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# RIFS STUDY

Research Institute for Sustainability (RIFS)

# The Politics of Green Hydrogen Cooperation

Emerging Dynamics in Morocco, Algeria  
and Mauritania

Potsdam, December 2023

Silvia Weko, Andrew Farrand,  
Dina Fakoussa, Rainer Quitzow



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# Executive Summary

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Europe's growing interest in securing green hydrogen from North Africa is part of a strategic effort to enhance its energy security. The promise of green hydrogen projects in Morocco, Algeria, and Mauritania is substantial, offering economic growth and job opportunities. However, numerous factors limit these countries' ability to develop robust local green hydrogen sectors, while political disputes—particularly around Western Sahara—complicate regional collaboration. European actors can play an important role in advancing green hydrogen's development in the region, but must tread carefully to secure local buy-in and avoid exacerbating tensions within or between these countries.

## Challenges for North African exporters

Potential North African exporters face challenges including securing buyers, establishing export infrastructure, and ensuring local acceptance. All three countries lack certainty about European demand, including agreements with offtakers which are needed to enable investment. This problem is most acute in Mauritania, where hydrogen will likely be developed primarily as an export in the short to medium term. Alongside ambitions to export green hydrogen, Morocco's is proceeding with plans to use green ammonia in fertilizer production, given its strong potential for local hydrogen offtake. Algeria, which has long relied on fossil fuel exports, has traced a less ambitious timeline. It is considering the development of green hydrogen exports to Europe and is exploring its use to decarbonize existing export products like fertilizers, cement, and steel. When it comes to infrastructure, Algeria and to a lesser extent Morocco could benefit from existing pipelines and short distances to the European market. However, if Morocco's gas demand triples by 2040 as projected, gas imports could preclude the use of existing infrastructure for hydrogen exports. Mauritania has no pipelines that can be repurposed and proposed offshore pipelines come with geopolitical risks. Shipping infrastructure is therefore more attractive for Mauritania but would require significant investments in both ports and basic infrastructure like roads.

All three countries are water-scarce (and becoming more so) and will therefore likely need to use either desalinated water or treated wastewater to avoid exacerbating water stress and social conflicts around water. However, desalination risks adversely impacting marine ecosystems, which are crucial for coastal livelihoods and economies, especially in Mauritania. Moreover, to ensure the long-term success of hydrogen development in the region, local communities must see tangible benefits. Previous experiences with large-scale projects, like Morocco's Noor CSP plant, have yielded only mixed results in this regard.

## Regional politics inhibit cooperation

Cooperation on hydrogen between Algeria, Mauritania, and Morocco is minimal due to regional tensions fuelled by historical rivalry between Morocco and Algeria, which is exacerbated by the conflict over the Western Sahara region. The rivalry is extending into green hydrogen, with both Morocco and Algeria aspiring to be regional hydrogen leaders and viewing the other as a competitor. Morocco is assertive in its leadership ambitions, maintaining a significant partnership with the International Renewable Energy Agency (IRENA) and spearheading the launch of the African Green Hydrogen Alliance. Algeria remains more isolated, emphasizing its sovereignty and selectively engaging on hydrogen as a potential new source of export revenues. Mauritania, neutral in regional politics, maintains a careful balance between Morocco and Algeria. It also does not engage substantively on hydrogen with its southern neighbours who have embarked on collaboration within the context of ECOWAS. For Mauritania, exports to Europe via pipeline are challenging due to territorial questions related to the Western Sahara conflict. Shipped exports would allow it to avoid these issues, making this more likely in the current geopolitical context.

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### The importance of European partners

Morocco, Algeria, and Mauritania exhibit distinct approaches to international partnership, shaped by their resources, geopolitical relations, and national identities. Algeria's cautious strategy keeps hydrogen projects primarily under the control of state-owned enterprises (SOEs), limiting international engagement to safeguard sovereignty. Any partners engaging with Algeria will do so through its SOEs. However, its interest in European import prospects has driven engagement with international partners on hydrogen, including bilateral cooperation with Germany, Italy, and China. Mauritania is engaging actively with G7 allies and development banks on energy and hydrogen policy. This reflects both its need for technical and financial assistance and its strategic importance for G7 countries who are keen to maintain Mauritania's status of an "island of stability" in the increasingly insecure Sahel region. Morocco has the highest level of international engagement from all three countries, but the Moroccan government is also increasingly asserting itself as a player in its own right. It is developing its new hydrogen policy ("Offre Maroc") with minimal international influence, befitting its growing self-confidence as a regional leader and concern about over-dependence on foreign investment and debts.

Germany emerges as an important partner across all three countries, with different engagement depending on national contexts. In both Morocco and Algeria, its longstanding energy cooperation has provided a starting point for further cooperation. In Morocco, Germany has been influential in the development of the national hydrogen roadmap and is funding a first electrolysis project. Germany has been instrumental in Algeria by providing studies on Algeria's hydrogen export potential and has shown interest in funding electrolysis as well. In Mauritania, Germany funds the G7 CONNEX Initiative, which is implemented by GIZ and supports the Mauritanian government in its negotiations with hydrogen developers. The EU is also an important partner in all three countries, engaging at the political level and for dialogue on hydrogen standards. Meanwhile the EIB has increased its engagement and is exploring possible financing of the sector. In June 2022, the EIB and Mauritanian President Ghazouani signed a joint declaration with the intent to cooperate on renewable energy and green hydrogen as part of the EU's Global Gateway project.

Overall, international development banks are most involved in Mauritania and least in Algeria, which is wary of accepting external financing. European hydrocarbon firms are important partners in Algeria. In Morocco and Mauritania, both hydrocarbon players and renewable energy developers are forming consortia for hydrogen projects. However, in Mauritania this is largely international firms while in Morocco there are more local developers and offtakers.

### Geopolitical considerations

Hydrogen trade between Europe and North Africa will impact and be impacted by geopolitical issues, in particular the Western Sahara question. Although European countries and the EU do not plan on devoting public funding to hydrogen projects in Western Sahara, the Moroccan government has provided large tracts of land for hydrogen developers in the Western Sahara and is enabling private hydrogen developments in this territory. In addition, projects like the Hydeal consortium's proposed green hydrogen pipeline, which would bypass Western Sahara, could still provoke controversy or upset the delicate balance Mauritania aims to strike between Algeria and Morocco. Shipped hydrogen would sidestep this controversy and help Mauritania avoid further increasing its economic reliance on Morocco.

European support for hydrogen may also impact the political balance in North Africa and beyond, as Algeria and Morocco vie for influence on the continent. Morocco aims to position itself as a gateway to Africa, while Algeria is an important security player. Supporting countries in their efforts to become hydrogen leaders can lend them further regional stature and influence and therefore indirectly affect regional politics. If international companies are involved in hydrogen projects in Western Sahara or purchase hydrogen from the region, this would likely be perceived as granting additional legitimacy to Morocco's claim to the territory. This in turn would raise tensions with Algeria.

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In addition, projects in Morocco and Algeria hinge on partnership with governments and major SOEs, making them highly vulnerable to local political dynamics. Situations where political leaders' interests diverge substantially from local communities' have considerable potential to jeopardize projects. Projects will require large tracts of land in regions where the population is often marginalized and the government may not directly redistribute revenues from land sales or energy production to locals, generating the potential for popular backlash against the state and its international partners. Sensitivity to such arrangements is heightened by the legacy of European colonialism in the region, including a history of resource extraction in collaboration with local elites, to the detriment of local populations.

Another concern is the comparative weakness of the local environmental ministries, which may not be empowered to sufficiently assess or address projects' environmental impacts. As regulatory scrutiny of companies' international supply chains is increasing through German and EU legislation on due diligence, these factors could pose additional risks to European partners active in North Africa. As this regulatory scrutiny will extend to SOEs like Sonatrach or OCP, there is also the potential for political friction between Europe and partner countries if this appears critical of government.

### **The potential for further cooperation**

Navigating these geopolitical questions will be complicated, but there are also complementarities between the goals of potential exporters and European importers, which could offer mutual benefits and strengthened relations. Algeria's interest in hydrogen exports and selling decarbonized products to the EU has enabled close exchange with Germany and an increased openness to foreign investment with promise for further cooperation. Morocco's ambitions for green technology and local development may complement European hopes to diversify critical manufacturing of clean energy components and develop support for its climate and energy agenda in the region. Mauritania's hopes for green hydrogen to deliver economic development as well as crucial energy and water infrastructure could strengthen local stability in a region in turmoil. European efforts to facilitate hydrogen developments could counterbalance Russian and Chinese engagement in the region. A key to success will be to develop approaches that deliver tangible economic benefits and domestic jobs. To do so, European governments should support private investments while ensuring sustainable models of infrastructure development that avoid negative impacts on local populations.

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Federal Foreign Office

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# 1 Introduction

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Low-carbon hydrogen has received increasing attention in recent years as countries around the world seek new means to produce, transport, and store energy without contributing to climate change. Currently, some 100 million tons of “gray” or “black” hydrogen (from fossil fuels) is used globally each year as a feedstock for certain industrial processes, as an input to make ammonia and methanol, and as fuel for industrial processes such as metals processing or glassmaking. Low-carbon hydrogen offers the possibility of decarbonizing these sectors with limited disruption or efficiency loss. It has also been proposed as a fuel, though widespread use in powering road transport, heating, and many other areas look increasingly unlikely to be unable to compete with electric alternatives in terms of cost and emissions-intensity (Plötz, 2022). Low-carbon hydrogen may also be considered as a vector for energy transport or storage, though here too, efficiency challenges may limit its adoption to particular use cases.

While debate continues around its utility as a fuel and energy store, today there is already a strong case for replacing “gray” hydrogen with “green” hydrogen (made with renewable energy and electrolysis) or “blue” hydrogen (made from natural gas with carbon capture and storage (CCS)). The EU and its member states plan to import large amounts of low-carbon hydrogen for both decarbonization and energy security purposes, sparking a wave of interest from Europe’s neighbors in hydrogen exports. Within Europe, the focus for the long-term is on green hydrogen over blue for two key reasons. First, producing low-carbon blue hydrogen requires capturing CO<sub>2</sub>, an expensive process that may not remain cost-competitive with green hydrogen if costs for renewables and electrolysis continue to fall. Second, green hydrogen can allow countries to diversify sources of energy imports, whereas blue hydrogen will follow existing natural gas export flows. International efforts to develop hydrogen value chains have been increasing, driven by the interest of future hydrogen consumers and potential exporters.

Countries with excellent renewable energy potential are beginning to position themselves as future green hydrogen exporters, rapidly developing policy frameworks and projects with international partners. In addition, proximity to hydrogen importers and existing infrastructure, such as ports or gas pipelines is important for competitive advantages.<sup>1</sup> Potential benefits for exporters include new revenue streams, economic diversification, local jobs, and industrial decarbonization.

The most important demand centers for hydrogen imports will be industrialized countries with relatively scarce renewable energy resources, such as Europe, Japan, and South Korea. This has raised political questions about future dependencies on hydrogen imports echoing patterns in the oil and gas sectors. While Europe has focused on developing a diversified set of green hydrogen suppliers, it has placed a special emphasis on North Africa due to its proximity and its renewable energy resources. Europe has previously attempted large-scale projects to export renewable electricity from North Africa, such as the German-led DESERTEC initiative which promoted the export of Concentrated Solar Power (CSP) from the Sahara to Europe via undersea electricity cables. While this project did not succeed, hydrogen has reignited interest in European-North African collaboration on renewable energy.

<sup>1</sup> Ammonia can be used for different applications including shipping fuel, fertilizer, and long-term storage. Methanol has fewer applications and requires a carbon feedstock, i.e. from carbon capture or from Direct Air Capture (DAC); however, DAC has not yet been tested in different climatic conditions such as desert climates (IEA, 2023).

This report provides an overview of hydrogen developments in Morocco, Algeria, and Mauritania, providing both a country-level and a regional perspective on the topic. These three countries have high renewable energy potential and have begun substantive collaboration with external partners on hydrogen, unlike other countries in the Maghreb region. (Tunisia's potential is comparatively small and Libya's status as a post-conflict state precludes much progress there at this time.) This report focuses particular attention on the role of international actors in promoting hydrogen developments in Morocco, Algeria, and Mauritania as well as the relationships between these countries. We explore how international efforts to shape hydrogen supply chains are taking shape on the ground and how this is affected by both national and regional politics.

There are geopolitical aspects that make this region at once very important for international partners, and complex to navigate. Morocco and Algeria have tight trade linkages with Europe, and Algeria is an important oil and gas supplier for Europe. Mauritania is often seen as an "island of stability" in the Sahel, cooperating closely with the EU and the G7 on questions of security and migration. In Africa as a whole, Europe also aims to counter the growing influence of Russia and China. However, relations with North Africa are complicated by political tensions between Algeria and Morocco. Algeria opposes Moroccan efforts to advance its claim to Western Sahara, and both countries are seeking to expand their influence in Africa. Mauritania aims to take a neutral stance but is highly dependent on Morocco as its economic lifeline. In the past, relations between Morocco and other countries have quickly deteriorated if they question Morocco's Western Sahara stance, including important partners such as Germany. Likewise, Algeria has retaliated against European countries like Spain for endorsing Morocco's control of the disputed territory.

The next section lays out the regional and international political dynamics that could come to affect North Africa's hydrogen plans and cooperation. Sections 3, 4, and 5 are in-depth case studies of hydrogen developments and the role of international actors in Morocco, Algeria, and Mauritania. Section 6 presents regional hydrogen dynamics including cross-cutting challenges and international engagement and summarizes the findings and key takeaways for international partners.

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## 2 Energy and Regional Politics

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Current relations between Morocco, Algeria, and Mauritania are shaped by the tensions over Western Sahara. The disputed territory is geopolitically relevant because of the access it provides Morocco to Mauritania and Western Africa (Werenfels, 2020), and its rich natural resources, including fish, phosphate rock, and renewable energy.<sup>2</sup> It is also symbolically important for Morocco as it is perceived as an integral part of Morocco's historical territory. The Kingdom's ability to maintain and legitimize its control over the territory is seen as a manifestation of its autonomy and power status. Algeria, which has long positioned itself as a leader and supporter of anti-colonial movements, opposes Morocco's presence in Western Sahara and supports Polisario, which the United Nations recognizes as the representation of the local Saharawi people.<sup>3</sup> Western Sahara's status has been disputed since Polisario's 1970s war against Morocco and Mauritania, in which both aimed to control the territory. While Mauritania withdrew from the territory it held in 1979, Morocco has maintained its claim to the entire Western Saharan territory and remains in conflict with Polisario. A 1991 ceasefire resulted in the division of the territory and UN monitoring, but Polisario withdrew from the ceasefire in 2020 (Reuters, 2020). The conflict has worsened tensions between Morocco and Algeria. In 2021, Algeria severed diplomatic ties and refused to renew an agreement to continue supplying Morocco with gas via the Maghreb-Europe pipeline (Rashad et al., 2021). Mauritania remains neutral in the conflict and receptive to cooperation with both countries.

North Africa is also affected by increasing conflict and instability in Libya and the Sahel region, which regularly threatens to spill over into Morocco, Algeria, and Mauritania. Driven by extreme poverty, land degradation and the rise of Islamist terrorist groups, the Sahel has seen conflicts in Mali and Niger, leading to migration to neighboring countries and Europe. The Sahel is geopolitically important for the EU and US because of migration and broader security concerns. G5 countries have long supported anti-terrorism actions and development efforts (Bleuse & Conkar, 2020). The EU and US also have business interests related to mineral extraction including uranium, oil and gas, gold, and iron (Cooper, 2018). The US and European countries are particularly concerned about Russian and Chinese involvement in the region, including the activities of the Russian Wagner Group in Mali (Gain, 2021). Morocco and Algeria also have an interest in intervening in the Sahel, as both countries aim to exert regional power. Algeria sees itself as a counterweight to France, while cooperating with the US as a mediator (Bobin, 2023).

More broadly, both Morocco and Algeria are interested in expanding cooperation with the rest of Africa beyond the Sahel using diplomacy and trade (Soler i Lecha, 2020). Morocco is pursuing religious and trade relations with West Africa, including energy trade via the proposed Nigeria-Morocco Gas Pipeline. Many of its exports must pass through Western Sahara and Mauritania to reach further markets such as Senegal. Morocco also seeks to become a "geopolitical gatekeeper" in manufacturing value chains in the West Africa-to-Europe corridor (Tanchum, 2020). Its state-owned enterprise,

<sup>2</sup> Around 2% of Morocco and Western Sahara's total reserves are at Bou Craa in Western Sahara (National Minerals Information Center, 2021). In 2016, around 25% of OCP's phosphate rock exports were from Western Sahara (Nedelciu et al., 2020), and phosphate rock made up 22% of OCP's total revenue (OCP Group, 2016).

<sup>3</sup> Polisario (the Frente Popular de Liberación de Saguía el Hamra y Río de Oro) has opposed Spanish, Mauritanian and Moroccan claims to the Western Sahara and proclaimed the Saharawi Arab Democratic Republic (SADR) with a government in exile in Algeria in the 1970s. See (MINURSO, 2016).

fertilizer giant OCP group, play a major role here as well (U.S. Department of State, 2023). Some of Morocco's overtures have been stymied by regional politics, as it withdrew from the African Union in 1984 after Western Sahara was accepted, only rejoining in 2017 (BBC News, 2017). Morocco's application to join the Economic Community of West African States (ECOWAS) also stalled due to economic and geopolitical concerns. Member countries feared that its entry would flood markets with cheaper Moroccan goods and upset the balance of power within the bloc, which is historically divided between French and English-speaking countries.<sup>4</sup> Algeria has been seen as an important regional partner for Sahel countries, due to its military and intelligence forces, its anti-imperialist stance, and its borders with Mali and Niger. Mauritania cooperates with its neighboring African countries on priority issues including energy, but its commitment to "Arabization" and related repression of French-speaking and other non-Arab groups makes closer cooperation unlikely.

North African countries are also strengthening energy ties with Asia, particularly China. Morocco joined China's Belt and Road Initiative (BRI) in 2017, and Algeria and Mauritania joined in 2018 (Nedophil, 2022; Green FDC, 2021; Wang, 2023). Chinese developers are present in Morocco's clean energy sector (Anouar, 2022), and Algeria and Morocco have received BRI investments in gas (Wang, 2023) and hydropower (Reuters, 2019). China is less active in energy in Mauritania but has been involved in major construction projects like roads and ports and is seen as an important partner for economic development. Japanese investors have backed renewables projects in Morocco and hydrocarbon projects in Algeria, and the Japan International Cooperation Agency (JICA) is active in all three countries.

