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Hydrogen Regulation in the Middle East and North Africa Region

Trends, Limitations, and Ways Forward

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6.1 INTRODUCTION

This chapter examines law and governance innovations required to integrate the production, distribution, and commercialization of hydrogen into the energy mix in the Middle East and North Africa (MENA) region. It examines current regulatory uncertainties and gaps in the design and implementation of hydrogen projects across the MENA region, and the legal pathways for addressing those challenges.

The development of low-carbon blue and green hydrogen has been identified as a national priority in several MENA countries.[1] For example, Qatar's national oil and gas company, Qatar Energy – which already oversees one of the world's most significant gas field and liquefaction facilities[2] – has signed an agreement with Shell to develop large-scale blue and green hydrogen projects.[3] In particular, 'Qatar plans to build a $1 billion plant to make blue ammonia, a fuel that can be converted into hydrogen'.[4] Similarly, Morocco is pursuing green hydrogen studies and exploring policies to promote investment in the country's green hydrogen economy.[5] A Belgian engineering firm recently entered into a joint venture agreement with Morocco to create an electrolyser manufacturing plant, which can offer integrated green hydrogen solutions.[6] Likewise, Saudi Arabia has already commenced work on the NEOM Green Ammonia project, a US$5 billion green hydrogen plant, and prospectively one of the world's largest

[1] Giampaolo Cantini, 'Hydrogen in the MENA Region: Priorities and Steps Forward' (*Atlantic Council*, 14 February 2023) <www.atlanticcouncil.org/blogs/energysource/hydrogen-in-the-mena-region-priorities-and-steps-forward/> accessed 31 October 2023.

[2] United States Energy Information Administration, 'Country Analysis Brief: Qatar' (28 March 2023) 2 <www.eia.gov/international/content/analysis/countries_long/Qatar/qatar.pdf> accessed 31 October 2023.

[3] MEED, 'Qatar Energy and Shell to Explore Hydrogen Projects' (*Offshore Technology*, 22 October 2021) <www.offshore-technology.com/analyst-comment/qatarenergy-shell-hydrogen-projects/> accessed 31 October 2023.

[4] Bloomberg, 'Qatar to Tap Global Hydrogen Market with $1 Billion Plant' (*Gulf News*, 31 August 2022) <https://gulfnews.com/business/energy/qatar-to-tap-global-hydrogen-market-with-1-billion-plant-1.90238648> accessed 31 October 2023.

[5] Theresa Smith, 'Electrolyser Manufacturing for Morocco Green Hydrogen Value Chain' (*ESI Africa*, 9 January 2023) <www.esi-africa.com/business-and-markets/electrolyser-manufacturing-for-morocco-green-hydrogen-value-chain/> accessed 31 October 2023.

[6] Ibid.

hydrogen facilities.[7] Similarly, the United Arab Emirates has announced seven green and blue hydrogen projects.[8] Efforts are also ongoing in Egypt to produce 20 million tons of green hydrogen annually by 2035, while Oman also signed a $3.5 billion deal for a green hydrogen plant.[9]

The MENA region is thus projected to become one of the world's largest exporters of hydrogen by the year 2050, boasting significant proven reserves of natural gas – a key fuel for blue hydrogen projects – and a demonstrated track record of experience in managing complex logistics and infrastructure for the energy industry.[10] However, while the proposed projects underscore increasing commitments across the region to diversify the energy mix and advance a low-carbon economy through the production of green hydrogen, the corresponding legal, governance, and institutional frameworks would need to be bolstered to keep pace with such hydrogen infrastructure investments.[11] A shift to a hydrogen economy in a region traditionally heavily reliant on fossil fuels will require the development of robust legal and governance frameworks that will provide a foundation for coherent implementation. The injection of significant amounts of hydrogen into the national energy networks comes with a wide range of logistical, infrastructure, and grid-balancing questions across the entire hydrogen production and supply chain. At the same time, health, safety, and environmental standards (HSE) for hydrogen infrastructure will need to be developed. Hydrogen is both complex to produce and store and capital intensive to distribute.[12]

After this introduction, Section 6.2 examines the drivers of the hydrogen revolution in the MENA region. Section 6.3 analyzes current regulatory uncertainties and gaps in the design and

[7] Joelle Thomas, 'The Energy–Water Nexus in the Middle East: Will Water Scarcity Compromise the Middle East's Green Hydrogen Future?' (*Energy Transition*, 8 September 2021) <https://energytransition.org/2021/09/the-energy-water-nexus-in-the-middle-east-will-water-scarcity-compromise-the-middle-easts-green-hydrogen-future/> accessed 31 October 2023.

[8] United Arab Emirates Ministry of Energy & Infrastructure, 'UAE Hydrogen Leadership Roadmap' (4 November 2021) <https://u.ae/-/media/Documents-2022/UAE-Hydrogen-Roadmap–Eng.ashx> accessed 31 October 2023 (hereinafter: United Arab Emirates Ministry of Energy & Infrastructure).

[9] Arab Finance, 'Egypt Could Produce 20m Tons of Green Hydrogen by 2035: EIB' (*Zawya*, 28 December 2022) <www.zawya.com/en/economy/north-africa/egypt-could-produce-20m-tons-of-green-hydrogen-by-2035-eib-fuhypv67> accessed 31 October 2023; and Adal Mirza, 'Oman Signs Land Deal for New Green Hydrogen Plant' (*Argus Media*, 24 August 2021) <www.argusmedia.com/en/news/2247165-oman-signs-land-deal-for-new-green-hydrogen-plant> accessed 31 October 2023.

[10] 'The MENA region holds the world's largest proven oil reserves (approximately 59%), approximately 45% of the world's proven natural gas reserves, and 30% of global mineral reserves.' Damilola S Olawuyi, 'Can MENA Extractive Industries Support the Global Energy Transition? Current Opportunities and Future Directions' (2021) 8(2) Extractive Industries and Society 100685, 1 <www.sciencedirect.com/science/article/abs/pii/S2214790X19303399> accessed 31 October 2023 (hereinafter: Olawuyi 2021).

[11] A hydrogen economy is one in which hydrogen is used as the major energy source. See Yi Dou and others, 'Opportunities and Future Challenges in Hydrogen Economy for Sustainable Development' in Antonio Scipioni, Alessandro Manzardo and Jingzheng Ren (eds.), *Hydrogen Economy: Supply Chain, Life Cycle Analysis and Energy Transition for Sustainability* (Academic Press 2017) 277, 279.

