Elcano Policy Paper

H_2 Med: hydrogen's geo-economic and geopolitical drivers and barriers in the Mediterranean

Gonzalo Escribano – May 2021

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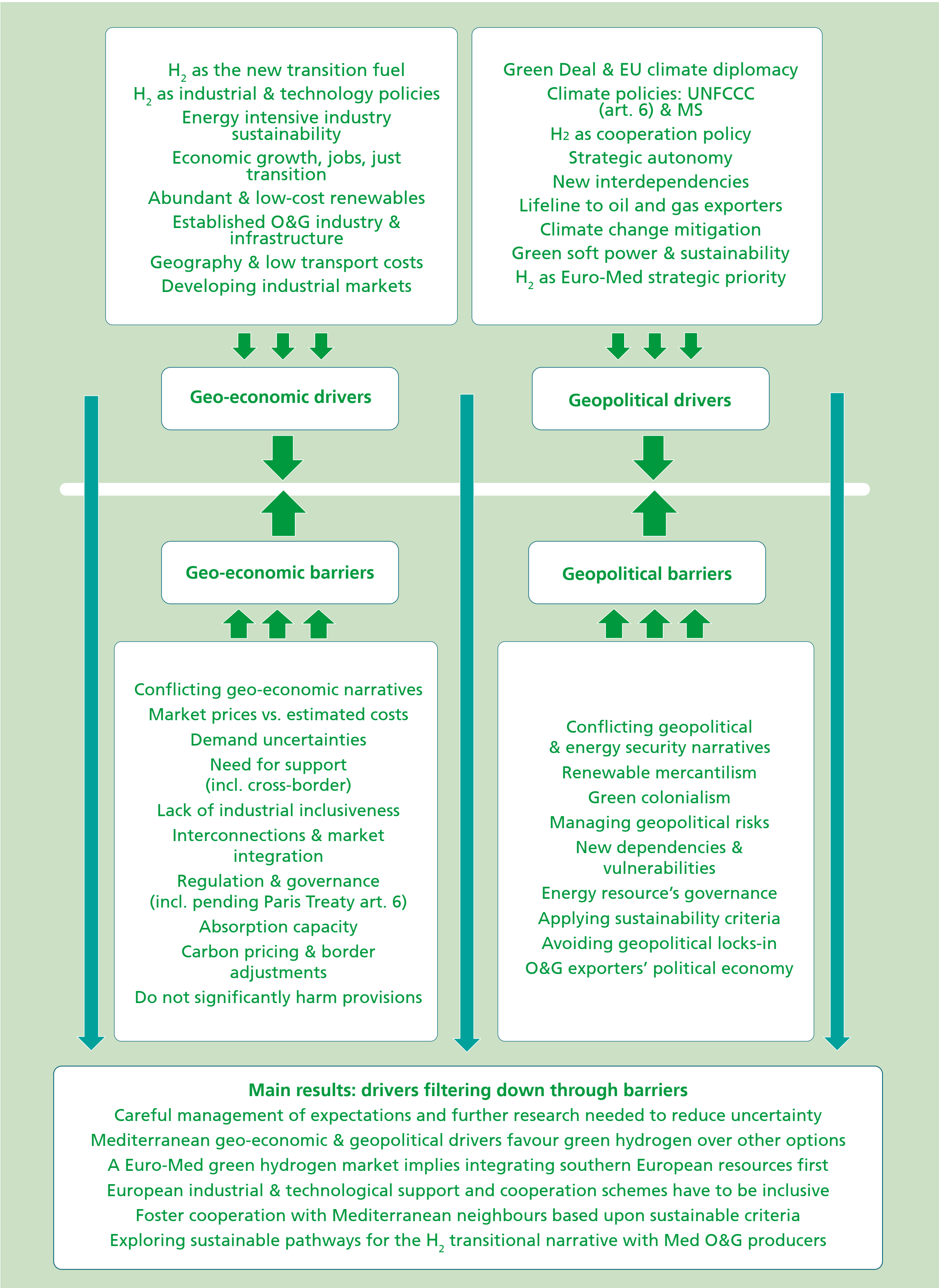


Executive summary

This policy paper aims to offer a preliminary assessment of the geo-economic and geopolitical drivers and barriers for the development of a hydrogen market that integrates both European and Mediterranean neighbours' renewable resources. The methods used include a review of the literature related to hydrogen in the Mediterranean, from European H_2 strategies and industry and think tank reports to academic research, as well as stakeholder consultations.

