energy projects.
    - o The domestic production of cheap, green hydrogen might attract energy intensive industries from other regions which can contribute to the diversification of a country's economy.
- More stringent global climate commitments might heavily reduce the region's revenues resulting from fossil-fuel exports with related impacts to countries' economies.
- Regarding the different hydrogen production technologies, the Gulf countries have varying approaches. Oman focuses on producing green hydrogen, Qatar is opting for blue hydrogen, and the UAE and Saudi Arabia plan to strike a balance between both options.
- A global uptake of hydrogen demand is a double-edged sword for the Gulf countries. It can be seen as a significant economic risk to the region due to declining demand for fossil fuels, but it also brings immense opportunities for sustainable economic diversification and positioning the region as a world leader for producing and exporting green hydrogen.

Climate change is one of the most significant challenges of our time. The world is facing unprecedented changes in climate patterns, with potentially devastating effects on natural ecosystems, human livelihoods, and global economic growth. The urgency to reduce carbon emissions and transition towards sustainable energy sources has become a top priority for many countries and regions worldwide (UNFCCC 2023). In this context, green hydrogen has emerged as a promising solution for decarbonisation, especially in the hard to abate sectors like heavy industry and heavy-duty transport as well as aviation and maritime transport (IEA 2022).

The Gulf Cooperation Council (GCC), consisting of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE), is one of the world's largest and most established energy exporters, with about 1/3 of the world's oil and 1/5 of the world`s natural gas reserves (SWP 2022). The emerging green hydrogen market presents significant opportunities, but also risks, for the Gulf region. On the one hand, the region has abundant renewable energy resources, including solar and wind power, that could be harnessed to produce green hydrogen – paving the way for large scale exports of green hydrogen and its derivatives. Moreover, its vicinity to major hydrogen consumption centres like Europe and Asia as well as its established energy transport infrastructure makes the region a perfect candidate to become a major hub for Power-to-X (PtX) export. However, the region also faces the risk of oil and gas demand declining by a large-scale ramp-up of the hydrogen markets which could heavily affect its economy (Michaelowa & Butzengeiger 2019).

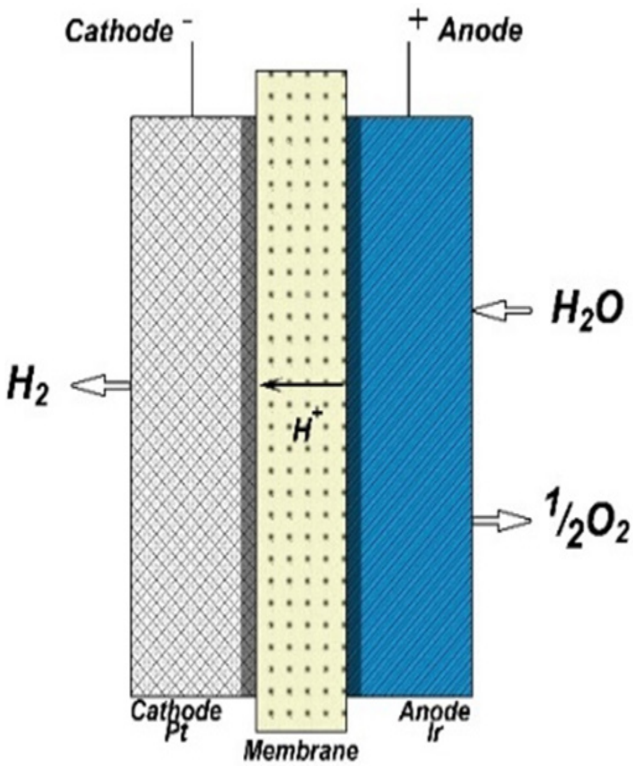
Gulf states have recognised the importance of diversifying their economies; and many countries have announced significant investments in renewable energies and PtX technologies. Especially the UAE, Saudi Arabia and Oman have published ambitious roadmaps to supply Asia and Europe as well as their domestic economies with green (and blue) hydrogen. Hence, green hydrogen could provide a significant boost to the region's economic growth by creating new sustainable industries, jobs, and export opportunities (Koch 2022). This report elaborates on the question "which opportunities and risks arise for the Gulf region from a globally emerging green hydrogen/PtX market?".

Global hydrogen production reached 94 million tonnes in 2021 and was mainly used as a feedstock in the refining and chemical industry. Approximately 82% of this production was met by unabated fossil fuel-based production technologies and approximately 18% as a by-product from chemical operations – in total emitting 900 Mt of CO2. This equals approximately 2.5% of global GHG-emissions. The two most mature technologies for low-carbon hydrogen production are blue hydrogen (fossil-fuel based hydrogen combined with Carbon Capture and Storage technologies) and green hydrogen (hydrogen produced via electrolysis powered by renewable electricity). Today, low-emission hydrogen represents less than 1% of global production (IEA 2022).

Today's hydrogen production is expected to grow 5-fold until 2050. Main demand drivers are demand from transport - mainly heavy-duty transport as well as air and maritime transport - steel production, electricity storage/ generation and to a smaller amount the building sector. However, demand in these applications was limited to around 40 kt H2 in 2021 (IEA 2022). It is important to mention that green hydrogen production is highly energy intensive, and less efficient than direct electrification with renewable energies (e.g., in the household sector). Therefore, policy makers should aim to prioritise hydrogen use in those sectors where the highest and most economically effective CO2-mitigations can be achieved (IRENA 2022A).