[12] 'The hydrogen value chain is both complex and capital intensive.' Arnout de Pee and others, 'The Clean Hydrogen Opportunity for Hydrocarbon-Rich Countries' (*McKinsey & Company*, 23 November 2021) <www.mckinsey.com/industries/oil-and-gas/our-insights/the-clean-hydrogen-opportunity-for-hydrocarbon-rich-countries> accessed 1 November 2023; and 'Hydrogen's low energy density, high volume and need for cryogenic storage are some of the biggest barriers to its growth'. Andrea Willige, '4 Ways of Storing Hydrogen from Renewable Energy' (*Spectra*, 30 November 2022) <https://spectra.mhi.com/4-ways-of-storing-hydrogen-from-renewable-energy> accessed 1 November 2023; see also Bernard Chukwudi Tashie-Lewis and Somtochukwu Godfrey Nnabuife, 'Hydrogen Production, Distribution, Storage and Power Conversion in a Hydrogen Economy – A Technology Review' (2021) 8 Chemical Engineering Journal Advances 100172 <www.sciencedirect.com/science/article/pii/S2666821121000880> accessed 1 November 2023.

implementation of hydrogen projects across the MENA region. Section 6.4 proffers legal pathways for addressing those challenges. Section 6.5 concludes.

6.2 DRIVERS OF THE HYDROGEN REVOLUTION IN THE MENA REGION

The growing emphasis on the transition to a hydrogen economy across the MENA region is due to four key drivers. First, there is an unprecedented rise in domestic energy demand in the region which will necessitate the diversification and expansion of supplemental energy supplies.[13] 'Intertwined with oil driven economic expansion is a geometric rise in population and energy consumption across the Gulf at a median rate of 5–10 per cent per year.'[14] 'Peak energy demand in the Middle East … is currently close to, and in some countries, slightly above installed capacity', 'especially during daytime in summer months when air conditioning use is highest'.[15] For example, as of 2013, electricity demand in Qatar had steadily risen by more than 30 percent over the previous four years.[16] 'In Saudi Arabia, it is projected that peak-time electricity demand will almost triple to 120,000 megawatts by 2032, from around 46,000 megawatts in 2010.'[17] Given these realities, investments in energy infrastructure for cleaner and potentially more efficient alternative supplies, including hydrogen grids, to meet the increasing peak demand for energy, and promote energy diversification, remains paramount across the region.[18]

A second driver of the increased interest in hydrogen investments in the region is the need for economic and energy diversification in preparation for the post oil and gas era. 'Oil and gas resources across the region are not infinite and could be depleted within the next few decades',[19] at least to the point that marginal rises in costs render conventional hydrocarbons less competitive in the face of secular improvements in the economics of renewable/clean technology investments. The International Energy Agency (IEA) and BP both predicted a decline in global oil demand, 'with demand falling by ten per cent this decade and by as much as 50 per cent over the next twenty years',[20] as those cleaner sources expand their share of the energy consumption basket. Studies show that the Middle East could run out of oil by 2057, while natural gas supplies could be depleted by 2064.[21] Given these statistics, MENA countries have embraced

[13] Damilola S Olawuyi, 'Advancing Innovations in Renewable Energy Technologies as Alternatives to Fossil Fuel Use in the Middle East' in Donald Zillman and others (eds.), *Innovation in Energy Law and Technology: Dynamic Solutions for Energy Transitions* (OUP 2018) 357 (hereinafter: Olawuyi 2018).

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Victoria R Nalule, 'How to Respond to Energy Transitions in Africa: Introducing the Energy Progression Dialogue' in Victoria R Nalule (ed.), *Energy Transitions and the Future of the African Energy Sector* (Palgrave MacMillan 2021) 8. See also Mohammad Al Asoomi, 'Time for Change in Gulf's Energy Policy' (Gulf News, 29 October 2018) <https://gulfnews.com/business/energy/time-for-change-in-gulfs-energy-policy-1.1553842> accessed 1 November 2023; Jamie Ingram, 'Kuwait Burns Record Crude to Meet Power Surge' (2020) 63(39) Mees <www.mees.com/2020/9/25/power-water/kuwait-burns-record-crude-to-meet-power-surge/82458f70-ff47-11ea-9e8d-7b6c0659de24> accessed 1 November 2023; 'Kuwait Ponders Long-Term Power Fuel Supply Options: MEES Analysis' (2013) 56(24) Mees <http://archives.mees.com/issues/1481/articles/50278> accessed 1 November 2023.

[20] Cameron Kelly, 'Leveraging Renewable Energy Technologies for Climate Change Mitigation and Adaptation in the Middle East' in Damilola S Olawuyi (ed.), *Climate Change Law and Policy in the Middle East and North Africa Region* (Routledge 2022) 232 (hereinafter: Olawuyi 2022).

[21] Olawuyi 2018 358. See also Steve Sorrell and others, *Global Oil Depletion: An Assessment of the Evidence for a Near-Term Peak in Global Oil Production* (UK Energy Research Centre 2009); R Aguilera and others, 'Depletion and the Future Availability of Petroleum Resources' (2009) 30(1) Energy Journal 141.

energy diversification through increased investments in hydrogen and renewable energy projects 'as ways of mitigating the oil and gas depletion, while also preparing for life after oil and gas'.[22] For example, the Pan-Arab Strategy for the Development of Renewable Energy (2010–2030) specifically sets a target of increasing installed renewable energy power generation capacity across the region from 12 gigawatts (GW) in 2013 to 75 GW in 2030.[23] Similarly, 'Qatar expressly indicates in its [Qatar National Vision] 2030 the intention to invest in world-class infrastructure necessary to achieve "a diversified economy that gradually reduces dependence on hydrocarbon industries" by the year 2030.'[24] In recognition of the key roles that hydrogen will play in meeting the energy and economic diversification targets, MENA countries are coming together to expand joint initiatives and projects aimed at integrating hydrogen production into the energy mix.[25]