Algeria has a historically strong relationship with Russia, owing to the Soviet Union's support of Algeria's independence struggle and Algeria's subsequent association with the Non-Aligned Movement. Algeria's anti-colonial position is an important driver of its support for the cause of Palestine and Polisario in Western Sahara (Ghettas, 2017). Some suggest that its historic ties and military resources could enable it to mitigate Sahelian conflicts (Camara, 2022), but others have raised concerns that it could join with Russia in destabilizing the region (Gain, 2021). Algeria's relationship with Russia has continued since the Russian invasion of Ukraine, even as trade with Europe has increased (Ghebouli, 2023). In parallel the US is deepening military cooperation with Morocco (Pecquet, 2023) and recognized Morocco's sovereignty over the Western Sahara in exchange for Morocco resuming diplomatic relations with Israel (Holland, 2020). Mauritania's proximity to the Sahel and strategic location for naval bases make it a new realm of geopolitical competition between the US and Russia (Fernandez, 2023; Pons, 2022). Recent high-level visits to Russia have been well-publicized, but experts on Mauritanian politics have identified resentment of the Wagner Group's role in Mali and an interest to maintain close relations with NATO and Europe (Expert Interviews Mauritania Policy 12, 13).

In all three countries, cooperation with Europe has fluctuated in recent decades. For Algeria and Morocco, European countries are the most important trading partners and buyers of energy, fertilizers, food, raw materials, and textiles (see Figure 1). Germany and German companies are strongly involved in the Moroccan economy, with €1.3 billion invested in 2020 (Kourrad, 2022). For Mauritania, China plays a larger role, representing the country's top export destination (over 42% of total trade, mainly in raw materials and fish), followed by European countries. Since the Russian invasion of Ukraine, Europe's interest in Algerian natural gas to cover its demand has increased (Al Jazeera, 2022). European countries have also been highly involved in the Moroccan energy transition, with the long-standing idea that Northern African countries could represent important sources of renewable energy via electricity and more recently hydrogen exports.

<sup>4</sup> Nigeria especially sees Morocco as a colonizing country due to Western Sahara, and countries have economic concerns about Moroccan products flooding markets, thereby damaging local manufacturing (Jebri, 2023).



Fund for Social and Economic Development (AFSED) and the UAE's Abu Dhabi Fund for Development funding development and energy projects in the region, including Mauritania (Gulf Today, 2023; Arab Fund, 2023). Turkey is also an important trade partner for Algeria and Morocco. It has put a particular strategic importance on Turkish-Algerian cooperation in recent years (Akpınar, et al., 2022), but has also been accused of stoking anti-French sentiment (France24, 2020).

These sensitive political issues and the broader threat of regional instability both complicate cooperation with these North African countries and raise the geopolitical stakes for Europe. They serve as a backdrop for the emerging hydrogen developments outlined in the remainder of the report.

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## 3 Morocco: A "Hydro-monarchy" in the making?

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Morocco has great ambitions to become a key hydrogen player, and numerous international actors have a keen interest to jointly develop projects in an expected lucrative business. The main drivers for the kingdom are the decarbonization of its large fertilizer industry, reducing the sector's dependence on imports and to position the country as a "hydromonarchy" with substantial exporting power. (Expert Interview Policy 2; Bayo, 2023). The government has launched policy initiatives and promoted international knowledge exchange and skill development to serve this cause, helping a number of promising projects, partnerships, and MOUs with countries around the world to take shape. But there are numerous challenges to overcome including developing policy and regulatory frameworks, financing major projects, and ensuring social acceptance given Morocco's existing water stress.

### 3.1 National politics and governance of energy and relevant key sectors

#### 3.1.1 Fossil fuels

Morocco is still heavily dependent on hydrocarbon imports, which account for 90% of its energy needs. The lion's share of imported fossil fuels is taken by refined oil, followed by coal and then gas (Kingdom of Morocco, 2021a). Morocco's electricity production in 2021 came mainly from coal (68.1 %), natural gas (10.3 %), wind (12.8 %), and solar (4.4 %) (Bennouna, 2022). The transport sector remains the largest energy consumer in Morocco, standing at 38 % of total consumption.

Morocco's gas demand is projected to triple by 2040 (Battersby, 2022). Covering this growing demand will be challenging, given Algeria's decision in 2021 to cut off the supply of natural gas via the Maghreb-Europe gas pipeline (GME). To diversify its energy generation mix, Morocco is relying on increased use of liquefied natural gas. In May 2021, the Moroccan Office of Hydrocarbons and Mines (ONHYM) launched a call for expression of interest for the development and operation of the country's first LNG terminal with a floating storage and regasification unit (Mulyungi, 2022), and there are plans for an LNG terminal with regasification at the Mohammedia Port (Sylla, 2023). In addition, Morocco has begun importing gas from Spain through the GME pipeline (Baratti & Elliott, 2022). In August 2021, the Moroccan Ministry of Energy, Mines, Water, and the Environment also announced a new national roadmap for the development of natural gas up to 2050 and has promoted exploration of oil and gas with a number of international partners, including Eni (Rome), Qatar Petroleum International (Doha), Europa Oil & Gas (London), and Chariot (UK). First projects for off-shore gas extraction are underway, and the National Office of Electricity and Drinking Water (ONEE) has agreed to purchase gas when the projects begin producing (Sound Energy PLC, n.d.).

#### 3.1.2 Renewable energy

Morocco is one of the region's pioneers in the energy transition, which the king has declared as a national priority. High oil prices following the 2008/2009 financial crisis exposed the kingdom's vulnerability in energy terms (Expert Interview Policy 1) and led to the launch of a new National

Energy Strategy in 2009. The strategy aimed at increasing the use of renewable energy, enhancing energy efficiency, decreasing dependence on foreign energy sources, and supporting regional integration.

The initial objective of the kingdom's energy strategy was to ensure 42 % of renewable energy in electricity production in 2020, a goal that proved to be unattainable. A barrier to more rapid development may have been the vested interests of large state and quasi-state entities. ONEE has invested heavily in new coal-fired facilities as recently as 2018, which has led to a significant rise in the share of coal power in the Moroccan energy mix since 2014 (Baumann, 2021). Hence, the share of renewable power, including hydropower, rose only from 6 % in 2000 to 19 % in 2020, achieving less than half the initial ambition. The objective was therefore revised to 52 % by 2030 and to 80 % by 2050, targeting an installed capacity of 10 GW by 2030, with 4.5 GW from solar, 4.1 GW from wind and 1.3 GW from hydropower (U.S. International Trade Administration, 2022b). Regarding the integration of regional energy markets, the kingdom has been developing interconnections with Portugal and Spain and is pursuing an ambitious initiative to create a high-voltage direct current interconnector with the UK.<sup>5</sup> It has also participated in European initiatives for regulatory cooperation around energy such as the Association of Mediterranean Energy Regulators (MedReg). Integration with Mauritania has also been mentioned, though little tangible progress has been made.

Morocco also launched a Solar Plan in 2009 and an Integrated Wind Energy Plan in 2010 (Hteit, 2023). The integration of local firms in wind and solar energy projects was considered decisive to generate employment and ensure social acceptance. Wind and solar farms were created as public-private partnerships, following calls for tenders managed by ONEE and the Moroccan Agency for Sustainable Energy (MASEN). Founded in 2010, MASEN's main task is the piloting and implementation of renewable energy projects in Morocco. Its high-quality performance has nurtured the confidence of foreign lenders and investors. Many international players have developed wind and solar projects, as well as Moroccan firms. Nareva Holding, a Moroccan company belonging to the royal group Al Mada is an important player in the field of clean energy (Iraqi, 2020; Reuters, 2016).

Financing of projects has been largely based on concessional funds provided by international financial institutions (IFI) (Berahab, 2022). Power purchase agreements (PPA) made under PPPs oblige ONEE to buy the electricity produced at an agreed price for a period of 25 to 30 years. MASEN's largest project is the multiphased Noor Solar Complex project, which combines one of the largest concentrated solar power (CSP) plants with large-scale PV installations. Noor was part of the Desertec project and has received funding from a range of development finance institutions including the African Development Bank (AfDB), the French Development Agency, the global Clean Technology Fund, the European Commission, the European Investment Bank, the World Bank, and Germany's Kreditanstalt für Wiederaufbau (KfW) (MASEN, n.d.).

The national infrastructure for research and development as well as technical capacity building related to renewable energy have also been reinforced. For example, in 2011 l'Institut de Recherche en Énergie Solaire et Énergies Nouvelles (IRESEN) was established with support from Germany's Gesellschaft für Internationale Zusammenarbeit (GIZ). Moreover, Training Institutes for Renewable Energies and Energy Efficiency (IFMEREE), one in Oujda in 2015, one in Tanger in 2019/2020, and one in 2020/2021 in Ouarzazate, were created with financial support from the European Union (EU Neighbors South, 2020). IRESEN and l'Université Mohamed VI Polytechnique (UM6P) have also joined forces to launch the Green Energy Park, a platform for research and development offering laboratories and several test and pilot platforms. The platform's activities are realized by partnering with various foreign universities and research centers and funds from actors such as the Korea International Cooperation Agency, the Fraunhofer Center for Silicon Photovoltaics, or the German Aerospace Center (Expert Interview Policy 1).

<sup>5</sup> Xlinks Morocco Project; for recent information on land use, see Ministry of Economics and Finance, p.9, 2023.

## 3.2 Hydrogen policies, stakeholders, and projects

### 3.2.1 Policies and strategies

Morocco is considered to be well-positioned to develop its green hydrogen production, given its existing renewable energy track record, its pre-established energy interconnection infrastructure, such as pipelines and ports, as well as its geographical proximity to Europe. Estimates of Morocco's green hydrogen production costs vary. According to MASDAR, Morocco is expected to produce green hydrogen at less than \$2 per kilogram in 2030 and less than \$1 per kilogram in 2050. According to another estimate, Morocco is expected to have the third lowest green hydrogen production cost in 2050, ranging between roughly \$0.7/ kgH<sub>2</sub> and \$1.4/kgH<sub>2</sub> (Blanco & Taibi, 2022). The best potential for hydrogen production is located in the disputed Western Sahara area of Dakhla-Oued Ed-Dahab region (less than \$0.02/kWh) (Marks, 2022).

Morocco started exploring the potential for developing its hydrogen sector in 2018. In 2019, it created the national Green Hydrogen Commission to establish a knowledge base for the development of a strategy. Its members are representatives from the Ministry of Energy, Finance, Transport, Higher Education, Industry as well as ONEE, MASEN, IRESEN, La Confédération Générale des Entreprises du Maroc (CGEM) and the Energy Federation.<sup>6</sup> In 2021, the Ministry of Energy, Mines and Sustainable Development published a green hydrogen roadmap, aimed at meeting local demand, promoting industrial development and economic diversification via exports of hydrogen and hydrogen derivatives (Kingdom of Morocco, 2021a). A publication realized in close cooperation with the German Federal Ministry for Economic Affairs and Climate Action and the GIZ served as an essential groundwork for the road map (Expert Interview Policy 3).

Developing a green ammonia industry is a particular priority. Morocco is one of the world's top importers of ammonia, mainly needed as an input for the production of fertilizers. It imports around 2 million tonnes of grey ammonia per year, mainly from Russia. The national fertilizer company OCP is a large international exporter, as the country has around 50 billion tons of phosphate, a key element for the production of phosphate fertilizers. Becoming self-sufficient in terms of synthetic ammonia would strongly reduce the firms import dependencies and vulnerability to international price shocks. The company is investing significant resources to green its production. In December 2022, OCP Group announced a 13-billion-dollar strategic program for 2023-2027 under the name Green Investment Strategy meant to augment mining and fertilizer production while becoming carbon neutral by 2040. The program equally foresees major investments in new green fertilizers, renewable energy, and water desalination units (OCP Group, 2022). In addition to the fertilizer industry, there is a potential for green hydrogen usage in the refinery industry, in the transportation sector, or as a storage and flexibility solution mitigating the intermittency of renewable power (Alnawafah et al., 2023). That said and according to expert circles, the fertilizer industry is expected to be the main if not sole beneficiary and consumer of nationally produced green ammonia (Expert Interview Policy 1).

In order to successfully create an industry around green hydrogen, the strategy emphasizes that international partnerships and investments are essential to secure sufficient financing. The roadmap outlines that the development of the green hydrogen industry in Morocco would require an investment of around 140 billion dirhams (€13 billion) to 1,000 billion dirhams (€95 billion) between 2020 and 2050 to meet potential demand by 2050. The strategy also includes the strengthening of research and development (R&D) through the establishment of a Moroccan R&D hub that would push forward pilot projects elevating the country to a center of knowledge and excellence in new technologies.

<sup>6</sup> The energy federation includes energy industry actors active in Morocco such as Masdar, John Cockerill, Enel, Engie, EDF Renewables, Chariot, ACWA Power, Huwai, Total, Siemens Gamesa, Shell, Petrom and more (Energy Federation, n.d.).

Skill development is considered key in these endeavors. Yet, the published roadmap has remained vague on important aspects. It makes no clear statement on policies and regulations to promote the domestic hydrogen market.

In November 2022, it was announced that the king had requested the development of a comprehensive Moroccan hydrogen strategy which would set out the regulatory framework (named the “Offre Maroc”) (Bayo, 2023). However, the Offre Maroc was not unveiled as of October 2023 and the government appears undecided whether the document will be a comprehensive strategy or whether it should be a rough orientation to be developed in subsequent documents (Expert Interview Policy 3). No external foreign actors such as consultancy firms or development agencies are involved in the formulation, and only a dozen or fewer persons are part of this highly exclusive and secretive circle working on the document. The king’s focus on developing this policy autonomously may also be also ideological. Experts highlighted that Morocco aims to project its status as a rising regional and global power, framing its handling of the pandemic and Western Sahara issue as a manifestation of its sovereignty and regional status.

Hence the official rationale is that the kingdom is capable of developing such a policy autonomously (Expert Interviews Policy 1, Policy 3). Some experts instead expect the working group to draft a skeleton document that will be completed through consultations with donors, development agencies, technical actors and other international institutions.

### 3.2.2 Major green hydrogen projects and activities

Announcements of projects, partnerships, and MOUs with countries worldwide have flourished (see Table 1). The first large-scale green hydrogen and ammonia project is being developed by MASEN, just north of the disputed region of Western Sahara. The German KfW has committed to fund this joint project with up to €300 million in loans and grants (Expert Communication, 2023). The synthetic ammonia that will be produced will be purchased by MASEN and sold to the fertilizer giant OCP. OCP is also collaborating with Shell and with Chariot Energy on pilot projects for green ammonia (Université Mohammed VI Polytechnique, 2022). Further major projects which target exports to Europe are under discussion by Total Energies (Biogradlija, 2023b), Fusion Fuel with Consolidated Contractors (project called HEVO Ammonia), and CWP Global (project called AMUN) (North Africa Post, 2023). For Total Energies, one challenge is agreement on the size of the land to be allocated. The government consents to allocate a site of 170,000 hectares, while the project developers are requesting an area of 187,000 hectares.

Although the “Offre Maroc” has not yet been announced, the government has already begun talks with companies and plans to provide land (The Desk, 2023). In August 2023, 8 projects were shortlisted by the government for support, which are expected to require approximately 1.4 million hectares (Sbiti, 2023b). Of these projects, four (Taqa, Cahamco, Power Sur, and Falcon) will take place in Dakhla-Oued Eddahab, which is fully in the Western Sahara. Projects by OCP, ORNX Boujdour and ORNX Laâyoune are in the region Laâyoune-Sakia El Hamra of which the majority of the land is in the contested Western Sahara area.<sup>7</sup> For example the ORNX project, a consortium of Nordex SE (a German wind turbine manufacturer), Acciona (a Spanish renewable energy developer), and Ortus Climate Mitigation (a US renewable energy developer) has reportedly received permission to conduct feasibility studies in an area near the cities of Laâyoune and Boujdour (Sbiti, 2023c). These cities are located in the Western Sahara, but there is no information about whether the site is within the Western Sahara boundaries. Unlike the projects spearheaded by Total, CWP and Fusion Fuel, there is very little information about these projects, except that they are listed as having

<sup>7</sup> Although sources do not list precise locations of these projects, there are three projects planned in Laayoune-Sakia El Hamra with a total of 345,681 hectares. This is just under half the land that is potentially available above the dividing line between Morocco and Western Sahara (see Annex).

been granted land in the 2024 Moroccan Finance Bill Report on Public Funding (Ministry of Economics and Finance, 2023).

Table 2: Hydrogen Projects announced in Morocco

Name	Project type	Location and land	Size	Actors	Finance	H2 Market	Timeline
MASEN-KfW	green ammonia	Unknown	100MW	MASEN, KfW	€320-350 million	will be purchased by MASEN and sold to OCP	production to begin in 2024 or 2025
AMUN project	green hydrogen	Guelmim-Oued Noun, near Tan Tan	15 GW wind and solar	CWP Global	unknown	Export, fertilizers	Phase 1 & 2 to contain 3GW each of wind/solar, phase 3 in early development
Guelmim-Oued Nour project	green hydrogen and ammonia	Guelmim-Oued Noun, 170,000 ha	10 GW	Total Energies	\$10.6 billion	Fertilizers, ?	production planned 2027 (Takouleu, 2022a)
HEVO Morocco	green hydrogen ammonia	vicinity of Jorf Lasfar, Essaouira or Agadir	600 MW PEM electrolyzer capacity	HEVO, Consolidated Contractors, Fusion Fuel, Vitol	estimated investment value \$850 million	Export to Europe, Vitol secured as offtaker for green ammonia	feasibility study done by 2022, goal to begin production in 2025
Energy China International Construction Group	green ammonia	unknown	6 GW solar and wind, 1.4 million tons ammonia/year	CEEC, Ajlan Bros, Gaia Energy	unknown	Export to Europe	project announced 2022
OCP Group and Chariot	green hydrogen pilot	R&D facility in OCP Jorf Lasfar	1 MW PEM electrolyzer	OCP, Chariot, UM6P, Oort Energy	unknown	Local research	operation of pilot project and technical capacity-building
OCP Group and Shell	green ammonia pilot	Jorf Lasfar industrial area (El Jadida)	unknown	OCP Group, Shell, UM6P	unknown	Local research	pilot project
CIP	Green hydrogen and ammonia	Guelmim-Oued Noun (possibly Western Sahara)	Unknown	Copenhagen Infrastructure Partners and AP	Unknown	Unknown	Land promised by government in 2024 Report on Public Funding

				Moller Capital			
ORNX BOUJ-DOUR + ORNX LAAY-OUNE	Green hydrogen and ammonia	145,331 ha Boujdour, 100,000 ha Laâyoune, Laâyoune -Sakia El Hamra (possibly Western Sahara)	unknown	Consortium includes Nordex SE, Acciona, Ortus climate mitigation	147,000 Mdh = \$14.5 billion	unknown	Land promised by government in 2024 Report on Public Funding; beginning impact assessment studies
OCP	Green hydrogen production	100,350 ha Laâyoune -Sakia El Hamra (possibly Western Sahara)	Unknown	OCP	70,000 Mdh = \$6.9 billion	Likely fertilizer as OCP is developer	Land promised by government in 2024 Report on Public Funding
Taqa Morocco Green	Green hydrogen and ammonia	70,000 ha Dakhla-Oued Eddahab (Western Sahara)	Unknown	Taqa Maroc	96,000 Mdh = \$9.4 billion	Export to Europe, potential local decarbonization	Land promised by government in 2024 Report on Public Funding
Falcon	Green hydrogen	150,446 ha Dakhla-Oued Eddahab (Western Sahara)	Unknown	Falcon	100,000 Mdh = \$9.8 billion	Unknown	Land promised by government in 2024 Report on Public Funding
DAHAMCO SA	Green hydrogen and derivatives production	553,435 ha Dakhla-Oued Eddahab (Western Sahara)	Unknown	Unknown	254 Mdh = \$25 million	Unknown	Land promised by government in 2024 Report on Public Funding
POWER SUR SARL	Green hydrogen production	15,000 ha Dakhla-Oued Eddahab (Western Sahara)	Unknown	Unknown	19,550 Mdh = \$1.9 billion	Unknown	Land promised by government in 2024 Report on Public Funding

Sources: Moroccan Competition Authority, (2023); Sbiti, 2023a; La Vie Eco, 2023; Enterprise Climate, 2023.

