Clean Molecules across the Mediterranean

The Potential for North African Hydrogen Imports into Italy and the EU

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IAI

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Foreword

Climate change is the existential challenge of our generation. Scientists have been warning of the risks of global warming for decades, and in recent years politicians and the public have begun to grasp the seriousness and urgency of the problem. Even more, the COVID-19 pandemic has underlined the need to rethink our world in a sustainable way, showing us what we can achieve when we act collectively.

But our efforts on climate change are still off-track. To avoid irreversible repercussions, the consensus is that we should try to contain global warming below 2°C, and ideally below 1.5°C. However, 2020 was the second warmest year on record and with economic activity expected to resume after the current pandemic we will not be able to achieve the target on time if carbon emissions are not reduced. This would have disastrous consequences for our planet. To stay within budget, we need our net carbon emissions to fall to zero by 2050.

This implies a revolution in the way we produce and use energy. It means decarbonising the way we generate electricity, changing our vehicles, modifying materials and the industrial processes we use to make them, and perhaps most challenging of all, heating our homes without fossil fuels. And it means transforming the system at a time when energy demand is accelerating.

Of course, the challenge is not small. Current obstacles to the green transition range from the dependency on intermittent renewables to increasingly fragmented energy systems. But in this evolving scenario, the unprecedented momentum of hydrogen suggests that this green gas could be the solution to empower the energy transition and become the next pillar of a global climate strategy.

Like an internet of energy, hydrogen can connect all the segments of economy and society to trigger competition and innovation across sectors and geographies, making energy more affordable, available and abundant for a growing population. Its ability to penetrate hard-to-abate sectors and its industrial applications could also allow it to coexist with our renewables in the energy spectrum, helping us achieve deep decarbonisation.

And the stars are aligning. Political support for hydrogen is building. Goldman Sachs and Bank of America predict investments of more than 10 trillion US dollars in hydrogen by 2050. A significant part of the post-pandemic recovery funds at an EU level are being directed to the development of green hydrogen, increasingly identified as the solution to decarbonising Europe. Technology is also on our side, and the falling costs of renewables – necessary to produce green hydrogen – are making it more and more cost competitive. Companies too are starting to prepare for the use of hydrogen, which would make large electrolysis capacity possible. In five years, hydrogen should be as cheap as diesel in certain applications.

Hydrogen could thus be at the heart of efforts to ensure a greener future. And it would do so by simultaneously encouraging cross-country cooperation, acting as a pacifier and easing geopolitical tensions, and transforming dependence into interdependence. As the report reveals, from North Africa through Italy to the European Union, hydrogen could increase overall energy interdependence, uniting nations and mitigating the impact of the fossil fuel phase-out. And in doing so, not only would it provide a cheaper clean energy source to European consuming countries, but also help to promote new jobs and development in producer countries in Northern Africa, where green hydrogen can easily be created through solar power. In fact, according to a Bloomberg New Energy Finance estimate, transport via pipeline from North Africa through Italy could be the cheapest way for Germany to get green hydrogen in 2050.

But of course, revolutions don’t start themselves and to allow hydrogen to fulfil its potential, a “coalition of the willing” is necessary, spanning from national governments to international organisations and all the way to the world of business, to push ambitious policies and provide a just transition, minimising costs and building a global hydrogen economy.

As a world leading energy infrastructure company, we are fully committed to advancing this transition. With a transport network of over 41,000 km, our pipelines across Europe, which are interconnected to North Africa, could be used to connect this new green energy system. Indeed, we have already started testing the application of hydrogen blends into the energy mix transported in our network, and half of our planned investments are aimed at making our infrastructure hydrogen-ready. We are also partnering with other leading companies worldwide to accelerate the goal of achieving fossil fuel parity. All we need is to build scale.

As we search for a solution to climate change that can be reconciled with more sustainable growth and the reduction of inequalities, hydrogen could lead the way. The most abundant element on the planet, easy to store and carry, hydrogen could be the missing link to decarbonise the energy system and reconnect the world.

Marco Alverà, Chief Executive Officer (CEO) – Snam SpA

Introduction

North African renewable energy resources have an important role to play in enabling the European Union and Italy to reach their ambitious decarbonisation targets, especially the commitment to climate neutrality by 2050. It is becoming increasingly clear that this target cannot be met with electrification alone and that a number of factors will limit local renewable energy production within the EU. Also, cost savings could be achieved by producing at least part of the EU's future renewable energy needs in high-yield regions outside of the EU. Hydrogen is the most promising vector for allowing North Africa's largely untapped renewable energy potential to contribute to EU climate targets. Within the EU, Italy is set to play a particularly important function as both a gateway and a catalyst for North African hydrogen exports. Italy has a lot to offer to North African countries that are interested in developing hydrogen trade and could in turn greatly profit from it.

This study by the Istituto Affari Internazionali (IAI) takes stock of the current initiatives promoting North African–EU hydrogen trade; explains how these plans can be advantageous for the EU and for Italy in particular; and investigates why Italy is a key country for North African hydrogen export schemes, discussing the enabling factors that create prospects for a long-lasting Italy–North Africa hydrogen partnership.

The analysis will be conducted from the perspective of EU decarbonisation plans as a point of departure, but a feature of this study is that it strives to identify mutual benefits for North Africa on the one hand and the EU and Italy on the other hand. In fact, North Africa stands to benefit from hydrogen both as a source of revenues and as an instrument of industrialisation and local economic development. The study takes into account social, political, foreign policy and economic enabling factors and outlines the potential social, political, foreign policy and economic benefits that could result from prospective North Africa–EU hydrogen trade.

This paper is a first attempt to provide an overview of prospects for North African hydrogen imports into Italy. It follows a number of calls to explore the subject. The September 2020 European House–Ambrosetti study for Snam

"H2 Italy 2050", for instance, highlights the opportunity for Italy to become an infrastructural bridge for North African hydrogen.[1] According to public information so far available, the upcoming Italian National Hydrogen Strategy is also expected to place emphasis on the potential role of Italy as a hydrogen hub also thanks to North African hydrogen trade.[2]

1. Harnessing North Africa's renewable energy potential: Evolving narratives

1.1 Challenges to renewable energy exports through electricity

The notion of harnessing North Africa's low-cost renewable energy potential to facilitate decarbonisation in the EU has been supported by both experts and policy-makers for the last two decades. Namely, it was strongly embraced by the Desertec project conceived in 2003 and by the Desertec Industrial Initiative (DII) launched in 2009. The original scheme revolved around the idea of exporting electricity produced from concentrated solar power (CSP), photovoltaic (PV) systems and wind parks in high-potential regions located at the margins of the Sahara Desert to the EU through high-voltage direct current transmission cables.

Most of the hurdles highlighted by sceptics – such as water requirements for dust removal from solar panels and for cooling turbines; geopolitical obstacles to cooperation in the region; concerns on European import dependency lock-in; the ethical and socio-political challenges posed by what was criticised as an "extractive" mindset; and risks associated with red tape[3] – are either partly overstated or at least solvable.

1 The European House - Ambrosetti, *H2 Italy 2050. Una filiera nazionale dell'idrogeno per la crescita e la decarbonizzazione dell'Italia*, September 2020, https://www.ambrosetti.eu/?p=76204.

2 Italian Ministry of Economic Development, *Strategia nazionale idrogeno. Linee guida preliminari*, November 2020, https://www.mise.gov.it/images/stories/documenti/Strategia_Nazionale_Idrogeno_Linee_guida_preliminari_nov20.pdf.

3 Thomas M. Schmitt, "(Why) Did Desertec Fail? An Interim Analysis of a Large-Scale Renewable Energy Infrastructure Project from a Social Studies of Technology Perspective", in *Local Environment*, Vol. 23, No. 7 (2018), p. 747-776.

The most important limitation to Desertec plans was the cost inefficiency of transporting renewable energy in the form of electricity, particularly when compared with the possibility of generating renewable electricity locally in the EU (when plenty of space was at the time still available for installing onshore wind turbines and solar plants). After almost 20 years since its inception, the original concept has so far failed to lead to massive exports of renewable electricity from North Africa to the EU. Siemens and Bosch first shook the project's pillars by pulling out of DII in 2012. Most of the founding companies have since left the consortium.

The construction of greenfield transmission lines across the Mediterranean was and remains expensive also because of remarkable water depths. An even bigger obstacle was the fact that in the early 2010s Southern EU countries like Spain were facing the challenge of excess renewable energy generation in relation to their electric system capacity.[4] Limited electricity transportation capacity from Southern EU countries to Central and Northern Europe was an additional hurdle, hampering plans to bring a stable supply of solar electricity where it was most needed (i.e., in the less irradiated regions of the EU) and aggravating local problems of excess RES generation.[5] Another important development that deteriorated the economic case for North African electricity exports was the collapse in EU power prices induced by the massive influx of zero-marginal cost RES (and compounded by low or negative GDP growth in those years).

Ambitions of harnessing North Africa's renewable energy potential were gradually scaled down in the second half of the 2010s, with a greater focus on the fulfilment of (fast-growing) local energy demand in North Africa through RES. The Moroccan government attracted funding from international investors to develop Noor, the world's largest CSP plant located in Ouarzazate (which also includes PV modules). The story of Noor is illustrative of the process whereby projects that were originally envisioned as export ventures were converted to schemes to increase local clean energy supply because of high electricity

4 Selwa Calderbank, "Desertec Abandons Sahara Solar Power Export Dream", in *Euractiv*, 31 May 2013, https://www.euractiv.com/?p=831687.

5 Ibid.

transportation costs. To date, only two 700-megawatt (MW) undersea cables connect Spain and Morocco,[6] while a third cable is under construction. This represents a fraction of the amount of energy that can be produced in Ouarzazate and a fraction of the amount of energy currently carried from North Africa to the EU as natural gas (see Section 3).