Third and related is the increased emphasis on decarbonization and net-zero emissions across the world in response to the climate change emergency.[26] Efforts to mitigate climate change across the world sparked a gradual 'shift away from carbon intensive fossil fuels, the bedrock of several MENA economies'.[27] Similarly, as signatories to the Paris Agreement and the United Nations Framework Convention on Climate Change, several MENA countries have already committed, via their intended nationally determined contributions (INDCs), to advance climate mitigation and adaptation efforts.[28] This includes 'investing in climate-smart energy systems, *ie* structures and systems that lower greenhouse gas (GHG) emissions, and improve [national capacity] to adapt to, and cope with, the risks posed by climate change'.[29] Through investments in green hydrogen projects that leverage on, and repurpose existing natural gas infrastructure, MENA countries now aim to be at the forefront of the low-carbon hydrogen revolution.[30] Increased production and use of green hydrogen as a sustainable and low-carbon fuel can reduce the volume of GHG emissions in the region, while also advancing the availability, accessibility, and reliability of energy for the region's growing population.[31] This will go a long way in advancing the realization of the United Nations Sustainable Development Goals (SDGs) across the region, particularly SDG 13 on climate change and 'SDG 7 on clean stable, and affordable energy for all by the year 2030'.[32]

A fourth key driver of the hydrogen revolution in the MENA region is the effort by gas-rich MENA countries to leverage their comparative advantages as hubs for blue and green hydrogen

[22] Olawuyi 2018 359.

[23] Mohammad El-Khayat and others, *Pan-Arab Renewable Energy Strategy 2030: Roadmap of Actions for Implementation* (International Renewable Energy Agency 2014) 17 <www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Pan-Arab_Strategy_June-2014.pdf> accessed 2 November 2023.

[24] Olawuyi 2018 359.

[25] See the MENA Hydrogen Alliance, which was launched in 2020 to 'bring . . . together private and public sector actors as well as science and academia to kick-start green hydrogen economies' in the MENA region. 'About MENA Hydrogen Alliance' (*Dii Desertenergy*) <https://dii-desertenergy.org/mena-hydrogen-alliance/> accessed 2 November 2023 (hereinafter: 'About MENA Hydrogen Alliance'). See also Olawuyi 2022.

[26] Olawuyi 2022 1–10.

[27] Olawuyi 2021 1.

[28] Ibid 2.

[29] Ibid.

[30] Faran Razi and Ibrahim Dincer, 'Renewable Energy Development and Hydrogen Economy in MENA Region: A Review' (2022) 168 Renewable and Sustainable Energy Reviews 112763, 4–8 <www.sciencedirect.com/science/article/abs/pii/S1364032122006487> accessed 2 November 2023.

[31] Ibid 4, 8.

[32] Damilola S Olawuyi, 'The Search for Climate and Energy Justice in the Global South: Shifting from Global Aspirations to Local Realization' (2023) 14 George Washington Journal of Energy and Environmental Law 98, 98; see also UNGA Res 70/1 (21 October 2015) UN Doc A/RES/70/1.

projects. The global momentum to transition to a hydrogen economy is projected to increase demand for natural gas, a transition fuel needed to drive the hydrogen revolution.[33] With significant deposits of natural gas, great sunshine intensity for solar-powered green hydrogen projects, and significant experience in infrastructure repurposing, MENA countries have elaborated plans to become the new hydrogen superpowers.[34] Oman and United Arab Emirates (UAE) have released National Hydrogen roadmaps and strategies, while such strategies are already under development in Morocco and Saudi Arabia, amongst other MENA countries.[35] For example, the UAE's Hydrogen Leadership Roadmap specifically aims to capture 25 percent of the global hydrogen market by leveraging the country's solar potential to attract investments in green hydrogen, while also pursuing investment plans in blue hydrogen projects.[36]

Given these main drivers, the appetite for hydrogen investments across the MENA region is currently very high and could remain so for the next decade. However, to ensure that hydrogen investments proceed in a safe, orderly, and sustainable manner, there is a need for a comprehensive legal framework on hydrogen that elaborates upon health, safety, and design standards for hydrogen infrastructure. Section 6.3 develops a profile of key legal issues and gaps in the design and implementation of hydrogen projects across the MENA region that must be addressed to support the safe, orderly, and sustainable transition to a hydrogen economy in the region.

6.3 ADVANCING A HYDROGEN ECONOMY IN THE MENA REGION: SURVEY OF LEGAL BARRIERS AND LIMITATIONS

As can be seen in jurisdictions such as France, Sweden, Finland, Denmark, and Germany, where significant progress has been recorded in the transition to a hydrogen economy, investments in hydrogen infrastructure and technologies must be backed by a clear and transparent legislative framework, including licensing and permitting processes and standards for hydrogen production, storage, commercialization, and export. Governments should design financial incentives to encourage the development of hydrogen projects and to offset the higher capital expenditures and operating costs associated with both investing in and utilizing hydrogen technologies, particularly as compared to conventional means.

There is an urgent need for MENA countries to put in place robust and coherent law and governance frameworks to support the ambitious hydrogen economy goals. This section discusses legal barriers that must be promptly addressed if current national and regional goals to develop hydrogen production across the MENA region are to come to pass.

[33] Although natural gas is a fossil fuel, studies have shown that it remains the cleanest, least polluting, and most hydrogen rich of all hydrocarbon energy sources. See Michael Levi, 'Climate Consequences of Natural Gas as a Bridge Fuel' (2013) 118 Climate Change 609; Xiaochun Zhang and others, 'Climate Benefits of Natural Gas as a Bridge Fuel and Potential Delay of Near-Zero Energy Systems' (2016) 167 Applied Energy 317; Fang-Yu Liang and others, 'The Role of Natural Gas as a Primary Fuel in the Near Future, Including Comparisons of Acquisition, Transmission and Waste Handling Costs of as with Competitive Alternatives' (2012) 6 (supp 1) Chemistry Central Journal S4; Damilola S Olawuyi, 'The Role of Natural Gas in a Just and Equitable Energy Transition' in Damilola S Olawuyi and Eduardo G Pereira (eds.), *The Palgrave Handbook of Natural Gas and Global Energy Transitions* (Palgrave Macmillan 2022).

[34] Studies already project Morocco and Saudi Arabia as two of the countries that 'are best placed to emerge as major clean hydrogen producers by 2050'. Thijs Van de Graaf and others, *Geopolitics of the Energy Transformation: The Hydrogen Factor* (International Renewable Energy Agency 2022) 48 (hereinafter: Van de Graaf et al.).