Further MOUs and expressions of interests with international developers from China have been announced, but not yet been converted into contracting agreements. In September 2022, Huanghe Company, China Railway Construction International Group Morocco Branch and Moroccan KIMA Holding Co., signed an MOU to establish a strategic partnership to further the development of photovoltaic, wind power, energy storage, green power and other renewable energy projects in the country. Chinese state-owned company China Energy Engineering Corporation Limited (CEEC) has also signed an MoU with the Saudi conglomerate Ajlan Brothers and Morocco's Gaia Energy

(Biogradlija, 2023a). Other major corporations who have signaled interest in green hydrogen projects are ACWA Power in Saudi Arabia and Adani Group of India.

Morocco also aims to increase local value creation by integrating itself into value chains for technology production and innovation. An announcement from Belgian firm John Cockerill to develop electrolyzer manufacturing in Morocco via a joint venture with a Moroccan energy company (John Cockerill, 2023) suggests that this may be in development. In addition, there are several research and development initiatives in cooperation with industry and international partners. For example the Green Hydrogen & Applications Park (also called Green H2A) is a research platform tackling the Power-To-X sector, in particular hydrogen, ammonia, green methanol, and the various synthetic fuels, in addition to desalination and water treatment. The Morocco Hydrogen Cluster aims to coordinate different actors related to the green hydrogen sector and its derivatives inside the country. The Green H2 Morocco Cluster initiated by the Ministry of Energy and Ministry of Industry seeks to support the growth and competitiveness of a green hydrogen sector in Morocco, looking at the development and industry dimension of the green molecule and promoting the transfer of know-how among Moroccan and international counterparts. The Green H2 Morocco Cluster as well as IRESEN, UM6P, and the National Hydrogen Commission will take part in capacity-building activities around the first green hydrogen micro-pilot installed in Benguerir in 2022. International partners also play an important role in R&D developments: for example, the Wuppertal Institute is planning a demonstration unit to illustrate the entire Power-to-Liquid value chain and develop the skills of Moroccan and international scientists and engineers concerning relevant technologies, including the Fischer-Tropsch synthesis (Rilling, n.d.). The PtX Hub in Morocco, which supports the establishment of this Power-to-Liquid pilot plant, is implemented by the GIZ in cooperation with German research bodies Agora Energiewende, DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V. (Rilling, n.d.). While German actors have a very visible hallmark here, collaboration on pilot projects has also emerged between actors such as Morocco's Gaia Energy and the Israeli company H2PRO.

### 3.2.3 Export infrastructure

In order for a green hydrogen sector with export capabilities to be functional, adequate port infrastructure and specialized maritime transport for synthetic liquid fuels are essential. Retrofitted gas pipelines for hydrogen transport between Europe and North Africa are considered the most cost-effective solution. Morocco is well-positioned due to its current port, maritime, and gas infrastructure and their potential for adaptation and upgrade for the storage, transport, and export of green hydrogen and ammonia.

The country has 34 operating ports, of which 13 are open to foreign trade. Among the major ones are Tanger Med Port hub, leading in container shipment, Jorf Lasfar, which is a large phosphate port, and the Port of Casablanca, the country's biggest multipurpose port which accounts for 35 % of domestic port traffic (AFDB, 2019a). Other well-positioned ports are Mohammedia which already has an oil terminal and pipeline network, and Nador West Med, a planned deepwater port in the north which should become operational in 2024. Moroccan ports attain very high scores in international container port performance rankings. The Tanger port took the fourth position in a global ranking carried out by the World Bank in 2022 (World Bank, 2023). Moroccan ports are also very well-connected and hence could serve well as hydrogen hubs (Alnawafah et al., 2023). The ports of Rotterdam and Hamburg for example are among the kingdom's major partner ports, linking it directly to the industrial heart of Europe.

Morocco is already importing ammonia through its port in Jorf Lasfar. Adaptation for export purposes would be feasible. Export of hydrogen is more challenging, given its highly flammable character (Expert Interview Policy 3). Various projects are planned to test transportation possibilities. For instance, CWP Global and German Hydrogenious LOHC Technologies have agreed to jointly carry

out a feasibility study in 2023. The study will explore a 500 tons per day hydrogen transport chain from Morocco to Europe using Hydrogenious' LOHC technology (Sebrantke, 2023). The European Bank for Reconstruction and Development is funding technical cooperation to assess if the port at Nador West can be used for green hydrogen trade (Zawya, 2022).

However, pipelines and port infrastructure are currently predominantly used for imports, and Morocco's priority for the next ten years will be to use this for its incoming gas supply (Expert Interview Policy 3). The GME is currently being used for imports from Spain but is envisioned by the European Hydrogen Backbone to be repurposed by 2040.<sup>8</sup> While Morocco aims to construct a new port at Mohammedia for LNG and to connect to Nigeria via pipeline, the timeline of these projects is uncertain. Therefore, if Morocco's gas demand indeed triples as it aims to ramp up hydrogen exports, exports of hydrogen and its derivatives may require investment in additional infrastructure. Particularly in the south, some expect the government to heavily invest in new infrastructure such as pipelines and ports to service new green hydrogen production sites and assure connectivity, with the Fraunhofer PtX study highlighting the importance of the port of Tan Tan (Fraunhofer ISE, 2023.). The action plan of the National Green Hydrogen Roadmap remained unclear regarding the financing of such plans, and the "Offre Maroc" is also meant to lay out a master plan for infrastructure developments.

### 3.2.4 Challenges and risks

A number of challenges serve to dampen expectations. These challenges are related to meeting Morocco's own water and energy needs vs exporting hydrogen, the importance of social acceptance and local value creation, and international politics surrounding the Western Sahara.

#### Trade-offs between exports and local needs

Morocco's water stress is increasing, resulting in empty reservoirs and the diversion of water towards drinking water and away from agriculture. There are already plans to invest billions in water projects, including 12 new desalination facilities to provide water for human use and eventually green hydrogen production. International partners highlighted that their funding would only go to hydrogen projects that would use desalinated water and that hydrogen could not utilize existing water supply for human consumption (Expert Interview Finance 2).

A major cost factor for desalination is its high energy requirement. ONEE estimated that energy represented around 45 % of the costs of desalination. While these plants are meant to be run on renewable energy, a recent large-scale plant in Agadir still runs on Morocco's (fossil-intensive) electricity grid (Eljechtimi, 2022). At the same time power demand is on the rise with a growing population, and consumption could significantly increase in the next decades (Hamann, 2022). Some sources estimate electricity demand to increase by 6 % per year by 2030 (Enerdata, 2023).

Therefore, producing green hydrogen would require additional massive investments in desalination plants and energy, i.e. more production and utilization of renewable energy. This requires liberalizing the energy sector, ending the quasi monopoly that has hindered Morocco from scaling-up clean energy production more quickly, despite ambitious government targets (Baumann, 2021). Whether this will materialize remains to be seen. Moreover, the government needs to invest simultaneously in areas such as healthcare, pension schemes, education, as well as water and green electricity. Given strict European carbon emission regulations and competition from other countries promoting green hydrogen in Africa, Morocco's hydrogen will have to be produced with renewables to access the European market. There is therefore concern within the country and from some international partners

<sup>8</sup> It is important to note that Morocco does not import at the full capacity of the GME which is 13 million bcm, and that the GME has 2 undersea pipes. However, there is no clear information in the European Hydrogen Backbone or other strategies the extent to which the pipeline could still be used while being repurposed, nor whether new infrastructure would be needed if Morocco's gas demand indeed triples by 2040.

that green molecules and energy will target exports at the expense of national needs and Morocco's own energy transition. There are also unanswered questions about the infrastructure needed to export hydrogen and to what extent this may conflict with Morocco's energy security goals (see section 'Export Infrastructure'). Unless Morocco reduces its projected gas imports, an eventual conflict between Morocco's energy security goals and its longer-term vision of exporting hydrogen may emerge.

### **Social acceptance and local value creation: lessons learned from Noor**

The experiences of Morocco's Noor solar power plant have also raised the importance of the financial and social impacts of mega-projects, which could resurface around hydrogen. Land appropriation for the Noor solar plant resulted in villagers losing their access to water and collective pasture, disrupting social and economic ties (Belghazi & Sammouni, 2020). While locals did not necessarily oppose the plant itself, they criticized the fact that they were not consulted or informed about the sale of their collectively owned land, and that they did not directly receive land revenues nor the hoped-for local jobs (Woodward, 2020). The fact that OCP, which will be a major hydrogen offtaker, does not report on its environmental and social impacts and scores poorly on the international Resource Governance Index is not reassuring (Resource Governance Index, 2021). The land needed for green hydrogen production is even larger; estimates range between 990 Km<sup>2</sup> to 1,660 km<sup>2</sup> exclusively for electrolyzed hydrogen production. Civil society organizations have therefore criticized the establishment of giant power plants, and there are advocates for locally produced hydrogen and decentralized solutions as opposed to massive land acquisition (Expert Interview Policy 2). Chances of these concerns reaching policymakers and altering policies are dim, as decisions are made in a top-down fashion preventing genuine participation.

When it comes to financing, Noor was also criticized for not generating local benefits even as Morocco accrued debts from IFIs (Expert Interview Policy 2). Approximately 80 % of the project cost was funded by debt issued by MASEN (ACWA Power, 2014). The repayment of these loans to international banks, including the German KfW which funded almost half of phases I and II, is seen by some experts as reason to reject public debt to finance future green hydrogen projects. The king seems therefore keen on primarily using private investments to establish a green hydrogen sector and to create as much local value creation as possible inside the country (Expert Interviews Policy 2 and 3). Placing the financing into the hands of the private sector, though, has raised concerns of a mere profit-oriented business that does not translate into genuine benefits for society at large. In any case, large amounts of foreign capital are required to build domestic value chains. Much depends on the quality of the *Offre Maroc*, the framework and regulations set by the government, and whether the international private sector will be convinced and willing to invest.

### **International politics and the Western Sahara**

Morocco's best potential for green hydrogen production is located in the disputed Western Sahara area (Marks, 2022). Locating high-capacity electrolyzers in the Western Sahara seems the optimum choice in terms of resources, but given the political sensitivity around the region's status, challenges would remain for many countries to engage and invest. The US endorsement of Morocco's sovereignty of Western Sahara has not been reversed so far, but for most other governments the area is still regarded as disputed territory. The kingdom decides who its friends and foes are largely based on their stance on the Western Sahara issue. Any country or international institution intending to engage will need to walk a tight rope to navigate this delicate issue (Expert Interview Policy 2). In 2021, German-Moroccan relations deteriorated tremendously as a result of "deep misunderstandings" related to the issue (Euractiv, 2022). Given European positions on the Western Sahara question, it is expected that European public funds will not be used for green hydrogen projects in the Western Sahara (Expert Interviews Policy 3, Finance 2). While the government has granted companies land to explore hydrogen in or near these regions, it is still unclear whether the US and European companies operating near the cities of Laâyoune and Boujdour are operating in Western Sahara or north of the border.

### 3.3 International engagement

As seen above, Morocco's green hydrogen policy-making and projects involve a considerable number of international actors. Despite the issue of the Western Sahara, long-standing cooperation with partners such as Germany and the EU has broadened into hydrogen. OCP is an important partner for international actors, with R&D partnerships and plans to purchase green ammonia. Firms that have been involved in previous energy projects have expanded this collaboration into hydrogen, such as ACWA and Total Energies, and new actors like CWP are entering the field. Other important actors with previous stakes in Morocco's energy sector, such as Engie or Chinese state-owned firms, have been less active. Morocco has also extended its hydrogen collaboration potential by working within international organizations like IRENA.

#### Germany

As outlined above, Germany has been closely engaged with the renewables industry in Morocco, which has been extended to the hydrogen sector. The German government signed a partnership agreement with Morocco on hydrogen development in 2020 and since then multiple agencies and private actors have promoted further connections. GIZ, which had previously supported IRESEN's establishment, has been supporting hydrogen policy development. Its publications together with the German Federal Ministry for Economic Affairs and Climate Action provided groundwork for the national hydrogen roadmap (Expert Interview Policy 3). The two German actors had already in 2012 together with the MTEDD established the German-Moroccan Energy Partnership, whose main objective is to promote renewable energy and energy efficiency, explore further avenues of cooperation and to thereby enhance Morocco's energy security (GIZ, n.d.). The PtX Hub, which is implemented by the GIZ on behalf of Germany's Ministry of Economic Affairs and Climate Action, is also involved in policymaking as its focal points include advising on the development of a regulatory framework and encouraging the expansion of Power-to-X markets as well as finding financing mechanisms. The German Development Bank (KfW) has also provided funding for the first larger-scale hydrogen production facility for local use, planning on providing grants and loans up to 300 million euros (the project itself is estimated to cost between €320-350 million). When it comes to private actors, the port of Hamburg and Tangiers have also signed a letter of intent for hydrogen cooperation (Ngounou, 2021) and several research centers have cooperations with Moroccan counterparts. In addition, German wind turbine manufacturer Nordex SE is part of a consortium seeking to develop green hydrogen in an area near Boujdour and Laâyoune.

However, the German government is ambivalent regarding its green energy needs. Apparently communication differs depending on the ministry involved. The Federal Ministry for Economic Development and Cooperation is very sensitive to the issue of neocolonialism and is very meticulous in demonstrating to the Moroccan side that it is not driven by its own energy needs (Expert Interviews Policy 3, Finance 1). The Federal Ministry for Economic Affairs and Climate Action is more outspoken about importing green hydrogen from North Africa. German hesitation on the issue of green hydrogen off-take may also be related to the fact that no clear green hydrogen import strategy is in place yet. So far, there are only rough estimates circulating of how much hydrogen Germany will need for its own green energy transition.

#### The European Union

The EU has engaged closely with Morocco on renewable energy by providing finance and technical assistance, and efforts to harmonize energy regulation. Its engagement with hydrogen in Morocco appears to be picking up: in October 2022, the EU signed a 'green partnership' which will provide new financing for projects and promote low-carbon development in both the EU and Morocco. It has been described as the first of its kind in the European Commission's effort to promote the external dimension of the European Green Deal by former European Commission Executive Vice-President Frans Timmermans (European Commission, 2022). The EIB has worked closely on renewable energy with MASEN, and sustainability in industrial zones in Morocco. However, it only recently begun working on hydrogen, motivated by the push from the European Commission. Early action by

the bank was focused on general feasibility studies for green hydrogen in a number of countries in Africa. Although the bank was involved in discussions on potentially funding MASEN's first hydrogen project, this was ultimately financed by grants from Germany's KfW.

### The Netherlands

Morocco also signed agreements with the Dutch government to jointly explore the green hydrogen sector. Following a visit of Dutch Prime Minister Mark Rutte to Morocco in June 2023, Dutch-Moroccan cooperation was expanded into a €300 million investment fund for green initiatives including hydrogen, of which 35 % will be grants (Zouiten, 2023). Given that the Netherlands will likely have a high demand for green hydrogen, this collaboration has the potential to help Morocco reach potential offtakers. The Port of Rotterdam, which is already an important trading partner for Morocco, has also been conducting exploratory studies on hydrogen imports.<sup>9</sup> Vitol, which is based in Rotterdam, has expressed interest in purchasing hydrogen from the HEVO Morocco project.

### France, Spain and Portugal

Bilateral cooperation on hydrogen between the French and Moroccan governments has not yet emerged (Plank et al., 2023). This is not particularly surprising given the currently frosty relations between the two countries. For example, Morocco refused aid from France following its deadly earthquake in September 2023. Nevertheless Morocco has accepted loans from the French development bank AFD to support Morocco's green transition plan, including technical assistance (Kasraoui, 2023). French firm Total Energies is also planning a major hydrogen investment in Morocco.

Spain, which has friendlier relations with Morocco since it changed its position on Western Sahara in 2022, is seen as a potential partner for hydrogen exports which would pass through the refurbished Maghreb-Europe gas pipeline (FuelCellsWorks, n.d.). However, Spain has still not signed high-level agreements with Morocco and appears less involved than other European countries. This is striking given the countries' proximity and Spain's role as a transit country for Moroccan exports to the EU (Escribano et al., 2023). However, Spanish firm Acciona is part of the ORNX consortium which is developing hydrogen projects near Laâyoune and Boujdour. Portugal, while not directly connected to Morocco via pipeline, has signed an agreement for further cooperation on green hydrogen in 2021 (Kingdom of Morocco, 2021b).

### Other international engagement

Firms from other European countries are also involved in the hydrogen sphere in Morocco such as John Cockerill (Belgium), Fusion Fuel (Ireland), CWP (Serbia), and Shell (UK). The EBRD is expanding its previous work on renewable energy in Morocco and the liberalization of its energy sector. It is now supporting port studies on green hydrogen (Zgheib, 2023) and has initiated a partnership with IRESEN to promote investments in sustainable energy, including hydrogen (EBRD, n.d.). Saudi Arabia and Morocco have in recent years increased their energy cooperation, most recently with a 2022 MOU to collaborate on renewable energy (Mancebo, 2022). The Saudi firm ACWA Power has developed major renewable energy projects in the country, and has now signaled an interest in developing green hydrogen locally (Dokso, 2022). Saudi conglomerate the Ajlan Brothers has become involved in hydrogen development, signing an MOU with Gaia Energy and Energy China International Construction Group to develop green hydrogen. There have been no announcements of bilateral Chinese-Moroccan hydrogen cooperation as of October 2023, although Chinese firms have played an important role in Morocco's renewable energy sector. No Korean or Japanese firms are believed to be currently developing hydrogen projects, but the Korean ambassador to Morocco has signaled an interest in green hydrogen cooperation, including projects including infrastructure, steel, and electrolysis technology (Ntungwabona, 2023).

<sup>9</sup> For Morocco as well as other potential partners including as South Africa and Oman, see (Port of Rotterdam, n.d.).