Highlights:

1. **The common elements in European hydrogen strategies constitute significant drivers** of H_2 market development, but partial inconsistency in some of their external approaches (ie, self-sufficiency vs cross-border trade) might constitute geo-economic and geopolitical barriers to market development and integration.

2. **Several geo-economic drivers support green hydrogen in the Mediterranean:** abundant renewable resources, existing infrastructures and industry, and relatively low transport costs when compared with other origins. However, uncertainties remain regarding prices, coverage of potential support measures and regulation, including carbon pricing alignment. This picture tends to favour intra-European integration and incentivises neighbours to converge towards EU's climate policy.

3. **H_2 Mediterranean geopolitics exhibits both drivers and barriers** regarding energy security, sustainability, governance and foreign policy. A geopolitically sustainable merit order would prioritise European integration and promote cooperation with those neighbours where geopolitical drivers clearly outweigh barriers.

4. As shown in Figure 1, from this preliminary assessment the **key messages** regarding the future development of H_2 markets in the Mediterranean are:

   - A careful management of expectations and further research are needed to reduce the uncertainties surrounding hydrogen in the Mediterranean.
   - Both Mediterranean geo-economic and geopolitical drivers tend to favour renewable hydrogen over other options.
   - The development of Euro-Mediterranean green hydrogen markets implies integrating southern European resources first by building South-North corridors.
   - There is a demand for ensuring that European support and cooperation schemes are inclusive and open to all member States and eligible neighbours.
   - Cooperation with Mediterranean neighbours is to be based upon sustainability criteria.

Introduction[1]

Hydrogen has become a hot topic in the global, European and Mediterranean energy debate. The current fervour of governments and the private sector for the new fuel is being mirrored by an increase in the attention paid to hydrogen geopolitics, which has been added to the portfolio of the emerging literature on the geopolitics of renewables.[2] It is not difficult to understand why it has raised such high expectations, including in the international arena. Hydrogen offers opportunities for both companies and countries, and this includes external economic and geopolitical considerations.[3]

Furthermore, hydrogen is apparently compatible with a fossil-like world that allows the good old oil and gas geopolitics to continue apace among scholars and decision-makers alike.[4] In this respect, it is also a transition fuel between fossil and renewable geopolitics. Geopolitical path dependence on the fossil energy regime is widespread among those approaches highlighting sustainable energy transitions' new vulnerabilities and dependencies, but seems to be particularly strong in assessing hydrogen's geo-economic and geopolitical features and prospects. This transitional script has been criticised for allowing the natural gas industry to appropriate the notion of a 'hydrogen utopia' and for perpetuating carbon lock-in through blue hydrogen.[5]

In the Mediterranean, some member States and neighbouring countries have the natural resources to become competitive hydrogen exporters, but past failures like Desertec or the Mediterranean Solar Plan make expectations vary between hype and hope.[6] The EU supports such hydrogen imports from neighbouring countries, and the recent 2021 ENP South Communication identifies hydrogen production as a new strategic priority.[7] However, while almost every Euro-Mediterranean energy player can foresee opportunities under the EU's hydrogen umbrella, technological choices and market integration models show diverging preferences across member States.

Within the EU, most member States are interested in developing the hydrogen industry, but some are more interested in green hydrogen than others. From an international perspective, Germany wants to develop green hydrogen imports, both from the EU and abroad, while France seems to follow a more self-sufficient approach supported by nuclear power (pink

1 The author acknowledges very useful contributions, comments and suggestions from Lara Lázaro-Touza on a previous draft of this paper, as well as research assistance from Rose Chancy, both from the Elcano Energy and Climate programme. He would also like to express his gratitude to all the presenters and participants in the Elcano's Energy and Climate working group for their relevant contribution in identifying these preliminary set of hydrogen's drivers and barriers in the Mediterra-nean during two closed meetings and further consultations. The usual disclaimer applies.