[35] Ibid. See also 'Oman Announces Investment Opportunities in Green Hydrogen' (*Foreign Ministry of Oman*, 23 October 2022) <https://fm.gov.om/oman-announces-investment-opportunities-in-green-hydrogen/> accessed 2 November 2023 (stating the country's aim to become one of world's leading green hydrogen hubs).

[36] United Arab Emirates Ministry of Energy & Infrastructure.

6.3.1 *Unclear Legal Framework*

One of the most important barriers to achieving the hydrogen economy visions of MENA countries is the absence of a clear and coherent legal framework on hydrogen. While there are several natural resource laws that may, directly or indirectly, apply to hydrogen projects in these jurisdictions, specific legislation or guidelines on the development, production, and commercialization of hydrogen has yet to come to fruition. For example, in the UAE, hydrogen investment may implicate the nation's oldest laws (numbers 4 and 7 from 1971 and 1976, respectively)[37] which formed the Abu Dhabi National Oil Company and granted it certain exclusive control of the energy sector. While such existing laws provide a general legal framework that can guide investments in hydrogen technology, they do not adequately address specific requirements and questions on the functioning of a hydrogen market, as well as export of hydrogen for cross-border trade. Under a strict reading of the UAE law, it is unclear how it would support or regulate the development, licensing, and implementation of new energy technologies such as green and blue hydrogen (with both conventional and renewable power source utilization).[38]

In addition to providing clarifications on what exactly is defined as green, gray, or blue hydrogen under the relevant laws of countries in the MENA region, a clear legal framework is required to clarify the standards to be complied with for the safe and reliable development and operation of hydrogen infrastructure and networks.[39] There are three relevant observations to be made. First, a clear regulatory framework should establish a licensing framework that will ensure the safe, orderly, and sustainable development of hydrogen. Second, given the need to attract foreign investment and technologies required to drive hydrogen expansion across the region, there is a necessity to integrate performance standards and financial incentives to increase the demand for hydrogen across the region, as well as the investments to meet such demand. Third, the integration of a significant amount of hydrogen into power grids requires substantial transformations of existing electricity laws to ensure coherence and remove barriers to achieving grid integration, balancing, storage, interconnection, and regional grid connection.[40] EU countries are also introducing sustainability and certification standards to ensure that the entire value chain of the production and distribution of hydrogen, including procurement practices, comply with all applicable laws, including ethical sourcing and respect for human rights.[41] With increased emphasis across the world on business and human rights, as well as environment, social, and governance (ESG) risks in the energy sector, investors in hydrogen projects will seek clear legislative guidance to properly anticipate and mitigate legal, financial, and reputational risks associated with hydrogen projects.[42] A selected review of some among those considerations

[37] '(Abu Dhabi) Law No. 4 of 1976 – Gas Ownership Law' (*International Energy Agency*, 15 February 2022) <www.iea.org/policies/12298-abu-dhabi-law-no-4-of-1976-gas-ownership-law> accessed 2 November 2023; and 'Hydrogen Law and Regulation in the Middle East' (*CMS Expert Guides*, 24 November 2021) <https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/middle-east> accessed 2 November 2023.

[38] Ibid.

[39] For example, Germany's recently amended Energy Industry Act (*Energiewirtschaftsgesetz* – EnWG) clarifies the standards to be complied with in the development and operation of hydrogen infrastructure and networks.

[40] Olawuyi 2021.

[41] Proposal for a Directive of the European Parliament and of the Council on common rules for the internal markets in renewable and natural gases and in hydrogen [2021] COM (2021) 803 final, 15 December 2021.

[42] Damilola S Olawuyi, 'Corporate Accountability for the Natural Environment and Climate Change' in Ilias Bantekas and Michael Ashley Stein (eds.), *Cambridge Companion to Business and Human Rights* (Cambridge University Press 2021) 257.

are also treated within Chapter 10, 'Sustainability Criteria for Renewable Hydrogen'. The adoption of clear and specific hydrogen laws and regulations could provide robust and tailor-made requirements to guide the industry going forward.

6.3.2 *Barriers to Private Sector Participation*

A key objective of the emerging hydrogen strategies across the MENA region is to promote participation of the private sector in hydrogen investments and projects.[43] The partnership approach adopted by several of the mentioned hydrogen development plans show the increased realization that government alone may not be able to meet the financial and technical requirements needed to finance, develop, and maintain capital-intensive energy infrastructure.[44] Despite this recognition, however, many MENA countries have yet to enact public–private partnership (P3) laws that set out 'the requirements and process[es] for developing, financing and implementing P3 projects'.[45] Hydrogen presents an excellent opportunity to do so. Currently only Egypt, Jordan, Abu Dhabi, Oman, Qatar, Kingdom of Saudi Arabia, Kuwait, and Dubai have implemented P3 legislation and many of these are recent developments, which means their overall impact in terms of enhancing private investments in infrastructure projects is yet to be fully tested. As a matter of comparison: in the United States of America more than thirty P3 laws have been enacted at the state and federal levels,[46] whereas Dubai's first P3 law was only enacted in 2015.[47] Even in those Middle East jurisdictions that have enacted P3 laws, 'poorly functioning legal structures (including contract enforceability and governance), poor regulatory frameworks, [and] lack of standardized contracts' are some of the impediments to effective deployment of P3s, according to recent research.[48]

Additional barriers for the deployment of P3 include blurry apportionments between the interests of private parties and the government, which are common problems with investments in the Middle East and other jurisdictions. Direct or indirect state ownership and control of many of the private sector's most influential actors is common. Contracts in the Middle East, therefore, often lack a precise risk allocation between a [P3's] public and private sector parties, while also saddling operators with the burden of incompetency of the national institutions that promote P3.[49] The economics behind P3 is that the private sector participants stand to achieve material benefits in the event of project success, but are often left to face unclear permitting and approvals processes, resulting in delays while awaiting regulatory clarity, and, when things go wrong, an uncertain limbo until backstops from state coffers can be actionable. This was the case, for example, with the landmark default, restructuring, and recapitalization of Dubai Ports

[43] United Arab Emirates Ministry of Energy & Infrastructure 9.

[44] See Olawuyi 2018 364–65; see also Organisation for Economic Co-operation and Development, *Public–Private Partnerships in the Middle East and North Africa: A Handbook for Policy Makers* <https://oecd.org/mena/competitiveness/PPP%20Handbook_EN_with_covers.pdf> accessed 26 October 2023.

