

Hydrogen: Fueling EU-Morocco Energy Cooperation?

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Abstract

The war in Ukraine and the looming threat of climate change are driving the strategic need to diversify sources of energy, including renewables. Therefore, the European Union aims to develop energy relations with non-EU member states, and Morocco has become a key priority. Both Brussels and Rabat are pursuing ambitious green policies and cooperation initiatives, including on hydrogen. Drawing on theories of international institutions and political economy, this article analyzes hydrogen-related relationship patterns and explains demand and supply factors as drivers of institutionalized energy cooperation. We examine the EU's hydrogen approach and development, its relations with Morocco, and the political interests of both sides. Our analysis shows that the complex interdependencies in the evolving EU-Morocco hydrogen relations indicate that demand can be met by supply. However, challenges remain, including the need to deepen the partnership and prepare the market for commercial hydrogen production.

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Secure and sustainable power is essential for the European Union and its member states. To achieve this, fossil fuels must be replaced by renewable energies as soon as possible, as expressed by the 6th IPCC Assessment Report, released in 2022. Indeed, the war in Ukraine shows that a resilient supply is of utmost importance. For this reason, hydrogen has moved to the top of the agenda in recent years.

Hydrogen has become a key energy carrier for the EU's ambitious plans to achieve net-zero emissions, a development that has attracted attention across European politics, economics, and society. The EU published a strategy in July 2020 that placed its bet on hydrogen to decarbonize sectors like iron and steel production, industrial processes that require high-temperature heat, aviation, shipping, long-distance road transportation, and heating for buildings.¹ Member states such as Spain, France, Portugal, and Germany have published their own hydrogen roadmaps. The debate on hydrogen in the EU frequently includes external partners as potential suppliers,² since it is assumed that 15 percent of the hydrogen needed to reach net-zero will have to be imported³ and that, in some member states, up to 70 percent of green hydrogen will be imported.

EU policy documents put supplier countries at the center of the discussion. For example, the European Commission emphasizes international cooperation with regions like North Africa or the Middle East in its 2020 hydrogen strategy.⁴ Morocco is seen as key partner for several reasons. First, the kingdom has a high potential for renewable-energy production due to its having coastal areas conducive to wind power and a capacity to produce energy from solar panels.⁵ Second, production costs of these energy sources and of green hydrogen are assumed to be considerably lower in Morocco than in Europe or other potential partners like Australia or Canada. Third, both Brussels and Rabat are pursuing ambitious climate-oriented or green policies, and cooperation is possible from natural gas to renewables. Finally, existing energy cooperation as well as geographic proximity make Morocco a potential exporter of hydrogen to the EU.

With both parties equally keen on developing green hydrogen—that is, hydrogen produced without a net increase of carbon-dioxide emissions—and with Rabat having already initiated partnerships with countries like Germany and Portugal, hydrogen seems to have a considerable potential to ignite collaboration and fuel cooperation across the Mediterranean. Against this background, this article's key question is how to explain the new cooperation on green energy, focusing on hydrogen. This includes identifying potential cooperation beyond hydrogen, such as on iron.

The relationship between Brussels and Rabat can be best described as strategic and mutually interdependent, including cultural interaction, political exchange, and economic cooperation.⁶

¹ Alejandro Nuñez-Jimenez and Nicola De Blasio, *The Future of Renewable Hydrogen in the European Union: Market and Geopolitical Implications* (Cambridge, MA: Belfer Center for Science and International Affairs, 2022).

² S&P Global, "European Hydrogen Imports to Be 'Cost-Competitive' with Local Production by 2030," 2021, <https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/european-hydrogen-imports-to-be-cost-competitive-with-local-production-by-2030-62287364>.

³ *EurActiv*, "Europe Could Save €2 Trillion by 2050 with Low-Carbon Hydrogen, Says Report," 2021, <https://www.euractiv.com/section/energy-environment/news/europe-could-save-e2-trillion-through-2050-thanks-to-low-carbon-hydrogen-says-report>.

⁴ Bob van der Zwaan, Sam Lamboo, and Francesco Dalla Longa, "Timmermans' Dream: An Electricity and Hydrogen Partnership between Europe and North Africa," *Energy Policy* 159 (2021): 1-11, <https://doi.org/10.1016/j.enpol.2021.112613>.

⁵ Britta Daum, "(In)consistency in European External Energy Governance in the EU's Southern Neighbourhood: the Case of Morocco," PhD dissertation, Technische Universität Darmstadt, 2020.

⁶ Michael Willis and Nizar Messari, "Analyzing Moroccan Foreign Policy and Relations with Europe," *The Review of International Affairs* 3, no. 2 (2007): 152-172.

Morocco is not only a neighbor but enjoys the status of a privileged partner country of the EU, reflected in the EU–Morocco Association Agreement (2000) and the EU–Morocco Fisheries Partnership Agreement (2006). Moreover, Morocco is covered by the European Neighbourhood Policy (ENP) of 2004 and is a member of the Union for the Mediterranean. This cooperation spans a range of sectors, from security and the economy to projects funded by development aid.⁷

The energy sector has become an area of focus in EU–Morocco relations over the past few years. In 2003, the partners signed a memorandum of understanding on the progressive integration of their electricity markets.⁸ Cooperation intensified in 2008 when Morocco obtained advanced status within the ENP and was required to implement strategies compatible with the EU’s energy objectives.⁹ In this context, Morocco began to demonstrate a strong interest in the promotion of renewables, the development of energy infrastructures, and the export of green electricity to the EU.¹⁰ This led to multilateral initiatives like Desertec, Medgrid, and the Mediterranean Solar Plan, projects that will be outlined in more detail below. These ambitious collaborations have failed or remain largely incomplete.¹¹

Scholars have increasingly turned their attention to energy relations between the EU and Morocco.¹² Studies have examined the geopolitics of this cooperation, the ties embedded in the Union for the Mediterranean, the EU’s external energy governance in Morocco, and EU framing processes after the Arab Spring.¹³ This article focuses on dynamics of energy cooperation between the EU and Morocco regarding another renewable source: hydrogen.¹⁴

To provide a systematic analysis, we draw on concepts in political economy like international institutions and complex interdependence.¹⁵ After explaining theories of supply and demand,

⁷ Patrick Holden, “Partnership Lost? The EU’s Mediterranean Aid Programmes,” *Mediterranean Politics* 10, no. 1 (2005): 19–37, <https://doi.org/10.1080/1362939042000338827>; Iván Martín, “EU–Morocco Relations: How Advanced is the ‘Advanced Status’?” *Mediterranean Politics* 14, no. 2 (2009): 239–45, <https://doi.org/10.1080/13629390902990877>; “Morocco,” European Commission, 2022, https://ec.europa.eu/neighbourhood-enlargement/european-neighbourhood-policy/countries-region/morocco_de.