Green hydrogen refers to hydrogen which is produced via electrolysis powered by exclusively renewable energies (RE). This renewable energy source should be newly built in order to guarantee that current resources are not diverted from the existing energy grid and thus ensure that actual emission mitigations are achieved. Within this context, this concept is called additionality (IEA 2022) and is a key criterion for considering the produced hydrogen as "green" – e.g., in the context of EU climate policy legislation.

Figure 1: Schematic of PEM electrolyzer cell



An electrolyser is an electro-chemical device which splits water in a catalytic reaction by the application of a constant current. An electrolyzer cell consists of two electrodes (anode, cathode) and an electrolyte (See Figure 1). When water is split, the oxygen is attracted to the cathode, while the hydrogen is attracted to the anode. There are several different hydrogen technologies on the market. The most mature and widely used ones are the alkaline and the proton-exchange-membrane electrolyser which both have an efficiency of approximately 60-70% meaning that 50 kWh of electricity is needed to produce 1 kg of hydrogen. (Abad & Dodds 2020)

Since the gaseous hydrogen released from electrolysis has a very low energy density which makes it highly inefficient and costly to be transported, it has to be processed to a better transportable form. The two most promising ways to transport hydrogen over long distances is either in compressed form via pipelines (where geographical conditions are beneficial) or the synthesis of hydrogen with nitrogen from ambient air to ammonia via the so-called Haber-Bosch process and its transportation via ships. Both alternatives can add significant costs and energy requirements to the hydrogen supply chain and should be considered cautiously (IRENA 2022B).

07 CURRENT ENERGY AND THE ENERGY EXPORT MATRIX

The combined proven oil reserves of the GCC countries represent about 30% of the world's total oil reserves. The GCC countries are also home to significant resources of natural gas, with a total proven reserve of ca. 40 trillion cubic meters as of the end of 2019 which account for about 13% of global exports (IRENA 2019). The energy sector is a major contributor to the GDP of the GCC countries. Oil and gas exports in 2019 accounted for approximately 42% of Kuwait's, 24% of Saudi Arabia's, 25% of Oman's, 17% of Qatar's and 16% of the UAE's GDP, showing the strong dependency of these countries on fossil fuel exports. The only exceptions are Bahrain and Oman where it accounted for a lower share (Al-Sarihi & Mansouri 2022). The largest share (approximately 70%) of the GCC`s primary energy resources are exported to the Asian market (primarily China, India, and Japan). The relevance of these countries as customers has been growing over recent years (IRENA 2019).

The Gulf countries' geographic location in the sunbelt offers remarkable potential for renewable energy production like solar and wind energy. Despite the abundant renewable resources available in the Gulf states, the primary energy needs of the GCC countries are still met 99% by hydrocarbons. Recognising the shifting energy landscape, the GCC countries have gradually increased their investments in renewable energies. The total installed capacity of renewable energies has risen from 17 MW in 2011 to 3,271 MW in 2020. However, the current contribution of renewables to the region's total primary energy consumption remains below 1%. Nonetheless, the Gulf countries have set ambitious targets for renewable energy deployment, with a goal of reaching a total installed capacity of at least 80 GW by 2030 (Al-Sarihi & Mansouri 2022).

As mentioned above, the Gulf countries are economically highly dependent on oil and gas exports. Those substantial cash flows which are partly distributed to residents through income transfers, public-sector employment, and public services, are an important pillar of current governments in the region. However, transitioning from petroleum to other industries and adopting a tax-based fiscal system would disrupt this model, jeopardising the governments' access to cash flows and thus creating a strong inertia (Ansasri 2022). Climate and sustainable development goals of the Gulf countries themselves but also of major importing centres make a phase-out of fossil fuels inevitable in coming decades. This ongoing transition poses major risks to the economic and political stability in the region.

Furthermore, the countries face significant risks from climate change, including coastal erosion, flooding, and saltwater intrusion due to rising sea levels. The region's extreme heat is expected to worsen, leading to more frequent and intense heatwaves with implications for public health, infrastructure, and energy demands. Additionally, changing weather patterns will exacerbate existing water scarcity challenges (UNFCCC 2023).

For those reasons a transition away from fossil-fuels while still maintaining their position as major energy exporters is obligatory for the Gulf countries. Hydrogen is considered key to enable a smooth transition away from their carbon intensive practices to a more sustainable and diversified economy. With their abundant renewable energy resources, their expertise in the energy sector, the geographic vicinity to major import centres and their massive investment resources, Gulf countries can establish themselves as a hydrogen export hub (Öko-Institut 2022).

As already noted, the Gulf region boasts impressive renewable energy resources and ranks among the cheapest hydrogen production locations in the world; with expected hydrogen production prices of <1.50$/kgH2 in 2050 (IEA 2021). Figure 2 shows a renewable energy suitability analysis that combines renewable energy resources with various factors such as population density, topography, land cover, and protected areas. In terms of solar PV technology, the analysis reveals substantial potential for deployment across all GCC countries, where utilising just 1% of the suitable area could yield a remarkable 608 GW of solar PV capacity. Similarly, the wind analysis indicates that harnessing just 1% of the suitable area for wind power could translate to an impressive capacity equivalent to 26 GW (IRENA 2019).