[45] Damilola S Olawuyi, 'Financing Low-Emission and Climate-Resilient Infrastructure in the Arab Region: Potentials and Limitations of Public-Private Partnership Contracts' in Walter Leal Filho (ed.), *Climate Change Research at Universities: Addressing the Mitigation and Adaptation Challenges* (Springer 2017) 539 (hereinafter: Olawuyi 2017).

[46] Dan McNichol, *The United States: The World's Largest Emerging P3 Market* (AIG 2013) <https://riskandinsurance.com/wp-content/uploads/2016/10/the-us-the-worlds-largest-emerging-p3-market.pdf>.

[47] 'Dubai Law No. 22 of 2015 on Public–Private Partnerships (in Arabic): Public–Private Partnership' (*Public–Private Partnership Legal Resource Center*) <https://ppp.worldbank.org/public-private-partnership/library/dubai-law-no-22-2015-public-private-partnerships-arabic> accessed 2 November 2023.

[48] Olawuyi 2022 234; Olawuyi 2018.

[49] Olawuyi 2022 234.

World that began in 2009 and was not functionally complete until 2020.[50] As this procedure, which saw a publicly traded company at the center of a major logistic initiative with tacit government backing file for bankruptcy, demonstrated: '[i]n the absence of a clear institutional and legal framework for the promotion of P3 investments', wide-scale development of hydrogen projects may face longer-term structural challenges.[51]

6.3.3 *Unclear Pricing and Financing Framework*

Another key implementation gap is the lack of clarity on the pricing and financing framework for hydrogen in the MENA region. Unlike other hydrocarbons markets where prices are, to a large extent, set by global and local supply and demand, with broad presumptive fungibility between similar energy carriers, hydrogen is a unique commodity. Without the infrastructure to support its distribution and combustion, regardless of its production costs, hydrogen is – due to the limited outlets for consumption via fuel cell vehicles (FCVs) or in specialized power-generative and as yet comparatively narrow swath of industrial applications – a zero-value commodity, except for where it can be utilized. The vagaries of hydrogen pricing are also evident in the wide range of prices throughout the globe: Japan: ~$10 per kilogram;[52] Europe: ~$20 per kilogram;[53] and North America: ~$7 per kilogram.[54]

Yet it is not fair to compare geographic pricing in a vacuum without a commensurate assessment of demand stability and supply growth, particularly with the advent of hydrogen 'clusters'[55] such as in Japan,[56] which boasts an expansive hydrogen mobility infrastructure worldwide.[57] Not only did Japan introduce a comprehensive Strategic Roadmap for Hydrogen and Fuel Cells in 2011, it also released a national Basic Hydrogen Strategy in 2017, a 'Green Growth Strategy through Achieving Carbon Neutrality in 2050', which was announced in 2020, and the 6th Strategic Energy Plan released in 2021.[58] These documents clarify the framework for the development and pricing of hydrogen in the country. Japan has taken, in a sense, a dual-track approach to pricing hydrogen at a level that can induce marginal supply with compelling producer economics while also stoking demand by getting consumers accustomed to using the fuel in everyday life at an affordable price. At present, this approach requires a number of

[50] 'DP World Returns to Full State Ownership, Takes on $8.1 Billion Debt' (*Reuters*, 17 February 2020) <www.reuters.com/article/us-dp-wrld-delisting-idUSKBN20B0F8> accessed 2 November 2023.

[51] Domilola S Olawuyi, 'From Energy Consumers to Energy Citizens: Legal Dimensions of Energy Citizenship' in Ruven Fleming and others (eds.), *Sustainable Energy Democracy and Law* (Brill 2021) 115.

[52] 'Japan – Eneos and Chiyoda to Slash Green Hydrogen Costs by Two Thirds' (*Hydrogen Central*, 21 June 2021) <https://hydrogen-central.com/japan-eneos-chiyoda-green-hydrogen-costs/> accessed 2 November 2023 (hereinafter: 'Japan – Eneos and Chiyoda to Slash Green Hydrogen Costs by Two Thirds').

[53] 'Hydrogen Price Trend and Forecast' (*ChemAnalyst*) <www.chemanalyst.com/Pricing-data/hydrogen-1165> accessed 2 November 2023.

[54] Ibid.

[55] Lucy Roue, 'What Is a Hydrogen Cluster and How Can It Boost the Regional Economy by £1.6bn' (*Manchester Evening News*, 1 November 2017) <https://www.manchestereveningnews.co.uk/business/business-news/hydrogen-cluster-peel-report-vehicle-13837281> accessed 2 November 2023.

[56] Jane Nakano, 'Japan's Hydrogen Industrial Strategy' (*Center for Strategic and International Studies*, 12 January 2023) <www.csis.org/analysis/japans-hydrogen-industrial-strategy> accessed 2 November 2023.

[57] Ibid. See also Noriko Behling, Mark C Williams and Shunsuke Managi, 'Fuel Cells and the Hydrogen Revolution: Analysis of a Strategic Plan in Japan' (2015) 48 Economic Analysis and Policy 204.

[58] Organisation for Economic Co-operation and Development, 'The Hydrogen Regulatory Landscape' (*OECD iLibrary*) <www.oecd-ilibrary.org/sites/6130062f-en/index.html?itemId=/content/component/6130062f-en> accessed 6 November 2023. See also Clifford Chance, 'Focus on Hydrogen: Japan's Energy Strategy for Hydrogen and Ammonia' <www.cliffordchance.com/content/dam/cliffordchance/briefings/2022/08/focus-on-hydrogen-in-japan.pdf> accessed 23 October 2023.

subsidies.[59] As a consequence, raw hydrogen prices cannot, strictly speaking, be compared in an apples-to-apples fashion and must be taken in the context of other associated economics, including FCV rebates, hydrogen producer incentives, carbon credit frameworks, and other energy costs associated with the creation and distribution of the fuel.

The multifaceted nature of hydrogen economics has meant that the general ambition of sovereign state sponsors of hydrogen tends toward stable but gradually declining hydrogen pricing over time. By construction, such a scheme serves as an impetus for immediate investment in the sector given the implied higher future rates of return necessary to compensate for the incremental risks of allocating capital to a new energy carrier in the grids.