Indeed, plans for exporting electricity from North Africa to the EU have not been completely shelved. There is still room for some renewable electricity exports from North Africa to the southernmost regions of the EU – with local benefits in terms of decarbonisation, employment and socio-economic development. While renewable energy projects have continued to be implemented in North Africa, they only entail residual exports to the EU. Current and planned electricity exports are small if compared to the original ambition of bringing 100GW of North African energy to the EU by 2050 at a cost of 400 billion euro.[7]

A project that remains on the table is TuNur, revolving around the concept of exporting solar electricity generated in Tunisia to the EU. In April 2019, Italy and Tunisia signed an intergovernmental agreement to jointly build a 600-MW cable between Partanna and El Haouaria, called Elmed.[8] This is certainly a positive step towards EU–North Africa electricity grid integration. The project is financed by Italy's Terna, Tunisia's STEG and the EU (having been included in the fourth list of Projects of Common Interest). The construction of Elmed should start in 2023 and the project should become operational by 2027.[9] Elmed however only has a fraction of TuNur's originally planned export capacity of 4.5 GW (with cables to France and Malta having been originally proposed in addition to the cable to Italy).

Investments in local RES generation capacity have been growing. Between 2015 and 2019, investments in renewable energy projects in the Middle East and North Africa (MENA) region from the European Bank for Reconstruction and Development amounted to 408 million euro and those from the European

6 Ad van Wijk and Jorgo Chatzimarkakis, *Green Hydrogen for a European Green Deal. A 2x40 GW Initiative*, Brussels, Hydrogen Europe, March 2020, https://www.hydrogen4climateaction.eu/2x40gw-initiative.
7 Selwa Calderbank, "Desertec Abandons Sahara Solar Power Export Dream", cit.
8 Sergio Matalucci, "Elmed Interconnector Aims to Bring Solar Power from the Sahara to Europe", in *Deutsche Welle*, 24 May 2019, https://p.dw.com/p/3IwU1.
9 Ibid.

Investment Bank amounted to 385 million euro.[10] Investments on North African RES from the EU and its multilateral banks are expected to increase further in the next years, also because of the European Investment Bank's decision to stop financing natural gas projects, which is likely to result in a rerouting of funds towards RES generation and other low-carbon/zero-carbon projects.

In spite of growing investments, the region's renewable energy potential remains largely untapped, with the notable exception of Morocco. A number of factors are responsible for the current sluggish investment in RES in most of North Africa.[11] These include regulatory barriers and inadequate support schemes, and insufficient or intermittent political backing. Difficult or expensive access to capital is also an obstacle. Cheap capital is important for low unit costs of production in RES, where capital expenditure (CAPEX) is high and operational expenditure is low. Expensive capital can offset the benefits of high levels of solar irradiation or ventilation for production unit costs. Fossil fuel subsidies are also an impediment to RES achieving relative cost advantage in North Africa.[12] Finally, electric infrastructure capacity is not yet sufficiently large in North Africa to allow for a wider penetration of RES.

1.2 Clean molecules come into the picture

This could change if prospects to export renewable energy to premium outlets, combined with necessary schemes for local industrialisation and economic development, became concrete. First of all, schemes involving exports to the EU could more easily attract European public and private funding and know-how. Secondly, the prospect of exporting part of North Africa's electricity production creates bigger incentives for local governments to invest in electricity production, as access to international markets allows export diversification, generates much-needed revenues, and brings in foreign currency. Export plans can thus be seen as enablers of hydrogen production (a

10 Ibid.

11 Margherita Bianchi, "Prospects for Energy Transition in the Mediterranean after COVID-19", in *IAI Papers*, No. 20|18 (July 2020), https://www.iai.it/en/node/11910.

12 Rahmatallah Poudineh, Anupama Sen and Bassam Fattouh, "Advancing Renewable Energy in Resource-Rich Economies of the MENA", in *OIES Papers*, No. MEP 15 (September 2016), https://doi.org/10.26889/9781784670696.

necessary basis for local hydrogen use) rather than something that foregoes local economic development.

The current early-stage plans to export North African hydrogen to the EU – which will be analysed in the next sections – share with earlier initiatives the general premise of harnessing North Africa's renewable energy potential for the mutual benefit of North Africa and the EU, promoting the three core objectives of energy policy (affordability, security and sustainability). However, they rest on a profoundly different concept regarding the mode of transporting energy. Thanks to this, they should have better chances of success for economic, technical and political reasons.

Timing for plans to import zero-carbon energy from North Africa seems more propitious today than 20 or even 10 years ago, as the European energy transition and the debate around it have entered a more mature stage. Not only have renewable energy installation costs fallen further, limitations to all-electric scenarios and to relying on locally produced RES in the EU have also become more evident.

In this context, hydrogen stands out as an enabler of plans to harness North Africa's zero-carbon energy potential. An unprecedentedly large and diverse coalition has gathered around hydrogen – comprising Transmission System Operators, energy-intensive industries, the automotive sector, electrolyser and fuel cell producers, utilities, governments, investment banks and so on. The consensus that hydrogen enjoys today is more multi-stakeholder and broad than support for electricity imports a decade ago.

The COVID-19 crisis has opened up new opportunities for capital-intensive, long-lead hydrogen investments. After initial fears of backlash on decarbonisation, political support for the energy transition has remained very strong in the EU. The European Green Deal, launched just before the outbreak of the pandemic in December 2019, has a strong external dimension and favours international partnerships in zero-carbon energy as well as alliances boosting European industrial competitiveness. The mobilisation of massive recovery funds through Next Generation EU (NGEU) and through the European Commission's Multiannual Financial Framework (MFF) has increased chances of an actual implementation of the European Green Deal. Of the 1.8 trillion euros collectively allocated by NGEU and by the MFF, at least 30 per cent will be spent for the green transition and a substantial share (20 per cent of NGEU) will be spent for the (closely related) digital transition. In the context of the European Green Deal, the European Hydrogen Strategy and the Energy System Integration Strategy (where hydrogen plays a key role) were adopted on 8 July 2020 together with the launch of the European Hydrogen Alliance, an industrial alliance.

This context creates an unprecedented momentum to build a hydrogen economy, including across the Mediterranean. The fact that Southern EU countries are the largest net beneficiaries of NGEU funds specifically helps green recovery plans in the Mediterranean Basin. Concretely, this means that Italy, Spain and all other member states are drafting national plans detailing how they intend to spend NGEU funds. These will be assessed by the Commission, which will check that they are in line with EU decarbonisation objectives.

2. Plans for North African hydrogen production and exports

With the support of EU partners, North Africa has recently started to look more seriously into clean molecules – including hydrogen – as a way to harness its large renewable energy potential, both for local consumption and for exports.

2.1 Morocco and Tunisia: New energy producers?

The North African country with the most advanced plans so far is undoubtedly Morocco, identified by a 2018 World Energy Council report as one of the world's six countries with the most promising potential to export clean energy around the world.[13] Key driving forces for plans to produce and export clean molecules include the Ministry of Energy, Mines and the Environment, IRESEN (*Institut de*

13 Badr Ikken et al., *Power-to-X in Morocco. Driver of Mediterranean Energy Market Integration*, presentation at the webinar "L'hydrogène Vert: Une nouvelle opportunité technologique et industrielle pour le Maroc", 25 June 2020, https://www.fedenerg.ma/wp-content/uploads/2020/06/2020-06-26_IKKEN_2020_IRESEN_PtX_V3.pdf.

Recherche en Energie Solaire et Energies Nouvelles), MASEN (Moroccan Agency for Sustainable Energy) and OCP (formerly *Office Chérifien des Phosphates*). In this country, the impetus came from the need to decarbonise raw materials used in industrial production, notably fertilisers. Thanks to Morocco's massive phosphate reserves (75 per cent of the known global reserves),[14] the fertiliser industry has become very important for the country, having generated an export value of 3.2 billion US dollars in 2018.[15] Morocco has however developed a chronic import dependency for ammonia, which needs to be mixed with phosphate in a number of fertiliser production processes. The country imported two million tons of ammonia in 2019,[16] with relatively adverse effects on its trade balance (estimated at around -1 billion US dollars in 2019).[17]

Through electrolysis, the process whereby electricity is used to split water (H_2O) molecules, renewable energy can be converted into hydrogen (H_2), which can in turn be converted into ammonia (NH_3) by adding nitrogen, the most abundant element in the Earth's atmosphere. The resulting product would not only be carbon-free, but also produced domestically thanks to the country's excellent wind and solar resources. A study by Fraunhofer estimates that Morocco's ammonia production in 2030 could be twice as large as today's Moroccan ammonia imports.[18] In addition to hydrogen and ammonia, methanol (CH_3OH, obtained from $CO + 2 H_2$ or $CO_2 + 3 H_2$) and synthetic fuels (Power-to-Liquids or PtL, obtained from the Fischer-Tropsch process) are also being considered by Morocco as molecular outputs from large-scale power production. Apart from being exported, methanol could be used for high-temperature heating, and synthetic fuels could be used in trucking and public transportation. The fact that Moroccan clean molecule plans were born out of a strategic local interest is an important consideration to highlight, to clear the air of criticisms that

14 Phosphate Price, *Morocco's Strategy to Diversify Economy Beyond Phosphates Pays Off*, 4 June 2020, https://phosphateprice.com/moroccos-strategy-to-diversify-economy-beyond-phosphates-pays-off.

15 UN Comtrade database. See also Trading Economics, *Morocco Export of Fertilizers*, updated March 2021, https://tradingeconomics.com/morocco/exports/fertilizers.