Figure 3 shows the annual technical production potential for green hydrogen in the Gulf region. This data is exclusively based on wind speed and solar irradiation data. As can be seen, especially Saudi Arabia and Oman and to lesser extend Qatar, Kuwait and UAE have a significant potential to produce green hydrogen. Other aspects like water availability, distance to infrastructure, or proximity to cities or the coast are not considered in this context. If one would take those aspects into account, the production potential would be reduced by more than one order of magnitude as can be seen in Figure 4 (Öko-Institut 2022). However, water stress in certain regions is not necessarily an exclusion criterion for hydrogen production, since water desalination plants can produce fresh water near coast lines and entail only marginal costs of approximately 1% of the overall hydrogen production costs, although initial investment costs are significant (Ansasri 2022). This is specifically relevant for the Gulf region, which might turn out to be a competitive advantage compared to poorer countries with less financial resources to invest in renewable energy-driven water desalination facilities.

Figure 2: Suitability analysis results for on-grid solar PV (left) and on-grid wind (right)

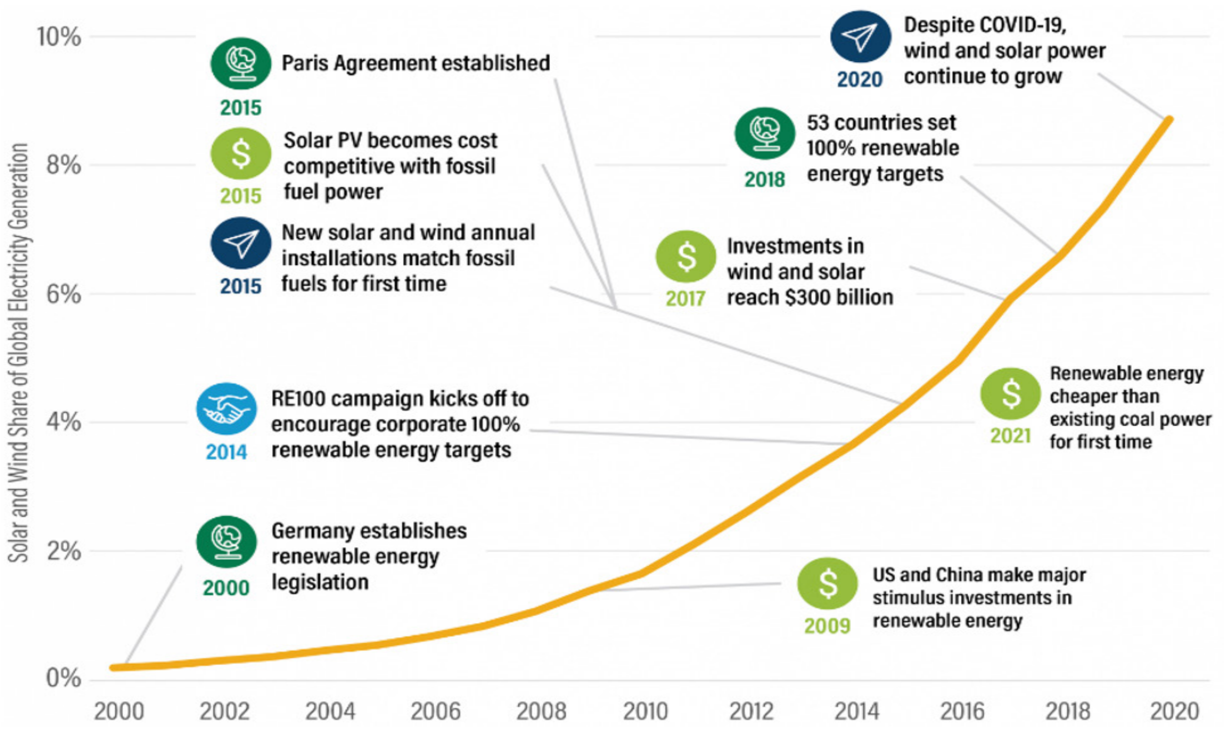


Figure 3: Theoretical green hydrogen production potential

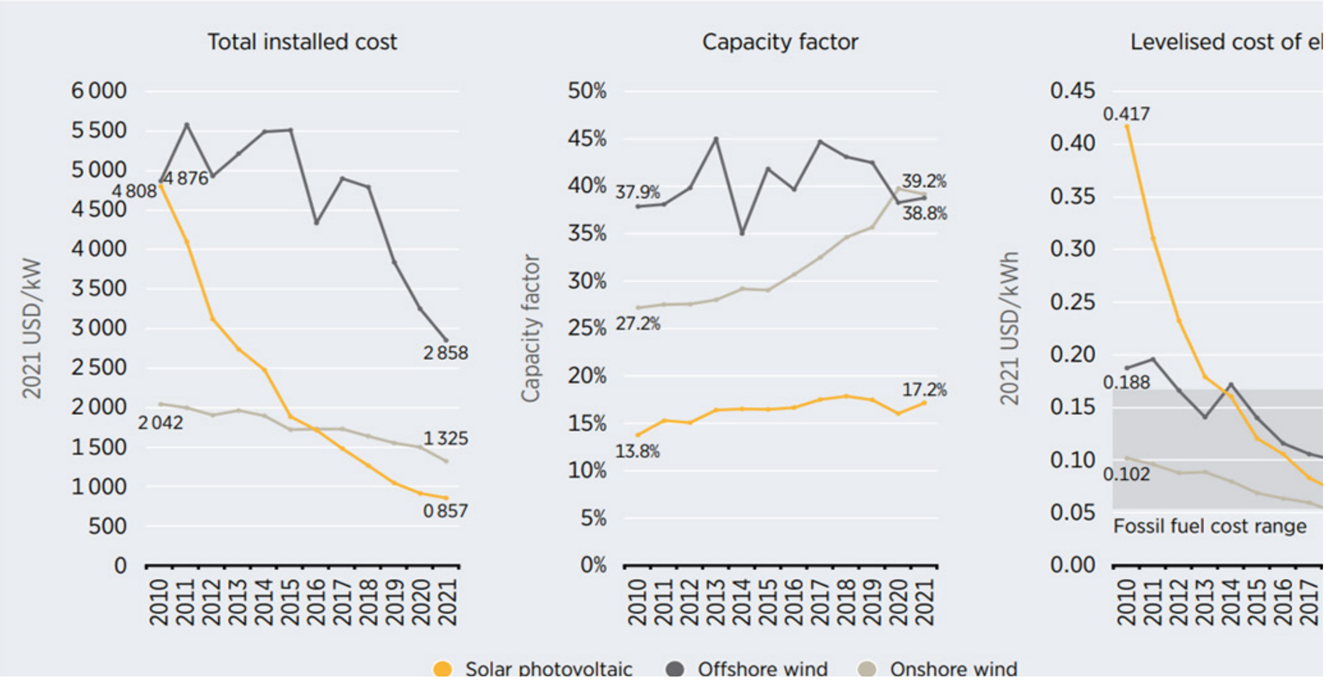
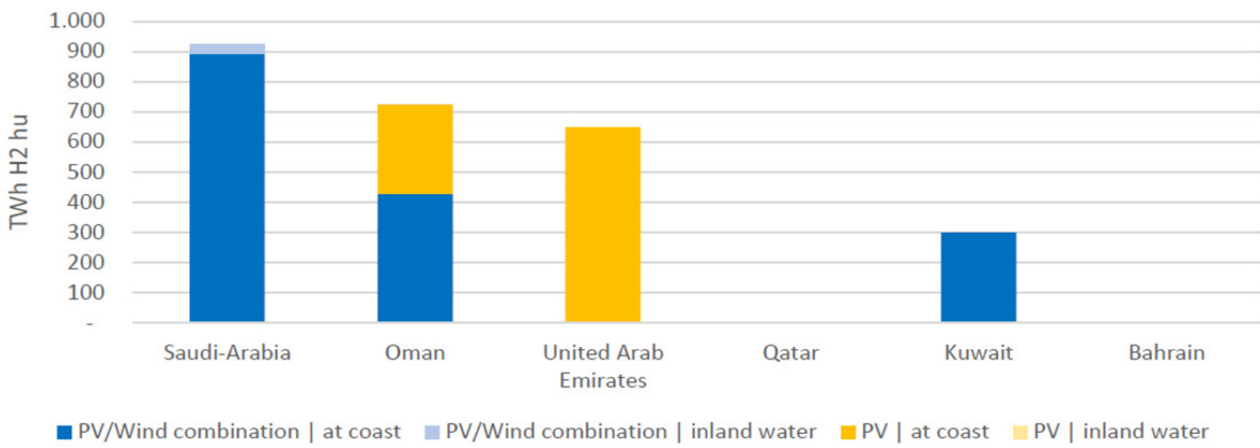


Figure 4: Annual production potential for green hydrogen considering additional restraining factors



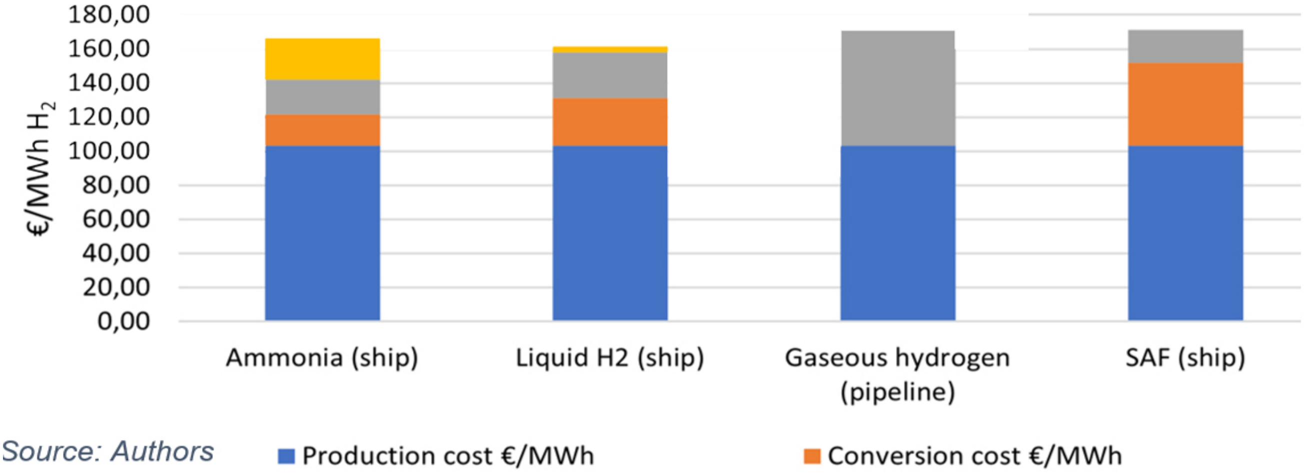
Source: Öko-Institut 2022

Regarding production prices an exemplary calculation for hydrogen production, conversion (to Ammonia, liquid hydrogen, sustainable aviation fuel (SAF)) and transport from the UAE to Germany was conducted and can be seen in Figure 5.