To provide a comparison, the US Department of Energy launched the Hydrogen Shot program in June 2021 with a goal of reducing green hydrogen costs by roughly 80 percent, to $1 per kilogram, within a decade.[60] 'The Hydrogen Shot establishes a framework … for clean hydrogen deployment', including the outfit of several dedicated offices and a total of approximately $400 million in financial year 2022.[61] Astonishingly, commitments to back hydrogen infrastructure within the recently enacted Inflation Reduction Act are nearly 100 times this amount,[62] attesting to the degree of priority attached to this energy source. Similarly, Japan has stated its ambition to reduce hydrogen pricing from the current level of 1,100 yen (~$100 per kilogram) to as little as 330 yen by 2030,[63] with billions in incremental funding to support cost reductions and further roll-out of the country's orthodox cluster-based system.[64]

Theoretically, notwithstanding the preemptive first-mover advantages enjoyed by the United States and Japan, MENA countries should be among 'the cheapest producers of hydrogen in the world, second only to Australia in markets assessed by Platts',[65] which makes a compelling case for a future MENA hydrogen hub. When it comes to the MENA region, moreover, hydrogen is likely to be a truly carbon-neutral proposition given that current expected cost prices for green hydrogen may underpin commercial competitiveness with the expected primacy of gray or blue fuel.[66] Bargain-priced renewable power has, in a sense, rendered the cost of both electrolysis and desalinization sufficiently marginal that the alternative of stripping hydrogen from fossil fuels

[59] Soon Chen Kang, 'Japan Keeps Auto Industry's Hydrogen Dreams Alive' (*S&P Global Market Intelligence*, 10 February 2021) <www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/japan-keeps-auto-industry-s-hydrogen-dreams-alive-62160857> accessed 2 November 2023.

[60] 'Hydrogen Shot' (*Office of Energy Efficiency & Renewable Energy*) <www.energy.gov/eere/fuelcells/hydrogen-shot> accessed 9 November 2023.

[61] Ibid.

[62] Alan Krupnick and Aaron Bergman, 'Incentives for Clean Hydrogen Production in the Inflation Reduction Act' (*Resources for the Future*, 9 November 2022) <www.rff.org/publications/reports/incentives-for-clean-hydrogen-production-in-the-inflation-reduction-act/> accessed 2 November 2023.

[63] 'Japan – Eneos and Chiyoda to Slash Green Hydrogen Costs by Two Thirds'.

[64] Petra Schwager and others, *Green Hydrogen Industrial Clusters Guidelines* (United Nations Industrial Development Organization 2023) <www.unido.org/sites/default/files/files/2023-08/GH2_ClusterGuidelines_0.pdf> accessed 2 November 2023; Daisuke Akimoto, 'A Look at Japan's Latest Hydrogen Strategy' (*The Diplomat*, 7 July 2023) <https://thediplomat.com/2023/07/a-look-at-japans-latest-hydrogen-strategy/> accessed 2 November 2023.

[65] James Burgess, 'Platts Launches Middle East Hydrogen Prices as Mega-Projects Underline Region's Ambitions' (*S&P Global Commodity Insights*, 22 November 2021) <www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/112221-platts-launches-middle-east-hydrogen-prices-as-mega-projects-underline-regions-ambitions> accessed 2 November 2023.

[66] Carol Nakhle, 'The Hydrogen Craze Hits the Middle East' (*Geopolitical Intelligence Services*, 16 May 2022) <www.gisreportsonline.com/r/middle-east-hydrogen> accessed 2 November 2023.

and offsetting (or capturing) the embedded carbon emissions is not necessarily demonstrably advantageous on a carbon-equivalent basis.[67]

Hence, the MENA region starts with better enabling conditions than other regions (such as Europe) for hydrogen, but it will still need to establish appropriate pricing frameworks that can mitigate risks associated with the high and uncertain costs of entering fixed-price supply contracts essential for attracting long-term competitive financing. Such mitigation will entail government support in the form of subsidies, grants, or preferential financing, as well as duly structured power-purchase agreements and access to clean water, even with low input costs to production, courtesy of some of the world's most competitive renewables and large reserves of surplus hydrocarbons.[68] If a private sector appetite to provide financing via green bonds or other more innovative mechanisms such as securitization of future carbon credits[69] materializes, the need for state support may be reduced commensurately. One can imagine any number of enhanced mobility schemes in which fresh hydrogen demand is spurred via well-constructed P3 to mimic programs from the United States or Japan. The MENA region, especially the Gulf Cooperation Council, has shown that it can leapfrog rapidly in terms of technological progress and the rapid adoption of innovations (including but not limited to mobile device coverage, flying cars, or high-speed intranational transport[70]) to create a cycle of hydrogen investment, production, and consumption for decades to come. To achieve this ambitious goal, clear and comprehensive legal frameworks that elaborate the pricing and financing framework for hydrogen, ranging from deliberate P3 programs to coherent incentive schemes and accommodative application of competition law, amongst other factors, would be essential to unlock a hydrogen economy in the region.

6.3.4 *Institutional Gaps*

'The absence of [a] legally recognized national authority for [hydrogen regulation], coupled with the lack of coordination amongst existing government institutions and ministries, remains one of the serious institutional challenges [undermining] the successful implementation of [hydrogen] projects in the [MENA] region.'[71] Despite the ambitious aims to transition to hydrogen economies, several MENA countries currently lack the dedicated institutional mechanisms to track the production, consumption, and sale of hydrogen.[72]

Oman is one of the few countries in the region to have, in 2022, established a focal agency on hydrogen, the Hydrogen Oman (HYDROM), specifically to lead the country's green hydrogen strategy.[73] HYDROM's mandate includes the supervision of land allocation and licensing and

[67] Jim Magill, 'Blue vs. Green Hydrogen: Which Will the Market Choose?' (*Forbes*, 9 November 2022) <www.forbes.com/sites/jimmagill/2021/02/22/blue-vs-green-hydrogen-which-will-the-market-choose/?sh=32cfdb643878> accessed 2 November 2023.

[68] Gajendra Yadav, 'Financing Green Hydrogen Projects in the Middle East' (*Synergy Consulting*, 23 November 2022) <www.synergyconsultingfa.com/industry-knowledge/financing-green-hydrogen-projects-in-the-middle-east/> accessed 2 November 2023.