### **Moroccan involvement in international initiatives**

Morocco is an active member of IRENA and has engaged with this platform on green hydrogen with the EU and European countries since at least 2020 (IRENA, 2020). In June 2021, Morocco and IRENA signed a strategic partnership to advance green hydrogen (IRENA, 2021a). Together with the European Commission, Morocco co-facilitated the IRENA Collaborative Framework on Green Hydrogen, which aims to coordinate green hydrogen action (IRENA, 2021b). Furthermore, Morocco was a founding member of the African Green Hydrogen Alliance which was announced at COP26 with partners Kenya, South Africa, Namibia, Egypt and Mauritania (Climate Champions, n.d.). These countries aim to position themselves as pioneers of green hydrogen development on the continent, and Morocco is particularly involved in topics such as standards and certification, signaling its interest in exports to Europe. While Moroccan firms including Gaia Energy have been promoting an offshore hydrogen pipeline that would connect Mauritania, Morocco and Spain, there are doubts as to whether this would be politically acceptable as well as technically feasible (see Mauritania section 6.2). These efforts at collaboration, especially targeted at other African countries, are in keeping with Morocco's larger foreign policy strategy of establishing itself as a regional leader.

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## 4 Algeria: New Partners Drive Cautious Embrace of Hydrogen

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Analyses of the emergent global market for green hydrogen often discount Algeria's potential role in favor of other North African countries, especially Morocco (Nuñez-Jimenez & Blasio, 2022). Studies that do look seriously at Algeria, however, tend to confirm its strong potential for producing low-cost green hydrogen at scale (Drenkard et al., 2021; Hank et al., 2023). But with an economic and political system built around hydrocarbon extraction, Algeria has been slow to embrace renewable energy or hydrogen. Intense interest from Europe—primarily driven by Germany—in recent years may finally be changing that. Spurred by new expressions of foreign demand, in the past two years Algerian authorities have at last begun accelerating efforts to capitalize on the country's strong green energy potential. A new hydrogen roadmap released in 2023 includes pilot projects aimed at developing local knowledge and expertise, to be followed by industrial-scale buildout of green hydrogen production in the coming decades. Algeria faces numerous challenges in implementing these plans but appears newly inclined to accompanying European partners into the green transition.

### 4.1 National politics and governance of energy and relevant key sectors

#### 4.1.1 Hydrocarbons

Hydrocarbon extraction and export have formed the backbone of Algeria's economy since independence in 1962. After over a century of colonization, Algerians view the country's oil and gas reserves as critical to preserving their sovereignty. They mark the country's accession to the Organization of Petroleum Exporting Countries (OPEC) in 1969 and nationalization of its hydrocarbons sector in 1971 as key milestones in this quest.

Today, oil and gas exports provide for approximately 50 % of government revenues and 85 % of Algeria's total exports annually (IMF, 2023a). Most Algerian products classified as “non-hydrocarbon exports” are in fact derivatives of oil and gas (fertilizer compounds urea and ammonia) or are produced using large quantities of them (iron, steel, cement) (Algerie Press Service, 2023a). Hydrocarbons are critical to the Algerian state's ability to maintain social stability. Energy revenues underwrite an extensive system of subsidies and free public services (Dris et al., 2023). In the past, sudden crashes in global energy prices have slashed Algeria's hydrocarbon revenues and jeopardized the state's ability to maintain spending levels, sparking unrest that challenged the state's authority (Ghanem, 2020). Despite these crises, leaders have largely resisted calls to diversify the economy and reduce the country's dependence on oil and gas.

The Ministry of Energy and Mines, led since February 2021 by Mohamed Arkab, is the key institution at the apex of Algeria's energy sector. The energy ministry oversees national oil company Sonatrach, national gas and electric utility Sonelgaz, and their many subsidiaries working throughout the energy sector and adjacent sectors. With earnings of \$60bn in 2022, Sonatrach, which is Africa's largest company by revenue, accounted for nearly a third of Algeria's GDP (Sonatrach, 2022a;

Rouaud, 2023). Foreign energy firms operate in the country as minority partners to Sonatrach, collaborating to identify and exploit deposits, often by contributing specific technical expertise. Because contracts are not made public, trends in the partnerships are hard to describe with confidence. Sonatrach also oversees Algeria's oil and gas sales, which are delivered to off-takers via several major ports and two active gas pipelines, the Medgaz pipeline to Spain and the Transmed pipeline to Italy via Tunisia.<sup>10</sup> The majority of Algerian energy exports go to Europe, helping to make the EU Algeria's largest trade partner, led by Italy, France, and Spain (WITS Data, n.d.). Algerian officials proudly describe their country as a "reliable partner" that honors its agreements with off-takers. Energy policy is officially set by a High Energy Council established in March 2022 (Algerie Press Service, 2022a) and led by Algeria's president, Abdelmadjid Tebboune. This cabinet-within-the-cabinet is composed of the ministers of energy, environment, foreign affairs, defense, interior, higher education and scientific research, and finance. But the council meets only rarely; in practice, the president and Algeria's powerful military set policy in coordination with the energy ministry, which executes it.

In setting strategy, these leaders must confront the central challenge facing Algeria's energy sector today: The country is dependent on hydrocarbon exports but has fewer and fewer resources available to export. Years of underinvestment and mismanagement of Algeria's energy reserves have left the country with limited short-term capacity to expand production (Fakir, 2022). Many of its oil fields are aging, requiring greater volumes of natural gas reinjection to continue producing (Cockayne, 2023). Amid stagnant output, growing domestic energy consumption is reducing the energy available for export. Some 45 % of Algeria's gas production and 31 % of its oil production are now consumed locally, and both %ages have more than doubled in the past two decades, fueled by a growing population and rising per capita energy usage.<sup>11</sup> Generous subsidies reduce energy costs by 52 % on average, limiting consumers' and firms' incentive to conserve energy (IRENA, 2022). Political leaders are loath to pare back the subsidies for fear of popular backlash. This dilemma became acutely visible in 2022, when Algeria failed to expand gas exports—and in fact witnessed a slight decline—to capitalize on record prices and unprecedented demand from European countries, who were scrambling to replace supplies from Russia after its invasion of Ukraine (Sonatrach, 2022b). That year, Algeria's gas pipelines to Spain and Italy operated at just 80 % and 63 % of nameplate capacity, respectively, owing largely to inadequate export supplies (Butt, 2023).

That missed opportunity has provided Algerian leaders with strong motivation to revitalize the hydrocarbons industry and expand the country's energy supply. In 2022, Sonatrach launched a five-year, \$40bn investment plan to boost exploration and production (Jeune Afrique, 2022). Energy officials finalized the rollout of a new hydrocarbons law that offers new incentives to entice foreign partners, and Arkab indicated that countries hoping to secure Algerian gas would first be expected to invest in long-term production partnerships (Bolliger, 2022). Sonatrach has signed new deals with existing upstream partners and announced plans for off-shore drilling. It is also negotiating with major US producers whose expertise it requires in order to finally access Algeria's massive shale-gas resources (Dalton, 2023). Arkab even revived previously shelved plans for a trans-Saharan gas pipeline to transport Nigerian gas overland to Algeria for export to Europe (though the recent coup in Niger raises fresh doubts about that project) (Chikhi, 2022).

These measures are intended to preserve Algeria's rentier-state model for the foreseeable future and reassure off-takers that Algeria remains committed to delivering oil and gas. But some foreign partners are wary of investing huge sums in new oil and gas projects and infrastructure, worrying they will become stranded assets. This is particularly true as Europe—Algeria's largest energy client—undertakes a concerted pivot away from hydrocarbons.

<sup>10</sup> A third pipeline, the Maghreb-Europe Gas Pipeline (GME), links Algeria to Spain via Morocco. Its operations ceased in October 2021, however, after Algeria declined to renew a supply contract amid political tensions with Morocco.

<sup>11</sup> Author's calculation based on (Statistical Review of World Energy, 2023)

The IEA now predicts that the world might reach “peak oil demand” as early as this decade, leaving hydrocarbon-dependent countries like Algeria as so-called “stranded nations” (Andres et al., 2023; Lawler, 2023). That would have substantial implications for Algeria’s domestic stability, as dwindling resources would exacerbate already tense debates over how best to allocate energy revenues. Even absent such extreme shifts, authorities’ latest efforts to alleviate Algeria’s deepening energy squeeze could stoke discontent. Previous government attempts to launch shale gas extraction in southern Algeria have led to major protests by residents concerned for local water resources, forcing authorities to halt the plans (Gall, 2015). Fears that Algeria’s hydrocarbon dependency may be untenable in the long run are creeping into public policy debates at the highest levels, prompting leaders to finally begin seriously considering diversifying Algeria’s energy mix.

#### 4.1.2 Renewables

Algeria’s size and geography lend it extremely high potential for solar and wind energy generation.<sup>12</sup> But the central place of oil and gas in the country’s economy have long bred skepticism among Algerian leaders about the value of developing renewables. Consequently, today Algeria boasts just 460 MW of installed renewables capacity, which contributes less than one % of the country’s electricity generation (CEREFÉ, 2023; IRENA, 2023).

Algeria spent the 1990s mired in a brutal civil war that precluded leaders from devoting attention or resources to energy transition. Until it emerged from that conflict in the early 2000s, academic research was virtually the only activity on renewable energy, with the Center for Renewable Energy Development (CDER), a public research agency that traces its roots back to a colonial-era solar lab, serving as a key hub. In 2002, Sonatrach, Sonelgaz, and a private agro-industrial firm partnered to establish New Energy Algeria (NEAL), a venture intended to kick-start Algeria’s renewables sector. Doing so as a new public-private entity with little support or political capital from key decision-makers while navigating an unfamiliar and nascent industry proved difficult. NEAL managed to see just a single 150MW CSP-gas hybrid facility in Hassi R’mel (the nexus of Algeria’s natural gas industry) completed in 2011 before the company was folded into Sonelgaz in 2012.

By that time, discussion had shifted toward a new initiative, DESERTEC, spearheaded by a German-led consortium launched in 2009 which aimed to export renewable electricity from the Sahara to Europe. The scheme’s neo-colonial overtones immediately pricked Algerian leaders’ sensitivities, especially since the original plan included no provisions to help Algeria meet its own energy needs (Farand, 2022). Subsequent versions failed to convince authorities in Algiers, who turned their backs on the plan, unlike their Moroccan counterparts. Algerian officials were largely content to watch Morocco move forward alone with its projects as cost overruns accumulated, while they opted instead for a series of pilot projects in hydropower, wind, and solar PV. These initiatives enabled Algerian leaders to claim progress (however modest) on renewable energy while also slowly building national capacity to construct and operate renewables facilities, albeit not yet at an industrial scale.

When President Tebboune took office in December 2019, he had three good reasons to accelerate Algeria’s modest efforts to develop renewables, starting with domestic politics. Elected in a contested vote amid a nationwide protest movement, Tebboune was desperate to mark a break from his predecessors wherever possible. He proclaimed a “new Algeria” and announced “54 Commitments to Build a New Republic,” one of which was “Promoting the production of fossil and renewable energies (solar and wind) with the goal of exporting” (Office of the Algerian President, 2019). The second reason was Algeria’s global reputation. Under the Paris Agreement, Algeria had committed to reducing greenhouse gas emissions by 7 % by 2030, or up to 22 % if sufficient external financing and technology transfer were provided (UNFCCC, 2015). To reach those targets, Algeria first

<sup>12</sup> For precise figures, see (Global Solar Atlas, n.d.) and (Global Wind Atlas, n.d.)

announced in 2011 a plan to build 22GW of renewable power capacity by 2030, including 10GW for export. But only small pilots from Sonatrach and Sonelgaz followed, as major tenders planned by the energy ministry failed to materialize. By 2020, Algeria had reached 411 MW of installed renewables capacity—less than one tenth of that year’s interim target of 4.5GW (CEREFÉ, 2023).<sup>13</sup> Recognizing the initial goal as unattainable, Tebboune revised it, setting a new target of 15GW of renewables capacity (plus a further 1GW of off-grid capacity) and extending the deadline to 2035. The final reason was Algeria’s unsustainable energy mix, which put the country on course to tip from the category of net energy exporter to importer. By 2020, electricity demand had grown by some five % annually for two decades and was forecast to continue increasing apace, roughly tripling Algeria’s overall electricity needs by 2040 (Sterl et al., 2023). With nearly all of Algeria’s electricity coming from natural gas turbines, that explosion in power consumption would directly threaten one of the country’s most critical exports (IRENA, 2023).

Hoping to avoid that outcome, in June 2020 Tebboune split the Ministry of Environment and Renewable Energies, elevating the latter portfolio into its own ministry under the leadership of veteran energy scientist Chems Eddine Chitour. The resulting Ministry of Energy Transition and Renewable Energy (MTEER) was intended to work alongside the Ministry of Energy, Sonatrach, Sonelgaz, and other state institutions to advance Algeria’s renewables agenda. It was supported in this effort by the Commission on Renewable Energies and Energy Efficiency (CEREFÉ), established in 2019 under the prime minister’s office to advise policymakers. Chitour proved an ambitious and effective advocate for MTEER’s mission but was ousted in 2021 for political reasons. With real power for energy policymaking still centralized in the energy ministry, MTEER struggled to influence decisions. In September 2022, President Tebboune dissolved MTEER, leaving the energy ministry officially in charge of large-scale, grid-connected installations while responsibility for small-scale, off-grid renewables projects reverted to the environment ministry.

MTEER’s demise gave energy minister Arkab full authority for catching up on Algeria’s renewables targets. The obvious vehicle for doing so was the Algerian Renewable Energy Company (known by its Arabic acronym, SHAEMS). Established in 2021 to oversee renewables tenders, SHAEMS is co-owned in equal parts by Sonatrach and Sonelgaz.

SHAEMS launched its long-awaited first tender for 1GW of solar capacity, known as Solar 1,000MW, in December 2021. With an estimated value of \$1bn, the tender covered construction and operation of solar photovoltaic installations between 50 and 300 MW at 11 pre-selected sites (Algerie Press Service, 2022b). According to press reports, over 100 independent power producers (IPPs) expressed interest in bidding on the project, which was to be contracted under a build-own-operate model including 25-year power purchase agreements (PPAs) with state electric utility Sonelgaz (Ivanova, 2022). The tender also imposed a 30 % local sourcing requirement to support Algeria’s nascent solar industry. (Local electronics leader Condor and a series of specialized startups are working to build up a domestic manufacturing base for solar panels and accessories, and have established an industry lobby, Green Energy Cluster Algeria.) Amid wrangling with bidders over site surveys, project financing restrictions, and other aspects, SHAEMS repeatedly pushed back the submission deadline, jeopardizing its goal to begin producing power by end-2023. Senior energy officials and political leaders were reticent to embrace the “project finance” model and PPA contract format, reportedly fearing that giving foreign IPPs such operational freedom and capital investment could compromise Algeria’s hard-fought sovereignty, despite the fact that such contract structures have been used for other projects, including NEAL’s hybrid solar-gas facility in Hassi R’mel (Interviewee, Industry 1, 2023). In mid-2022, SHAEMS announced an indefinite delay of the submission deadline, prompting speculation that authorities had abandoned Solar 1,000 MW.

<sup>13</sup> Note: Government officials sometimes cited higher figures, which they reached by including some or all of Algeria’s roughly 200MW of installed hydropower capacity alongside solar and wind capacities. This is misleading, however, as authorities have decommissioned nearly all hydroelectric generation facilities at Algeria’s reservoirs in recent years in order to preserve dwindling water resources for irrigation.

In March 2023, on the orders of the energy ministry, Sonelgaz launched a new tender for 2GW of photovoltaic solar power generation across 15 pre-selected sites ranging from 80MW to 220MW (Sonelgaz, 2023). This new tender employed a turnkey engineering-procurement-construction (EPC) format including a local content requirement, but without a PPA.<sup>14</sup> This choice was immediately decried by voices within Algeria’s budding renewables community. It would leave Sonelgaz—which has only limited experience managing solar installations—on the hook for operations and maintenance of large-scale facilities that it did not build. This could lead to higher operating and maintenance costs, particularly in the initial phase as Sonelgaz develops its in-house expertise to manage such facilities and would be less transparent than the IPP model promoted by SHAEMS. Algerian experts have argued that this could substantially raise costs for renewable power generation, and thus constitutes a grave misuse of public funds (Algerie Eco, 2023). Cost overruns could also make renewables more expensive, dissuading energy officials from a mass deployment of renewable power generation.

Despite these arguments and delays to the submission deadline, the tender finally closed in July 2023. Energy minister Arkab announced that 90 bids had been received from 20 candidates and called the 2,000 MW tender “the first step toward realizing Algeria’s ambitious renewable energy development program” (Algerie Press Service, 2023b). The project, he added, will allow Algeria to become a “reliable supplier” of green power to Europe—the first time an energy leader had adapted Algeria’s longtime oil-and-gas slogan to renewables. This potent phrasing suggests Arkab may have turned a corner and embraced renewables as a pillar of Algeria’s future energy strategy, but it remains too early to tell. Conservatives who prefer business as usual have long outnumbered the renewables champions scattered throughout the energy ministry, Sonatrach, Sonelgaz, and other key institutions. One argument, however, does seem to be winning more adherents to renewables with each passing year: Every kWh of electricity generated from renewables helps save more gas for export. Recent estimates suggest that over the next decade, Algeria’s solar development plans could enable it to save as much as 40bcm of gas—slightly more than it currently exports each year (EnergyMagazine, 2023).

All these factors appear to be generating new momentum for renewables in Algeria. Shortly after closing the 2GW tender in July, energy officials announced that the Solar 1,000 MW tender is still alive and would close in September (a deadline they missed), and that an additional 3GW solar tender will open in November (Algerie Press Service, 2023c). The energy ministry has also announced new initiatives including tests of locally produced lithium batteries for green energy storage, negotiations with European partners for construction of undersea cables to export green power, and numerous green hydrogen initiatives.

### 4.1.3 Related sectors

Several major sectors of Algeria’s economy could one day serve as domestic consumers of green hydrogen. The predominance of SOEs in these sectors means that any decisions to transition from grey to green hydrogen would be subject to political considerations alongside market incentives.

Algeria already produces gray hydrogen (derived from natural gas through steam methane reforming) for use as a chemical feedstock in oil refining and fertilizer production. Sonatrach operates five domestic crude oil refineries (located in Adrar, Algiers, Arzew, Hassi Messaoud, and Skikda) with a sixth under construction in Hassi Messaoud. Through its petrochemical and fertilizer subsidiaries and various joint ventures, Sonatrach is also the national leader in ammonia and methanol production, which is primarily concentrated in Arzew. With over 3MT/year and 2MT/year exported

<sup>14</sup> Bidders were required to source a minimum of 35% of materials and 100% of civil engineering and installation works from Algerian providers (Abdelkrim, 2023).

respectively, urea and ammonia are among the country's largest non-hydrocarbon exports, with Brazil, the US, and EU countries serving as the largest buyers (Algerie Press Service, 2022c).