16 Marc Engelhardt, "Morocco-to-X: Badr Ikken and His Team at IRESEN Plan to Transform the Country into a Hub for e-Fuels", in *Energy Stories Newsletter*, 23 April 2020, https://www.siemens-energy.com/global/en/news/magazine/2020/power-to-x-morocco.html.

17 0.5 billion in Frank Wouters, "Hydrogen, a New Energy Vector in Morocco", in *VN Forum Dossiers*, 14 April 2020, https://nvvn.nl/?p=5362 (but referring to OCP imports of 1 MT.

18 Wolfgang Eichhammer, "Carbon-Neutral Energy from Power-to-X: Economic Opportunity and Ecological Limitations for Morocco", in *Fraunhofer Press Releases*, 25 September 2019, https://www.isi.fraunhofer.de/en/presse/2019/presseinfo-24-klimaneutrale-energie-aus-power-to-x-marokko.html.

plans involving energy exports from North Africa to the EU are inspired by an extractive, Eurocentric mindset. This zero-sum criticism does not appear well-grounded as it is possible to combine local use and exports. As argued above, the two can actually strengthen each other.

Ammonia could be used domestically in the amounts that it is needed, but also exported to global markets (thanks to the fact that it is transported easily and affordably on sea-going tankers). By using existing (gas) pipes, hydrogen could also be exported as such (i.e., without being converted into ammonia), particularly if hydrogen consumption kicks off in nearby EU. In the medium to long term, hydrogen could also be employed domestically in Morocco in applications such as urban public transportation and trucking. It can also play an important role in balancing the Moroccan energy system, which will increasingly have to cope with RES intermittency. For the purpose of boosting all these developments, the country has launched a National Commission for Power-to-X (PtX) in 2019 and a 2050 Power-to-X Roadmap is being drafted.

The first step for fulfilling ambitious plans to export green hydrogen is to install more renewable energy capacity in Morocco. Political support for this is strong. The country has recently set the target to reach 52 per cent RES capacity in the power sector by 2030. So far, Morocco has had a good track record in RES deployment, as it is about to meet its 2020 target of 42 per cent RES in the power sector. This is the highest share in North Africa and a higher share than in numerous EU countries, including Italy (where RES provides around 35 per cent of electricity). As mentioned above, the Noor CSP and solar PV plant in Ouarzazate, one of the flagship renewable projects of the MENA region, is now operational and will have a peak capacity of 582 MW when finalised.

Renewable energy production costs have decreased over time in Morocco and are now comparatively low, with recent bidding prices of 3 cents/kWh in wind.[19] For solar, the reported cost of 5 cents/kWh[20] is the result of an average of PV and CSP, while PV costs should be in line with competitive North African benchmarks (around 2 cents/kWh).[21] Among other factors, cost abatements

19 Badr Ikken et al., *Power-to-X in Morocco. Driver of Mediterranean Energy Market Integration*, cit.
20 Ibid.
21 Emiliano Bellini, "Lowest Bid in Tunisia's 500 MW Solar Tender Comes in at $0.0244", in *PV Magazine*,

have been enabled by the Moroccan model based on competitive bidding processes, attracting international private players.[22] Cooperation between governmental agencies and the private sector, and a stable regulatory environment, have been key ingredients for successful RES deployment in Morocco.

Adding renewable energy capacity is just the first step in building a hydrogen economy (and contemplating hydrogen exports). Morocco will have to increase load factors in RES generation, including by creating synergies between wind and solar. The country will also have to build sufficient electrolyser capacity in order to produce hydrogen. For this, a significant upscaling of production from the 5 MW pilot projects under consideration is paramount. According to current plans, 100 MW of electrolyser capacity will be developed in Morocco in the next stages of PtX planning.[23] In parallel, the country will have to construct adequate water desalination facilities, as hydrogen production from electrolysis requires water which is not abundant in all of the country's regions.

Also, it will have to adapt infrastructure for evacuating hydrogen from production sites, including to international markets. One way to export hydrogen to international markets would be to adapt the existing pipeline (carrying Algerian gas to Spain), initially for blending hydrogen with natural gas above the small shares that could already be achieved without adaptations, and later, potentially, for exclusive hydrogen transportation. Building dedicated pipelines would also be possible, albeit probably more expensive. Furthermore, Morocco will have to arrange storage facilities for hydrogen and, if the plan is also to use hydrogen domestically, convert distribution infrastructure and appliances, and stimulate demand in end-user sectors. Knowledge transfer, capacity building, stable and well-crafted regulations not only for RES but also specifically for hydrogen, loans, incentives and public and private partnerships will also be needed for a Moroccan "hydrogen backbone" and hydrogen economy to emerge.

23 July 2019, https://www.pv-magazine.com/2019/07/23/lowest-bid-in-tunisias-500-mw-solar-tender-comes-in-at-0-0244.

22 RES4MED, *Press Release - RES4MED Day - Morocco 2016*, Rabat, 9 March 2016, https://www.res4africa.org/wp-content/uploads/2017/05/RES4MED-Day-Morocco-2016_Press-release.pdf.

23 Federal Ministry for Economic Cooperation and Development (BMZ) website: *Green Hydrogen and Power-to-X Products*, https://www.bmz.de/en/issues/wasserstoff.

Germany is very active in hydrogen schemes in North Africa, and this is particularly the case in Morocco.[24] The technical studies for the feasibility of Power-to-X ventures have been conducted by the German research centre Fraunhofer with financing from GIZ. In June 2020, after the adoption of the German National Hydrogen Strategy (which foresees the allocation of 2 billion US dollars on international partnerships, out of a total allocation of funds of 9 billion US dollars), Germany and Morocco signed an agreement for cooperation on PtX including green hydrogen.[25]

The possibility to produce and export hydrogen is also being considered by other North African countries, although no other North African country has plans as advanced as those of Morocco.

Tunisia is the North African country most comparable to Morocco as it is also poor in indigenous fossil fuel resources. This entails that green hydrogen would be the most attractive export option for Tunisia. Fossil fuel resource scarcity makes the country dependent on foreign energy exports. Tunisia's energy import bill is increasing as energy demand rises due to population growth, higher cooling needs and low energy prices that stimulate consumption.

Another common ground between Morocco and Tunisia is that both are transit countries for Algerian gas pipelines. This means that if Tunisia were to produce green hydrogen with plans to export it to Italy, it would have to cooperate and coordinate with Algeria (in addition to Italy) to make use of existing pipelines.

Unlike Morocco, Tunisia does not have advanced roadmaps to produce and export clean molecules. It also has much less renewable energy installed, in spite of excellent solar and good wind potential (including onshore wind) and falling costs (recent tenders have recorded rates of 2.4 cents/kWh).[26] Tunisia is listed in the same category as Morocco in terms of attractiveness as a future hydrogen supplier, with comparable estimated costs of delivery (but lower potential volumes).[27]

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24 "Deutschland will Wasserstoff-Land Nummer eins werden", in *Deutsche Welle*, 10 June 2020, https://p.dw.com/p/3dc7K.

25 BMZ website: *Green Hydrogen and Power-to-X Products*, cit.

26 Emiliano Bellini, "Lowest Bid in Tunisia's 500 MW Solar Tender Comes in at $0.0244", cit.

27 Workshop attended by the author in June 2020.

2.2 Algeria, Egypt, and Libya: From oil and gas to clean molecules?

In Algeria, hydrogen has recently resurfaced in the political and public debate as an option for diversifying and future-proofing the country's exports and as an incentive to exploit the country's renewable energy potential. Thanks to its abundant hydrocarbon resources, Algeria has more options to evaluate than Morocco and Tunisia when it comes to hydrogen production modes. It could either deploy Steam Methane Reforming (SMR) technologies to derive grey hydrogen from natural gas, which it produces and exports in abundant quantities (86 billion cubic metres [bcm] in 2019);[28] produce blue hydrogen, also derived from SMR of natural gas with the addition of Carbon Capture, Utilisation and Storage (CCUS); or obtain green hydrogen from renewables and electrolysis.

While grey hydrogen has substantial cost advantages relative to both blue hydrogen and green hydrogen, it is not a low-carbon energy option and it thus clashes with the decarbonisation objectives of the EU (the prime market outlet for prospective Algerian hydrogen exports). While grey hydrogen is not a viable export product in the long term, it could help kick-start the development of a hydrogen value chain and export scheme between Algeria and the EU, particularly if it is blended in small quantities with natural gas (with a neutral effect on total CO_2 emissions). Algeria currently exports natural gas to the EU via three pipelines (two to Spain and one to Italy).

Blue hydrogen is an option for Algeria if it wants to continue exporting large amounts of energy in future, as it could be acceptable for the EU as a medium-term or "bridge" option, even if the focus of EU plans is on green hydrogen. This is because CCUS makes it possible to cut CO_2 emissions by up to 90 per cent. The notion that blue hydrogen could be a "transition fuel" until significant cost

28 BP, *Statistical Review of World Energy 2020*, 69 ed., June 2020, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf.

savings in electrolysis are achieved has been endorsed by a number of studies[29] and by the European Hydrogen Strategy itself.[30] Algeria, specifically, already has experience with CO_2 sequestration in geological structures, notably thanks to the In Salah project launched in 2004 and successfully carried out as a joint venture between Algeria's national gas company Sonatrach and international partners Equinor and BP. It is worth highlighting that In Salah is one of only four large-scale projects around the world where CO_2 is captured in geological structures, and the only one in a developing country (the other three being Sleipner and Snoevhit in Norway and Gorgon in Australia).