[69] Garrett Monaghan and Alan Heuston, 'Green IFSC: Securitisation of Carbon Offsets and Creation of a New Crossover Credit – Structured Finance' (*Mondaq*, 1 March 2011) <www.mondaq.com/ireland/structured-finance/124580/green-ifsc-securitisation-of-carbon-offsets-and-creation-of-a-new-crossover-credit> accessed 2 November 2023.

[70] 'Chinese "Flying Car" Makes First Public Flight in Dubai' (*Reuters*, 13 October 2023) <www.reuters.com/technology/chinese-flying-car-makes-first-public-flight-dubai-2022-10-11/> accessed 2 November 2023.

[71] Olawuyi 2017 541.

[72] Van de Graaf et al. 31.

[73] 'Home' (*Hydrom*) <https://hydrom.om> accessed 2 November 2023.

structuring of associated large-scale, world-class green hydrogen projects in Oman.[74] While Oman's example is expected to guide other MENA countries to put in place similar tailored institutional and governance structures to guide the coherent development of hydrogen projects, institutional development in this regard remains scarce. In addition to facilitating the coherent development and implementation of a country's hydrogen strategy, a focal agency in countries of the MENA region will also play key roles in 'serving as a one-stop shop' that streamlines and simplifies the licensing processes for projects, including ensuring land access and promoting data collection to ensure that hydrogen production is accounted for in official statistics on energy production and consumption in a country.[75] Similarly, a focal agency can help to promote coordination and create synergies 'between all government institutions, both new and old, to fast track and simplify the implementation of' hydrogen infrastructure projects.[76]

The progress made in hydrogen infrastructure development in France, Germany, and Denmark, amongst others, is due largely to the existence of regulatory bodies and industry institutions, both old and new, to guide and monitor the development of hydrogen projects. For example, German energy regulator the Bundesnetzagentur is now in charge of hydrogen infrastructure, while France in 2021 established a National Hydrogen Council (Conseil National de l'hydrogène) to monitor hydrogen development projects and policies. The French association for hydrogen and fuel cells (France Hydrogène, previously Afhypac) also plays a key role in promoting the sharing of knowledge and best practices amongst private sector operators and investors on hydrogen development. Similarly, in 2020 Germany also established the National Hydrogen Council (Nationaler Wasserstoffrat), a multidisciplinary body made up of experts in science, business, and law to facilitate the coherent implementation of the country's National Hydrogen Strategy.[77] In addition to promoting public awareness about hydrogen projects, such focal expert bodies, agencies, or councils can play key roles in providing clarifications and guidelines to investors when proposing and developing hydrogen infrastructure projects in order to ensure that such projects 'are in line with the country's national vision[s]'.[78] This 'can result in real, measurable and long-term [environmental and socio-economic] benefits'.[79] The lack of clear and coordinated governance structures in several MENA countries is a key barrier that must be addressed if hydrogen development and commercialization is to proceed in a safe, orderly, and coherent manner.

The gaps and barriers in ongoing efforts to transition to hydrogen economies in the MENA region must be addressed through holistic law and governance systems. Section 6.4 now discusses legal pathways for addressing those challenges.

6.4 IMPROVING LAW AND GOVERNANCE FRAMEWORKS ON HYDROGEN IN THE MENA REGION

While setting national strategies and targets for hydrogen development reflects the political commitment towards a progressive transition to a hydrogen economy, the next step would be for

[74] Conrad Prabhu, 'Hydrogen-Powered Green Future Awaits Oman' (*Oman Observer*, 28 February 2023) <www.omanobserver.com/article/1133416/business/energy/hydrogen-powered-green-future-awaits-oman> accessed 2 November 2023.
[75] Olawuyi 2018 369.
[76] Ibid 366.
[77] 'The German National Hydrogen Council' (*Nationaler Wasserstoffrat*) <www.wasserstoffrat.de/en/national-hydrogen-council> accessed 2 November 2023.
[78] Olawuyi 2018 367.
[79] Ibid.

national authorities across the MENA region to develop a 'comprehensive and holistic legal framework'.[80] That framework should support and govern ongoing hydrogen projects while also attracting new ones. In the following, four recommendations to that effect will be made.

First, for hydrogen to play a substantial role in the future blend of energy consumption in the region – for mobility, consumer living, or industry – it must be viable for both investors and consumers. The cost dynamics of today's hydrogen markets mean that everything from fuel distribution stations to hydrogen fuel cells in cars to public sector implementation of systems capable of integrating hydrogen use are not, at a baseline, financially viable. Thus, a starting point is for MENA countries to put in place clear, tailored, and comprehensive laws to streamline and incentivize large-scale investments in hydrogen projects.

Current natural resource laws should also be expanded to establish clear guidelines that specifically mention and cover hydrogen. Such laws should also clarify questions relating to permitting, licensing, and pricing and include mandatory performance standards, especially amongst state-owned entities to integrate hydrogen into their energy mix. Such a requirement will increase demand for hydrogen, which will then further boost investor confidence and stimulate a competitive and attractive investment climate for hydrogen projects.

Second, building that competitive environment will require a wide range of legislative reforms aimed at streamlining market access requirements, while promoting private sector participation in hydrogen projects. To streamline market access, MENA countries will need to expand the use of tax-free or special economic zones to allow for streamlined registration and formation of dedicated operational entities to import and deploy the energy carrier, related equipment, hardware, and capital necessary to build the desired hydrogen infrastructure. Exempting hydrogen projects from stipulations on the involvement of minimum percentages of local partners and/or domestic content requirements can also enhance market upscaling. Moreover, it is necessary to enact P3-specific laws[81] or, if already enacted, to ensure that the local compliance regulations are structured to maintain the interest of international investors in pursuing projects in the MENA region. For example, P3 laws should include transparency measures to help with due diligence and equitable risk allocation so that the private sector does not have to carry all the risks associated with projects and to ensure that the finite delineation of responsibility between investor and state sponsor is clear.