⁸ We understand the energy market as a specific type of commodity market, facilitating the process, trade, and provision of energy resources, including electrical energy and hydrogen.

⁹ Ministry of Economy and Finance, “The Launching in Rabat of Morocco–EU Institutional Twinning Project,” 2011, <https://www.finances.gov.ma/en/Pages/detail-actualite.aspx?fiche=2887>.

¹⁰ Esther Barbé and Anna Herranz-Surrallés, *The Challenge of Differentiation in Euro-Mediterranean Relations: Flexible Regional Cooperation or Fragmentation* (London: Routledge, 2013).

¹¹ Hakim Darbouche, “Third Time Lucky? Euro-Mediterranean Energy Cooperation under the Union for the Mediterranean,” *Mediterranean Politics* 16, no. 1 (2011): 193–211, <https://doi.org/10.1080/13629395.2011.547412>; Simone Tagliapietra and Georg Zachmann, “Energy across the Mediterranean: a Call for Realism,” Bruegel Policy Brief 3 (2016).

¹² Barbé and Herranz-Surrallés, *Challenge of Differentiation*; Eduard Soler I Lecha, “Converging, Diverging and Instrumentalizing European Security and Defence Policy in the Mediterranean,” *Mediterranean Politics* 15, no. 2 (2010): 231–248, <https://doi.org/10.1080/13629395.2010.485050>; Angelos Katsaris, “Europeanization through Policy Networks in the Southern Neighbourhood: Advancing Renewable Energy Rules in Morocco and Algeria,” *Journal of Common Market Studies* 54, no. 3 (2015): 656–673, <https://doi.org/10.1111/jcms.12320>.

¹³ Gonzalo Escribano, “The geopolitics of renewable and electricity cooperation between Morocco and Spain,” *Mediterranean Politics* 24, no. 5 (2018): 674–681, <https://doi.org/10.1080/136229395.2018.1443772>; Darbouche, “Third Time Lucky”; Daum, “(In)consistency”; Barbé and Herranz-Surrallés, *Challenge of Differentiation*.

¹⁴ We understand energy and electricity cooperation as formal and institutionalized mode of cooperation (including guiding principles, norms and legal contract) between two or more actors; van der Zwaan et al., “Timmermans’ Dream.”

¹⁵ Robert Keohane and Joseph Nye, *Power and Interdependence* (New York: Longman, 2001); Robert Keohane, *After Hegemony: Cooperation and Discord in the World Political Economy* (Princeton: Princeton University Press, 1984); Walter Mattli, *The Logic of Regional Integration: Europe and Beyond* (Cambridge: Cambridge University Press, 1999).

the article analyzes the structure of EU-Morocco energy interdependence with a focus on hydrogen-related relationship patterns. We then explain demand and supply factors as drivers for institutionalized energy cooperation between the partners. This includes references to their hydrogen backgrounds, the EU's approach toward relations with Morocco, and their corresponding political interests. In a last step, we discuss the findings and lay out the challenges unfolding.

COMPLEX INTERDEPENDENCY AND SUPPLY-DEMAND PATTERNS

According to Keohane and Nye, “Interdependence in world politics refers to situations characterized by reciprocal effects among countries or among actors in different countries.”¹⁶ Cooperation problems in international relations emerge and exist against the background of patterns of interdependence between actors, especially states, in specific issue areas.

But what drives a state's disposition to cooperate? Political economists argue that the intensity of an interdependent relationship between two or more countries impacts their cooperation. A strong pattern of interdependence implies a prospect for higher cooperative gains compared to a lower one.¹⁷ Research shows that a combination of mostly economic demand and supply factors drives regional-integration processes.¹⁸ Political economists argue that demand for international cooperation and integration originates mainly among private economic actors.¹⁹ Most countries in the global south, like Morocco, lack substantive potential to exploit economies of scale or benefit from comparative cost advantages. Instead, they often depend on a few export commodities or natural resources.²⁰ Against this background, demand for international cooperation and economic integration is motivated by the prospect of attracting foreign direct investment (FDI). A larger, integrated market with credible institutions that monitor policy implementation and ensure political stability will attract more FDI than will a developing economy of “outsiders.”²¹

An additional demand factor in developing countries connects to foreign aid and external donor funding. Many international donors—including the EU—increasingly follow policies that privilege international cooperative projects and integration initiatives in the Global South. Unsurprisingly, this triggers demand in low- and middle-income countries to act accordingly and engage in institutionalized cooperative initiatives to attract and benefit from external donor support.²² Successful cooperation initiatives and sustainable integration projects, however, only materialize

¹⁶ Keohane and Nye, *Power and Interdependence*, 8.

¹⁷ Mattli, *Logic of Regional Integration*; Stefan Schirm, *Globalization and the New Regionalism: Global Markets, Domestic Politics and Regional Cooperation* (Malden: Blackwell Publishers, 2002); Oran Young, “Interdependencies in World Politics,” *International Journal* 24, no. 4 (1969): 726-750, <https://doi.org/10.1177/002070206902400407>.

¹⁸ Mattli, *Logic of Regional Integration*; Schirm, *Globalization and the New Regionalism*.

¹⁹ Bela Balassa, *The Theory of Economic Integration* (London: George Allan & Unwin Ltd, 1961); Jacob Viner, *The Customs Union Issue* (New York: Stevens, 1950).

²⁰ W. Andrew Axline, “Underdevelopment, Dependence and Integration: The Politics of Regionalism in the Third World,” *International Organization* 31, no. 1 (1977): 83-105, <https://doi.org/10.1017/S0020818300006494>; Mattli, *Logic of Regional Integration*, 64.

²¹ Mattli, *Logic of Regional Integration*, 58-59; Schirm, *Globalization and the New Regionalism*, 21.

²² Axline, “Underdevelopment”; Mattli, *Logic of Regional Integration*, 60.

if demand is met by supply. The willingness of political leaders to act accordingly is a crucial supply condition in this regard, and proactive policy entrepreneurs are of key importance.²³

Against this theoretical background, we expect new cooperation between the EU and Morocco on green energy if we observe

- substantial patterns of interdependence in the issue area of energy
- evidence of demand for energy cooperation in both partners
- evidence of supply that meets the demand among those actors.