Sequestration at In Salah is part of a gas production project and was conceived because the CO_2 content of gas production was exceeding the requirements for delivered gas (and venting CO_2 would have incurred strong penalties).[31] In its first decade of operations, it made it possible to avoid half a million tonnes of CO_2 emissions per year on average.[32] Prospects for CO_2 utilisation (in addition to just capture and sequestration) for enhanced oil recovery and as a feedstock for the production of synthetic fuels, chemicals and building materials, could be explored by Algeria to improve the economic attractiveness of a "blue route" to hydrogen. Blue hydrogen would also allow Algeria to monetise hydrocarbon resources and upstream infrastructure that might otherwise become stranded as decarbonisation in import markets progresses. A challenge to blue hydrogen production in Algeria is that production at historical gas fields is declining and the country needs to mobilise additional upstream investments in a difficult conjuncture with low international gas prices.

Green hydrogen is also worth exploring for Algeria as its potential is huge and it enjoys greater support in Europe. The first structured discussions date back to June 2005, when the First International Workshop on Hydrogen was

29 Ralf Dickel, "Blue Hydrogen as an Enabler of Green Hydrogen: The Case of Germany", in *OIE Papers*, No. NG 159 (June 2020), https://www.oxfordenergy.org/?p=38308; Jabbe van Leeuwen, "International Approaches to Clean Molecules: Five Cases on Hydrogen", in *CIEP Papers*, No. 2019|01 (January 2019), https://www.clingendaelenergy.com/publications/publication/international-approaches-to-clean-molecules-five-cases-on-hydrogen.

30 European Commission, *A Hydrogen Strategy for a Climate-Neutral Europe* (COM/2020/301), 8 July 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301.

31 Ralf Dickel, "Blue Hydrogen as an Enabler of Green Hydrogen: The Case of Germany", cit.

32 P.S. Ringrose et al., "The In Salah CO_2 Storage Project: Lessons Learned and Knowledge Transfer", in *Energy Procedia*, Vol. 37 (2013), p. 6226-6236, https://doi.org/10.1016/j.egypro.2013.06.551.

organised in Algiers. A concept project for exporting hydrogen generated from solar energy – MedHySol – was presented. Part of MedHySol was HySolThane, a project involving production of hydrogen-enriched compressed natural gas to be deployed in urban public transportation.[33]

While no project has materialised so far, the debate on green hydrogen continues. In 2019, Noureddine Yassa, commissioner at the newly created Committee for Renewable Energy and Energy Efficiency, pledged to lobby in favour of launching pilot projects for green hydrogen through an inclusive approach involving businesses and universities.[34] The Renewable Energy Development Centre (*Centre de Développement des Energies Renouvelables*) has set up a research and development hydrogen division and conducted studies especially on the potential for green hydrogen production from solar energy and on possible industrial uses of hydrogen.

Numerous scientific studies have found that Algeria has excellent renewable electrolytic hydrogen potential, particularly from solar.[35] The potential is especially significant in Southeastern Algeria, while the lowest potential is found in Northeastern Algeria. Northwestern Algeria is a promising production region thanks to good potential and higher population density (i.e., lower distance from production to consumption and economies of scale). Stand-alone systems have also been found to have good potential, prompting calls to incentivise small producers to acquire solar PV and electrolysers in addition to favouring grid-connected solutions.[36]

Overall, it is quite evident that the success of green hydrogen production in Algeria crucially hinges on a significant expansion of the country's renewable energy production. At the moment, Algeria's installed solar power capacity is

33 Soumia Rahmouni et al., "Prospects of Hydrogen Production Potential from Renewable Resources in Algeria", in *International Journal of Hydrogen Energy*, Vol. 42, No. 2 (12 January 2017), p. 1383-1395.

34 Sofia Ouahib, "Exploitation de l'hydrogène… pourquoi pas?" in *El Watan*, 19 December 2019, https://www.elwatan.com/?p=625441.

35 Djamila Ghribi et al., "Study of Hydrogen Production System by Using PV Solar Energy and PEM Electrolyser in Algeria", in *International Journal of Hydrogen Energy*, Vol. 38, No. 20 (9 July 2013), p. 8480-8490; Belkhir Negrou et al., "Valuation and Development of the Solar Hydrogen Production", in *International Journal of Hydrogen Energy*, Vol. 36, No. 6 (March 2011), p. 4110-4116; Soumia Rahmouni et al., "Prospects of Hydrogen Production Potential from Renewable Resources in Algeria", cit.

36 A. Mraoui and S. Menia, "Renewable Electrolytic Hydrogen Potential in Algeria", in *International Journal of Hydrogen Energy*, Vol. 44, No. 49 (11 October 2019), p. 26863-26873.

only 423 MW according to IRENA. The country has ambitious plans to increase PV capacity to 13.6 GW and zero-carbon energy production capacity to 22 GW by 2030[37] (entailing a projected share of 27 per cent RES in power generation) but these targets will be hard to attain. As part of the efforts to reach these objectives, the Algerian government plans to launch the solar mega-project Tafouk1 (with a capacity of 4 GW) through five annual tenders up to 2024. The project's hefty cost (3.6 billion US dollars, or about 390 billion Algerian dinars)[38] is a challenge, particularly given the current state of Algeria's budget. Conditions to attract foreign investors need to be improved and balanced with traditionally strong pressures to ensure adequate local content.

As said, Algeria could export hydrogen as a way to future-proof its energy exports, an important source of hard currency. Algeria could also use hydrogen domestically. In particular, Algeria could use hydrogen for industrial applications, building on its experience with gas reforming and with the production of ammonia and methanol.[39] Hydrogen could be used to produce both of these gases. Value chains could be set up such as methanol-to-olefins and related value chains, where olefins can be reacted to generate polyolefins (used to produce plastics) and steel-making from direct reduction of iron. When organised in industrial clusters, these activities could benefit from significant economies of scale.

Egypt has some common traits with Algeria in that it is also a historical oil and gas producer that is grappling with natural output decline in historical fields and skyrocketing domestic energy demand due to a fast-growing population and fossil fuel subsidies that discourage parsimonious consumption. But whereas Algeria is still firmly a net exporter of both oil and gas, Egypt became a net petroleum importer in 2011 after having been a net exporter for decades. In a remarkable turn of events, Egypt also became a net importer of natural gas in 2014. Its two Liquefied Natural Gas (LNG) export terminals (Idku and Damietta) were left severely underutilised and the country even had to quickly build two floating storage and regasification units to import spot LNG cargoes,

37 Emiliano Bellini, "Algeria Plans 4 GW of Solar Tenders", in *PV Magazine*, 29 May 2020, https://www.pv-magazine.com/2020/05/29/algeria-plans-4-gw-of-solar-tenders.

38 Ibid.

39 Ali Kefaïfi, "L'hydrogène comme source alternative", in *Liberté Algerie*, 12 February 2020, https://www.liberte-algerie.com/contribution/lhydrogene-comme-source-alternative-333723.

as well as arrange reverse-flowed imports through the Arab Gas Pipeline from its former buyer Israel.

Thanks to the discovery of the massive Zohr natural gas field by Italy's ENI, Egypt's natural gas production has recovered and the country regained its net natural gas exporter status in 2018. Egypt exported 5 bcm of LNG and 1.5 bcm of piped gas to Jordan in 2018–2019 while importing 1.5 bcm of LNG. Gas production is expected to rise by a further 7 bcm per year once Zohr production plateaus. At that point, Egypt will have a natural gas surplus of around 15 bcm per year.[40] This will mostly be exported through existing LNG terminals Idku and Damietta and topped off with marginal regional exports.

An increase in energy exports would be a welcome development for Egypt, as it would be a source of much-needed government revenues and hard currency for a country that is financially weak. Egypt could consider blue hydrogen as a way to expand its energy exports. Zohr alone contains 850 bcm of natural gas and could be exploited beyond current production plans. Further exploration in the Egyptian offshore is also likely lead to new gas discoveries, as demonstrated by the recent gas discovery of Bashrush in July 2020.[41]

Unlike Algeria, however, Egypt would not be able to export hydrogen to large markets via existing pipelines. The only existing conduit, the Arab Gas Pipeline, is not connected to any large energy market and is now reverse-flowed for the reasons explained above. Relative to Algeria, Egypt might lack a strong incentive to decarbonise its gas production because it almost exclusively exports gas as LNG. This means that Egyptian gas will mostly target Asian markets, which will be open to import unabated gas for longer than EU markets.

The notion of building a dedicated hydrogen pipeline from Egypt is not a mainstream one. However, it has been explored by one study, which found it to

40 Stuart Elliot, "Analysis: Egyptian LNG Exports More than Double in 2019 to 4.8 bcm despite Autumn Lull", in *S&P Global Platts*, 14 January 2020, https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/011420-analysis-egyptian-lng-exports-more-than-double-in-2019-to-48-bcm-despite-autumn-lull.

41 Eni, *Eni: New Gas Discovery in the Mediterranean Sea Offshore Egypt*, 1 July 2020, https://www.eni.com/en-IT/media/press-release/2020/07/eni-new-gas-discovery-in-the-mediterranean-sea-offshore-egypt.html.

be cost-competitive.[42] That study considered a 2,500 km dedicated hydrogen pipeline from Egypt to Greece and Italy with a capacity of 66 GW, which would have an estimated cost of 16.5 billion euro. Assuming a load factor of 4,500 hours per year, the study projects that 7.6 million tonnes of hydrogen (300 TWh) could be transported annually, with a levelised cost of hydrogen of 0.2 euro/kg,[43] which is indeed just a fraction of current hydrogen production costs (and also a reasonable fraction of future costs of deliveries from North Africa; see Section 3). Of course these calculations rest on numerous assumptions and it cannot be denied that such a venture would face significant technological, commercial and even geopolitical challenges.