2 Lázaro and Escribano (2021).

3 For a geo-economic approach see Frontier Economics (2018); for a geopolitical angle, see Pflugmann and De Blasio (2020).

4 See for instance Van de Graaf (2021) and Van de Graaf *et al.* (2020).

5 On hydrogen's fossil lock-ins see Szabo (2020).

6 See Van Wijk *et al.* (2019), Willis (2020), Van Renssen (2020) and Furfari & Masson (2021).

7 European Commission (2021).

hydrogen). Portugal and Spain aim to become green hydrogen exporters and hope that the opportunity to design a truly integrated European market for hydrogen will not be missed this time. Spain also considers that applying sustainability criteria implies a preference for European green hydrogen exports that are aligned with the EU's decarbonisation pathway towards a Net Zero economy by 2050.

Rather than a purely conceptual, techno-economic, business-oriented or normative approach, this Policy Paper tries to identify the main geo-economic and geopolitical drivers for the development of hydrogen markets in the Mediterranean, both within Europe and with its neighbourhood. It does not intend to measure or balance them, nor to analyse each driver/barrier in depth or how they could be enabled/overcome. The approach followed here is rather to propose an exploratory inventory of enablers and obstacles that can provide a guide to navigating through the geopolitics of hydrogen in the Mediterranean. The results from this initial analysis could also be complemented with further research.

With this aim, the paper starts by analysing the dominant geo-economic and geopolitical narratives underlying the EU, Dutch, French, German, Portuguese and Spanish hydrogen strategies. It then explores the broader geo-economics and geopolitics of hydrogen in the Mediterranean, addressing its drivers and barriers.[8] The latter have been derived in an exploratory manner from the academic, think-tank and grey literature, as well as European hydrogen strategies themselves. They have then been contrasted and completed through consultations with Spanish industry representatives, public officials and scholars, both privately and during dedicated sessions of the Elcano Royal Institute's Energy and Climate working group. Only drivers/barriers intrinsic to hydrogen have been considered, but not developments in other technologies that could imply further relative enablers or obstacles (ie, slower cost reductions in electricity transmission and storage technologies or lower oil and gas prices).

The concluding section summarises the results regarding the identification of drivers and barriers, but it also analyses the combination of drivers that could prove to outweigh the barriers described. In particular, it selects some elements that could combine in a realistic but appealing set of drivers for the development of the Mediterranean hydrogen markets: the need to carefully manage expectations, further research and credible proposals; promoting green differentiation, European industrial inclusiveness and market integration; cooperating with Mediterranean neighbours on green hydrogen; and exploring the transitional narrative with oil and gas producers while asserting the EU's attachment to clear sustainability and governance criteria.

8 The drivers and barriers framework is commonly used in the literature of innovative renewable energy technologies. See for instance on Concentrated Solar Power economic and geopolitical drivers and barriers Kiefer & del Río (2020) and Escribano *et al*. (2019). It has also been applied to the inclusion of hydrogen technologies by Trinomics (2020), which also identifies some of the economic drivers retained in this policy paper.

1 H_2 Europe: EU and member States' strategies

According to the International Renewable Energy Agency (IRENA), hydrogen strategies are the first pillar to reach a minimum threshold for market penetration. Nonetheless, these strategies should be followed by identifying policy priorities, establishing enabling governance mechanisms and a system for guarantee of origin for green hydrogen.[9] The EU's Hydrogen Strategy aims to install 6 GW of renewable hydrogen electrolysers by 2024 and 40 GW by 2030.[10] Six member States have published their national hydrogen strategies to date, and others are developing theirs.

By the end of 2020 the overall target as regards electrolysis capacity by 2030 of the seven member States that have set a target was 27.8 GW, around 70% of the EU's 2030 goal. France, Germany and the Netherlands have announced public funding for around €17 billion, while Italy, Portugal and Spain have announced planned mobilised investment from €25.9 billion (Figure 2). In Spain, companies like Cepsa, Enagás, Endesa, Iberdrola, Naturgy and Repsol, among other industrial players, are already implementing hydrogen projects. Hydrogen also plays a substantial role among the projects presented by Spain to the Next Generation programme.[11]

9 IRENA (2020).

10 European Commission (2020), *A Hydrogen Strategy for a Climate-Neutral Europe*. Brussels.

11 Miguel Ángel Noceda (2021), 'El hidrógeno se convierte en la principal apuesta de las eléctricas en los fondos europeos', *El País*, 12/II/2021, https://elpais.com/economia/2021-02-11/el-hidrogeno-se-convierte-en-la-principal-apuesta-de-las-electricas-en-los-fondos-europeos.html.