Drawing on official documents, previous studies, and insights derived from experts in the field, we use a deductive case study to analyze EU-Morocco hydrogen cooperation.²⁴ This is a key case study since Europe has placed its bet on Morocco as an energy partner, and the kingdom has increasingly emphasized that the EU is a main partner for its energy development and export.²⁵ While single case studies do not allow us to generalize across the entire political economy of energy, this analysis will provide insights into the growing relationship between the EU and Morocco, transnational governance, and partnerships in a world that is transforming its approach to energy carriers.

EU-MOROCCO ENERGY RELATIONS

Euro-Mediterranean cooperation dates back to the 1970s, with energy a pivotal aspect of the relationship. Cooperation grew substantially in the mid-2000s, especially under the European Neighbour Policy.²⁶ It is now mainly centered on technical and financial assistance and takes different forms, through memoranda of understanding, contracts, and ad-hoc collaborations.²⁷

Cooperation was boosted in October 2008, when Morocco was granted advanced status by the EU via the adoption of a general roadmap. The document foresees a substantial intensification of diplomatic and trade relations between the partners and includes enhanced dialogue, trade liberalization, and adjustments of Morocco's economy to meet the standards of the EU's single market. A key feature is the alignment of Moroccan regulations to EU laws, mirroring processes that are usually limited to candidates for EU expansion.²⁸ This allowed Morocco to be singled out as the EU's main Mediterranean partner and to increase its economic ties with the single market. For the EU, the advanced status facilitated its exports to the kingdom and, more important, cooperation on key issues such as migration, energy, organized crime, and counterterrorism. The EU

²³ Mattli, *Logic of Regional Integration*, 51.

²⁴ Jack S. Levy, "Case Studies: Types, Designs, and Logics of Inference," *Conflict Management and Peace Science* 25, no. 1 (2008): 1-18, <https://doi.org/10.1080/07388940701860318>.

²⁵ Anna Herranz-Surrallés, "Thinking Energy Outside the Frame? Reframing and Misframing in Euro-Mediterranean Energy Relations," *Mediterranean Politics* 23, no. 1 (2018): 122-141, <https://doi.org/10.1080/13629395.2017.1358903>; van der Zwaan et al., "Timmermans' Dream"; Daum, "(In)consistency"; Friedrich Plank, Johannes Muntschick, Michèle Knodt, and Arne Niemann, "Talking Hydrogen: Assessing Hydrogen Discourses in the European Union (EU) and Its Member States," *Mainz Papers on International and European Politics*, no. 27 (2023).

²⁶ Astrid Boening, Jan-Frederik Kremer, and Aukje Van Loon, *Global Power Europe, Vol. 2: Policies, Actions and Influence of the EU's External Relations* (Berlin: Springer Science & Business Media, 2013).

²⁷ *Ibid.*; Herranz-Surrallés, "Thinking Energy."

²⁸ Kristina Kausch, "Morocco's 'Advanced Status': Model or Muddle?" *Fride Policy Brief*, no. 43 (2010).

also saw Morocco as a buffer against potential security threats emanating from the Sahel.²⁹ From that time, Morocco has been required to implement energy strategies compatible with those of the EU and aligned with the union's objectives of energy security, competitiveness, and sustainability.

From Morocco's perspective, alignment with Brussels was desirable, as it seemed to complement Rabat's own energy strategy. Given that Morocco's energy sector depends heavily on imported hydrocarbons—about 90 percent—and that energy use has increased steadily by about 5 percent over the past 20 years, the kingdom was keen to reduce this dependency, including through renewable sources.³⁰ In 2019, for instance, national electricity generation depended mainly on coal (38 percent), natural gas (18), and fuel oil (8), as well as hydroelectricity (16), wind (11) and solar (7) (see Figure 1).

Current Trends in the Energy Relationship

Morocco has begun to demonstrate a strong interest in the promotion of renewables, the development of energy infrastructures, and the export of green electricity to the EU.³¹ This is due, in part, to EU policies against importing CO₂-intensive electricity, such as the carbon border adjustment mechanism. Multilateral initiatives, such as the Mediterranean Solar Plan (MSP), Desertec, and Medgrid, sought to support the development of renewable energies and energy efficiency within the southern Mediterranean countries by developing production capacities through integrated regional markets. The MSP aimed to develop renewable sources in the region, with a special focus on wind and solar. Among MSP's objectives was the development of 20 gigawatts of additional renewable-electricity capacity. Desertec, the most prominent of these initiatives, sought to install a Euro-Mediterranean network based on renewable-electricity production in the Sahara and its surrounding regions, including coastal areas. The generated supply would be transmitted to European and African countries by a super grid of high-voltage, direct-current cables. Unfortunately, Desertec has been regarded a failure since many stakeholders left the consortium in 2014.³² Medgrid had similar aims.

The basis for bilateral energy relations between the EU and Morocco is the Association Agreement (AA) of 1996 and the associated action plans that define social, economic, and political reforms to implement the AAs. The focus is largely on renewables, energy efficiency, and electricity, including a development component to integrate the Moroccan energy market into the EU's. Brussels and Rabat share interests within energy policy, especially the integration of their energy systems. The European Commission signed a declaration with Morocco in 2007 with the aim of strengthening the kingdom's role as "a transit country for gas supplies to the EU as well as an electricity exporter to the EU." Subsequently, great significance has been accorded to the convergence of Moroccan and European energy policies. In 2009, the partners signed a Financing Agreement for the Reform of the Energy Sector Support Program to bolster the

²⁹ Larbi Jaidi, "The Morocco/EU Advanced Status: What Value Does It Add to the European Neighbourhood Policy?" IEMed Mediterranean Yearbook, 2009, <https://www.iemed.org/publication/the-morocco-eu-advanced-status-what-value-does-it-add-to-the-european-neighbourhood-policy/>; Kausch, "Morocco's 'Advanced Status.'"

³⁰ Barbé and Herranz-Surallés, *Challenge of Differentiation*.

³¹ Ibid.