In any case, due to its lack of pipelines ready to use for exporting hydrogen, Egypt appears to have a stronger incentive than Algeria to pursue long-distance hydrogen export solutions such as liquid hydrogen (which is however quite expensive and technologically challenging, given that hydrogen liquefies at temperatures as low as -253°C), ammonia or methylcyclohexane-toluene.

On top of blue hydrogen, Egypt also has a very good potential to produce cost-competitive green hydrogen thanks to excellent solar resources and outstanding wind resources in the Zaafarana region, along the western coast of the Gulf of Suez. Egyptian green hydrogen could also be an interesting option for the external dimension of the European Green Deal, which is increasingly being cited as an instrument to boost energy cooperation in the East Mediterranean in a context of political instability surrounding fossil fuels. At the moment, however, there is no advanced plan to produce and export green hydrogen and the country significantly needs to expand its renewable energy production base as a first step.

In Libya, all efforts in the energy sector are momentarily channelled towards restoring oil production levels. After the October 2020 ceasefire and the restarting of production at the Sharara field, Libyan oil production has increased from 100,000 to 500,000 barrels per day. While this is a positive development, it

42 Ad van Wijk et al., *A North Africa-Europe Hydrogen Manifesto*, Dubai, Dii Desert Energy, November 2019, https://dii-desertenergy.org/wp-content/uploads/2019/12/Dii-hydrogen-study-November-2019.pdf.

43 Ibid., p. 12.

is a far cry from production levels of 1.3 million barrels per day reached before the latest escalation of the conflict between the Government of National Accord and the Libyan National Army. It is even further from pre-war production levels, which peaked at 2 million barrels per day.

If Libyan oil production continues to grow, so will associated gas production. Total gas production has averaged 8–9 bcm/y between 2017 and 2019, approximately half of pre-war output (15–16 bcm/y in 2009–2010).[44] In future, hydrogen produced from gas could be exported to Italy via the Greenstream pipeline (which has a capacity of 6 bcm/y). Similarly to Algeria, grey hydrogen exports via blending from Libya could just be a temporary solution aimed at kickstarting hydrogen trade, because grey hydrogen is not a low-carbon energy carrier and it thus clashes with Italian and European climate commitments.

Blue hydrogen exports could be viable in the medium term. There are of course major uncertainties as the political and security situation in the country remains highly volatile. Among other things, the Government of National Accord and the Libyan National Army would have to agree on an energy revenue sharing scheme. Moreover, some fields have suffered permanent damage and resuming oil and gas production is problematic in the current market environment, even if Libya is exempted from OPEC production quotas.

Prospectively, Libya also has great green hydrogen potential particularly because of its outstanding solar irradiation. However, renewables are still at an extremely early stage of development in the country. The success of any hydrogen production and export scheme in Libya hinges on a significant improvement of the political and security situation. It is desirable for Libya that this happens before other countries in the region move forward too much, closing Libyan hydrogen's window of opportunity. To accelerate hydrogen developments, preparations should start now in anticipation of such improvements in the political context.

44 BP, *Statistical Review of World Energy 2020*, cit.

3. The role of North African hydrogen for decarbonisation in Italy and in the EU

Hydrogen is an enabler of increasingly ambitious European decarbonisation plans. The EU adopted a commitment to reach climate neutrality by 2050 in December 2019 and is now reviewing its 2030 target upwards with the objective to cut emissions by 55 per cent compared to 1990 levels, up from the previous target of 40 per cent. In the next months, the entire body of EU regulations will have to be reviewed to make sure that legislation is "fit for 55".

Italy supports and adheres to the EU's 2050 climate neutrality objective. Italy's National Energy and Climate Plan (NECP)[45] adopted in December 2019 was conceived in pursuit of the 40 per cent emission reduction target. Therefore, its ambition will have to be stepped up further in light of the upcoming 55 per cent target. Hydrogen already features in the Italian NECP, which calls for exploring power-to-gas technologies to achieve flexibility and security of supply through sector integration. The plan also says that the Italian gas network will become the centrepiece of the "hybrid" electric-gas energy system, adding that solutions envisaging two dedicated infrastructures will also be considered. However, the NECP does not explicitly set ambitious targets for hydrogen, mentioning only a small target in transportation.

There is significant room for expanding the role of hydrogen relative to what is sketched in the NECP. This will actually be necessary to achieve Italy's increasingly ambitious decarbonisation objectives. In line with strategies adopted by other EU countries, Italy's upcoming National Hydrogen Strategy will hopefully fill the void, by outlining a roadmap with targets to establish a hydrogen economy in Italy. According to the Strategic Guidelines, released for consultation by the Italian Ministry for Economic Development, the Italian Hydrogen Strategy will foresee 10 billion euro in investments and will focus on stimulating hydrogen demand in trains, heavy duty vehicles, petrochemicals and refining. Hydrogen blending with natural gas will also increase hydrogen consumption. The Italian Strategy is expected to favour green hydrogen and refrain from opposing blue

45 In Italian: *Piano nazionale integrato energia e clima*, PNIEC.

hydrogen when energy companies want to carry the investment costs. Overall, the Italian energy system is expected to reach 5 GW of installed electrolysis capacity in 2030. Hydrogen is expected to represent 2 per cent of Italy's total final energy consumption by 2030, targeting a 20 per cent share in 2050.

While electricity produced from renewable energy will continue to be an important component of EU decarbonisation plans, there are some technical and financial limitations to electrification. These are becoming more visible as RES penetration increases across the EU. In the energy transition debate, the focus is shifting away from RES installation costs (which have been falling) to system adaptation costs (which have increased and will continue to increase). The EU's direct electrification rate today is 22 per cent. In its most optimistic scenario, the industrial association of European power producers Eurelectric sees electrification reaching 60 per cent of EU energy use by 2050.[46] This implies that, at the very least, around 40 per cent of the EU's energy consumption will need to be decarbonised by means of non-electric energy carriers. The outlook for Italy is very much in line with the general outlook for the EU: Italy's current direct electrification rate is 21 per cent, and in Eurelectric's most optimistic scenario it will reach 59 per cent in 2050 (and 36 and 47 per cent in the other Eurelectric scenarios).[47]

The special attractiveness of hydrogen lies in its flexibility and in the system role that it can play. Hydrogen can be used as a fuel, as an energy carrier or as a feedstock. Hydrogen is often described as the missing link in the EU energy transition because it can be produced from multiple energy sources (natural gas, renewables, nuclear, etc.) and can potentially be exploited for every energy use (transportation, power production, industrial heating, and commercial and residential heating). Hydrogen is a particularly efficient decarbonisation option for "hard-to-abate" sectors such as aviation, shipping, heavy duty vehicles, petrochemicals and industrial production that requires high-temperature heating.

46 Eurelectric, *Decarbonization Pathways. European Economy. EU Electrification and Decarbonization Scenario Modelling*, May 2018, https://www.eurelectric.org/news/decarbonisation-pathways-electrification-part. It is worth highlighting that in the other Eurelectric scenarios electrification rates by 2050 are 38 and 48 per cent (see p. 15).

47 Ibid., p. 26.

Hydrogen is also an efficient solution to store renewable electricity particularly for seasonal storage, owing to the high cost of batteries. Because molecules can be transported much more easily and cost-effectively than electrons, hydrogen will also be needed to connect production sites and distant demand locations. Hydrogen can enable (clean) energy trade among EU countries, contributing to the EU energy policy's long-standing goal of enhancing security of supply and affordability by means of a functioning internal market where energy can flow freely, reacting to price signals. An all-electric system would be much more fragmented.

An additional advantage of hydrogen is that it enables the re-use of natural gas pipelines and storage sites, which would otherwise risk becoming stranded assets as decarbonisation progresses and unabated gas use decreases. The EU has an excellent natural gas infrastructure stock on which substantial amounts of taxpayer money has been (and is still being) spent. It would be inefficient to leave such infrastructure unutilised or severely underutilised. This is even more the case in Italy, where natural gas has traditionally played a very important role in the country's energy system. As a result, Italy is endowed with excellent and widespread gas transmission and distribution lines, as well as large gas storage. Snam for example estimates that up to 70 per cent of the Italian national gas transmission network is ready to transport hydrogen without substantial additional investments. On the other hand, assessments are ongoing to evaluate the hydrogen readiness of compressor stations and storage sites.

Building a hydrogen economy will take time and require substantial efforts from both the public and the private sector. First of all, hydrogen production costs need to be brought down. This can be attained through further research and development, technological improvements and significant upscaling. Efforts will mostly be channelled towards abating SMR+CCUS and electrolyser production costs, but there could be breakthroughs in other technologies, such as pyrolysis. Carbon price design will also be important to support low-carbon hydrogen relative to grey hydrogen. Moreover, hydrogen requires complex interdependent investments at all the stages of the future value chain: large and coordinated investments will have to be allocated not only on production, but also on infrastructure (which needs to be adapted, or in some cases built on purpose) and in the end-user sector (in order to create a critical mass of hydrogen demand). This requires strong political commitment and coordination. Coordination to drive costs down is also desirable among private companies, along the lines of the recently established Green Hydrogen Catapult initiative. This is a global coalition that has the objective of accelerating the scale and production of green hydrogen 50-fold in the next six years, aiming to drive down costs to below 2 US dollars per kilogram.[48]

Given the sheer size of the challenge outlined above, any option that enables kickstarting a hydrogen economy and beginning to achieve cost savings should be considered and supported. It is particularly important to exploit synergies and economies of scale to bring down unit costs across the future hydrogen value chain. The European Hydrogen Strategy, which contemplates blue hydrogen as an intermediate step and green hydrogen as a destination fuel, explicitly recognises a role for green hydrogen imports.[49] The Strategy notably endorses Hydrogen Europe's 2x40 GW approach, which calls for the deployment of 40 GW in electrolyser capacity in the EU (to produce 10 million tonnes of hydrogen), and another 40 GW in North Africa and Ukraine (7.5 GW for production of hydrogen consumed locally and 32.5 GW earmarked for exports).[50]

Achieving 40 GW in installed EU electrolyser capacity by 2030 is an ambitious proposition. At the moment, 1.5–2.3 GW of green hydrogen production projects are under construction or have been announced in the EU. The intermediate target set out by the Strategy is 6 GW by 2024. This means that as much as 34 GW in new electrolyser capacity will have to be installed in the EU over just six years to achieve the 2030 electrolyser capacity target. Considering the upstream segment only, the Strategy estimates that investments in EU electrolyser capacity over the next decade will have to amount to 24–42 billion euro.[51]

48 Rocky Mountain Institute, *World's Green Hydrogen Leaders Unite to Drive 50-Fold Scale-Up in Six Years*, 7 December 2020, https://rmi.org/press-release/worlds-green-hydrogen-leaders-unite-to-drive-50-fold-scale-up-in-six-years.