Two other key Algerian export products, steel and cement, represent hydrocarbon-intensive sectors classified as “hard-to-abate” through electrification, making them candidates for future conversion to green hydrogen. The steel and cement sectors are dominated, respectively, by the state-owned IMETAL Group and Algerian Cement Industrial Group (GICA), both overseen by the Ministry of Industry. Several steel facilities operate under joint ventures between Algerian public companies and foreign investors, including from Turkey and Qatar. Historically concentrated around Annaba, steel production is now developing rapidly in the west, while cement production is distributed across northern Algeria.

## 4.2 National hydrogen developments

### 4.2.1 Early steps

In Algeria, research on renewable hydrogen for transport or storage date back to at least the late 1990s, with CDER serving as a key research hub. Authorities introduced a section for “hydrogen and fuel cells” within the “energy security” rubric of Algeria's 2010 National Research Program, expanding available public funding (Renewable Energy Development Center, 2010). CDER established its hydrogen division in 2013 to explore renewable hydrogen production, applications, conversion systems, storage, and safety. Research in this period largely focused on generating hydrogen from micro-scale electrolyzers powered by solar panels and on mapping Algeria's renewable energy and hydrogen generation potentials.

Interest in developing renewable hydrogen as an export product, energy vector, or input to local industry has been slower to develop. After a high-level energy dialogue between the EU and Algeria in 2015, leaders signed an agreement that makes no mention of hydrogen, reflecting how far it was from either side's priorities at that time (European Commission, 2015). Interest from Sonatrach—whose refining and fertilizer subsidiaries are the country's largest producers and consumers of gray hydrogen—emerged soon after, paralleling the uptick in discussions worldwide. This dynamic has subsequently continued, with Algeria's rising prioritization of green hydrogen closely reflecting external expressions of demand.

MTEER Minister Chitour did much to bring hydrogen to the fore of Algeria's energy policy debate. In April 2021, Chitour and Minister of Higher Education and Scientific Research Abdelbaki Benzi-ane signed “the Algiers declaration,” an agreement for public-sector collaboration on hydrogen research and planning. As its grandiose name suggested, however, Chitour intended the document to be a launchpad for a national renewable hydrogen strategy as well as a wider government embrace of the energy transition, even asserting that hydrogen could one day replace gas exports (Chitour, 2022).

Tebboune's dismissal of Chitour in July 2021 temporarily stalled the momentum around hydrogen. But the publication, in November 2021, of a GIZ study detailing Algeria's considerable potential as a PtX hub ignited new interest (Drenkard et al., 2021). That same month, Energy and Mines Minister Arkab designated the ministry's Director General of Economic Studies and Foresight, Miloud Medjelled, to head a new inter-ministerial working group to develop a national hydrogen strategy. The committee included representatives of CEREFÉ, CDER, Sonatrach, Sonelgaz, and the ministries of

energy transition and renewable energy, higher education and scientific research, industry, finance, foreign affairs, knowledge economy and startups, and vocational training.<sup>15</sup>

The committee's work assumed new importance as natural gas prices rose to record levels around Russia's invasion of Ukraine. The higher prices stimulated interest in renewables and made them more cost-competitive, helping Algeria to overcome a critical first hurdle to considering a domestic low-carbon hydrogen industry. In May 2022, the European Commission unveiled REPowerEU, its plan to end dependence on Russian fossil fuels, which called for 10MT of renewable hydrogen imports by 2030. That target provided Algeria with greater certainty of future hydrogen demand, even if many questions—including who the off-takers were and how they would import the hydrogen—remained unresolved.

### 4.2.2 Roadmap

The working group completed a national hydrogen roadmap that was presented to the government in December 2022, approved, and publicly unveiled by Arkab in a March 2023 ceremony. The energy ministry has not yet published the final roadmap but expects to do so during 2023.<sup>16</sup>

The roadmap presents Algeria's objectives and vision for a future hydrogen industry, which includes largely phasing out usage of gray hydrogen in favor of renewable blue and green hydrogen, much of it produced for export. With this plan, the roadmap states, "Algeria aspires to become a regional and even international leader in the production and marketing of clean hydrogen and its derivatives" (Ministry of Energy and Mines, 2023a). While the roadmap does not include performance indicators or intermediate milestones for measuring progress toward its objectives, it outlines a three-phase plan for developing the sector as follows:

**Phase 1:** Learning and startup (2023-2030) will focus on implementation of a series of pilot projects and showcase initiatives intended to develop know-how among key national actors, test different technologies and industrial procedures, identify operational constraints, and further develop international partnerships. Feasibility and cost studies will assist policymakers to evaluate different steps of the future hydrogen value chain in relation to the evolving international hydrogen market. Other tests will help determine optimal sites for solar and wind power generation, options for water usage and industrial integration, costs of installing and operating equipment, and the viability of transporting hydrogen through existing pipelines. These initiatives should enable future investments at scale based on accurate assumptions, firsthand experience with the technologies in question, and a sound business model. Authorities will also expand the existing regulatory and institutional architecture as needed to facilitate large-scale deployment.

**Phase 2:** Deployment (2030-2040) will build on the first phase's conclusions to install hydrogen infrastructure and systems at industrial scale. This will involve mass deployment of selected technologies for renewable energy generation and for hydrogen production, compression, transport, storage, and utilization. Economies of scale will drive down costs, enabling Algeria to begin local use and international export of low-carbon hydrogen at competitive prices. Hydrogen production levels are forecast to expand progressively to 40TWh (approximately 1.2MT) by 2040. The majority of this supply, an estimated 1MT of green hydrogen, would be primarily destined for export, while the remainder would likely be produced as blue hydrogen and be reserved for local use in industry or in electricity production. However, the document provides little information about blue hydrogen needs such as carbon capture and storage. Nor does it contain information on export infrastructure or routes, which is expected to be answered by offtakers or international partners.

<sup>15</sup> Following MTEER's dissolution in September 2022, the Ministry of Environment and Renewable Energies took its place on the working group.

<sup>16</sup> The analysis presented in this report is based on a recent draft of the roadmap obtained by the author.

**Phase 3:** Industrialization and export (2040-2050) will aim to consolidate Algeria's place in the international hydrogen market, solidifying renewable hydrogen's role in national industry and competitiveness as an export product generating foreign reserves for the country. The working group described it in considerably less detail than previous phases, reflecting the expectation that plans will evolve substantially over the coming decades.

According to this plan, by 2040 Algeria will be able to cover 10 % of the 10MT of green hydrogen that Europe anticipates importing under REPowerEU. To reach this goal, the roadmap estimates that Algeria will need to build 14GW of solar PV and nearly 5.3GW MW of wind capacity and install 2.45GW of electrolyzer capacity. Considering these factors and hydrogen transport (but not storage), the plan estimates a total implementation cost of \$24.8bn. It projects annual revenues from the green hydrogen exported to Europe at \$10bn, and savings from reduced domestic consumption of natural gas (offset by converting hydrogen back to electricity) at as much as \$21.2bn. Under this scenario, the investment could pay for itself by the time exports reach full capacity in 2040 (though the roadmap's figures remain subject to confirmation through the pilot phase activities).

### 4.2.3 Implementation

Sonatrach, already Algeria's largest user of hydrogen, has shown considerable interest in ensuring the roadmap's success, in part because its executives find the business case highly compelling. From its current \$40bn investment plan, Sonatrach has pledged to spend "nearly \$1bn" on renewables, including green hydrogen (Calik, 2023). To that end, the company is set to lead implementation of an initial series of green hydrogen pilot projects under Phase 1 of the roadmap. Although the roadmap mentions potential blue hydrogen pilots, none have yet been announced, as authorities remain focused on the form with highest export potential. Planning for the pilot projects continues to evolve, with some version of the following anticipated to launch in the coming months:<sup>17</sup>

**Project 1:** Generation, transport, and storage. Sonatrach will use power from a solar PV facility to run a small electrolyzer, generating hydrogen that will be injected into a pipeline. The hydrogen will be extracted using membranes, then stored, potentially in an underground salt cavern. Likely project sites are Hassi R'mel and/or Hassi Messaoud.

**Project 2:** Storage. Sonatrach and an international partner (possibly Eni, see next section) will experiment with generation and storage of green hydrogen at a remote site in the southern desert, potentially Bir Rebaa North, then reconversion to electricity via a gas turbine or fuel cell. This will simulate a scenario in which renewable power is converted to hydrogen for storage then re-converted to electricity to smooth the power supply. While inefficient from an energy perspective, this cycle can help to overcome the intermittency problem associated with renewable energy.

**Project 3:** Ammonia/methanol production. Sonatrach intends to install a mid-sized electrolyzer to generate green hydrogen for production of ammonia and/or methanol as an industrial feedstock. The anticipated project site is Arzew, where Sorfert, a major fertilizer producer co-owned by Sonatrach and Dutch chemical group OCI NV, recently indicated it is preparing to expand its production lines and is exploring integration of green hydrogen (Lamia, 2023). The Fraunhofer Institute study described below offers more details that align closely with this pilot project.

After these initial tests, Sonatrach anticipates conducting follow-up studies under the roadmap's first phase. One will be a Power-to-X study employing a mix of solar and wind generation capacity to

<sup>17</sup> Details of the pilot projects come from a presentation delivered at a recent Algeria-EU energy dialogue workshop (Ministry of Energy and Mines, 2023b) and are supplemented by additional details from expert interviews (Interviewees Policy 1 and 4).

power a larger electrolyzer. Others will build on the pilot projects to refine Sonatrach's understanding of optimal production, storage, transport, and utilization methods while expanding its in-house expertise. Further planning will evolve in light of lessons learned from the above activities. The working group who drafted the roadmap will continue to meet regularly to evaluate progress and adapt the document as needed, including based upon pilot project findings, technological advances, or shifts in the emerging hydrogen market.

#### 4.2.4 Challenges and risks

To successfully implement Algeria's hydrogen roadmap and develop a robust hydrogen sector, Algerian authorities will need to overcome several challenges. Some, like regulation (which includes updating safety protocols and developing a green hydrogen certification system, among other tasks), are under the government's control and thus straightforward. Others are more complex:

**Hydrogen transport:** Algeria's plans to export 1MT of hydrogen annually to Europe will require transport by methods that remain unclear today. Both shipping and pipelines face substantial technological challenges, with the eventual solutions likely to require high costs for retrofitting or replacing existing infrastructure and equipment. LOHCs and other proposed innovations hold uncertain promise. Apart from the pilot project to evaluate the feasibility of transporting hydrogen in the domestic pipeline network, Algerian authorities seem to be counting on their foreign partners to explore international transport options.

**Water:** The roadmap lists Algeria's water reserves as one of the country's strengths, despite the fact that Algeria is considered water-stressed and growing more so due to climate change. Electrolysis near the coast, even at industrial scale, is unlikely to strain water resources thanks to authorities' substantial investment in seawater desalination stations. But electrolysis performed directly adjacent to solar and wind installations in the arid interior—a potential scenario outlined in the roadmap—risks bringing hydrogen production into direct conflict with local communities who count on scarce water resources for agriculture and drinking water. To reduce those chances while avoiding tapping precious aquifers, the government is exploring using treated wastewater to produce hydrogen. Sonatrach and Eni have announced they will explore using water from oil fields for electrolysis (Reuters, 2021).

**Renewables capacity:** Reaching the roadmap's 2040 export goal will require building significant new green energy capacity. The roadmap's estimation of the needs—14GW of solar PV and 5.3GW of wind capacity—are 35 times Algeria's current solar capacity and 250 times its current wind capacity. Quickly closing those gaps may prove difficult for Algeria, given its struggles in launching its first large-scale solar PV tenders. Foreign firms may hesitate to bid on tenders until concerns about Algeria's contracting processes are resolved. This is all the more likely given Algeria's already challenging business climate, even if authorities attest that a new investment law passed in 2022 has settled all such concerns. Much rests on the ability of Sonelgaz and SHAEMS to successfully manage the outstanding renewable energy tenders and issue contracts in the months ahead.

**Cost estimation:** Before investing billions in renewable hydrogen, Algerian authorities will want a solid business plan in hand, based on details of the international hydrogen market and local input costs. While they will need to rely on foreign partners for market indicators, their own costs may prove just as opaque, since many of the inputs—from electrolyzers to solar panels to wind turbines—will likely be sourced from abroad. CDER officials have disputed the levelized cost of hydrogen (LCOH) estimates presented in GIZ's 2021 Power-to-X study. Because Algeria currently has no electrolyzer manufacturing capacity or concrete plans to develop such capacity, that study assumed electrolyzers would be imported from Europe or the United States. But the researchers contend that Algeria will develop local capacity to produce electrolyzers at prices equivalent to Chinese ones, reducing capital expenses. They calculate the resulting LCOH at less than \$2/kg, a key

benchmark (M'raoui, 2023). Green electricity is another input whose price could prove uncertain, if critics are correct that Sonelgaz's choice to operate its own solar installations rather than using PPAs leads to higher costs.

**Human resources:** Large numbers of trained personnel will be needed to facilitate such a dramatic shift in Algeria's energy landscape and economy. Plans to launch an Energy Transition Institute in Algiers appear to have been shelved, leaving the recently established National Renewable Energies School as the country's only institution exclusively dedicated to meeting this rapidly growing need. The higher education ministry is working to expand renewables curricula at other institutions, with plans to offer a specialized green hydrogen program (Algerie Press Service, 2023d). Algeria's large number of highly trained petroleum engineers have skillsets readily convertible to the green economy, but job re-training programs are limited.

**Competition:** Algeria's late start on renewables and relatively unhurried timeline to hydrogen exports opens the door for regional rivals to surpass it and corner the European market, a concern raised by expert interviewees and seen by some as a motivating factor in developing Algeria's own hydrogen strategy (Expert Interviews Finance 1, Policy 3). Egypt, Morocco, and deep-pocketed Gulf countries have more ambitious plans that could make them more appealing partners for Europe. Algeria can attract capital investment and ensure a foothold in the emerging Mediterranean hydrogen market by leveraging its key assets: proximity and existing gas pipelines. Doing so may require experimenting with hydrogen transport in pipelines and/or spending big on infrastructure upgrades.

### 4.3 Hydrogen stakeholders and international engagement

Algerian policymakers' growing interest and investments in green hydrogen have emerged primarily as a response to European, and particularly German, demand as well as the worry that regional rivals could corner EU exports. While Algeria's hydrogen roadmap mentions joining international and regional initiatives and developing bilateral partnerships, so far such ties remain limited.

#### 4.3.1 Bilateral cooperation

Even before the REPowerEU plan, German expressions of interest had begun to attract the attention of officials at Sonatrach and the energy ministry. The November 2021 Power-to-X study commissioned by GIZ and conducted by Engie subsidiary Tractebel catalyzed a major growth of interest in Algeria's hydrogen production potential, including within the government. Its conclusions that Algeria could produce green hydrogen at economically competitive prices and use it to decarbonize multiple sectors and diversify its energy exports jump-started the energy ministry's process of developing the national hydrogen roadmap. The study also substantially influenced the roadmap's contents, which reflect numerous GIZ recommendations (Expert Interviews Policy 3, Policy 4).

The Power-to-X study was a product of the German-Algerian Energy Partnership, agreed between the two governments in 2015 and implemented by GIZ. Under this partnership, GIZ provides technical assistance and facilitates the partnership's work, which often focuses on green hydrogen, such as the annual German-Algerian Energy Day. In 2023, GIZ launched a new €12 million project on renewables and green hydrogen, beginning by hosting a six-month series of webinars on aspects of the hydrogen economy. Complementing these efforts, the German Chamber of Commerce (AHK) in Algeria has organized study missions for Algerian officials to explore the green hydrogen sector in Germany. GIZ, AHK, and Germany's federal Ministry of Economy and Climate Protection (BMWK) inaugurated a hydrogen resource center at AHK's Algiers office in 2023 and will issue grants to small businesses for hydrogen pilot projects as part of BMWK's International Hydrogen Ramp-up Program (H2Uppp).

Algeria's relations with Europe as a whole are also evolving—albeit more slowly than the German bilateral relationship—and ultimately hold the greatest promise for helping to develop Algeria's renewable hydrogen sector and linking it to a stable export market. Algeria and the EU established a regular energy dialogue mechanism in 2015, augmented by trade fairs to build business-to-business ties. At the last two dialogue meetings, held in October 2022 in Algiers and October 2023 in Brussels, Arkab and EU Energy Commissioner Kadri Simson discussed a potential EU-Algeria hydrogen partnership but did not reach agreement. Such a bilateral accord—or a multilateral one within a potential Mediterranean Green Hydrogen Partnership, a possibility that European leaders are exploring—could open new financing opportunities for Algeria and also help advance discussions around green hydrogen transport, market structure, certification, and other unresolved topics. Algerian leaders have also voiced interest in renegotiating the EU-Algeria Association Agreement signed in 2002, which would give Europe and Algeria further chances to expand green hydrogen collaboration.

In such discussions, Algerian officials will look to Europe to define the future hydrogen market and finance capital investments for green hydrogen production. Potential EU financing is an important factor motivating Algeria's present enthusiasm for green hydrogen. So too is fear of what might happen if it maintains its current energy mix. The EU's Carbon Border Adjustment Mechanism (CBAM), is entering into force in a gradual three-year process that began in 2023, potentially making leading Algerian exports like steel, cement, and fertilizers less competitive in European markets (The African Climate Foundation, 2023). This possibility also appears to be motivating Algerian policymakers to accelerate investments in green hydrogen (Expert Interview Policy 2).

### 4.3.2 Projects

While planning and discussions around green hydrogen in Algeria have grown substantially, the list of active or forthcoming projects by Sonatrach and international partners remains limited. At the fourth German-Algerian Energy Day, organized in December 2022, European gas consortium VNG AG and Sonatrach signed an agreement to establish green hydrogen and ammonia projects with the aim of developing future exports to Germany (Roos, 2022). Few details have emerged about implementation, though reports indicate that VNG AG is preparing to establish a plant with 50 MW of electrolysis capacity (Leal, 2023). Those plans would dovetail well with the third pilot project Sonatrach plans to execute under the hydrogen roadmap.

German state-owned development bank KfW has substantially expanded its engagement with the Algerian energy sector in recent years. In 2021 it commissioned the Fraunhofer Institute to conduct a study of Algeria's Power-to-X market, complementing that year's GIZ Power-to-X study by costing out two potential projects proposed by the energy ministry in order to evaluate their investment potential. The study is being finalized, with no plans for public release, but is already informing KfW's discussions with Germany's Ministry of International Cooperation (BMZ) and the Algerian energy ministry over the installation of a mid-sized electrolyzer to produce green hydrogen (Expert Interview Finance 1). The proposed facility would have a capacity of 50 MW linked to 80-110 MW of new solar and/or wind arrays, be located at Arzew, and be co-financed by BMZ and Sonatrach. With financing of €50mn from KfW helping to offset a total estimated cost of €133-196mn, the study projects that the facility could achieve a LCOH of €4.50-5.00/kg.<sup>18</sup> While not seeking to be cost competitive, a facility of this scale would allow Sonatrach to begin testing industrial uses and the export potential of green hydrogen and its derivatives, building technical expertise and helping define a scalable business model. The second proposed project evaluated in the report entails the installation of 2.6GW of solar and wind arrays around Hassi R'mel to power a 1GW electrolyzer. Co-locating the electrolyzer at that site would require construction of parallel pipelines to carry water some

<sup>18</sup> The analysis presented in this report is based on a recent version of the study obtained by the author (Fraunhofer ISI & ISE, 2023). More recent official statements indicate KfW may be considering a smaller donation of €35mn (Algerie Press Service, 2023g).