The prices shown here are average levelized cost of hydrogen (LCoH) between 2023 and 2050.

Production costs are approximately 103€/MWh H2. Depending on the specific PtX product significant costs for conversion and transport between 38 and 68 €/MWh are added to the production costs.

Figure 5: Cost breakdown of PtX production and transport costs from UAE to Germany



Source: Authors

Table 1: Carbon intensity of different hydrogen production technologies

Grey hydrogen	Blue hydrogen (50-90% capture-rate)	Green hydrogen
10.9 – 14.2 $kgCO_2/kgH_2$	3.1 – 9.2 $kgCO_2/kgH_2$	0 $kgCO_2/kgH_2$

Source: Authors (based on IEA 2021)

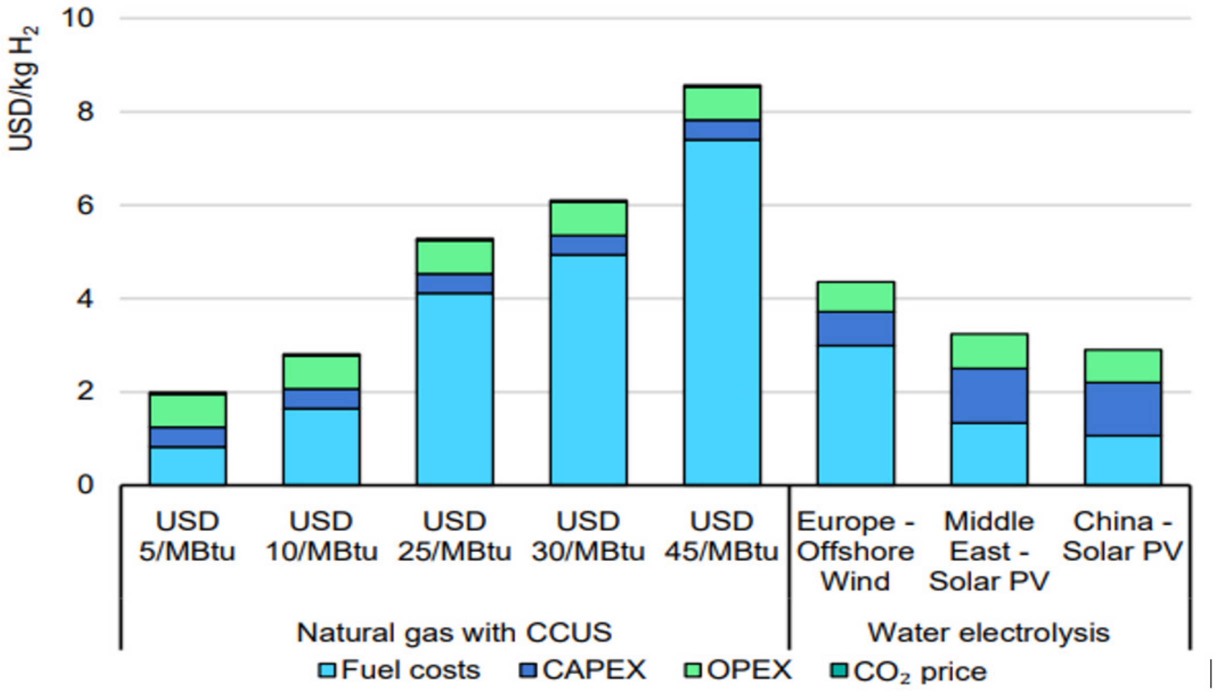
Even though this study investigates the opportunities of green hydrogen for the Gulf region, blue hydrogen must be considered as an alternative, especially regarding the rich natural gas reserves in the region. Blue hydrogen is – like grey hydrogen – produced by the steam methane reformation process, splitting natural gas (CH4) in H2 and CO2. To make grey hydrogen "blue", part of the CO2 is captured and stored or utilised. The capture rate and share of permanently stored CO2 are the key drivers of CO2-intensity of 'blue' hydrogen. In addition, the emission intensity depends significantly on the system boundary chosen. Especially upstream (extraction, processing, and transport of natural gas) and downstream emissions (transport emissions) can have a significant effect on the overall embodied emissions.

Upstream emissions from grey and blue hydrogen can lead to embodied emissions of up to 5.2 kgCO2/kgH2.

Table 1 shows, blue hydrogen production can have similarly high embodied emissions as grey hydrogen which makes the ecological benefit questionable.

Especially natural gas exporting countries like i.e., Qatar have a high interest in developing blue hydrogen technologies. If blue hydrogen will be a true alternative or just a sunken investment for the Gulf countries, will heavily depend on the political will of both the exporting and importing countries as well as the raw material and technology prices necessary for different hydrogen production technologies. Figure 6 shows a comparison of green vs blue hydrogen prices depending on natural gas prices.