49 European Commission, *A Hydrogen Strategy for a Climate-Neutral Europe*, cit.

50 Ad van Wijk and Jorgo Chatzimarkakis, *Green Hydrogen for a European Green Deal*, cit., p. 26.

51 European Commission, *A Hydrogen Strategy for a Climate-Neutral Europe*, cit., p. 7.

While this is a sizeable amount of money, it is smaller than the investment that is estimated as necessary to expand and connect the solar and wind energy needed by electrolysers, which is estimated at 220–340 billion euro over the same period.[52] Through green hydrogen, North Africa could potentially help contain these costs and overcome hurdles to generate sufficient renewable energy within the EU thanks to its abundant and steady renewable energy resources.

Italy, like the rest of Southern Europe, has excellent renewable energy resources. To be sure, exploiting them is going to be crucial for decarbonisation, and local green hydrogen production should be supported. But North Africa's renewable energy resources are even larger than Italy's. Irradiation levels in the Sahara Desert are among the world's best, with an annual average of 3,600 sunshine hours.[53] This compares to 2,500–2,800 annual sunshine hours in Central-Southern Italy (where average annual utilisation hours are around 1,300).[54] The difference in irradiation between Central-Southern Italy and the Sahara Desert is approximately the same as between Rome and Brussels (or London). Translated in energy terms, the Sahara's annual insolation levels reach 2,500–3,000 kWh per square meter.[55]

Moreover, it should not be forgotten that parts of North Africa also have very good wind potential. In the Sahara, yearly ground level wind speed is 5 m/s on average. Along Morocco's Atlantic coast and in Central-Western parts of Egypt's Guel of Suez, the figure goes up to 8–9 m/s.[56] Vast regions of all five North African countries have onshore wind speeds that compare to offshore wind speeds in the Mediterranean. This is an important observation, because installing wind capacity offshore is much more capital-intensive than installing it onshore. Apart from abundance, a key feature of wind and solar energy resources in North Africa is that they are stable throughout the year, with much lower seasonal variations than in the EU. Exploiting both wind and solar

52 Ibid.
53 Ad van Wijk and Jorgo Chatzimarkakis, *Green Hydrogen for a European Green Deal*, cit., p. 10.
54 Gestore dei servizi energetici (GSE), *Solare fotovoltaico. Rapporto statistico 2019*, June 2020, p. 39, https://www.gse.it/documenti_site/Documenti%20GSE/Rapporti%20statistici/Solare%20Fotovoltaico%20-%20Rapporto%20Statistico%202019.pdf.
55 Ad van Wijk and Jorgo Chatzimarkakis, *Green Hydrogen for a European Green Deal*, cit., p. 10.
56 Ibid., p. 11.

in synergy allows reaching extremely high load factors in renewable energy systems.

Furthermore, North Africa (total area: 6,017,221 km2) has much larger land availability than the EU and, obviously, Italy (total area: 4,233,262 km2 and 301,340 km2 respectively). While wind turbines and solar panels cannot be built everywhere, North Africa has much more available land than would be needed to power the entire world through RES. North African population density (31/km2) is significantly lower than EU (106/km2) and Italian (201/km2) population density. The average figure of 31/km2 actually hides population density figures close to zero in vast desert areas. As public acceptance of renewable energy production sites is increasingly going to be a challenge in the EU, building as many wind turbines and solar plants as possible in scarcely populated areas is a sensible course of action. While at the moment there seems to be plenty of land available for renewable energy production sites in the EU and Italy, an increase in RES installations triggered by deep decarbonisation will gradually reduce this availability – also because interactions with ecosystems and protected areas, landscape effects and public opposition need to be taken into account.

In North Africa, renewable energy production costs have already decreased substantially and have become competitive. As mentioned in Section 1, recent bidding prices of 3 cents/kWh in wind and around 2 cents/kWh in solar were recorded in North Africa.[57] Further cost savings can be achieved along the lines of what has been observed in other parts of the MENA region, and notably in the United Arab Emirates where a record low solar bid of 1.35 cents/kWh has taken place in 2020.[58] North African PV and onshore wind costs are projected to fall to 1 cent/kWh before 2030.[59]

Assuming future electrolyser efficiencies of 80 per cent[60] and CAPEX of 300 euro per kW, independent experts estimate that green hydrogen could be produced

57 Badr Ikken et al., *Power-to-X in Morocco. Driver of Mediterranean Energy Market Integration*, cit.
58 Emiliano Bellini, "Abu Dhabi's 1.5 GW Tender Draws World Record Low Solar Bid of $0.0135/kWh", in *PV Magazine*, 28 April 2020, https://www.pv-magazine.com/2020/04/28/abu-dhabis-2-gw-tender-draws-world-record-solar-bid-of-0-0135-kwh.
59 Ad van Wijk et al., *A North Africa-Europe Hydrogen Manifesto*, cit., p. 6.
60 With higher heating value.

for about 1 euro per kg in North Africa.[61] According to the same estimate, EU green hydrogen production costs will be higher than in North Africa by a factor of 0.5–1 euro per kg in 2030 because of higher RES production costs.[62] Over the 2030–2050 period, it is estimated that North African hydrogen production costs could fall well below 1 euro per kg and that EU hydrogen production costs could approach 1 euro per kg by 2050.[63] Electrolysis requires water, which is available in some regions of North Africa with good electrolytic potential, such as Northwestern Algeria (Section 1). However, water is not available in all of the regions that could target green hydrogen production. In such cases, desalination of sea water would be required, together with pipes to carry water from the coast to the production sites. Even assuming that these water pipes had to cover distances of 1,000 km, this would add only a couple percentage points to total hydrogen production costs.

According to Snam's projections, green hydrogen production costs in North Africa (Algeria and Tunisia) will be approximately 1.5 euro per kg in 2030, 1 euro per kg lower than in Southern Italy. This is based on assumptions of solar costs of 24 euro/MWh in Southern Italy (approximately half of current cost levels) and large-scale electrolysis CAPEX of 243 euro/kW (27 per cent of current unit CAPEX). According to the same projections, the window where North African green hydrogen is projected to be the most competitive relative to Southern Italian green hydrogen would be 2025–2040. North African green hydrogen would remain attractive also after 2040, with a production cost discount of approximately 0.2 euro per kg between 2040 and 2050.

Of course hydrogen still needs to be transported to the EU after being produced in North Africa, and those costs need to be added to the calculation in order to compare the cost of North African hydrogen imports to local production in the EU. Transporting hydrogen is more affordable than transporting electricity from North Africa to the EU. Affordability is a result of the much larger capacity than can be achieved in gas/hydrogen pipelines relative to transmission cables: existing gas pipelines from North Africa to Spain and Italy

61 Frank Wouters, "Hydrogen, a New Energy Vector in Morocco", cit.

62 Ibid.

63 Ad van Wijk et al., *A North Africa-Europe Hydrogen Manifesto*, cit., p. 8.

have a cumulative capacity of 60 GW,[64] compared with only 1.4 GW available in transmission cables (in addition to 1.3 GW under construction). On average, the cost of transporting hydrogen via a pipeline is eight times lower than the cost of transporting electricity via a transmission cable.[65] In natural gas and hydrogen transport, energy losses are also smaller than in electricity transport. Hydrogen can also be stored more easily and cost-competitively and it is easier to manage in terms of balancing compared to electricity. At the moment, it is estimated that storing hydrogen in salt caverns is at least 100 times cheaper than storing electricity in batteries.[66] Taking everything into account, it is estimated that carrying large volumes of hydrogen from North Africa to the EU through existing pipelines would cost up to 0.2 euro per kg.[67] Considering the cost advantages of North African hydrogen production, this would essentially make imported North African hydrogen competitive with EU green hydrogen.

Along similar lines, Snam estimates that in the long term importing North African green hydrogen into Italy would cost 10 to 15 per cent less than producing hydrogen in Italy, thanks to better land availability for RES installations in North Africa, higher irradiation, lower RES variability (both intra-day and season) and the lower costs associated with managing a centralised hydrogen-carrying infrastructure compared to collecting energy from dispersed RES production sites throughout Italy.[68] Snam's vision encompasses a South-North backbone hydrogen infrastructure corridor that will enable the transportation of green hydrogen from North Africa, through undersea and land infrastructure, towards large consumption centres in Northern Italy and Central and Northern Europe. At the same time, according to the company's vision, a South-North flow of renewable biomethane could travel in the opposite direction from Northern and Central Italy towards Southern Italy.

64 Ad van Wijk and Jorgo Chatzimarkakis, *Green Hydrogen for a European Green Deal*, cit., p. 16; Sebastian Timmerberg and Martin Kaltschmitt, "Hydrogen from Renewables: Supply from North Africa to Central Europe as Blend in Existing Pipelines - Potentials and Costs", in *Applied Energy*, Vol. 237 (1 March 2019), p. 795-809.