200km inland from Arzew and hydrogen back to the coast for export. Building the electrolyzer at Arzew and linking it to the power generation facilities by high-voltage cable could reduce project costs by 10 % (from €4.3bn to €3.9bn), enabling the project to achieve a LCOH near €4.00/kg. Many of the study's economic estimates are in fact conservative, suggesting that even lower prices might be achieved, in line with previous arguments from CDER. Depending how attractive Algerian energy officials find these projections, they may accelerate or curtail progress on the country's hydrogen roadmap, potentially impacting plans around the pilot projects.

Alongside these collaborations focused exclusively on green hydrogen development, multiple oil-and-gas deals concluded by Sonatrach in the past several years have included hydrogen add-ons. In 2016, Sonatrach and Eni broke ground on a 10 MW solar PV facility at Bir Rebaa North oil field in Ouargla province. In 2022, alongside a series of gas deals worth billions, the partners announced that they would explore the development of a green hydrogen facility at the site (Eni, 2022). Those plans align closely with the description of Sonatrach's second pilot project under the hydrogen roadmap, making Eni's Bir Rebaa North facility a likely implementation site. Similarly, in July 2023, TotalEnergies and Sonatrach signed a set of hydrocarbons exploration and purchase deals as well as an MOU for renewables cooperation that would "pave the way to many prospects" including "low-carbon hydrogen" (Algerie Press Service, 2023c). The initiatives often are pitched as small pilots and generally do not seek to produce in a cost-competitive manner; an analysis of Eni's plans for Bir Rebaa North found its green hydrogen would cost 11 times more than natural gas even before considering transport (Bernard, 2022). Comparable agreements have recently been discussed and/or signed with Chinese firms including Sinopec, which is active in the Algeria oil and gas sector and has held talks with Algeria about renewables in 2023 (Maghreb Emergent, 2023). During Tebboune's July 2023 visit to China, the president also signed an MOU on renewables and hydrogen (Algerie Press Service, 2023e).

In partnership with South Africa's Sasol, Sonatrach also hopes to develop the Hybla "Hydrogen Valley" project in Sicily, where both companies have large facilities (in Sonatrach's case, the Augusta refinery) (Reuters, 2023a). Under the €200mn project, the partners would produce some 7,800 tons of low-carbon hydrogen and 25,000 tons of synthesis gas annually (Africa Business+, 2023). Though outside Algeria, that proposed project could be another valuable opportunity for Sonatrach to hone its in-house hydrogen expertise.

A final project under study is the Galsi pipeline, which would link eastern Algeria to Sardinia and mainland Italy. First proposed as a gas pipeline in 2001, the project was shelved in 2008 for economic reasons after completion of feasibility studies. In December 2022, Arkab revived the idea, reimagining it as a pipeline for carrying hydrogen and ammonia. The following month, Algeria and Italy signed an agreement to officially reopen project studies (Agenzia Nova, 2023). The project would help advance Italy's new "Mattei Plan," under which it hopes to become the primary conduit for African energy imports to Europe (Reuters, 2023b). If built, the estimated \$2.5bn pipeline would enable Algeria to export up to 25MT of hydrogen annually to Europe—more than double its 2040 target. It would also establish a dedicated export link from Algeria to the South2 hydrogen corridor planned to channel North African supplies to Italy, Austria, and Germany. By building a new pipeline, Algeria would avoid risks associated with gas mixing in its existing pipelines.

### 4.3.3 Future prospects

When Algeria's energy ministry unveiled the national hydrogen roadmap in March, reactions were mixed. Multiple foreign and Algerian experts interviewed suggested that the document lacked ambition considering Algeria's huge renewable energy potential (Expert Interviews Finance 1, Policy 3). Unlike other countries in the region that appear to have embraced green hydrogen wholeheartedly, Algeria's plans are measured, and hydrocarbons remain its first priority. In developing the roadmap, it appears that Algerian renewables advocates' ambitions were tempered by skeptics wary of

Europe's precipitous embrace of hydrogen. One interviewee suggested that Algerian officials' caution was well founded and applauded what he saw as a deliberate choice to move forward more slowly than European partners wished (Expert Interview, Policy 3). In contrast, another felt that "There is a change in Sonatrach, as they look at others and see [hydrogen] is a movement they cannot miss" (Expert Interview, Finance 1). But that does not mean Algeria will pursue it at all costs.

Algeria and its principal foreign energy partner, Europe, are entering a nascent, relatively untested field replete with unanswered questions (and almost certain to disturb their existing energy relationship). Algeria—which is following the shift, not driving it—is hesitant to abandon the lucrative status quo and also afraid to overextend itself by making massive new investments alone. Algerian officials fear that further testing might reveal hydrogen use cases to be more limited or its handling to be more difficult than anticipated. That might lead European countries to scale back hydrogen import plans, perhaps in favor of longstanding proposals to link Algeria to Europe by undersea electric cables, a less technically complex option for energy export—and one that Algerian officials continue to press for in parallel (Algerie Press Service, 2023f). Or Europe could improve its capacity to produce its own green hydrogen or other renewables without reliance on external partners like Algeria.

For Europe, meanwhile, the greatest risk is a lack of political will in Algeria to join the growing wave of hydrogen development. Assisting renewables champions within Algeria's administration to demonstrate to their skeptical colleagues that green hydrogen has a place in the country's energy future is the critical task ahead. To encourage Algerian authorities to buy into the emerging hydrogen economy, European partners must take steps to build trust and resolve challenges and risks that Algeria faces. These include the challenges and risks enumerated in section 5.2 as well as several related ones.

For example, Europe has already taken steps to assuage Algerian fears that a future green hydrogen industry would not find sufficient off-takers. In 2022, the EU announced the H2Global funding instrument, which will subsidize the establishment of a robust hydrogen import market, beginning with ammonia, methanol, and sustainable aviation fuel. And in 2023, it rolled out the AggregateEU platform, which pools energy demand across EU member states and companies and will soon accommodate hydrogen purchases. In September 2023, GIZ also organized a study mission for Algerian authorities to meet prospective German off-takers and SouthH2 corridor officials face-to-face (German-Algerian Energy Partnership, 2023). And at an EU-Algeria strategic energy workshop in Algiers in June, authorities indicated that two buyers, VNG AG and German chemicals giant BASF, had already expressed interest in purchasing the entirety of Algeria's planned IMT of green hydrogen production (Sharif, 2023). More recently, Spanish Enagás has expressed interest in Algerian hydrogen (Sorge, 2023).

Similarly, European actors are helping to resolve Algerian concerns about regulation. The Fraunhofer Institute study outlines factors, including the location of renewables generation facilities and the timing of their construction and operation, that Algeria will need to consider in order to comply with the EU's emerging green hydrogen certification schemes. GIZ is also preparing a study on Algeria's existing hydrogen regulations and how to harmonize them with emerging EU regulatory frameworks.

European firms are also beginning to propose their own solutions for transporting Algerian hydrogen to the European market. If realized, industry proposals for a "European hydrogen backbone"—to include the SouthH2 corridor linking North Africa to Germany via Italy and the H2Med corridor linking Spain and southern France—would offer Algeria two possible entry points via pipeline. Reaching them will still require either repurposing an existing pipeline or building a new one. Revived plans to build the Galsi pipeline to Italy are one possibility. Sonatrach and fellow owners of the Medgaz pipeline, which links Algeria to Spain, announced last year that they would test hydrogen blending in the pipeline but have released no updates (Reed, 2022).

Europe could do more in other areas, including education and training. With strained higher education budgets and few academic or technical experts well versed in hydrogen science, Algeria is at a disadvantage in developing the human resources it will need to launch and sustain a robust hydrogen sector. It is also poorly placed to contribute to cutting-edge global research into how best to produce, transport, store, use, and safely handle hydrogen, leaving it largely dependent on external partners to make the scientific advances that will improve efficiencies and safety. GIZ and KfW are reportedly exploring the development of specialized training programs and scientific exchanges between Algeria and Germany, but partners could do much to accelerate progress in this area. A new €15mn EU-funded technical assistance project for the Algerian energy ministry, announced in October 2023, may also help fill some of these gaps (EEAS, 2023).

Perhaps most crucially, Algeria is looking to external partners to provide financing for green hydrogen infrastructure, as the national hydrogen roadmap makes clear at several points. Algerian authorities have shown unusual openness to external financing for hydrogen projects, something they often forego in other domains. Without external financing, chances are significant that a budget crunch sometime in the coming decades will give conservative forces in the energy sector a pretext for slashing hydrogen spending. The recent announcement of a \$245mn EU-sponsored green hydrogen fund in Chile confirms Algeria's belief that Europe is willing to spend substantial sums to support green hydrogen partners. It also reaffirms Algerian leaders' desire to land such a deal before shifting from the pilot testing phase to industrial-scale buildout.

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## 5 Mauritania: International coordination and hopes for local development

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### 5.1 National politics and governance of energy and relevant key sectors

Mauritania has a population of around 4 million, which is widely dispersed around the country.<sup>19</sup> The main industries in Mauritania are currently fishing (around 4-10% of GDP) and mining (around 25% of GDP in 2020) (U.S. International Trade Administration, 2022). The majority state-owned National Industrial and Mining Company (SNIM) is Africa's second-largest producer of iron ore which is exported from the port of Nouadhibou (AFDB, 2019b). Other resources include gold and copper, which are exported in concentrates by two Canadian companies, Kinross and First Quantum Minerals (Expert Interview I2). Other firms such as Aura (Australia) plan on mining uranium and are exploring critical minerals (Aura Energy, n.d.). Key challenges for the country are regional stability and security as Mauritania borders the Western Sahara and Mali. Economically, it suffers from a high dependency on commodity exports of iron, copper, and gold, which are vulnerable to price shocks (IMF, 2023b). Water scarcity is another key challenge, which is worsening with climate-change related droughts. Severe droughts in 2021 led to 20 % of the population facing food insecurity (Belgacem, 2022).

#### 5.1.1 Current energy landscape

In 2020, around 47 % of the Mauritanian population had access to electricity and 43 % had access to clean cooking technologies. Much of the country's energy needs are currently met from firewood,<sup>20</sup> driving deforestation and climate vulnerability (Tomalka et al., 2020). The government aims to achieve country-wide electricity access and 100 % clean cooking in urban areas by 2030, meeting energy demand with renewables and new natural gas resources (USAID, 2022). The Ministry of Petroleum, Mines, and Energy sets the strategic direction and regulations for electricity and resource extraction from oil and gas to mining (Ministry of Petroleum, Energy, and Mines, 2017). Key entities are publicly owned including SNIM and the national electricity company SOMELEC (Société Mauritanienne d'Electricité). SOMELEC owns and manages energy infrastructure. The only exceptions are smaller projects for rural energy access, and mining companies which power their own operations (Bordat & Curnier, 2019). The cornerstone of the current electricity strategy, co-developed with the World Bank, is to extend electricity transmission and mini-grids to more sparsely populated areas. In addition, the country hopes to reduce its energy imports of heavy oil and diesel which put a serious strain on state budgets (Expert interview Policy 1).

Mauritania's relatively small and fragile electricity grid has just under 40 % of renewables penetration. Most of this capacity is solar and wind, which is developed by foreign firms for SOMELEC such as UAE's Masdar and Germany's Siemens and funded by donors including the Arab Fund for

<sup>19</sup> Around 60% of the population live in cities; a quarter of households are nomadic (*ClimateScope Mauritania*, 2022).

<sup>20</sup> 66% of energy needs (Bordat & Curnier, 2019).

Economic and Social Development (AFESD) (Climatescope Mauritania, 2022). There have been few new investments in energy generation in the past years, and energy shortages are increasing (Expert Interview Policy 3). Outages due to technical issues are also frequent (Climatescope Mauritania, 2022). Given the challenges of managing renewable energy fluctuations, the government is planning an energy storage strategy.

Regional electricity interconnections are an important priority for policymakers, in order to support the balancing of the electricity grid and enable further integration of renewables. Planned and existing connections are primarily with Mauritania's southern neighbors, which is interesting because Mauritania often aims to cooperate more with Arab countries and withdrew from ECOWAS in 2000. Part of this is geographical, and part political. An electricity interconnection to Algeria is not seen as technically feasible because of the long distances to infrastructure. Interconnections with Morocco would have to pass through the Western Sahara, which is politically impossible. Mauritania currently imports electricity from a hydropower plant in Mali which is co-owned by the members of the Senegal River Basin Development Authority (OMVS) (Mauritanian Electricity Company, 2021). OMVS cooperation between Mauritania, Senegal, Mali, and Guinea has been ongoing since the 1970s and has weathered many political changes (Expert Interview Policy 14). Further regional interconnections are being planned with the support of the African Development Bank (AfDB), including a new power line between Mauritania and Mali (African Development Bank, 2023). Mauritania is also a member of the AfDB's Desert-to-Power initiative which seeks to link 11 Sahelian countries and install up to 10 GW of solar electricity.<sup>21</sup>

Mauritania's electricity mix may change with the exploitation of offshore gas reserves. There have been attempts at extracting fossil fuels in Mauritania in the past, such as BP's failed engagement in the Chinguetti oil field. Continued oil and gas exploration have resulted in the Grand Tortue Ahmeyim gas project, located on Mauritania and Senegal's border with the two countries sharing revenues (Offshore Technology, 2023). The project was developed for LNG exports by BP and Kosmos in cooperation with the Mauritanian and Senegalese national oil companies. The World Bank supported the Mauritanian government during negotiations and in developing a regulatory and legal framework aimed at providing local benefits (Arfaa, 2023). However, Mauritania still lacks the infrastructure to use gas resources from the GTA project to replace imported and environmentally harmful diesel in its power sector (Expert Interviews Policy 3, Industry 2). According to experts, SNIM may develop a gas-fired power plant and infrastructure to bring gas to Nouadhibou for industrial uses. BP, Shell, and other players are exploring further oil and gas deposits. Mauritania has also signed an MOU to explore gas exports via an offshore pipeline to Morocco and Europe as a part of the Nigeria-Morocco gas pipeline. However, these plans remain in an early stage and some local experts see pipelines as less desirable than shipped LNG which is more flexible (Expert Interview Industry 4). All in all, Mauritania's new gas resources were seen by some interviewees as a reason for growing international engagement with Mauritania.

### 5.1.2 New energy policy developments

Several strategies and policies are being developed together with international actors with the goal of making the energy sector attract investment. Western donors such as the AFD, World Bank, and EU have provided technical assistance and support for energy sector strategies and reforms. For example, the World Bank supported Mauritania's Gas Master Plan, while the French Development Agency (AFD) is involved in the development of Mauritania's 2050 energy strategy alongside representatives from other development banks (Ministry of Petroleum, Energy, and Mines, 2023).

<sup>21</sup> These include Burkina Faso, Ethiopia, Eritrea, Djibouti, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan and Chad. See (AFDB, 2019c).

The EU has been an important supporter of energy sector reforms, including the unbundling of SOMELEC as part of the updated Mauritanian electricity code. This change would allow independent power producers to generate electricity with SOMELEC as the single buyer (Ministry of Petroleum, Energy and Mines, 2022). SOMELEC would retain sole responsibility for electricity distribution and regional electricity interconnections for exports. As of mid-2023, the law to reform SOMELEC has been approved but the legal document developed with the support of the EU Technical Assistance Facility with details of the unbundling has not yet been released. Some experts noted that the government is proceeding carefully with liberalization due to issues with IPPs in neighboring countries (Expert Interview Policy 8). Others suggested that the agenda has been driven more by the EU and lacks real, high-level attachment. They were less optimistic that the code would be implemented and enforced, giving the private sector the certainty needed to increase investment. The lack of a truly independent regulator in Mauritania was also seen as a barrier for investment. However, some European companies have already expressed interest in renewable electricity generation once they can form IPPs (Expert Interview Policy 4).

## 5.2 National hydrogen developments

Hydrogen is seen as an opportunity for the country to increase and diversify its exports and develop new industries such as green steel. The government's goal from 2023 onwards is small-scale green hydrogen production and green steel and ammonia nitrate pilot projects. By 2030, green hydrogen production should be scaled up for export. The government has also expressed an interest in eventually switching its as-of-yet non-existent gas electricity generation to hydrogen in the longer term (MSGBC Oil, Gas & Power, 2023).

Mauritania's best potential for green hydrogen production is located near the coastline, where it has excellent wind and solar resources and seawater for desalination (Braun et al., 2023). Experts universally highlighted Mauritania's attractiveness for hydrogen production due to the quality, consistency, and complementarity of its resources. For example, possible hybrid wind and solar sites in Mauritania could have average full load hours for electrolysis of over 6,000 hours per year versus sites in Morocco with around 4,000 hours or in Algeria with less than 3,000 (Global PtX Atlas, n.d.).<sup>22</sup> Mauritania is also more attractive than neighboring countries due to its sparse population in regions with abundant wind and solar resources, making conflicts over land less likely. Compared to other countries, Mauritania's main disadvantage is its relative lack of basic infrastructure, such as roads, railways and electricity networks. If hydrogen is to be exported via ship, its port infrastructure will also require significant investment (Expert Interview Policy 5).

International developers have already expressed interest in producing hydrogen and constructing infrastructure for exports. Several projects have been announced and are at varying stages of development (see Table 1). The deals are enormous relative to Mauritania's current economy: CWP Global and BP have announced projects with investment volumes of up to \$40 billion each, totaling about four times the annual nominal GDP of Mauritania (Expert Communication Policy 6, 2023). All initiatives involve external actors: Chariot and TotalEren (US and France), CWP Global (Serbia), Conjuncta (Germany) and Infinity (JV of Abu Dhabi's Masdar and Egypt's Infinity), and BP (UK). The projects aim to start producing hydrogen or ammonia by or before 2030, but most are currently in the pre-feasibility study stage. A further project "Hydeal Africa" by Gaia Energy (Morocco) and Hydeal (Europe) aims to both produce and export hydrogen via pipeline from Mauritania and Morocco, connecting with the H2Med pipeline in Europe (Day, 2023).

<sup>22</sup> Full-load hours and seasonality for hydrogen (compressed), high temperature.