Figure 2. National hydrogen strategies: electrolysis capacity and investment targets (1) (GW and € bn)

(1) Spanish and italian figures refer to mobilised investments while German and French figures refer to spent public funds. 2. Electrolysis target is 2-2.5 GW and total mobilised investment is 7-9 bn including 1 bn public funding. 3. Electrolysis target is 3-4 GW 4. Figures according to National Hydrogen Strategy Preliminary Guidelines. 5.Draft strategy refers to electrolysis target of 1-2 GW.
Source: Hydrogen Europe, National Hydrogen Strategies, December 2020, https://hydrogeneurope.eu/sites/default/files/Map_%20National%20H2%20Strategies.pdf.

1.1. The external dimension of the 2030 EU H_2 Strategy

While the existence of the EU's H_2 strategy is a positive step clearly driving the development of hydrogen markets, there are some substantial differences among EU and member States' hydrogen strategies.[12] Figure 4 summarises the main elements of these strategies for the EU, France, Germany, the Netherlands, Portugal and Spain. From an international perspective, the main differences that arise are the varying emphases on the shades of hydrogen considered and their respective external narratives.

12 See Westphal et al. (2020), Bouacida & Berghmans (2020), and Philibert (2020).

Figure 3. Hydrogen shades[13]

There are different definitions for hydrogen types or 'colours', but for the sake of simplicity this paper adopts the following:

- **Grey** and **black** hydrogen are mainly obtained from natural gas, coal and heavy oil without carbon capture or storage (CCS). Grey (gas) has high carbon intensity while black H_2 has very high carbon intensity.
- **Blue** hydrogen is mainly obtained from natural gas: when obtained through Steam Methane Reforming (SMR) with CCS it has a low carbon intensity; if obtained through pyrolysis it is potentially carbon neutral and is often referred to as **turquoise** hydrogen.
- **Pink** hydrogen is obtained through electrolysis from nuclear power and is carbon (but not environmentally) neutral.
- **Green** hydrogen is obtained through electrolysis from renewable energy sources and is carbon neutral.

Source: the author.

Regarding H_2 'colours' (see Figure 3), the EU's Strategy prioritises green hydrogen, but includes blue and turquoise hydrogen 'on a transitional basis', as in the German strategy. France bets on 'decarbonised' hydrogen, including pink hydrogen without explicitly mentioning it. The three also tend to conceive decarbonised hydrogen as the new transition fuel (instead of natural gas), contributing to develop markets, regulations and infrastructures to pave the way towards green hydrogen. By contrast, the Portuguese and Spanish strategies, especially the latter, are unambiguously in favour of green hydrogen. These different technological approaches are relevant because they influence the external dimension of national hydrogen strategies at both the intra- and extra-EU levels.

13 The gas industry advocates for an accurate taxonomy based on technical criteria instead of colour terminologies. Since 2019 European natural gas associations have publicly requested a taxonomy of renewable and decarbonised gases based on sustainability criteria and carbon footprint along the following definitions: conventional hydrogen (eg, produced without CCS from natural gas), decarbonised or low-emission hydrogen (eg, depending on the degree of CO_2 capture-yet to be defined), and renewable hydrogen. For terminology, see https://ec.europa.eu/info/sites/info/files/energy_climate_change_environment/events/presentations/02.a.02_mf_33_presentation_-_new_gases_network_-terminology_gas_industry_perspective_-_deblock.pdf.