65 Author's interview with Snam officials.

66 Ad van Wijk et al., *A North Africa-Europe Hydrogen Manifesto*, cit., p. 24.

67 Ad van Wijk and Jorgo Chatzimarkakis, *Green Hydrogen for a European Green Deal*, cit., p. 17.

68 The European House - Ambrosetti, *H2 Italy 2050*, cit., p. 25.

4. Wider benefits of North Africa–Italy–EU hydrogen trade

In the previous Section it was argued that North African hydrogen imports into the EU and Italy are not only technically feasible, but also potentially cost-competitive with hydrogen locally produced in the EU. It was also explained why North African hydrogen could play a role in plans to decarbonise the EU's and Italy's energy mix to achieve climate neutrality by 2050. Further, in Section 1 it was shown that hydrogen could succeed in harnessing North Africa's renewable energy potential by unlocking viable large-scale export options.

Apart from being an enabler of decarbonisation in the EU and Italy, North African hydrogen can also be an enabler of decarbonisation in North Africa itself. Moreover, it can bring significant social, political and economic benefits to both shores of the Mediterranean. While a quantitative macro-economic analysis is premature as it is unclear how much hydrogen production and exports will eventually materialise, a few preliminary observations can be made.

The first element that needs to be highlighted is that, as shown in Section 2, local use of hydrogen in North Africa can be combined with export plans. Actually, the possibility to export hydrogen to the EU and Italy is likely to be a catalyst for hydrogen production in North Africa. There are three main reasons: 1) hydrogen is a sector where economies of scale matter a lot; 2) the prospect of accessing export revenues and hard currency is an important incentive for North African governments to look into hydrogen; and 3) the prospect of importing North African hydrogen when investing in local projects can more easily attract EU capital and know-how than ventures that only aim at production for local use. As a new market needs to be created from scratch, it is clear that production and consumption need to be stimulated simultaneously. Local production of hydrogen is an important stimulus for local consumption of hydrogen. In turn, the prospect of using hydrogen locally is a stimulus for producing it locally.

As shown in Section 2, Morocco has clear plans for hydrogen as part of a national PtX strategy that can deliver green ammonia to be employed for domestic fertiliser production. The numerous types of clean molecules that revolve around hydrogen value chains (and of which hydrogen is an input) can be used in several industrial applications across the entire region, including in Algeria, Tunisia, Libya and Egypt. These include for instance fertilisers, petrochemicals, methanol, and steel-making from direct reduction of iron. Hydrogen could also more generally be used as a low-carbon source of energy for industrial productions where high-temperature heating is required.

In other words, hydrogen can favour future-proof industrialisation in North Africa, opening up new economic opportunities and helping diversification. North African countries all have social and economic vulnerabilities that call for a change of pace in socio-economic development models. Tables 1 to 3 below summarise some of North Africa's key socio-economic indicators, offering a comparative overview.

Table 1 | North Africa – Oil and gas imports and exports, main trade partners, oil and gas rents (2018)

Country	Oil and gas on yearly imports (%)	Oil and gas on yearly exports (%)	Export partners (%)	Oil rents (% of GDP)	Natural gas rents (% of GDP)
Morocco	Refined petroleum 9.4 (largest share of imports) Petroleum gas 3.1	Petroleum gas 4.6 Refined petroleum 3.2	Spain 22.1 France 20.6 Italy 4.1 Germany 3.3	negligible	negligible
Algeria	Refined petroleum 4.8 (largest share of imports) Petroleum gas 0.4	Crude petroleum 42.1 (largest share of exports) Petroleum gas 33.8 Refined petroleum 18.6	Italy 16.4 Spain 13.8 France 12 UK 7	15.7	3.1

Tunisia	Refined petroleum 11.9 (largest share of imports) Crude petroleum 1 Petroleum gas 0.5	Crude petroleum 4 Refined petroleum 1.9 Petroleum gas 0.2	Italy 20.2 France 18 Germany 8.7	2.6	0.3
Libya	Refined petroleum 17 (largest share of imports)	Crude petroleum 86.8 Petroleum gas 5 Refined petroleum 3.6	Italy 16.4 Spain 13.1 France 8.9 Germany 13.3	42.4	1
Egypt	Refined petroleum 5.3 Crude petroleum 3.9 Petroleum gas 2.8	Crude petroleum 14 (largest share of exports) Refined petroleum 5.6 Petroleum gas 3.3	China 14.7 Russia 9.2 USA 5.8 Germany 4.6 Italy 4	5.3	1.2

Sources: CEPII BACI dataset (2020); World Bank (2020).

Morocco and Tunisia are net energy importers and their oil and gas imports are constantly increasing due to rising domestic demand. Before oil and gas prices contracted in 2014, Morocco's and Tunisia's energy import bill was becoming more and more unsustainable, negatively impacting on the countries' trade balance.

Conversely, the region's largest net hydrocarbon exporters, Algeria and Libya, are excessively reliant on oil and gas for their government revenues, export revenues and GDP growth (Table 1) – displaying some of the symptoms of Dutch disease. These countries are exposed and vulnerable to global commodity price volatility, which also impacts on their national currencies. Low oil and gas prices since 2014 have significantly drained their foreign exchange reserves, exposing and aggravating their vulnerabilities. Unlike Gulf countries, North

African countries have scarce buffers to limit the adverse socio-economic effects of hydrocarbon price declines. Algeria has limited room for manoeuvre to cut public expenditure because of its large public sector, where the State has to pay salaries to millions of workers. If it stopped doing so, political instability in the country would further increase. This is just an example of how the macro-economic conjuncture of countries in North Africa is strongly intertwined to social and political dynamics there. Besides, in Libya the war has brought widespread devastation and provoked a fall in oil and gas production. In both countries, overreliance on hydrocarbon exports has stifled industrialisation and both countries are struggling to achieve economic diversification.

Table 2 | North Africa – Key macro-economic data

Country	GDP growth (annual %) in 2019	GDP per capita (current USD) in 2019	IMF economic growth forecast (annual %)	Government debt (% of GDP)	Foreign exchange reserves (USD bn)
Morocco	2.3	3,204	-7 (2020) +4.9 (2021) +3.6 (2022)	66.1 (2019)	33 (2020)
Algeria	0.8	3,948	-5.5 (2020) +3.2 (2021) + 2.6 (2022)	46.1 (2019)	60 (2019)
Tunisia	1	3,317	-7 (2020) +4 (2021) +2.9 (2022)	76.7 (2018)	7.92 (2019)
Libya	2.5	7,683	-66.6 (2020) +76 (2021) +54.9 (2022)	16.5 (2016)	84.6 (2019)
Egypt	5.6	3,020	+3.6 (2020) +2.8 (2021) +5 (2022)	90 (2019)	38.3 (July 2020)

Sources: Bank of Algeria (2019); Bank Al-Maghrib (2019); Central Bank of Libya (2019); Central Bank of Egypt (2020); Central Bank of Tunisia (2019); IMF (2020), World Bank (2020).

Egypt's position is peculiar because it is a net importer of oil and a net exporter of gas. Egypt is a poor country with a large, rapidly rising and young population. Its rising energy demand is a challenge because it entails additional oil import requirements and limits the room for gas exports. It also puts a strain on the government's budget, particularly because energy is sold domestically at heavily subsidised prices.

A common problem across North Africa is very high unemployment, especially among the youth (Table 3). This is one of the main triggers of migration, often to EU countries including Italy. Hydrogen can offer local employment opportunities, as new jobs will be created by the installation of new renewable energy capacity needed for green hydrogen, in water desalination facilities, directly in hydrogen production sites, in the abovementioned industries that can be developed thanks to hydrogen, in hydrogen infrastructure adaptation or construction, and in ancillary construction and services.

Table 3 | North Africa – Social-economic indicators

Country	Unemployment rate (%) in 2020	Youth unemployment (%) in 2020	Female unemployment (%) in 2020	Net migration rate (‰) in 2019	Human flight and brain drain index, 0 (low) - 10 (high) in 2019
Morocco	8.9	21.9	10.4	-1.9	7.9
Algeria	11.5	29.7	20.5	-0.9	6.1
Tunisia	16.2	36.5	22.8	-1.4	5.9
Libya	18.6	50.9	24.7	-0.7	6
Egypt	10.1	30	21.4	-0.3	5.3

Sources: CIA World Factbook (2020), Fragile State Index (2019), World Bank (2020).

By contributing to industrialisation and economic diversification, by increasing employment and by providing future-proof sources of export revenues and hard currency, hydrogen can help social and economic development across North Africa. This can in turn improve the resilience of North African societies and political stability in the region, reducing the risk of conflict and radicalisation. New employment opportunities can also reduce migration flows.

Italy, as a Central Mediterranean country that is particularly exposed to social and political instability in North Africa, stands to benefit from this. Negative security spinoffs from civil conflicts and radical Islamism in Italy's immediate neighbourhood are probably the most important threats to the country's security. While it is debatable whether migration should be interpreted as a security threat, the influx of migrants from North African coasts is certainly divisive and polarises the national political debate. It is clear that hydrogen alone is not the silver bullet solution for all of North Africa's problems. However, by being an important enabler of harnessing two of North Africa's biggest resources – wind and solar – hydrogen can contribute to improving social, political and economic conditions.

Another important element is that hydrogen is going to be a key enabler for the continuation of large-scale trade across the Mediterranean in the next decades. Oil and (unabated) gas exports – which today represent North Africa's largest exports – will gradually decline as Italy and the EU further decarbonise their energy mixes in pursuit of their 2030 and 2050 climate targets. In addition to decarbonisation, the war has permanently damaged some of Libya's fields. Algeria is grappling with declining historical fields and struggles to attract new investment to develop new oil and gas fields. Egypt has already turned into a net oil importer.