Figure 6: LCoH of blue hydrogen at various gas prices vs green hydrogen



Source: IEA 2022

13 DOMESTIC UTILISATION AND EXPORT POTENTIAL FOR GREEN HYDROGEN

Countries producing green hydrogen can either use it domestically or export it. If used domestically, green hydrogen can be used to decarbonise the industry and transport sector, and support grid stability in scenarios of a very high renewable energy share. The industry sector, the chemical sector, fertiliser production and the heavy industry (e.g., steel production) are prime candidates. Hydrogen can also be used to decarbonise the transport sector; this application though should be limited to heavy-duty and long-distance vehicles (IEA 2022). Using green hydrogen instead of oil and gas domestically, no matter in which sector, will also help Gulf states to achieve their commitments under the Paris Agreement. Several Gulf states have pledged net-zero targets in their Nationally Determined Contributions (NDCs): for example, Saudi Arabia & Bahrain by 2060, the UAE and Oman want to be carbon neutral by 2050, Qatar 25% and Kuwait 7.4% reduction by 2035 (Khan, & Al-Ghamdi 2023).

Potential domestic applications in the Gulf region will most probably focus mainly on oil refineries, fertiliser production, steel industry and the transport sector. Especially for the steel and chemical sector it is possible that due to the high hydrogen transport costs, in the long term, industries currently located in regions with lower renewable energy potentials will relocate their operations to certain Gulf countries and rather transport the end product to demand centres instead of importing green hydrogen at high prices (IRENA 2022C). This could open substantial new economic opportunities for the regarded countries.

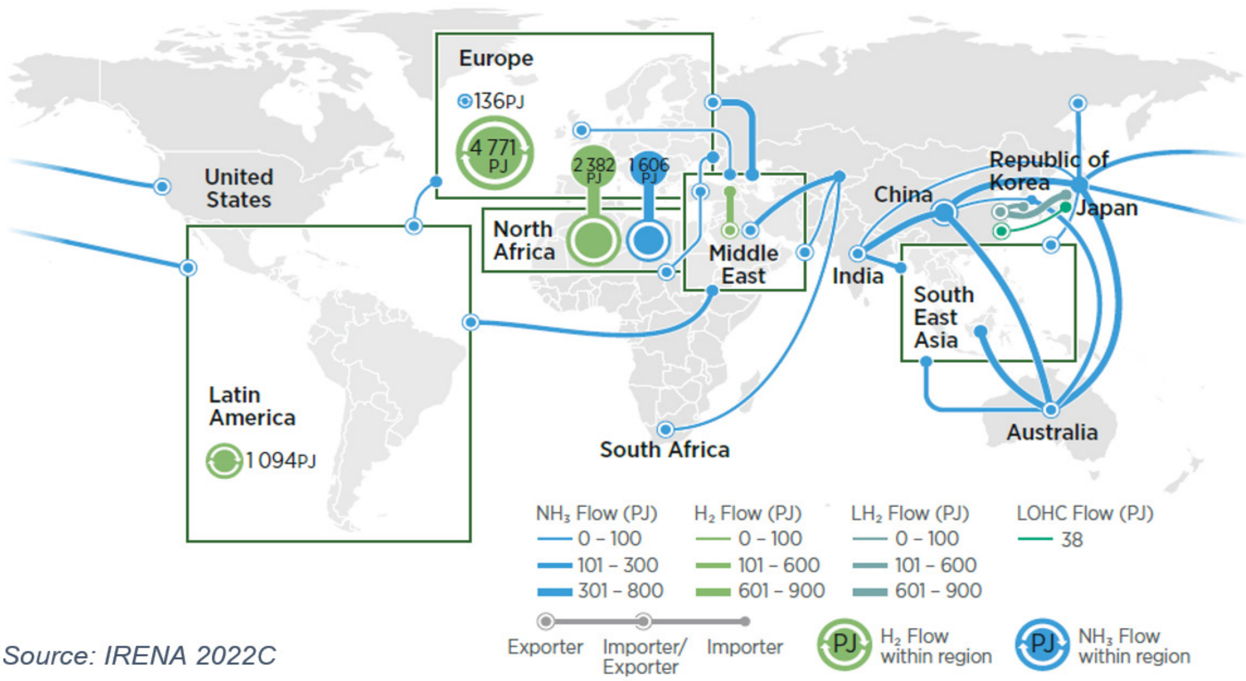
Due to the aforementioned reasons, Gulf countries have the potential to establish themselves as world leading exporters of green hydrogen.

The most important questions regarding future hydrogen trade are:

- What quantities of hydrogen will be demanded?
- What will be the main demand centres (markets)?
- What type of hydrogen will be demanded?

IRENA expects 5000 TWh/year of hydrogen and hydrogen derivatives to be traded by 2050. Figure 7 shows expected trade volumes globally (IRENA 2022C). Recent reports by IRENA, the Hydrogen Council and DNV suggest that the EU, Japan, and South Korea will become key importers of hydrogen, whereas Australia, the Middle East, North Africa, and South/Central America are commonly seen as major potential exporters – with varying market positions due to transport distances. China, India, and the US are expected to join the club of demand centres, but they have the potential to become self-sustaining or even exporters depending on their political choices (DNV 2022; IRENA 2022C; Hydrogen Council, 2022).

Figure 7: Global expected hydrogen trade map in 2050



Source: IRENA 2022C

Not all countries/regions will become similarly active. Investment capabilities and political preferences play an important role. Gulf countries have the ability to invest both in hydrogen infrastructure - and benefit from existing energy infrastructures and long experience as energy exporters -, whereas financial capacities in central/south America are limited, and even more so those in many African countries (IRENA 2022A).

The question "What type of hydrogen will be demanded?" is crucial for the investment strategy of (future) hydrogen producers. Grey and blue hydrogen follow a different production type than green hydrogen and, hence, a good understanding of future demand patterns is decisive for a successful investment strategy.