Figure 4. External H_2 selected European narratives

	Shades of H_2	Electrolysers	Export/Import	Narratives
EU	Clean (Green; Blue & Turquoise on a 'transitional basis') CCS ('interim')	6 GW (2024) 40 GW (2030)	- Unrestricted intra-EU cross-border trade - Imports from neighbours (40GWx2 2030)	- Clean H2 as the new transition fuel - H2 as industrial & cooperation policies - Reducing energy & technological dependence - High on external energy policy agenda: re-designing energy partnerships with neighbours - Agreements: Ukraine, North Africa, Western Balkans, Africa - Multilateral forums & standards - Benchmark for € transactions
France	Decarbonised (incl. pink)	6.5 GW (2030)	Self-sufficiency	- Decarbonised H_2 as industrial policy - Reducing energy & technological dependence
Germany	Green (Blue & Turquoise on a transitional basis) No CCS	5 GW (2030)	Imports in the medium term	- Blue H_2 as lifeline to Russia - Green H_2 enabling cooperation and industrial policies - Agreements: Morocco, Ukraine
Netherlands	Clean, zero-carbon, sustainable CCS	3-4 GW (2030) 500 MW (2025)	- Becoming an H_2 'hub' - Interconnections by 2030 - Imports in the long term	- Sustainability of energy intensive industries - H_2 as industrial and technology policies - Regional policy cluster approach - Agreements: 'North-West European' ('if possible, global') & Portugal
Portugal	Green CCS (limited)	250-500MW (2025) 1.75-2GW (2030)	Exports from 2025	- Green H_2 enabling cooperation and industrial policies - Reducing energy & technological dependence - Agreements: Morocco, Spain, Netherlands
Spain	Green No CCS	300-600MW (2024) 4GW (2030)	Exports from 2030	- Green H_2 enabling cooperation and industrial policy - Reducing energy & technological dependence - Countries: Portugal, Italy[1]

Sources: EU and member States Hydrogen Strategies: European Commission (2020), Dutch Ministry of Economic Affairs and Climate Policy (2020), French Ministry for the Economy, Finance, and Recovery (2020), German Federal Ministry for Economic Affairs and Energy (2020), Portuguese Ministry for the Environment and Climate Action (2020), Spanish Ministry for the Ecological Transition and Demographic Challenge (2020), and stakeholders' consultations.

Internally, the EU strategy aims to complete an open and competitive European hydrogen market by 2030, including cross-border operational rules and infrastructure development to achieve the benefits of 'unhindered cross-border trade': competition, affordability and security of supply. However, the word 'interconnections' is only mentioned once when highlighting the role of existing physical interconnections with Ukraine and the Southern Neighbourhood countries. Nothing is said, for instance, about the lack of gas interconnections to be repurposed between the Iberian Peninsula and France.[14]

Externally, the EU's strategy welcomes imports from eastern and southern neighbours. It explicitly refers to the 2X40 GW Green Hydrogen Initiative, an initiative of the European industry association (Hydrogen Europe) to reach 2x40 GW of electrolysers by 2030: 40 GW in Europe and 40 GW more in its neighbourhood to be exported to the EU.[15] The strategy also develops other external narratives, for instance green hydrogen promotion as a European industrial and a cooperation policy, or as a way of increasing energy security and strategic autonomy by reducing energy and technological dependence.

Hydrogen is also expected to rank high on the EU's external energy policy agenda, which intends to re-design energy partnerships with Ukraine, North Africa, the Western Balkans and Africa (through the Africa-Europe Green Energy Initiative). Nothing is said about Latin America, where countries like Chile, Mexico and Brazil have a great potential, if not for exporting in the short-term due to long shipping routes, at least for businesses, industrial and technological cooperation. The strategy, indeed, emphasises the need to participate in multilateral forums, global research networks and standard setting. It also states the goal of developing a euro-denominated benchmark for hydrogen transactions.

1.2. Member States' H_2 external strategies

Member States' H_2 strategies share some objectives, both among themselves and with the EU strategy. Common objectives include the reduction of energy dependence and reducing value-chain vulnerabilities as strong geopolitical drivers of H_2 strategies. Other common objectives include the achievement of decarbonisation goals, hydrogen promotion as industrial policy in the EU and abroad (for instance regarding electrolysers) and fostering cooperation with other countries. Commonalities across H_2 strategies additionally include the desire to participate in international forums and research networks and to contribute to designing international standards.