In a context of growing fragmentation and autarchic temptations around the world, it is important to reiterate the message that trade usually brings peace. The interdependence created by large-scale exchange of essential products is a major deterrent to conflict and incentivises the cultivation of good, long-lasting political relationships. While energy crises make the headlines, crises averted by energy cooperation unfortunately do not. Energy is sometimes depicted as a bone of contention, but the truth is that, more often than not, there are such high stakes around energy that it incentivises conflicting parties to come to an agreement.

A recent example of this is offered by the Ukrainian crisis that broke out in 2014: in spite of a proxy war ravaging the country's Eastern districts, Russian gas exports to the EU through Ukraine continued undisturbed, actually reaching record levels in 2018–2019. In December 2019, Russia and Ukraine set their disagreements aside and successfully renegotiated a new gas transit contract. This happened while Crimea and Eastern Ukraine were still occupied by Russia or pro-Russian separatists. Also in North Africa there is a valuable example of how energy can bring countries with difficult political relations to the negotiating table. Algeria and Morocco have traditionally had complex political relations, also because of divergences on the Western Sahara dossier. In spite of this, the two countries have effectively cooperated on energy to enable Algerian gas transit through Morocco, which is clearly a win-win for both countries.

Italy has close political relations with all of the region's countries. The continuation (or strengthening) of interdependence between Italy and North Africa in a deeply decarbonised future will also be beneficial politically. As shown by an in-depth June 2020 IAI study, new positive bonds of interdependence can be established thanks to renewable energy, of which hydrogen is an enabler.[69] An important additional consideration is that the Italian government can exploit its close diplomatic ties with North African countries and good understanding of social, political and economic dynamics in North Africa to create synergies and economic opportunities for Italian businesses.

This brings us to the next point, which is that North African hydrogen can open up profitable opportunities for Italian business players. These include wind and solar plant operators and utilities; companies that produce wind and solar equipment; producers of electrolysers, valves and other equipment or components whose use will increase with the establishment of a hydrogen economy; transmission system operators; pipe-laying companies and providers of pipeline coatings and other infrastructural work that is needed to make infrastructure hydrogen-proof; and construction companies. IAI's June 2020 study contains an in-depth analysis of Italian leadership and comparative advantage in renewable energy.[70] The September 2020 study by The European House-Ambrosetti for Snam provides an updated and extensive mapping of Italian comparative advantages in hydrogen technologies and ancillary technologies, as well as of the key Italian stakeholders across the hydrogen value

69 Luca Franza, Margherita Bianchi and Luca Bergamaschi, "Geopolitics and Italian Foreign Policy in the Age of Renewable Energy", in *IAI Papers*, No. 20|13 (June 2020), https://www.iai.it/en/node/11696.
70 Ibid.

chain.[71] It can thus be used as a reference to conclude that Italian businesses have great expansion potential in the sector. Not only will Italy benefit from the North African hydrogen, but North Africa could in turn benefit from Italian know-how, technology and investments.

Finally, thanks to cost-competitive and year-round available North African hydrogen supplies, Italy could become the core of North-South hydrogen trade within the EU and across the Mediterranean. Trade could be bidirectional. Northern Europe could in fact also offer abundant hydrogen supplies, mainly produced from offshore wind. Northern Europe would also benefit from North African hydrogen produced from solar and wind energy with very little intermittency. Hydrogen could confer to Italy the central location in energy flows that the country has long tried (and struggled) to obtain. Becoming an energy hub is strategic for Italy, as it boosts both security of supply and affordability. Apart from earning transit fees, Italy could benefit economically by arbitraging between North African and Northern European hydrogen. This would eliminate today's structural disadvantage whereby Italy is located at "the end of the pipe" in gas trade, thus having to pay higher gas procurement costs than Northwestern European countries simply due to its geographical location. Filling gaps in energy supply costs is important to improve Italy's relative industrial competitiveness.

Conclusions and policy recommendations

North African hydrogen production and exports to Italy and the rest of the EU can benefit countries along both shores of the Mediterranean. Green hydrogen has the potential to harness North Africa's untapped and massive renewable energy potential. Blue hydrogen is an option for North African hydrocarbon producers to continue exporting energy to Italy and the EU, where the space for unabated fossil fuels will shrink due to increasingly ambitious climate targets (55 per cent emission reduction by 2030 and climate neutrality by 2050). Hydrogen exports from North Africa to Italy and the rest of the EU are not only technically feasible, studies show they could also be cost-competitive

71 The European House - Ambrosetti, *H2 Italy 2050*, cit.

with locally produced hydrogen if certain conditions are met (cf. various estimates in Section 3). The projected cost competitiveness of North African green hydrogen is determined by affordable transportation options (namely, the possibility to use existing gas pipelines that have an aggregate capacity of 60 GW) and low costs of electrolytic production in North Africa (1 euro per kg in 2030, cf. Section 3 for the underlying assumptions), which boasts not only excellent irradiation levels (2,500–3,000 kwh per square metre annually) but also outstanding ventilation in some areas (wind speeds up to 8–9 m/s).

Hydrogen is also going to be a key enabler of EU decarbonisation plans, as it is becoming increasingly clear that not all energy uses can be electrified (with a direct electrification rate of 60 per cent achieved in the best-case scenario). There is unprecedented momentum for capital-intensive hydrogen projects, including across the Mediterranean. The COVID-19 crisis has led to the mobilisation of huge amounts of money. Coincidentally, Italy is the largest beneficiary of EU funds (209 billion euro) and decarbonisation is the policy area where the relative majority (37 per cent) of NGEU funds will be spent. The European Hydrogen Strategy explicitly recognises a role for North African hydrogen, having embraced the 2x40 GW initiative. The upcoming Italian Hydrogen Strategy, which will mobilise additional funding (10 billion euro), should also strongly target imports of North African hydrogen and scale up ambitions to make Italy a European hydrogen hub. This will hopefully allow Italy to catch up with other EU countries that have already adopted a hydrogen strategy and signed hydrogen partnership agreements with North African countries.

Apart from contributing to decarbonisation on both sides of the Mediterranean, hydrogen could unlock new industrial opportunities for North African countries, favouring economic diversification. Hydrogen production and exports could have far-reaching socio-economic benefits for North Africa by providing much-needed export revenues and hard cash and by creating employment. This would in turn improve social resilience, increase political stability, reduce the risk of radicalisation and limit migration flows. Italy has a particularly strong strategic interest in all of these areas, given its geographic location in the Central Mediterranean and marked exposure to social, political and security developments in North Africa. North African hydrogen could also create interesting business opportunities for Italian companies, which have valuable know-how to offer to North African countries. Strong coordination between the private sector and the Italian government is going to be key for cooperation schemes to succeed.

Hydrogen can contribute to fighting climate change while preserving trade interdependence across the Mediterranean, which is beneficial to peace, security and development. Italy has a particularly strong strategic interest in this and can and should play a fundamental role as a catalyst for North African hydrogen. This is an opportunity that needs to be seized now as conditions to kickstart hydrogen trade across the Mediterranean have never been so favourable as they are today.

In order to harness North Africa's renewable energy potential and reap the benefits of hydrogen imports, the Italian government should include hydrogen imports among national energy policy objectives and enact legislation to develop guarantees of origin for tracking hydrogen sources. Having an interest in the success of regional hydrogen developments, Italy should commission and support feasibility studies on hydrogen projects in various countries, particularly those where the debate on hydrogen is still at an early stage and that are geographically closer, namely Algeria and Tunisia. It could also promote know-how exchange initiatives through study trips, international mobility programmes and partnerships among public and private knowledge centres, also involving the private sector. Italy should also consider contributing to funding the most promising pilot projects for hydrogen production and export, especially in countries that have not yet launched any.

Within the EU, Italy has an interest in mobilising political capital to promote the allocation of EU funds to North African hydrogen schemes through the Green Deal, Important Projects of Common European Interest, and the European Neighbourhood Policy Instrument. Coordinating with EU institutions and the International Energy Agency, the Italian government could also establish a Mediterranean Hydrogen Forum to promote the exchange of technologies and regulatory best-practices. Upon a careful and inclusive process of consultation with stakeholders from industry, academia, think-tanks, governments and civil society, the Forum could produce a Mediterranean Hydrogen Strategy or Master Plan. This document would have the function of providing guidelines to coordinate investments and create complementary initiatives to kickstart a hydrogen economy across the Mediterranean.

Clean Molecules across the Mediterranean

The Potential for North African Hydrogen Imports into Italy and the EU

Hydrogen is the most promising vector for harnessing North Africa's largely untapped renewable energy potential. Low-carbon hydrogen produced in North Africa can play an important role in enabling the European Union and Italy to reach their increasingly ambitious decarbonisation targets as a complement to electrification and locally produced renewables. It is estimated that the EU could achieve cost savings by producing at least part of its future renewable energy needs in neighbouring high-yield regions. Italy is set to play a particularly important function as both a gateway and a catalyst for North African hydrogen exports. In turn, North Africa stands to benefit from hydrogen both as a source of revenues and as an instrument of diversification, industrialisation and local economic development. This would in turn improve social resilience, increase political stability, reduce the risk of radicalisation and limit migration flows. Italy has a particularly strong strategic interest in all of these areas, given its geographic location in the Central Mediterranean and marked exposure to social, political and security developments in North Africa. North African hydrogen could also create profitable business opportunities for several Italian companies. In sum, hydrogen can contribute to fighting climate change while preserving positive trade interdependence across the Mediterranean. Strong coordination between the private sector and policy-makers is going to be key to abate costs along the hydrogen value chain and launch successful international hydrogen trade schemes.

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