³² Thomas M. Schmitt, "(Why) Did Desertec Fail? An Interim Analysis of a Large-Scale Renewable Energy Infrastructure Project from a Social Studies of Technology Perspective," *Local Environment* 23, no. 7 (2018): 747-776, <https://doi.org/10.1080/13549839.2018.1469119>.

capacity necessary for Morocco's national energy.³³ Although the EU and Morocco lean toward renewable energies and energy efficiency, the impact of these policies has often been perceived as moderate. Multilateral energy cooperation projects, such as MSP and Desertec, have been disappointing and only shown limited success so far.³⁴

Moreover, the Arab Spring had geopolitical consequences, like “the emergence of new international actors in the Mediterranean energy game,” since the Mediterranean's energy resources attract an ever-increasing number of countries seeking new energy partnerships, such as Russia, China, and the Gulf states.³⁵ Against this background, the dynamics within the partnership started to change in the mid-2010s, affected by an overall cooling of the EU-Moroccan partnership. Morocco unilaterally suspended contact with the EU between 2016 and 2019 due to disagreements over trade. However, the intensified efforts toward energy transition in discussions of a European Energy Union restarted the partnership.³⁶

At the 2016 COP22 climate summit in Marrakesh, the EU and Morocco agreed to establish a roadmap for facilitating sustainable electricity trade between Europe's internal energy market and North Africa. In 2018, Morocco, Germany, France, Spain, and Portugal signed another declaration that included more concrete plans to facilitate cross-border trade.³⁷ In July 2019, the European Council and the kingdom agreed to enhance cooperation on renewables and energy efficiency.³⁸ In 2020, these objectives were reconfirmed with the intention of the partners to establish a “Green Partnership” aimed at advancing the external dimension of the European Green Deal by spurring the energy transition, protecting the environment, and boosting the green economy.³⁹

At the same time, the EU's carbon border adjustment mechanism—a proposed import tariff on carbon-intensive products, such as cement and steel—has slowed down Moroccan projects with Portugal and Spain. For example, such a mechanism would negatively affect CO₂-intensive electricity exports from Morocco's coal-fired Safi power plant to Spain. Against this background, one can understand the idea of exporting green energy in the form of hydrogen from Morocco to the EU. This relates both to the high dependency of Morocco on the import of fossil fuels and potential opportunities generated for both sides. In fact, the salience of EU-Morocco energy relations has increased substantially.⁴⁰ Specifically, a growing interest among Europeans and worldwide in hydrogen, especially its green form, suggests Morocco as a potential partner for exports to the EU.⁴¹

³³ Daum, “(In)consistency.”

³⁴ Magherita Bianchi, Lorenzo Colantoni, Federico Mascolo, and Nicolò Sartori, “Assessing EU-Mediterranean Policies in the Field of Energy from a Bottom-Up Perspective: the Case of Morocco,” *MEDRESET Working Papers* 32 (2018); Tagliapietra and Zachmann, “Energy across the Mediterranean.”

³⁵ Nicolò Sartori, “The Mediterranean Energy Relations after the Arab Spring: towards a New Regional Paradigm?” *Cahiers de la Méditerranée* 89 (2014): 145-157, <https://doi.org/10.4000/cdlm.7762>.

³⁶ Daum, “(In)consistency.”

³⁷ *Ibid.*

³⁸ European Council, “Joint Declaration by the European Union and Morocco for the Fourteenth Meeting of the Association Council,” 2019, <https://www.consilium.europa.eu/en/press/press-releases/2019/06/27/joint-declaration-by-the-european-union-and-the-kingdom-of-morocco-for-the-fourteenth-meeting-of-the-association-council/>.

³⁹ European Commission, “The EU and Morocco Form a Green Partnership on Energy, Climate and the Environment Ahead of COP 26,” 2021, https://ec.europa.eu/clima/news-your-voice/news/eu-and-morocco-form-green-partnership-energy-climate-and-environment-ahead-cop-26-2021-06-28_fr.

⁴⁰ Van der Zwaan et al., “Timmermans' Dream.”

⁴¹ Plank et al., “Talking Hydrogen.”

EU-Morocco Hydrogen Relations

Hydrogen, a highly flexible energy carrier and an important intermediary in several processes, is seen as key to energy transformation. Around 73 metric tons of pure hydrogen are produced annually worldwide, of which 38 are used in the refining of petrol and 31 in the production of ammonia. Only around four metric tons are used in other applications, including transportation and heat generation.⁴² However, given the strong global interest in increasing hydrogen generation and use, these numbers are expected to increase significantly.⁴³

Hydrogen is produced by electrolysis—that is, the splitting of water into hydrogen and oxygen. At present, the energy for electrolysis comes mainly from fossil sources such as oil, gas, and coal. Because of this, CO₂ is produced unless it is captured and stored. Creating hydrogen from renewable sources is considered crucial to the clean-energy transformation.⁴⁴ Hydrogen is labeled “green” if the power used in the production process comes exclusively from renewable sources such as wind and solar, rendering it CO₂-free. Other production processes cannot be considered carbon neutral unless the energies are captured and stored, as with “blue” hydrogen.⁴⁵

Announcements in 2020 and 2021 establishing net-zero-emissions goals sparked an unprecedented global commitment to hydrogen, with total investments by 2030 expected to exceed \$300 billion.⁴⁶ With around 70 percent of the world’s announced hydrogen production capacity to come from renewables, green hydrogen is a central focus.⁴⁷ Given their competitive advantages, the Middle Eastern and North African countries—above all, Morocco, Saudi Arabia, and the UAE, but also Algeria and Mauritania—are investing in hydrogen production and formulating hydrogen strategies.

COMPLEX INTERDEPENDENCY IN EU-MOROCCO ENERGY POLITICS

In this section, we trace the substantial patterns of mutual interdependency in hydrogen relations between Morocco and the EU by identifying patterns of demand and supply.

⁴² International Energy Agency, “The Future of Hydrogen: Seizing Today’s Opportunities,” 2019, <https://www.iea.org/reports/the-future-of-hydrogen>.

⁴³ European Commission, “The European Green Deal,” 2019, https://ec.europa.eu/info/sites/default/files/european-green-deal-communication_en.pdf.

⁴⁴ John A. Turner, “A Realizable Renewable Energy Future,” *Science* 285, no. 5428 (1999): 687–689, <https://doi.org/10.1126/science.285.5428.687>; George W. Crabtree, Mildred S. Dresselhaus, and Michelle V. Buchanan, “The Hydrogen Economy,” *Physics Today* 57, no. 12 (2004): 39–44, <https://doi.org/10.1063/1.1878333>.