However, there are nuances depending on the technology prioritised by the different national strategies. While France focuses on industrial policies promoting so-called decarbonised (ie, pink) hydrogen and the Netherlands sustainable (ie, blue) hydrogen, the remaining member States bet on developing a vibrant green hydrogen sector. Figure 2 highlights the main differences across H_2 strategies.

14 European Commission (2020), *A Hydrogen Strategy for a Climate-Neutral Europe.*

15 Van Wijk & Chatzimarkakis (2020).

Regarding trade patterns, the German and Dutch strategies include importing green hydrogen in the medium to long term, while the Portuguese and Spanish strategies bet on exports from 2025 and 2030 onwards, respectively. France seems to follow a self-sufficient strategy supported by its nuclear capacity via pink hydrogen. These divergences have the clear implication that even if Germany could match its import needs with Iberian exports, these will continue to face the barrier of France following a self-sufficient, closed market model. This would hamper hydrogen transit through repurposed gas pipelines or newly built dedicated infrastructures, given the insufficiency of existing gas interconnections across the Pyrenees. North African hydrogen exports will face the same bottlenecks as Iberian countries in reaching Northern European markets unless new transit pipelines are built or sea-borne transport becomes competitive.

By contrast, the Dutch strategy aims to develop a 'North-West European, and if possible global' hydrogen hub, focusing on 'direct contact' with the European Commission, the Pentalateral Forum (Benelux, Germany, France, Austria and Switzerland), North-Sea countries and Portugal. The French mostly inward-looking approach does not consider specific bilateral partnerships. Germany and Portugal also see hydrogen as an opportunity to align cooperation policies with their own national strategies, both having developed hydrogen partnerships with Morocco.[16] Sustainability criteria are key in the German strategy, which includes ensuring that green hydrogen exported from third countries is at the top of their domestic renewable energy production and requiring sustainable water use and value chains.

While striving for international cooperation, Spain's international hydrogen roadmap prioritises the EU dimension: developing an integrated European hydrogen market conducive to 'unhindered cross-border trade' as literally stated by the EU Hydrogen Strategy, allowing the country to become a future net exporter. Regarding the European (and external) dimension of hydrogen as industrial policy, Spanish players highlight the need for an 'inclusive' policy that limits the concentration of EU projects, standards and research programmes to a few member States that would arguably prioritise their preferred technological and normative choices. While the Spanish strategy does not explicitly reject extra-EU hydrogen imports, it is confident that the alignment with the Energy Union and the European Green Deal supports exploiting and integrating the most competitive European renewable resources first.

Either with repurposed or newly dedicated corridors, both Portugal and Spain want to ensure that they will not face past and present hurdles to achieve the EU's electricity and gas interconnection targets. While large-scale exports would not be a priority for at least the next decade, as a significant volume of cross-border hydrogen trade is not expected with the current state of technology, it is important to prepare for the future as the market evolves. Ensuring from the start the real future integration of the Iberian Peninsula with the EU's hydrogen markets should not only be an Iberian priority, because the economic and environmental benefits of integrating the renewable resources of countries with the highest

16 See for instance the Morocco-Germany energy and H_2 partnership, https://www.energypartnership.ma/home/about/; and the Morocco-Portugal Declaration of Cooperation on Green Hydrogen, https://www.mem.gov.ma/Pages/actualite.aspx?act=234.

potential and lower costs span all of Europe. This prioritisation of the European integration path may partially explain why Spain has signed memorandums of understanding with Italy and Portugal to evaluate cooperation on hydrogen-related Projects of Common Interest but has not yet reached agreements with any other neighbouring Mediterranean partner.