The emission intensity of hydrogen is expected to become a key parameter for buyers and will therefore affect achievable prices. The EU for example already implements strict regulations on the carbon intensity of hydrogen.

The recently agreed Renewable Energy Directive (RED II) defines renewable hydrogen as: i) It derives its energy content from renewable sources other than biomass; and ii) achieves a 70% GHG emission reduction compared to fossil fuels. Low-carbon hydrogen is defined as hydrogen with an energy content that is derived from non-renewable sources, and that meets a GHG emission reduction threshold of 70% compared to fossil-based hydrogen. This can be translated to an emission intensity threshold of approximately 3.4 kgCO2/kgH2 (EU Commission 2022). From a technical point of view, it will be very challenging to reach this threshold with blue hydrogen. With this regulation in place, the European market is expected to become the key demand centre for green hydrogen in the next years.

The US seem more agnostic to different hydrogen types, but its recently introduced tax incentives give a clear priority to green hydrogen: the Inflation Reduction Act (IRA) gives tax incentives for low-carbon hydrogen production between 0.60 USD/kgH2 to up to 3 USD/kgH2. The lower the carbon intensity, the higher the tax credit (BlueGreen Alliance 2022). Japan is another existing key demand centre. As of today, Japan is open to both blue and green hydrogen, but one can expect that in the mid- to long-run, Japan will focus on green hydrogen as well, in order to meet its net-zero target for 2050 (Ministry of Economy Japan 2017).

Overall, in view of more ambitious national climate policies and international climate commitments, one can expect that some countries/regions will accept blue hydrogen in a transitional phase but will switch to green hydrogen with clearly defined emission thresholds (such as the 3.4 kgCO2 / kgH2 already defined by the EU) in the mid- to long-term. In summary, blue hydrogen may serve as an interim solution due to the currently lower production costs compared to green hydrogen in most locations. Investment in new fossil-fuel based hydrogen production might entail long-term lock-in effects for producers and result in missed opportunities (i.e., lack of green hydrogen production capacities) if, in a few years from now, the world demand more and more green hydrogen. Gulf countries should therefore develop a forward-looking green hydrogen strategy that enables them to proactively participate in the global energy transformation and become world-leaders in clean energy production.

DIFFERING FRAMEWORK OF GULF COUNTRIES REGARDING HYDROGEN

When it comes to the hydrogen colour spectrum, the Gulf states have different approaches. Oman is primarily focused on producing green hydrogen, Qatar is opting for blue hydrogen, while the UAE and Saudi Arabia are planning to strike a balance between both options.

In October 2021, Saudi Arabia's Minister of Energy, expressed the ambition to become the world's largest hydrogen producer. While the national hydrogen strategy is currently being finalised it was already stated that hydrogen technologies will attract $36 bn (www.csis.org). The country's hydrogen policy is closely aligned with Vision 2030. Vision 2030 outlines a comprehensive transformation of Saudi Arabia. Although hydrogen is not explicitly mentioned in the document, its strategic objectives emphasise significant increases in domestic value creation, non-oil exports, renewable energy, and the natural gas industry. Furthermore, Saudi Arabia played a role in co-developing the Circular Carbon Economy, a concept adopted by the G20 during its presidency, which is relevant to (blue) hydrogen. This framework focuses on energy efficiency, carbon-neutral power generation, natural carbon reduction, and extensive carbon capture. Furthermore, Saudi Arabia has signed several MoUs (i.e., with Germany and Japan) to establish cooperations regarding hydrogen (Öko-Institut 2022).

Similarly, Oman's Vision 2040 does not explicitly refer to hydrogen but emphasises the general diversification of energy sources. In February 2020, a national hydrogen strategy was announced and is expected to be unveiled soon. In August 2021, Oman established the "Hy-Fly Alliance," which brings together government agencies, the oil and gas sector, educational and research institutions, and the ports of Sohar and Duqm in a collaborative platform. Additionally, several ministries have established hydrogen divisions, and a state-owned hydrogen company named Hydrogen Development Oman has been formed (Öko-Institut 2022).

In 2021 the UAE published its Hydrogen leadership roadmap with the objective of establishing the country as a leader in the hydrogen sector. The roadmap aims to create new value chains for the export of low-carbon hydrogen and its derivatives, as well as the production of steel and jet fuel using hydrogen. The UAE plans to develop a regulatory framework with appropriate policies, standards, and certifications to support these efforts. Within the roadmap the UAE has set a target of capturing 25% of the global hydrogen market, aiming to be a "top 10" global hydrogen producer by 2031 (www.solarquarter.com).

Qatar's approach focuses on the potential for partnership to produce blue hydrogen, by capitalising on its position as the leading exporter of liquefied natural gas (LNG). Until recently Qatar did not have plans for a policy framework or measures to increase domestic hydrogen production. Instead, its focus was to export LNG and allow or partner with importers to produce blue hydrogen abroad (Öko-Institut 2022). However, it has recently been announced that Qatar intends to build the world`s biggest blue hydrogen plant with a production capacity of approximately 1.2 million tons of ammonia per year which is supposed to start production in 2026 (www.reuters.com). Furthermore, hydrogen is mentioned in Qatar's NDCs as a means to fulfill its determined contributions.

While Kuwait has yet to adopt a national hydrogen strategy, a white paper for a strategy was presented in 2021. The white paper aligns with the overarching Vision 2035 "New Kuwait" and suggests promoting carbon capture, renewable energy, and both green and blue hydrogen production. It also advocates for domestic use of hydrogen and increased cooperation with other GCC countries. Green hydrogen is considered more realistic for Kuwait, as the country is a net importer of natural gas (www.tresor.economie.gouv.fr).