⁴⁵ Crabtree et al., “Hydrogen Economy”; Peter Markewitz, Wilhelm Kuckshinrichs, Walter Leitner, Jochen Linssen, Petra Zapp, Richard Bongartz, Andrea Schreiber, and Thomas E. Müller, “Worldwide Innovations in the Development of Carbon Capture Technologies and the Utilization of CO₂,” *Energy & Environmental Science* 6 (2012): 7281–7305, <https://doi.org/10.1039/C2EE03403D>.

⁴⁶ McKinsey & Company, “Hydrogen Insights: A Perspective on Hydrogen Investment, Market Development and Cost Competitiveness,” 2021, <https://hydrogencouncil.com/wp-content/uploads/2021/02/Hydrogen-Insights-2021-Report.pdf>.

⁴⁷ IHS Markit, “Hydrogen Project Announcements Surge past \$500 Billion: Hydrogen Council,” 2021, <https://ihsmarkit.com/research-analysis/hydrogen-project-announcements-surge-past-500-billion-hydrogen.html>.

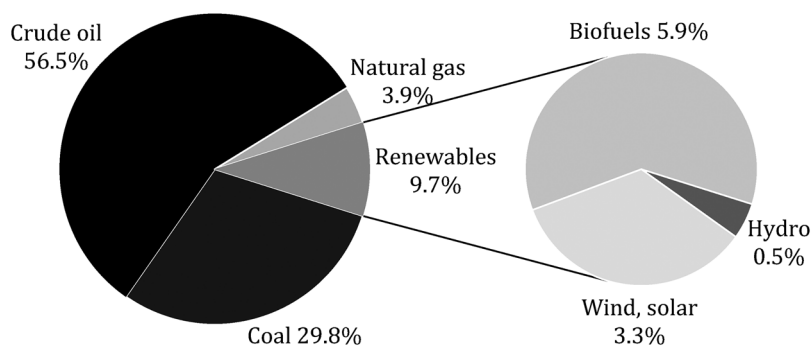


FIGURE 1 Morocco's Total Energy Supply by Source, 2019.⁴⁸

Demand Patterns in EU-Morocco Energy Relations

Establishing or enhancing hydrogen cooperation represents a mutually beneficial opportunity: While Morocco aims to reduce its energy dependency and become a major hydrogen exporter in the long term, the EU needs hydrogen to drive decarbonization in heavy industry and in heavy and marine transport.

The majority of Morocco's imported oil comes from the Middle East, while gas is primarily imported from neighboring Algeria. That bilateral relationship is tense due to an ongoing conflict over the Western Sahara between the kingdom and the Polisario Front, an Algeria-backed independence movement. Morocco also relies heavily on coal power, which makes up around 40 percent of its electricity mix (see Figure 1). It is against this background that the Moroccan government has placed renewables at the heart of its energy strategy. The country ratified the 1995 UN Framework Convention on Climate Change, the Kyoto Protocol in 2002, and the 2016 Paris climate agreement. It was also the first African member state to host the UN climate negotiations twice (COP7 in 2001 and COP22 in 2016). Under King Mohammed VI, Morocco has firmly anchored the right to sustainable development in its constitution and developed a National Charter for the Environment and Sustainable Development, which fixes the legal framework for foreign investments in the country. Key elements of the 2009 national energy strategy are security of supply, accessibility of energy and environmental preservation (similar to the EU's objectives), and regional integration.

One aim of the strategy is the installation of 42 percent of renewable-energy capacity by 2023, compared to 34 percent in 2015. The target was initially set for 2020 but missed. This goal includes the development of solar, wind, and hydro capacity, at 2 gigawatts each. After COP21 in Paris, Morocco extended these goals. By the end of 2020, the country had installed about 37 percent of renewable capacity, and it now targets an installed power capacity of 52 percent by 2030 (see Figure 1).⁴⁹ Two initiatives are central to achieving the kingdom's targets. One is the Moroccan solar plan NOOR, anchored in Ouarzazate, the world's largest concentrated solar complex with a capacity of 580 gigawatts. The other is the Moroccan Integrated Wind Programme, which is composed of two parts: the Taza wind farm (150 MW) and the 850 MW wind project

⁴⁸ International Energy Agency, "Morocco. Key energy statistics," 2023, <https://www.iea.org/countries/morocco>.

⁴⁹ International Trade Administration, "Morocco—Country Commercial Guide," 2021, <https://www.trade.gov/country-commercial-guides/morocco-energy>.

comprised of sites in Tanger, Midelt, Jbel Lahdid, Tiskrad, and Boujdour. With these strategies and projects, Morocco seeks to extend its leading role in regional and global climate-change policies and to position itself—thanks to its location between Europe and Africa and its access to the Mediterranean and Atlantic—as a green-energy hub. Indeed, to keep its commitments to the Paris accords, the kingdom raised the objectives of its nationally determined contribution in 2021, now seeking to achieve a 45.5 percent reduction of its greenhouse-gas emissions by 2030 (up from 32 percent), even in CO₂-heavy sectors like cement and phosphates.

For Morocco to achieve these objectives and move forward with the energy transition, hydrogen will play an enormous role. The kingdom is developing a National Roadmap for Hydrogen Energy, after putting in place a National Hydrogen Commission in 2019, focusing on green hydrogen. The country aims to cover about 4 percent of global green hydrogen demand by 2050—though it does not specify the amount of hydrogen this would require.⁵⁰

Morocco's hydrogen strategy is centered around three strategic pillars: technology, investment, and new market opportunities. With green hydrogen considered key to national economic development and to decarbonization, the strategy must include creating both an export market and a domestic market. Morocco is one of the largest phosphate producers and exporters in the world, accounting for around 13.5 percent of global production.⁵¹ However, the country relies heavily on imported (or grey) ammonia, which is added to phosphoric acid to produce fertilizer. The kingdom plans to establish its biggest hydrogen/ammonia project, an \$850 million plant expected to produce around 183,000 tons of green ammonia by 2026 for local use as well as export.⁵² In the long term, the country also plans to examine the use of hydrogen in other sectors, such as transport.⁵³ As Morocco's hydrogen strategy is based on international cooperation, it seeks not just European partners but to intensify cooperation with non-European actors, especially in the Global South. At the organizational level, Morocco signed an agreement on hydrogen research with the International Renewable Energy Agency and is a member of Hydrogen Europe, a Brussels-based European association representing about 300 large players, small and medium-sized enterprises, and national associations.⁵⁴

For its part, the European Commission in July 2020 published its strategy to decisively upscale hydrogen as part of the European Green Deal—which aims to achieve climate neutrality by 2050—and its post-pandemic green recovery. It emphasizes cooperation with regions like northern Africa and the Middle East. To make green hydrogen affordable and leverage the high capital expenditures for electrolyzers, one needs low-cost renewable energy and a high-capacity factor (the ratio of electrical energy generated over a time period to the installed capacity). The northern African countries, above all Morocco, benefit from a competitive advantage, with capital expenditures and production costs for renewable energy being much lower than in other

⁵⁰ MEM, "Feuille de Route: Hydrogène Vert: Vecteur de Transition Énergétique et de Croissance Durable," 2021, <https://www.mem.gov.ma/Pages/actualite.aspx?act=278>.