Table 3: Hydrogen Projects announced in Mauritania

Name	Location and land	Size	Actors	Finances	H2 Market	Timeline
Nour Project	Northern Mauritania, 14,440 km <sup>2</sup>	10 GW, 1.2Mt Targeted Green H <sub>2</sub> production by 2030	Chariot, TotalEnergies	Investment volume est. \$12 billion	Shipping to port of Rotterdam; potential for local use	September 2021: MOU signed May 2022: agreement with Port of Rotterdam September 2022: partnership with Total March 2023: Acquired Singaporean desalination company Eneo Water
AMAN green hydrogen project	Dakhlet Nouadhibou and Inchiri regions, 8,500 km <sup>2</sup>	30 GW wind and solar, 1.7 million tons h <sub>2</sub> or 10 million tons ammonia per year (Takouleu, 2022b)	CWP Global	\$40 billion	Export, local use	November 2021: MOU signed May 2022: Framework agreement signed
Infinity Con-juncta Project	North of Nouakchott	80 million tons of h <sub>2</sub> , electrolyzer capacity up to 10GW	Masdar, Infinity, Con-juncta	\$34 billion	Export	March 2023: MOU signed Goal of 400MW electrolyzer capacity by 2028
Nessim Project	North of Nouakchott	30 GW generating power, 2 million tons of H <sub>2</sub> /year	BP	Up to \$40 billion	Export	November 2022: MOU signed between President of Mauritania and BP executives to collaborate on R&D and large-scale hydrogen production
Arce-lorMittal-SNIM cooperation MOU	unknown	2.5 million tonnes per year of “green steel”	SNIM, Arce-lorMittal	unknown	Local use possibly 2 plants, iron pellets, reduced iron (DRI)	May 2022: MOU signed
Hydeal Africa	unknown	10 GW in Mauritania planned by Gaia (Gaia Energy, n.d.)	Hydeal, Gaia Future Energy	unknown	Export to Europe via offshore pipeline	June 2023: Project announced, goal of 1MT of hydrogen by 2030 and 5 MT by 2035 (both Morocco and Mauritania) (Energy Capital Power, 2023a);

Sources: Media reports, expert interviews and expert communications.

Although no formal hydrogen policy has yet been published, there is a hydrogen roadmap which is not yet publicly available. The roadmap defines potential pathways for Mauritania’s hydrogen economy, putting the focus squarely on green hydrogen, due to technical issues and uncertainties with carbon storage potential for blue hydrogen. While it lays out the ways that Mauritania could benefit from hydrogen developments, it also notes several obstacles including a lack of infrastructure and

skilled labor. Another important point it raises is the importance of maximizing domestic revenues, for example via long-term land leases and royalties on hydrogen produced.

The Mauritanian government is now developing a multi-year hydrogen strategy and legal and regulatory frameworks with the support of the World Bank and EU (EITI, p.3, 2023). The World Bank is conducting an infrastructure study which should identify priorities and in turn help the government make decisions on its priorities. The EU Technical Assistance Facility (TAF) is assisting with the “hydrogen code”, which will set the legal framework for hydrogen activities including revenue distribution. As of October 2023, the negotiations between the government and hydrogen developers were paused while the hydrogen code is finalized. Experts highlighted that Mauritania had been unprepared to negotiate important aspects of hydrogen development, including how revenues and responsibilities would be distributed. The Government of Mauritania has therefore also requested technical assistance in negotiations with hydrogen developers from CONNEX. CONNEX is a G7 program implemented by Germany’s GIZ that supports emerging economies in contract negotiations for mining and infrastructure. The Mauritanian government aims to at once ensure its attractiveness as an investment location for green hydrogen, while also setting up mechanisms for future revenues (Expert Interview Policy 11).

Beyond revenues, the Mauritanian government places an emphasis on projects providing local economic and development benefits. The Ministry of Energy sees hydrogen as having potential to bring down water and energy and therefore mining costs within the country (Event 1, March 2023). Different hydrogen stakeholders have expressed interest in arrangements to share electricity and water infrastructures with local users. Others suggest that developers will only sell excess electricity and water, which will be desalinated but non-potable. For such projects to enable local water access, further investments in infrastructure and water treatment by the government would be needed. Decisions on such infrastructure will likely depend on the World Bank study as well as the hydrogen code and negotiations between the government and developers.

Although hydrogen is not currently used locally, there is also the potential for it to be adopted to build local industries. Given Mauritania’s vast iron resources, the government hopes to develop a green steel industry, primarily for export to Europe. This is seen as having a higher value-added than Mauritania’s current model of exporting unprocessed raw materials. SNIM and ArcelorMittal have signed an MOU to explore using hydrogen for Direct Reduced Iron (DRI) including creating a pilot pelletization facility. According to expert interviews, this facility would initially use local water resources and move to desalination if it were to be done at a larger scale. However, SNIM is still in the first steps of exploring the potential for green hydrogen and has made no firm commitments to use it. Although it is technically under the authority of the energy ministry, experts saw SNIM as having far greater resources and bargaining power than the government. Therefore, SNIM could also decide to use Mauritania’s new gas reserves for steel processing rather than hydrogen. Beyond steel, the government also sees the potential to produce green ammonia nitrate for mining, thereby reducing imports and increasing security of supply.

## 5.2.1 Challenges for hydrogen development

### 5.2.1.1 Setting the local conditions for hydrogen production

Despite its abundant renewable resources, Mauritania faces important challenges for developing hydrogen production. These include constraints related to infrastructure, financing, local employment and the social license to operate, and environmental and governance issues. Moreover, the government may face capacity constraints in creating institutional frameworks and enforcing regulations and standards.

Many stakeholders highlighted the low levels of basic infrastructure in Mauritania as a competitive disadvantage vis-à-vis Algeria or Morocco (Expert Interviews Finance 1, Policy 5). For example, the port at Ndiago which is the center of oil and gas operations lacks basic infrastructure such as roads and electricity to link it to the capital (Energy Capital Power, 2023b). The current port and road infrastructure is insufficient for transporting machinery and heavy-duty components for industrial-scale renewable energy and hydrogen production. Exporting hydrogen and derivatives may also require the expansion of port capacity and depth renovations. The Mauritanian government has initiated a feasibility study to renovate the port at Nouakchott, to be completed by 2025. If implemented, construction could be completed by 2028-2030 (MSGBC Oil, Gas & Power, 2023). Delays in implementation would constrain Mauritania's ability to export hydrogen and secondary products. To provide water for electrolysis, infrastructure would be needed for desalination of seawater near the shore at Nouadhibou and Nouakchott as well as infrastructure to transport desalinated water inland. There is also a need to develop hydrogen storage with salt caverns being currently explored as a possibility (EIB, 2023). The question of how these needs should be prioritized, and how roles and costs can be divided between stakeholders, should be addressed by the World Bank's infrastructure gap study.

Excluding port refurbishments, and the transport of electricity and water, the Hydrogen Roadmap estimates costs of 21 billion euros to meet its 2030 production goals, and 69 billion from 2030-40. Such major projects are difficult to finance in Mauritania. This is due to the country's limited financial resources and a generally challenging investment environment because of fluctuating commodity prices and regional security issues. The government has therefore called on the international community and especially development finance institutions for further support for green hydrogen in its "Nouakchott Message" in April 2023 (Green Hydrogen Organization, 2023).

There are several issues that Mauritania will need to address for hydrogen to be socially and environmentally sustainable. First is the need for skilled workers, which is at once a challenge and an opportunity. The government puts an emphasis on projects employing locals, which will require long-term planning and investment in skilled labor. In the past, the oil and gas industry has provided job training and contracted services from Mauritanian-owned logistics companies (Expert Interview Industry 5). However, other experts noted that this practice has had only minimal community benefits, and many employees are still international. They suggested that companies should instead fund public technical schools, and then provide additional employee training upon hiring. Companies' social license to operate in Mauritania may also depend on land use (Expert interviews Policy 1, Industry 3, Policy 7). It is especially important to consider nomadic groups, who make up around 25% of households in Mauritania. While they may only use areas at certain times of year for grazing or water, their rights must nevertheless be considered (Expert interviews Industry 2, Industry 4). The relationships between different populations, local governments, and the national government require careful negotiation to avoid politically costly missteps.

When it comes to environmental sustainability, the key issue in Mauritania is water and marine life. There are already serious water shortages in Mauritania, and international actors were insistent that no project should add to Mauritania's existing freshwater stress.<sup>23</sup> This leaves desalination as the main option. However, desalination projects must consider potential impacts on marine ecosystems as the marine environment of Mauritania is one of the most biodiverse and fish-rich in the world. Approximately 30 % of Mauritania's coastline, the Banc D'Anguin, is a protected area and UNESCO world heritage site. Mauritanian waters are also crucial for the reproduction of fish that make up an important part of the region's economy. Given the importance of fishing for local livelihoods, any potential environmental impacts on marine life also have an important socio-economic dimension (Expert Interviews Policy 10, Policy 15).

<sup>23</sup> Access to potable water is 50% in rural areas, and 89% in urban areas.

### 5.2.1.2 Managing infrastructural politics and security

It remains uncertain to what extent Mauritania will be able to use hydrogen locally, as SNIM is still in the first stages of exploring green hydrogen's potential for steel. Therefore, exports of green hydrogen or green ammonia will be of key importance (Expert Interviews Industry 1, Industry 2, Finance 2). The Hydrogen Roadmap emphasizes the necessity of its hydrogen production meeting EU standards and increasing bilateral cooperation with EU countries, especially Germany and the Netherlands as major importers. This is mainly expected to be via ship, and a first partnership with a potential European buyer (the Port of Rotterdam) has been announced. Shipping is also of interest for Mauritania because it could become an important refueling station for international trade if ammonia is used as fuel (Expert Interview Finance 2).

While the idea of a Mauritania-Europe hydrogen pipeline has been floated by international actors, such projects would be geopolitically complex. Building an onshore pipeline from Mauritania via Morocco would be impossible at present because of the disputed territory in the Western Sahara and associated safety concerns. A pipeline via Algeria would be longer and therefore more costly, as well as unsafe given the security challenges from terrorism and criminal activity related to instability in Mali. However, European consortium Hydeal is lobbying for an offshore pipeline which would circumvent the Western Sahara. The project envisions Mauritania and Morocco making up a "North-western Africa" hub to export 7.5Mt to Spain via both pipeline and international shipping (EIB, 2023). Such a project would require Mauritanian cooperation with Spain and Morocco, and within-European collaboration between France and Spain. However, it remains uncertain whether Mauritania would be able to cooperate on such a large-scale infrastructure project given its delicate position within regional politics. Even an offshore pipeline which avoids Western Sahara's territorial waters could create tensions with Algeria. Mauritania would have to compensate such a move by appeasing Algeria elsewhere or risk losing its neutral position between the two regional powers (Expert Interviews Financial 2, Policy 12). A pipeline would also create additional dependence on Morocco. Given these various geopolitical concerns, shipping seems a more viable option for now.

Whether hydrogen is exported by pipeline or ship, there will be a need to monitor and address security challenges for within-country infrastructure. This includes terrorism or acts of violence and emergency security procedures. Despite regional insecurity, most experts were positive about the government's ability to maintain security and prevent terrorist attacks. Interviewees praised Mauritania's success in ensuring internal stability and cooperation on security with international partners such as the US, UK, and Europe. However, critical infrastructures such as hydrogen storage would still require security guarantees and policing by the government. In addition, interviewees and official documents highlighted the importance of establishing and enforcing safety standards on handling and storage of hydrogen. Renewable energy projects would likely also require low-level security to prevent theft.

Some of these infrastructural uncertainties should be addressed by the development of the hydrogen code and by the forthcoming World Bank infrastructure study. The government has also been seeking to create linkages with potential offtakers by pursuing bilateral and international cooperation. The next section therefore looks at how international hydrogen stakeholders are involved in Mauritanian hydrogen developments.

## 5.3 Hydrogen stakeholders and international engagement

Mauritania's Hydrogen Roadmap places an important emphasis on raising Mauritania's profile at international events and establishing international cooperation on hydrogen. Potential partners are judged by their future demand, ability to finance projects, geographic distance by maritime route, and diplomatic proximity. Europe, especially Germany and the Netherlands are seen as promising, while geographic distance makes Japan, Korea, and Singapore less likely to be trading partners.

European cooperation is seen as having potential to support local development, and partners see examples like German-Chilean Hydrogen cooperation as promising for Mauritania. A number of G7 donors support hydrogen development in Mauritania, including the EU, its member states, and development banks.

### International development banks

The World Bank has increased its focus in Mauritania on energy in the past years. It has supported the development and implementation of the Mauritanian electrification strategy. The World Bank has also supported negotiations related to the Grand Tortue Ahmeyim gas project, and Mauritania's implementation of the Extractive Industries Transparency Initiative (Larsen, 2022). As of October 2023, the World Bank was providing technical assistance to the Government of Mauritania for a study of infrastructural requirements for hydrogen production and transmission. This study should help form the basis of negotiation on infrastructural developments between the government and developers (see section above, Addressing Hydrogen Challenges).

The African Development Bank is an important development partner in Mauritania with a portfolio of \$140 million. This includes investments in interconnections with Mali and the Desert-to-Power initiative which promotes Sahelian solar electrification and interconnection (African Development Bank, 2023). These major interconnection projects were seen as an important priority by local energy actors, and it was suggested that they would create the potential for eventual hydrogen developments. Experts from the bank are involved in strategic discussions on hydrogen with government and other partners such as the World Bank and AFD. Other development banks such as Islamic Development Bank and AFSED are major development funders and sometimes fund energy projects. However they are not active in hydrogen and tend to provide funding rather than influencing policy via technical assistance (Expert interviews Policy 1, Policy 3).

### Germany & German actors

Germany is seen in Mauritania as an important hydrogen importer, and the government is eager to increase cooperation. Currently, several German institutions are present in Mauritania and are beginning to become involved in hydrogen and related topics. Germany funds the G7 CONNEX Initiative, which is implemented by GIZ and supports the Mauritanian government in its negotiations with hydrogen developers. CONNEX has provided financial, geo/environmental engineering and legal expertise for negotiations with CWP and Chariot since 2022. Following a request by the Government of Mauritania to extend this support to negotiations with BP and the Conjuncta consortium, Connex may also provide support to these projects as of July 2023. This support is likely to continue into 2024. Local actors reported that this negotiation support is well-perceived and that Germany is thereby also seen positively (Expert interview Policy 7). The GIZ also provides technical assistance for the mining sector, including trainings and projects to promote local employment. These could potentially be expanded to promote skill development in the renewable energy and hydrogen sector. German firm Conjuncta is a member of a consortium which is developing a major hydrogen project with the goal of exporting hydrogen to Europe. While the German Federal Ministry for Education and Research also funds ECOWAS hydrogen activities, Mauritania is not involved in this initiative.

### France & French actors

Mauritania was characterized by some experts as relatively open to cooperation with France compared to others in the region. The French development bank AFD is highly active in Mauritania on energy topics. Unlike the World Bank, the AFD does not fund projects in oil, gas or mining. The AFD's three main energy topics are access to services, efficiency and resilience, and decarbonization. It coordinates closely with different development banks and actors through quarterly meetings to discuss energy projects and challenges, including hydrogen. The AFD and EU have cooperated on SOMELEC's restructuring including reforms to the electricity code and the integration of renewables. So far, hydrogen-specific cooperation has been relatively limited. The AFD has focused on providing the Mauritanian government with technical assistance and information to which can be used for contract negotiations. This includes support for the creation of a land registry to identify

available spaces for renewable energy generation with IFPEN (formerly the French Institute of Petroleum). French firm Total which has been involved in oil and gas exploration in the past is now developing a major hydrogen project with Chariot.

### The European Union & EU institutions

The EU has been involved in energy in Mauritania via its Technical Assistance Facility (TAF) and the European Investment Bank (EIB). On the ground, the EU External Action Service (EEAS) has been working closely with the TAF and other development banks such as the EIB, AFD, World Bank and African Development Bank on energy issues including hydrogen. As part of EU-Mauritanian energy cooperation, the TAF has supported electricity market reforms and is now funding legal and technical assistance for the hydrogen code. The EIB has increased its presence in Mauritania and engages with the Mauritanian government in coordination with the EU delegation and TAF on hydrogen policy. The EIB also supports private sector companies, mainly from the EU, and participates in events (including those arranged by the World Bank) to meet and coordinate with public and private sector stakeholders. In June 2022, the EIB and Mauritanian President Ghazouani signed a joint declaration with the intent to cooperate on renewable energy and green hydrogen as part of the EU's Global Gateway project. In the same month, the EU launched a new €13.25 million initiative with Mauritania on "Affordable access to clean, renewable electricity" as part of its Global Gateway strategy (European Commission, 2023a).

The EU is now expanding its role coordinating member state and EIB action through the Global Gateway initiative. In late October 2023 it announced the launch of a Team Europe initiative focused on developing green hydrogen in Mauritania, with the explicit purpose "to support investment in the energy transition and decarbonisation of Mauritania's economy, by developing its green hydrogen industries" (European Commission, 2023b). The initiative is backed by the EC, France, Germany, Spain, and the EIB.

### Other EU member states

Spain is more closely geographically linked than other European countries to Mauritania via the Western Sahara and Morocco. This makes Spain an important destination for Mauritanian exports, and Mauritania an important partner for Spain on migration and security. The Spanish Agency for International Development Cooperation provides funding and support for development initiatives including food security and agriculture. However it is relatively less engaged than other international actors on energy issues in Mauritania, with the exception of its participation in the aforementioned Team Europe green hydrogen initiative. Given that Spain would be an important partner if Mauritania were to export its hydrogen via offshore pipeline, this appears to be a rather long-term vision at best.

Although the Mauritanian hydrogen roadmap targeted cooperation with the Netherlands, the Dutch government is currently scaling down its operations in Mauritania and does not appear to be highly involved in energy topics (Pleek & Gavvas, 2022). However, Dutch companies have expressed an interest in importing Mauritanian hydrogen, as the Port of Rotterdam signed an MOU with Chariot in 2022.

### The G7, China and Russia

While the UK has a smaller staff than other local delegations and a limited aid budget in Mauritania, it is nevertheless seen as an important cooperation partner for security (Expert interviews Industry 2, Industry 7, Industry 13). The UK's engagement in Mauritania has increased since BP's involvement in gas extraction, and it is also involved in discussions on energy and hydrogen. The US has publicly announced further energy cooperation with Mauritania on energy access (U.S. Embassy Mauritania, 2022), and US diplomats are increasingly involved in Mauritanian energy issues. American counterparts are involved in meetings on energy and hydrogen with development banks. For both the US and the UK, energy is an important area to promote Mauritanian development and promote close ties between Mauritania and the G7. This is strategically important for the G7 as China and Russia are seen as attempting to expand their roles in the region. China has not yet been involved in energy in

Mauritania but plays a crucial role in development finance and has increased its diplomatic efforts in recent years (Expert Interviews Policy 1, Policy 12, Policy 13). Russia has also increased diplomatic efforts in Mauritania, as for example in February 2023 when Russian minister of foreign affairs Lavrov visited the country to offer support on security issues in the Sahel. However, some interviewees saw Mauritians as skeptical of Russian overtures due to the Wagner Group's role in Mali. They characterized Mauritania as interested in economic cooperation with China, while focused on maintaining close relations with NATO and Europe.