Bahrain initially approached hydrogen cautiously, commissioning feasibility studies for a domestic hydrogen economy in November 2020. However, the government expressed its intention to observe developments. It wasn't until the publication of the Industrial Strategy 2022-2026 in January 2022 that the production of green and blue hydrogen was declared a goal (Öko-Institut 2022).

17 CONCLUSION

The Gulf countries have outstanding potential for hydrogen production and to establish themselves as major hydrogen/PtX export hubs. There are mainly four reasons for this auspicious potential:

1. The region boasts enormous renewable energy resources and has the necessary space to produce green hydrogen on large scale and at highly competitive prices. Additionally, the major gas-exporting countries like Qatar, have significant natural gas reserves for producing blue hydrogen at very low costs.
2. The region's geographical vicinity to major demand centres like the European Union but also Asia, positions it at the forefront to establish itself as a major export hub due to relatively low transport costs.
3. Most countries in the region are established primary energy exporters, which gives them vast experience as well as existing infrastructure to realise innovative energy projects like hydrogen or PtX.
4. Due to massive cash flows caused by the export of fossil fuels, the Gulf countries have a substantial investment potential at their disposal, which is necessary to establish themselves as major producers and exporters of hydrogen. Additional to the economic opportunities of exporting hydrogen, the availability of cheap domestically produced hydrogen might attract industries from other regions in the world which are dependent on cheap sustainable energy and hence diversify the region's economy. Prime examples for this are the steel and the chemical sector.

However, Gulf countries are heavily dependent on the export of fossil fuels. More stringent climate targets might in the long-term heavily reduce the revenues from oil- and gas exports. In this regard, a global uptake of hydrogen is a double-edged sword for the Gulf countries. It may be seen as a significant economic risk to the region. However, hydrogen would be the best alternative for the Gulf countries in a carbon-constraint world, because – contrary to a scenario in which main oil and gas consumers transition to 100% domestically produced renewable energies – it still offers Gulf countries the opportunity to continue their roles as global energy exporters.

To establish itself as a green hydrogen production centre and globally leading exporter, the Gulf countries can take various actions. It is important to create a clear hydrogen vision until 2030 and 2050 and to mobilise financing for large scale hydrogen projects. Additionally, it is important to develop international hydrogen partnerships with energy-importing countries. Europe can become a key partner for hydrogen, but the Gulf region may compete with North African and South American countries. Hence, it is important to be among the first movers before Europe focusses too strongly on other hydrogen supply regions. Also, the Gulf region is well-positioned for hydrogen delivery to Japan, South Korea, and other South-East Asian countries. In this region, competition with Australia can be expected.

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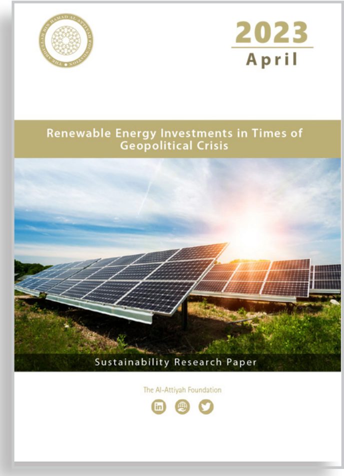
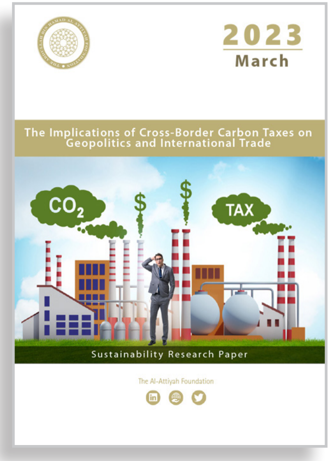


April - 2023

Renewable Energy Investments in Times of Geopolitical Crisis

Since the beginning of the 21st century, renewable energy (RE) for power generation has experienced remarkable global growth and development. By the end of 2022, global RE generation capacity amounted to 3,372 gigawatts (GW), growing the renewable power generation capacity by a record 295 GW or by almost 10% compared to 2021.

(QRCO.DE)

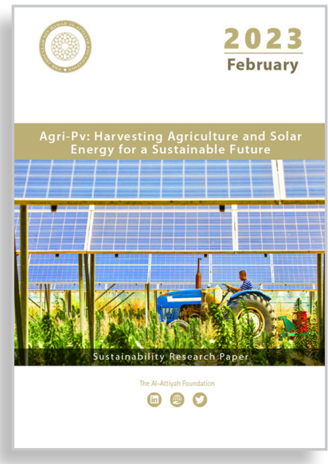


March - 2023

The Implications of Cross-Border Carbon Taxes on Geopolitics and International Trade

Climate change mitigation through greenhouse gas (GHG) reduction or removal from the atmosphere is a global public good that requires significant investments by governments and businesses.

(QRCO.DE)



February - 2023

Agri-Pv: Harvesting Agriculture and Solar Energy for a Sustainable Future

Several challenges prevent the widespread uptake of Agrivoltaics (Agri-PV) including existing farming practices, high initial investment costs due to low market penetration and awareness, lack of government incentives and limited technical knowledge of best practices for adoption.

(QRCO.DE)

Our partners collaborate with The Al-Attiyah Foundation on various projects and research within the themes of energy and sustainable development.

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