⁵¹ United States Geological Survey, National Minerals Information Center, "Phosphate Rock Statistics and Information," 2021, <https://www.usgs.gov/centers/national-minerals-information-center/phosphate-rock-statistics-and-information>.

⁵² Energy & Utilities, "Fusion Fuel and CCC to Develop \$850m Morocco Green Hydrogen Project," 2021, <https://energy-utilities.com/fusion-fuel-and-ccc-to-develop-850m-morocco-green-news113290.html>.

⁵³ MEM, "La Nouvelle Stratégie Énergétique Nationale," 2010, https://www.amee.ma/sites/default/files/inline-files/LA_NOUVELLE_STRATEGIE_ENERGETIQUE_NATIONALE.pdf.

⁵⁴ International Renewable Energy Agency, "Morocco and IRENA Partner to Boost Renewables and Green Hydrogen Development," 2021, <https://www.irena.org/newsroom/pressreleases/2021/Jun/Morocco-and-IRENA-Partner-to-Boost-Renewables-and-Green-Hydrogen-Development>.

parts of the world. One reason is that the country can rely on favorable conditions for solar and wind energy, as well as for biomass, thanks to its huge agricultural waste—and thus has the potential to generate large quantities of green electricity. While solar potential comes above all from the Sahara Desert, wind potential comes from the Moroccan coastline, notably Essaouira, Tanger, and Tetouan, as well as Tarfaya, Taza, and Dakhla.⁵⁵

Against this background, the EU and Morocco announced a green partnership on energy, climate, and the environment in summer 2021.⁵⁶ The partnership covers many areas, such as renewable-energy infrastructure, energy efficiency, and water use, with a main aspect the production of green hydrogen.⁵⁷ In addition, the European Bank for Reconstruction and Development (EBRD), is increasing its involvement in Moroccan hydrogen development. Since 2012, the EBRD has invested in more than 44 projects in Morocco, at a cost of more than €1.6 billion. About \$148 million of this went to Morocco's energy sectors, with a clear focus on sustainable energy.⁵⁸ As part of this, green hydrogen was included in a memorandum of understanding signed with the Moroccan Research Institute for Solar Energy and New Energies.⁵⁹

In addition to the EU's hydrogen strategy, many member states, like Portugal, Spain, France, Germany, the Netherlands, and Norway, have published their own national roadmaps. While there have been calls in some of these countries to engage in a dialogue with Morocco or other North African countries, not all are doing so or seeking closer relations with the Maghreb country. For example, Germany signed an agreement with the kingdom to implement the first hydrogen plant in Africa, funded by the German development bank Kreditanstalt für Wiederaufbau.⁶⁰ The facility would eventually produce about 10,000 tons of green hydrogen per year by 2025, allowing Morocco to produce green ammonia for its big fertilizer industry and to make use of so-called Power-to-X technologies that allow the storage or use of surplus electricity for other sectors, such as transport or heating.⁶¹ The Federal Ministry for Economic Cooperation and Development is supported by the Gesellschaft für Internationale Zusammenarbeit (GIZ), a federal nonprofit that has been in Morocco since 1975, with its own office in Rabat since 1999. The GIZ supports the German government's "Strategic Energy Partnership" by providing political or technical assistance. The group was involved in a study on the potential of Power-to-X technologies and the development of a roadmap for a green-hydrogen-based economy.⁶²

⁵⁵ Daum, "(In)consistency."

⁵⁶ Josephin Norris, "EU: Morocco—How Might the New 'Green' Partnership Fit with Plans to 'Green' Trade Relations?" 2021, <https://www.linkedin.com/pulse/eu-morocco-how-might-new-green-partnership-fit-plans-norris/>.

⁵⁷ European Commission, "EU and Morocco."

⁵⁸ European Bank for Reconstruction and Development, "The EBRD in Morocco," 2021, <https://www.ebrd.com/morocco.html>.

⁵⁹ European Bank for Reconstruction and Development, "EBRD and IRESEN to Boost Renewables, Green Hydrogen and New Technologies," 2021, <https://www.ebrd.com/news/2021/ebrd-and-iresen-to-boost-renewables-green-hydrogen-and-new-technologies.html>.

⁶⁰ Bundesministerium für Wirtschaft und Klimaschutz, "The National Hydrogen Strategy," 2020, https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.pdf?__blob=publicationFile&v=4.

⁶¹ Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, "Grüner Wasserstoff und Power-to-X," 2021, <https://www.bmz.de/de/entwicklungspolitik/wasserstoff>.

⁶² Deutsche Gesellschaft für Internationale Zusammenarbeit, "Morocco: On Track towards the Technology of the Future," 2020, <https://reporting.giz.de/2020/our-work-around-the-world/sustainable-resilient-recovery/morocco-on-track-towards-the-technology-of-the-future>.










	 EU	 Germany	 Spain	 Portugal
 Strategy	Hydrogen Strategy for a Climate-Neutral Europe	National Hydrogen Strategy	Hydrogen Roadmap: A Commitment to Renewable Hydrogen	National Hydrogen Strategy
 Aim	<ul style="list-style-type: none"> • 2024: Produce 1m tons/year • 2030: Produce 10m tons/year • 2030-2050: Produce large-scale 	<ul style="list-style-type: none"> • Build 5 GW hydrogen generation facilities by 2030 • Invest €9B (of which €2B for foreign production) 	<ul style="list-style-type: none"> • 2024: 300-600 MW electrolyzer plants • 2030: 4 GW electrolyzer plants • 2050: Hydrogen economy 	<ul style="list-style-type: none"> • 2030: Achieve 5% each in final energy consumption, industry and transport • Invest €7-9B
Cooperation with Morocco				
 Agreement	Establishment of a green partnership on energy, climate and the environment	Germany-Morocco Hydrogen Agreement (June 2020)	Establishment of a hydrogen partnership being studied	Portugal-Morocco Declaration on Cooperation on Hydrogen (February 2021)
 Objective	Low-carbon, climate-resilient economy & transition to green economy	<ul style="list-style-type: none"> • Development of the Power-to-X sector 		<ul style="list-style-type: none"> • Implementation of a roadmap for green hydrogen and ammonia • Development of an MoU on green hydrogen
 Roadmap		<ul style="list-style-type: none"> • Pilot plant with the aim of installing 10 GW electrolyzer capacity 		

FIGURE 2 European Hydrogen Strategies and Collaboration with Morocco.