### **African Green Hydrogen Alliance and ECOWAS**

Mauritania is also involved in emerging collaboration with other regional hydrogen frontrunners via the Africa Green Hydrogen Alliance. The alliance was established in May 2022 and includes Egypt, Kenya, Mauritania, Morocco, Namibia, and South Africa (Owen-Burge, 2022). It serves as a convener for member countries and actors from finance, the private sector, and civil society. Mauritanian representatives from the energy ministry are highly active within the group and participate in discussions around hydrogen standards. While Mauritania has also signed a cooperation agreement with ECOWAS, it does not appear to be participating in the ECOWAS green hydrogen program funded by Germany's Ministry of Education (ECREEE, 2023).

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## 6 Regional green hydrogen politics and their implications for cooperation

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International engagement will be required for the development of international hydrogen supply chains. Europe, and European member states that aim to import hydrogen, have increasingly focused on North Africa for their imports. At the same time, potential exporting countries have demonstrated their interest in European cooperation on hydrogen. International partners should be aware of emerging challenges including social and environmental sustainability, and regional politics. A careful negotiation of the relationships between Europe, Morocco, Algeria and Mauritania is needed to ensure energy security and regional stability.

### 6.1 Cross-cutting hydrogen challenges for national hydrogen development

Morocco, Algeria, and Mauritania have a high potential to produce green hydrogen and are engaging with international partners to develop hydrogen value chains. They face similar interconnected challenges shared by many countries looking to export hydrogen: ensuring sustainable local development, finding hydrogen offtakers, and developing export infrastructure.

Governments see hydrogen projects as promising for local jobs and value creation. This focus on social benefits is particularly strong in Morocco and Mauritania, which have a more limited public budgets than Algeria. However, there may be risks of promising long-term and well-paid jobs if these are not delivered. As Morocco's experience with the Noor CSP plant shows, many jobs are in temporary construction, which raises the potential for local backlash. For some interviewees, Noor is also a cautionary tale of government taking on debt to external actors for technologically unproven solutions. Others have highlighted the importance of considering land and water rights. In some cases, governments have sold collectively-owned land without redistributing revenues directly to locals, who lost access to water and pastureland. Even if, as was the case with Noor, the government is legally entitled to sell land to developers, international investors and project partners may find themselves facing damaging accusations of land-grabbing.

Hydrogen plants are also water-intensive, and Mauritania, Algeria, and Morocco all face differing degrees of water scarcity. Water access problems persist in poorer rural areas in all three countries. European partners have highlighted that hydrogen exports must not take away water that would be used for human consumption. This will necessitate large-scale desalination powered by renewable electricity to avoid the growth of CO<sub>2</sub> emissions. In addition, governments and firms must ensure that waste from desalination does not pollute local marine ecosystems. This is important for all three countries where many livelihoods depend on fishing, especially for Mauritania which has few other industries. In addition, Mauritania's protected marine areas are crucial for regional biodiversity – so any impacts of desalination on local marine life could have ripple effects for its neighbours. There is therefore a need to carefully assess environmental impacts before projects and during operation. In some cases this may be difficult, as environmental ministries are often weaker than the interests of business.

A further challenge for hydrogen development is identifying offtakers to improve certainty and reduce financial risks. While the potential for local offtake is uncertain, these buyers would mostly be made up of politically powerful state-owned entities (SOEs). These include Morocco's OCP, Algeria's Sonatrach, and Mauritania's SNIM. In most cases, it is not the ministries but the SOEs themselves that will set hydrogen strategies based on their own long-term objectives and cost assessments. High-level interest from influential players, such as the Moroccan king in OCP's case, could present exceptions. OCP may also be motivated by its reliance on ammonia imports, unlike SOEs in Algeria and (potentially) Mauritania which have access to low-cost gas.

To export hydrogen to Europe, all three countries will need to upgrade existing infrastructure. Algeria is well-positioned, with an existing gas pipeline to Italy that is not currently being used at full capacity but is still exploring construction of a dedicated pipeline. So long as Algeria refuses to resume gas provision to Morocco, the latter may need its pipeline to Spain for importing increasing volumes of gas to meet projected demand. In the short- to medium-term, trade-offs therefore look likely between Morocco's gas imports and hydrogen exports via pipeline. In the longer-term, hydrogen exports will be contingent on planned expansions of gas supply and import infrastructure or the replacement of fossil gas imports by local energy resources by the time hydrogen exports ramp up. For Mauritania, export infrastructure is a highly geopolitical question (see next section). The preferred short-term solution would be shipped exports rather than pipelines. There are also remaining uncertainties about intra-EU hydrogen infrastructure and the degree of interest from some transit countries like France and Spain in piped hydrogen.

## 6.2 Regional dynamics and challenges for cooperation

There is relatively little cooperation between the three countries on hydrogen development. This is due in part to regional politics including Morocco-Algerian competition and the Western Sahara issue.

Both Morocco and Algeria wish to become hydrogen frontrunners and see the other as a rival – perhaps motivating more ambitious action. This may help Algeria, which is a relative latecomer to renewable energy, to gain ground. Morocco and Algeria are both engaged in research and development cooperation initiatives with (largely European) public and private international actors on energy and draw on their existing relationships to accrue knowledge. For Algeria, this primarily means oil and gas companies with whom Sonatrach has existing relationships. For Morocco this is related to both its fertilizer industry and fossil fuel partners, as well renewable energy research partnerships with European public institutions.

While seeing limited prospects for collaboration with its North African neighbours today, Morocco has embraced broader partnerships as a means of asserting its dominance in renewables, aiming to position itself as a leader among hydrogen exporters. Its strategic partnership with IRENA on green hydrogen, signed in 2021, collaboration with the EU, and a key role in establishing the African Green Hydrogen Alliance (AGHA) all contribute to this goal. The AGHA initiative provides a platform to coordinate on best practices with other energy ministries and holds the potential for Morocco to strengthen its links with Mauritania. In contrast, Algeria has not sought such a role for itself, reflecting its attachment to oil and gas and correspondingly tepid outlook toward renewables.

Prospects for cooperation with countries to the South to spur hydrogen development currently appear limited. Although there have been initiatives for hydrogen collaboration in ECOWAS, the series of 2023 coups is likely to set these projects back. In addition, political obstacles prevent Morocco and Mauritania from collaborating via this bloc, while Algeria is not involved at all. Morocco's membership application to ECOWAS has been stalled due to opposition from countries that are concerned about changes to the balance of power and markets being flooded with cheaper Moroccan products. Mauritania left ECOWAS in 2000 and remains focused on "Arabization". So far, Mauritania's

interest in energy cooperation with Senegal, Mali and other Sahel countries is limited to gas and electricity and does not extend to hydrogen.

The degree to which Mauritania may collaborate with Morocco and Algeria on hydrogen depends on regional politics and security. Mauritania has strong economic links with Morocco as well as security ties with Algeria, aiming to maintain a neutral balance between the two countries. Hence, it is unwilling to engage in energy projects that would pass through the Western Sahara, such as an electricity interconnection or onshore hydrogen pipeline with Morocco. Any such project would have destabilizing effects on the region's delicate political balance and likely also become a target for attacks in the context of the Western Sahara conflict. A hydrogen pipeline through Algeria is seen as too costly due to the longer distance and security concerns linked to the conflict in Mali. An offshore pipeline that bypasses any disputed areas would be the only alternative. However, this possibility would create an additional dependency on Morocco and could still be considered politically sensitive. If Algeria sees Mauritania as increasing its cooperation with Morocco too strongly, Mauritania would likely need to grant other concessions to Algeria. Shipping may be the most secure option for Mauritania and carry the least geopolitical risk.

### 6.3 International engagement in Algeria, Morocco, and Mauritania

Morocco, Mauritania and Algeria differ in their approach to international partnerships due to existing relationships, resources and self-understanding.

In Mauritania, energy and hydrogen policy are developed in close cooperation between the government and international development partners. This international engagement reflects the need for technical support and financing from the Mauritanian government, as well as its interest in developing high-value activities and close cooperation with Europe and the G7. There are economic and security interests from the G7 and European partners to pushing local hydrogen projects. Both international and local partners expressed the hope that hydrogen could provide economic development and investment that are needed for Mauritania to maintain social and political stability within the volatile Sahel region. The greater US and UK presence in Mauritania than in Morocco and Algeria may reflect these security interests. In addition, European and G7 firms are the primary developers of hydrogen projects, and Germany is expected to be the main offtaker of Mauritanian hydrogen.

Despite its close ties with Europe, Morocco appears to be seeking international investment while reducing external involvement in its policy development. To date, international partners have played an important role, especially Germany through its energy partnership. Of the three cases, Morocco has the highest degree of involvement from actors outside the EU, including China and Saudi Arabia. At the same time, the Kingdom's "Offre Maroc" for hydrogen is being developed without external foreign actors such as development agencies or consultancies. Some experts have related this to the increasing ideological importance placed on Moroccan sovereignty and autonomy. This reluctance to involve international actors may also be due to the experience of the Noor CSP plant and the resulting indebtedness to international investors, which is seen critically. Trust-building will be necessary, given sensitivities to neo-colonialism and the perception that hydrogen development could detract from Morocco's ability to meet its own energy needs – factors that some European actors are aware of and weighing carefully. In addition, the kingdom has recently granted developers land to explore green hydrogen in the Western Sahara, which could complicate relations with some international partners.

In Algeria, the government is tightly intertwined with the fossil fuel industry and concerned with maintaining its sovereignty. It has historically opposed foreign ties that it perceives as potentially constraining its choices, including external financing or independent power production. Algerian interest in green hydrogen has been driven by Germany's and Europe's interest in imports and more recently by the potential to decarbonize exports to the EU and thus avoid future penalties under

CBAM. Another driver is the concern that regional rivals might surpass Algeria in hydrogen development, weakening its status as a regional energy leader. Sonatrach, which would also be the main local hydrogen offtaker, is expanding existing fossil collaborations with Eni, TotalEnergies, and other partners to include hydrogen. These discussions sometimes enable bilateral developments, such as Algerian-Italian discussions of a new pipeline for hydrogen export to Europe. China could become an important partner in the future, as Sinopec is active in Algeria and has discussed renewables with Sonatrach. Few external actors are involved in policy processes except for the GIZ, reflecting Germany's strong role in driving developments in Algeria.

Across these cases, Germany is an important player. The GIZ is working in Morocco and Algeria through its existing energy partnerships and is expanding its engagement to Mauritania via the CONNEX initiative. The depth of German engagement seems highest in Morocco, perhaps due to the historical bilateral cooperation on renewables between the countries. There are multiple platforms for business and technical exchange, and the provision of studies has influenced Morocco's policy trajectory. In addition, Germany has provided grant funding for a hydrogen production pilot and is promoting research collaboration. Similar measures are under discussion with Algeria. German involvement is lower in Mauritania, where international actors have largely focused on technical assistance. Algeria's involvement with Italy appears to be growing, pushed by Sonatrach and Eni's close collaboration. In Mauritania, the EU appears to be a very important influence and is directly involved in policymaking alongside development partners and banks. In contrast, Moroccan and Algerian high-level strategies are ostensibly being developed without the input of external actors, in keeping with Algeria's emphasis on sovereignty and Morocco's self-perception as an important regional player. However, both countries are still very interested in the priorities and standards of likely offtakers in Europe.

While international hydrogen developers operate across the region, their role and relations with local firms differ between countries. Hydrocarbon firms appear to be branching out into green hydrogen in both Mauritania and Algeria. In Algeria this is done on Sonatrach's terms and any involvement in Algerian green hydrogen will need to be negotiated directly with SOEs. In Mauritania, developers have not created partnerships with local firms. Instead, they have moved to secure agreements with the government for access to areas with excellent geographic potential. Morocco bears similarities to Algeria in that more local actors are involved in hydrogen developments alongside international partners. Morocco's experience in renewables and the potential for OCP to act as a hydrogen offtaker appear to have enabled the development of joint ventures and pilot projects.

## 6.4 Prospects for future cooperation

If North African countries are able to overcome the difficulties of funding hydrogen projects and finding offtakers, there will still be political challenges for hydrogen developments. Partners may be confronted with complicated regional politics, environmental and social sustainability, and governance issues. If European partners are to support hydrogen developments and trade with North Africa, these need to be approached carefully.

European hydrogen imports and the form they take could have geopolitical implications for regional relationships between North African countries. European governments and government-funded institutions will continue to avoid developing hydrogen projects in the Western Sahara so long as the region's status remains disputed. However, Morocco is likely to continue pushing firms to operate there in order to legitimize its claims over the territory while capitalizing on its high renewables potential. Even projects that are not located directly in the Western Sahara but are seen as supporting Morocco's status in the region, such as the Hydeal consortium's proposed offshore hydrogen pipeline connecting Mauritania to Morocco and Spain, are sensitive. Such a project risks upsetting Mauritania's delicate balancing act between its larger neighbours.

A further challenge for international partners is to ensure environmentally and socially sustainable hydrogen imports. In Morocco, social tensions have emerged from mega-projects that reduced local communities' access to land and water and failed to deliver on promises of sustainable local job creation. Algeria will also need to ensure social sustainability due to its water stress, an issue that previously caused social unrest in the context of proposed shale gas projects that were perceived to threaten local water supplies. Given its lower level of development compared to Morocco and Algeria, local benefits are particularly important for Mauritania, which hopes to leverage hydrogen projects to improve its infrastructure and access to water and electricity. To ensure that these local benefits are delivered, ministries need technical assistance and support to negotiate with developers. The impacts of large-scale desalination also need to be carefully assessed and monitored, given the critical place of fishing in the economy of Mauritania and its neighbours. International partners need to be all the more attentive to such impacts given Mauritania's limited domestic capacities to mitigate environmental damage.

An interconnected issue is that the main cooperation partners for hydrogen developments are national governments and their SOEs. This means that populations are likely to view the state as being responsible for any social and environmental harms caused by hydrogen projects, raising a possibility of political unrest. Governments that offer land to hydrogen developers may be within their legal rights but could nonetheless face popular backlash if they fail to involve local communities in decision-making or fairly compensate them. Moroccan civil society has already begun advocating for avoiding massive land acquisition, but centralized governance structures in all three countries offer limited openings for genuine popular participation in such decisions. European partners could find themselves implicated by association in land-grabbing, impacting their international reputations and potentially triggering legal problems back home. In addition, European companies are increasingly subject to policies and laws that require disclosure of their environmental and social impacts. For example, Germany's supply chain act and the EU's Corporate Sustainability and Due Diligence Directive could require hydrogen producers to monitor and report on project impacts. Disclosures would then be independently audited or certified. SOEs like OCP and Sonatrach do not often disclose information on local impacts or finances, but collaborating with European partners subject to such regulations could compel them to do so. This could generate substantial friction between international partners and potentially generate domestic backlash if disclosure reveals negative impacts.

If these issues are taken into account, hydrogen development could offer potential for EU-North Africa cooperation. European partners are building on existing cooperation with Morocco and Algeria to expand into hydrogen. Algeria has signalled its openness in pursuing joint projects with European states and firms. For Europe and the US, which are keen to see Algeria expand its cooperation with the West, this could be a promising avenue for collaboration. Morocco's aims to position itself as a regional leader and develop local manufacturing can be supported by European investment and scientific cooperation. Given that some countries wish to diversify supply chains, Morocco could be an important partner for green technology component trade. Mauritania's hydrogen potential has piqued international interest, which if well-governed could deliver economic development and the provision of energy and water for its population. Europe and the G7 can build on their strong relationships with Mauritania by providing material support for Mauritania's infrastructural development such as roads, power lines, and ports. This would help to address Mauritania's primary roadblock for hydrogen development, while promoting broader economic advancement. This could help strengthen Mauritania's role as an "island of stability" in the Sahel. Currently China provides many such major infrastructure investments. Therefore, further European investment could continue to encourage Mauritanian interest in strengthening Western cooperation.

## 7 Annex

### Morocco sources

Type	Expertise, Interview Month
Interview	Policy 1, June 2023
Interview	Policy 2, June 2023
Interview	Policy 3, June 2023
Interview	Policy 4, July 2023
Interview	Policy 4, July 2023
Interview	Finance 1, July 2023
Interview	Finance 2, July 2023

### Algeria sources

Type	Expertise, Interview Month
Interview	Industry 1, July 2023
Interview	Finance 1, July 2023
Interview	Policy 1, July 2023
Interview	Policy 2, July 2023
Interview	Policy 3, July 2023
Interview	Policy 4, July 2023
Event	E1: Workshop with experts on policy, industry and finance, May 2023

### Mauritania sources

Type	ID#, Expertise, Interview Month
Interview	F1: Financial, June 2023
Interview	F2: Financial, July 2023
Interview	I1: Industry, May 2023
Interview	I2: Industry, June 2023
Interview	I3: Industry, August 2023
Interview	I4: Industry, September 2023
Interview	I5: Industry, September 2023
Interview	I6: Industry, September 2023
Interview	I7: Industry, September 2023
Interview	I8: Industry, September 2023
Interview	P1: Policy, July 2023
Interview	P2: Policy, July 2023
Interview	P3: Policy, July 2023
Interview	P4: Policy, July 2023
Interview	P5: Policy, July 2023
Expert communication	P6: Policy, August 2023
Interview	P7: Policy, September 2023
Interview	P8: Policy, September 2023
Interview	P9: Policy, September 2023
Interview	P10: Policy, September 2023
Interview	P11: Policy, September 2023

Interview	P12: Policy, September 2023
Interview	P13: Policy, September 2023
Interview	P14: Policy, September 2023
Interview	P15: Policy, September 2023
Interview	P16: Policy, September 2023
Interview	P17: Policy, October 2023
Interview	I9: Industry, October 2023
Event	E1: Closed-door workshop with experts on policy, industry, and finance, March 2023
Event	E2: Closed-door workshop with experts on policy, industry, and finance, September 2023

Annex -Figure 1: Moroccan administrative regions, CIA World Factbook 2021. Guelmim-Oued Noun and Laâyoune-Sakia El Hamra lie partially in Western Sahara, and Dakhla-Oued Ed-Dahab lies fully in Western Sahara.



Note: The planned volume of the three hydrogen projects in the area of Laâyoune Sakia El Hamra is 345,681 hectares. It is theoretically possible that all projects are within non-disputed areas, but this would entail just under half the area of Laâyoune Sakia El Hamra which is north of the Western Sahara dividing line. These calculations are estimated as follows. The area of Laâyoune Sakia El Hamra located north of the Western Sahara border as it appears on maps is approximately 7537 km<sup>2</sup>. This excludes Khenifiss National Park because this delineation was clearly visible on the map. It does not exclude land used for other purposes such as roads, human settlements, or other industry. The estimation can be recreated with the following link: <https://rb.gy/uw4px>

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## 8 Literature

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## RIFS STUDY

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