Third, to promote the coherent development of hydrogen 'projects, it is important to establish a focal institution or administrative unit that will coordinate the design, approval, and implementation of such projects', including setting clear roles for different administrative entities.[82] Depending on the specific situation of each MENA country, such an institutional framework can be in the form of expanding the mandates and budgets of existing energy agencies to enable them to regulate and monitor hydrogen investments and development or of establishing new and dedicated agencies on hydrogen. 'Apart from serving as a one-stop shop that will streamline the approval processes for projects, such an institution would also provide capacity development opportunities for administrators to acquire technical knowledge about the methods, requirements, and challenges of' the hydrogen value chain.[83] 'By empowering and establishing a focal institution on' hydrogen projects, a country can develop a systemic understanding, including

[80] Damilola S Olawuyi, 'Local Content Requirements in Oil and Gas Contracts: Regional Trends in the Middle East and North Africa' (2017) 37 *Journal of Energy & Natural Resources Law* 93, 113.
[81] Damilola S Olawuyi, 'Energy Poverty in the Middle East and North African (MENA) Region' in Iñigo del Guayo and others (eds.), *Energy Justice and Energy Law* (Oxford University Press 2020).
[82] Olawuyi 2018 369.
[83] Ibid.

statistical data analysis and gathering of the contributions of hydrogen to the energy mix and ways to further enhance hydrogen development and commercialization.[84]

Fourth, regional collaboration and knowledge sharing between countries with experience and expertise on hydrogen can help to promote the adoption of hydrogen development and its efficiency across the Middle East. While countries such as Oman, the UAE, Saudi Arabia, and Morocco have some experience with hydrogen projects, 'several other countries within the [MENA region] have little to no experience at all'.[85]

> It is therefore important to promote cooperation and knowledge sharing between regional networks and institutions, within and outside of the [region], on [hydrogen], low-carbon transition, and on how P3 models can help facilitate [hydrogen] development and integration. Regional centres and platforms can also enhance the exchange of ideas, best practices, and knowledge on existing [hydrogen] project opportunities, model contracts, and practical steps for planning and implementing [hydrogen] projects.[86]

In Europe, the European Clean Hydrogen Alliance, founded in 2020, is part of EU efforts to accelerate the decarbonization and 'support[s] the large-scale deployment of clean hydrogen technologies . . . by bringing together renewable and low-carbon hydrogen production, demand in industry, mobility and other sectors, and hydrogen transmission and distribution'.[87] The MENA Hydrogen Alliance is already filling a gap in this respect, although current membership is not very widespread across the region.[88] There is a need for more active engagement of the Arab League, national authorities, regulators, and research institutions across the region in this and other regional bodies that can strengthen knowledge sharing on hydrogen development. Finally, more active participation and engagement by policymakers in knowledge-sharing platforms can accelerate region-wide deployment of clean hydrogen technologies.

6.5 CONCLUSION

Endowed with conventional and renewable energy sources needed to drive the large-scale production and commercialization of green and blue hydrogen, MENA countries have increasingly announced strategic investments and plans to become hydrogen superpowers over the next decade. The wide-scale deployment of hydrogen can provide viable opportunities for countries in the region to diversify their economies, become less oil dependent, lower their carbon emissions, and generate a greater share of domestic energy from clean sources.

However, lack of regulatory clarity on the standards, certifications, and incentives to drive hydrogen production, especially to stimulate required hydrogen grid integration, distribution, and storage infrastructure in the region, is exacerbated by the absence of robust institutional frameworks to streamline and supervise hydrogen projects. Legal barriers that stifle the development of a coherent hydrogen market must be addressed to advance the comprehensive implementation of hydrogen visions and targets across the region.

[84] Ibid.
[85] Ibid.
[86] Ibid.
[87] 'The European Clean Hydrogen Alliance brings together industry, public authorities, civil society, and other stakeholders. Alliance members meet twice a year in the Hydrogen Forum to discuss the large-scale deployment of clean hydrogen technologies and what this requires.' 'European Clean Hydrogen Alliance' (*European Commission*) <https://single-market-economy.ec.europa.eu/industry/strategy/industrial-alliances/european-clean-hydrogen-alliance_en> accessed 2 November 2023.
[88] 'About MENA Hydrogen Alliance'.

To do so, there is a need for a robust regulatory framework that not only introduces transparency and certainty to the hydrogen market but also promotes and supports sustained P3 investments. Regulatory coherence and clarity can boost investor confidence on the economics of hydrogen, in terms of both profitability and long-term sustainability value. Promoting such clarity requires equilibrating risk-adjusted returns for hydrogen through focused incentives, guaranteed pricing frameworks, and, critically, a feed-in-tariff system, to offset the higher costs associated with producing energy from hydrogen or tax credits. The regional sharing of expertise, knowledge, and best practices could also provide an effective platform for MENA countries to identify unique challenges for hydrogen development in the region.

FURTHER READING

Nalule VR (ed.), *Energy Transitions and the Future of the African Energy Sector* (Palgrave MacMillan 2021)

Olawuyi DS, 'Advancing Innovations in Renewable Energy Technologies as Alternatives to Fossil Fuel Use in the Middle East' in Donald Zillman and others (eds.), *Innovation in Energy Law and Technology: Dynamic Solutions for Energy Transitions* (Oxford University Press 2018)

'Can MENA Extractive Industries Support the Global Energy Transition? Current Opportunities and Future Directions' (2021) 8(2) The Extractive Industries and Society 100685 <www.sciencedirect.com/science/article/abs/pii/S2214790X19303399> accessed 31 October 2023

Climate Change Law and Policy in the Middle East and North Africa Region (Routledge 2022)

'Financing Low-Emission and Climate-Resilient Infrastructure in the Arab Region: Potentials and Limitations of Public-Private Partnership Contracts' in Walter Leal Filho (ed.), *Climate Change Research at Universities: Addressing the Mitigation and Adaptation Challenges* (Springer 2017)

Razi F and Dincer I, 'Renewable Energy Development and Hydrogen Economy in MENA Region: A Review' (2022) 168 Renewable and Sustainable Energy Reviews 112763 <www.sciencedirect.com/science/article/abs/pii/S1364032122006487> accessed 2 November 2023

Scipioni A, Manzardo A and Jingzheng R (eds.), *Hydrogen Economy: Supply Chain, Life Cycle Analysis and Energy Transition for Sustainability* (Academic Press 2017)

United Arab Emirates Ministry of Energy & Infrastructure, 'UAE Hydrogen Leadership Roadmap' (November 4, 2021) <https://u.ae/-/media/Documents-2022/UAE-Hydrogen-Roadmap–Eng.ashx> accessed 31 October 2023

Van de Graaf T and others, *Geopolitics of the Energy Transformation: The Hydrogen Factor* (International Renewable Energy Agency 2022)