Other European states are looking to partner with Morocco. Among them is Spain, an important source of refined products and electricity for the kingdom, which adopted a hydrogen roadmap in October 2020.⁶³ Neighboring Portugal has also signaled a growing interest in the region and aims to develop a partnership with Morocco; the two signed a corresponding declaration in February 2021.⁶⁴ By contrast, France has not shown any interest, which is surprising given its strong foothold in the Mediterranean. The focus of the country's foreign energy policy remains on promoting nuclear power, which is not a main priority for Morocco (Figure 2).

Finally, nonstate actors are promoting a green hydrogen system connecting the two regions. One example is Dii, a consortium of about 40 large multinational and international energy firms aimed at supporting Desertec and its transmission of solar power from the Sahara to Europe. In 2020, the MENA Hydrogen Alliance was established as part of the rise of "Desertec 3.0," which aims to convert renewable electricity into hydrogen for export.⁶⁵

Supply Patterns in EU-Morocco Energy Relations

One aspect of the supply pattern is the potential of renewables and the geographic proximity of Morocco to the EU. The kingdom has an enormous solar and wind potential that remains largely

⁶³ Maroc, "Morocco, Spain Discuss Means to Strengthen Partnership in Energy Sector," 2020, <https://www.maroc.ma/en/news/morocco-spain-discuss-means-strengthen-partnership-energy-sector>.

⁶⁴ MEM, "Maroc/Portugal: Déclaration de Coopération sur l'Hydrogène Vert," 2021, <https://www.mem.gov.ma/Pages/actualite.aspx?act=234>.

⁶⁵ Dii Energy, "Our Mission: No Emissions," 2021, <https://dii-desertenergy.org/>.

unexploited due to a lack of storage capacity.⁶⁶ Using surplus electricity produced from renewables for water electrolysis could unlock this potential and transform Morocco into a green-hydrogen supplier. Pilot projects include an electrolyzer with a capacity of 20 kilowatts, photovoltaic solar panels developed by Morocco's Research Institute for Solar Energy and New Energies, and a project between phosphates producer OCP and Shell to assess the feasibility of large-scale production.⁶⁷ Moreover, lower production and generation costs may foster economies of scale, and Morocco's proximity to Europe will allow some of this green electricity to be exported.⁶⁸ An additional competitive edge is Morocco's infrastructure. In the long term, it should be cheaper to produce green hydrogen in Morocco and export it to the EU than to produce it on the continent. The International Renewable Energy Agency reported that Morocco is expected to have the third lowest green-hydrogen production cost in 2050, ranging between \$0.70 and \$1.40 per kilogram. The kingdom ranked third behind China and Chile, placing it ahead of well-established players like Australia, Mexico, India, and the United States.⁶⁹

Low-cost transportation is an important factor for the successful establishment of the value chain. Hydrogen has a high mass and low energy density. It must be compressed or liquified to be transported by modes such as pipelines, ships, or trains. Morocco enjoys competitive advantages in transport. Green hydrogen can be shipped from the Nador West Med Port or sent through already-existing channels like the Maghreb-Europe Gas Pipeline that connects Algeria to Spain and Portugal via the kingdom. Given the tensions between Morocco and Algeria over the Sahara conflict, future connections include the planned 5,700 km Morocco-Nigeria Gas Pipeline, which will transit 12 African countries. It is currently in its development phase and will continue the already existing West African Gas Pipeline.⁷⁰

A second key aspect is that supply patterns can leverage the financial potential of the EU and technological synergies between the two partners. While Morocco boasts the ideal geographical conditions for hydrogen production and export, European countries have the investment capacities necessary to spur green-hydrogen production—which is still two to three times more expensive than producing blue hydrogen.⁷¹ While economic and political costs could substantially decrease if Russia's war in Ukraine accelerates the energy transition, the EU and its member states may also perceive an interest in the development of cost-reducing technologies in the Moroccan energy sector. Although the kingdom is politically, economically, and financially stable and generally considered very business friendly, international-development financing has played an important role in the introduction of green energy in Morocco in recent years. The top European

⁶⁶ Daum, "(In)consistency"; Bauke Baumann, "Green Hydrogen from Morocco – No Magic Bullet for Europe's Climate Neutrality," Heinrich Böll Stiftung, February 9, 2022, <https://eu.boell.org/en/2021/02/09/green-hydrogen-morocco-no-magic-bullet-europes-climate-neutrality>.

⁶⁷ Hafid Boutaleb, "Morocco to Ramp Up Green Hydrogen Production," *Al-Monitor*, May 23, 2022, <https://www.al-monitor.com/originals/2022/05/morocco-ramp-green-hydrogen-production>; "Morocco Establishes Its First Green Hydrogen Production System," *Morocco World News*, 2022, <https://www.moroccoworldnews.com/2022/09/351348/morocco-establishes-its-first-green-hydrogen-production-system>.

⁶⁸ Daum, "(In)consistency."

⁶⁹ Morocco World News, "Morocco to Provide World's Third Cheapest Green Hydrogen in 2050," 2022, <https://www.moroccoworldnews.com/2022/06/349444/morocco-to-provide-worlds-third-cheapest-green-hydrogen-in-2050>.

⁷⁰ Daum, "(In)consistency."

⁷¹ International Renewable Energy Agency, "Making Green Hydrogen a Cost-Competitive Climate Solution," 2020, <https://www.irena.org/newsroom/pressreleases/2020/Dec/Making-Green-Hydrogen-a-Cost-Competitive-Climate-Solution>.

clean energy lenders are the German Kreditanstalt für Wiederaufbau and the European Investment Bank. The fact that Morocco hosts a mature financial market that facilitates intermediation between international lenders and local banks certainly helps.⁷²

In addition to their financial strength, the European partners also have the necessary technical expertise and strive to promote industrial leadership by pursuing appropriate policies and measures. Knowledge transfer is highly appreciated by the Moroccan side, which has regularly benefited in the past from Germany's experience with the *Energiewende*, notably in solar and hydro technologies. Nevertheless, Germany's objective to export this technology has not always been appreciated in Morocco (such as with the Desertec project).⁷³ Overall, there is a risk of disconnection between the approaches of the EU and the Maghreb region to cooperation. While the latter seeks a more comprehensive form of cooperation, the EU generally wants a purely economic or market-driven approach.⁷⁴

In sum, we can identify several demands in the EU-Morocco energy relationship with regard to hydrogen. The kingdom aims to reduce its dependence on fossil imports and wants to become a major green-energy hub, specifically of hydrogen, for trade and for domestic use. The EU seeks to upscale a hydrogen market and partner with exporting countries. Moreover, EU member states desire hydrogen partnerships and are developing such relations. Through Morocco's infrastructure advantages, geography, and lower costs of production, plus the EU's technical and financial support, supply patterns can meet the demand patterns.

CONCLUSION

This article set out to trace interdependencies and patterns of demand and supply in the energy relationship between Morocco and the EU. With the looming threat of climate change, increasing demands for green-energy solutions, and the need to diversify energy imports, the EU has placed its bet on Morocco as a key partner, especially in hydrogen production.

Against the backdrop of increasing interdependencies in the EU-Morocco hydrogen relationship and patterns of demand and supply, current trends point to a high potential for energy cooperation. As our analysis has shown, the complex interdependencies in the still-evolving relationship indicate that potential demands can be met by supplies. However, we also observe challenges, including these four:

First, the partnership must enable a regulatory environment to transfer investment and technology. Morocco is well positioned for this, as the development of renewable-energy sources is managed by the state. The royal family and its advisers exercise by far the biggest influence, with the king "the supreme institutional power" and the ultimate agenda setter. Further, Morocco has a very strong regulatory framework, with its key focus on security of supply, accessibility of energy, and environmental preservation, as well as regional integration. Regarding the development of renewable-energy projects (solar, wind, geothermal, and biomass), the kingdom has established a legal framework for both investors and developers. However, Morocco remains relatively closed

⁷² Antoine Vagneur-Jones, "2030 Morocco Roadmap: Multiplying the Transition: Market-based Solutions for Catalyzing Clean Energy Investment in Emerging Economies," Climate Investment Funds, October 2021, https://www.climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/bnef-cif_fi_project_2030_roadmap_slide_deck_morocco.pdf.

⁷³ Bundesministerium für Wirtschaft und Klimaschutz, "Hydrogen Strategy."

⁷⁴ Daum, "(In)consistency."

to private actors, at least when it comes to electricity investments, though there has been progress in recent years.⁷⁵ In view of the massive renewables capacities required to move forward with the country's hydrogen plans, a greater liberalization of the electricity market and integration of small-scale renewable energy systems into the grid may be beneficial. This opposes the interests of the state-owned Office National de l'Electricité et de l'Eau Potable, which owns a large portfolio of assets based on fossil fuels.⁷⁶

Second, market readiness is a major challenge. The global hydrogen market is still in its infancy and, like any relatively immature technology, carries a risk profile that can affect investments. Although market development might be accelerated in response to the war in Ukraine, clean power is critical to green hydrogen production—extra volumes of renewables are required. Water scarcity is another concern. Morocco ranks 22nd in the World Resources Institute's (WRI) National Water Stress Ranking, meaning the country is naturally short of this resource needed for hydrogen production.⁷⁷ One answer is the improvement of waste-water management. Another is the desalination of seawater. However, for the hydrogen to be considered green, such plants would have to be powered by clean electricity, meaning even more power will have to be generated from renewables. Alternative energy sources, such as iron, would need to be developed. Although hydrogen is also needed to store energy in iron, it remains in the cycle and thus in the country. Another risk factor is that the electrolysis system itself is not very efficient, as a lot of the energy of the input electricity is lost, and costs for water electrolyzers are still very high.⁷⁸

Third, with hydrogen booming worldwide, Morocco may have to compete with other hotspots for market shares going forward. Apart from North Africa, potential sites are South America and other parts of the Middle East. Significantly more important, Europe may have to compete with other interested hydrogen importers and technology exporters such as the United States or Asian countries like China, Japan, and Korea.

Finally, a lack of mutual understanding or political inequality can lead to distrust and undermine large-scale projects. In the past, accusations of imbalances or resource grabbing have led to project bottlenecks.⁷⁹ The most important potential conflicts are territorial disputes and the Sahara question. For example, Morocco and Spain have regular sovereignty disputes over the enclaves of Ceuta and Melilla, as well as over maritime borders. But the Sahara question is *the* decisive foreign-policy shaper; its resolution has been one of the king's highest priorities.⁸⁰ While some progress has been made, the dispute is still largely frozen since the parties have never really altered their positions. Insecurity over the status of the Sahara may negatively affect both diplomatic and business relations.⁸¹

Still, this represents a huge cooperation opportunity for Morocco, as well as for the EU, which has put hydrogen at the center of its fight against climate change. This has already led Europe into

⁷⁵ *Maroc*, "Morocco, Spain Discuss."

⁷⁶ Baumann, "Green hydrogen."

⁷⁷ Baumann, "Green Hydrogen"; World Resources Institute, "17 Countries, Home to One-Quarter of the World's Population, Face Extremely High Water Stress," 2019, <https://www.wri.org/insights/17-countries-home-one-quarter-worlds-population-face-extremely-high-water-stress>.

⁷⁸ International Renewable Energy Agency "Making Green Hydrogen."

⁷⁹ Daum, "(In)consistency."

⁸⁰ Irene Fernandez-Molina, "Morocco and the Middle East under Mohammed VI," Discussion Paper, HH Sheikh Nasser Al-Sabah Programme, Durham University, 2014; Irene Fernandez-Molina, *Moroccan Foreign Policy under Mohammed VI, 1999-2014* (London: Routledge, 2015).

⁸¹ Yahia H. Zoubir, "Stalemate in Western Sahara: Ending International Legality," *Middle East Policy* 14, no. 4 (2007): 158-77.

closer partnerships with countries like Namibia, Israel, and Oman. Hydrogen has the potential to help tackle climate change and create new revenue streams while enhancing energy security. Indeed, a closer EU-Morocco partnership would not only accelerate the energy transition but also create new markets. The kingdom, with its advantages in infrastructure and geography, is well placed to send hydrogen to Europe.

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