Other countries also have hydrogen strategies, or are implementing them. By 2025 it is expected that hydrogen strategies will cover markets representing over 80% of global GDP. In Europe, the UK, Italy, Switzerland, Norway, Ukraine and Russia deserve especial attention.[17] Italy and Poland are also developing their strategies. While the former focuses on green hydrogen, the Polish strategy seems to combine both green hydrogen from Baltic wind farms and blue hydrogen.[18] The US, for instance, has a strategy for low carbon, oil and gas hydrogen, but not yet for green hydrogen. [19]The Australian strategy aims at becoming a major global exporter by 2030 based upon 'clean hydrogen', including both green and CCS technologies.[20] Japan's strategy aims to lead a global hydrogen supply network and importing from overseas to substitute natural gas.[21] Chile also has a clear exporting strategy since 2025, aspiring to 'conquer' global markets from 2030 on.[22] South Korea, China, California and Morocco are other countries developing strategies or roadmaps.[23]

Morocco is one of the countries commonly highlighted by most studies on international and Euro-Mediterranean hydrogen geopolitics and market development. This is due to a combination of elements such as its proximity to Europe, a large local ammonia market for the fertiliser industry and underutilised natural gas export infrastructure.[24] Its significant renewable generation potential results in auction prices among the world's lowest, and relatively sizeable complementary hydropower capacities. The country seems on track to achieve its targets of 42% renewable energy production by 2020 and 52% by 2030. A 'Power to X' roadmap is being developed to position Morocco as a lead producer and exporter of green hydrogen, expecting to be able to provide 2%-4% of global demand,[25] promoting its national technological and industrial base. However, domestic use is also seen as a way to reduce imported coal and gas. Due to its fertiliser industry and phosphate resource base, green and competitive ammonia production is also seen as an important driver in the industrial sector and an export vector.[26]

To conclude, the inconsistency between some external elements in European hydrogen narratives poses the first significant geo-economic and geopolitical barrier to the hydrogen market development in both the EU and the Euro-Mediterranean. These divergences span

17 World Energy Council Germany (2020).

18 Bartosz Bieliszczuk (2020), 'Clean gas: prospects of hydrogen energy development in the EU', PISM Bulletin, nr 168, 12/VIII/2020, https://pism.pl/publications/Clean_Gas__Prospects_of_Hydrogen_Energy_Development_in_the_EU.

19 US Department of Energy (2020).

20 COAG Energy Council (2019).

21 Ministry of Economy, Trade and Industry-METI (2019). See also Nagashima (2020).

22 Ministerio de Energía, Gobierno de Chile (2020).

23 World Energy Council (2020).

24 Pariente-David (2020).

25 Eichhammer *et al.* (2019).

26 See the chapter on Morocco in World Energy Council (2020).

across the policy process, from failure to identify consistent policy and sectoral priorities, to the capacity to establish enabling governance schemes, including the certification of origin for green hydrogen. For now, there is no governance problem in the certification of hydrogen produced outside the EU, since there are no imports yet. However, European standardisation associations have already been working on the definition of a European methodology to certify hydrogen production based on its emissions. Some think tanks are also working on the sustainability criteria that such certification should include. They also affect Mediterranean neighbours, constraining their expectations to integrate within an eventual Euro-Mediterranean hydrogen market, whatever its size.

2 H_2 Med: geo-economic drivers and barriers

This section explores hydrogen's specific geo-economic drivers and barriers in the Mediterranean. As explained above, they are identified from the existing literature and European hydrogen strategies, as well as the 2021 Communication 'Renewed Partnership with the Southern Neighbourhood: A New Agenda for the Mediterranean', which proposes hydrogen production in the Mediterranean as a new strategic priority. They were thereafter completed with stakeholder consultations, offering an exploratory account summarised in Figure 5. Its aim is not to provide a detailed account of existing strategies, cooperation schemes or quantitative results, but rather to obtain a preliminary mapping of the drivers and barriers embedded in their respective external dimensions.

Figure 5. H_2 Med geo-economic drivers and barriers

Geo-economic drivers	Geo-economic barriers
- H_2 as the new transition fuel	- Conflicting geo-economic narratives
- H_2 as industrial & technology policies	- Market prices vs. estimated costs
- Sustainability of energy intensive industries	- Demand uncertainties
- Economic growth, jobs, just transition	- Need for support (incl. cross-border)
- Abundant & low-cost renewables	- Lack of industrial inclusiveness
- Established gas industry & infrastructures	- Interconnections & market integration
- Geographic proximity & low transport costs	- Regulation & governance (incl. pending Paris Treaty art. 6)
- Developing industrial markets	- Absorption capacity
	- Carbon pricing & border adjustments
	- Do not significantly harm provisions

Source: literature review and stakeholders' consultations.

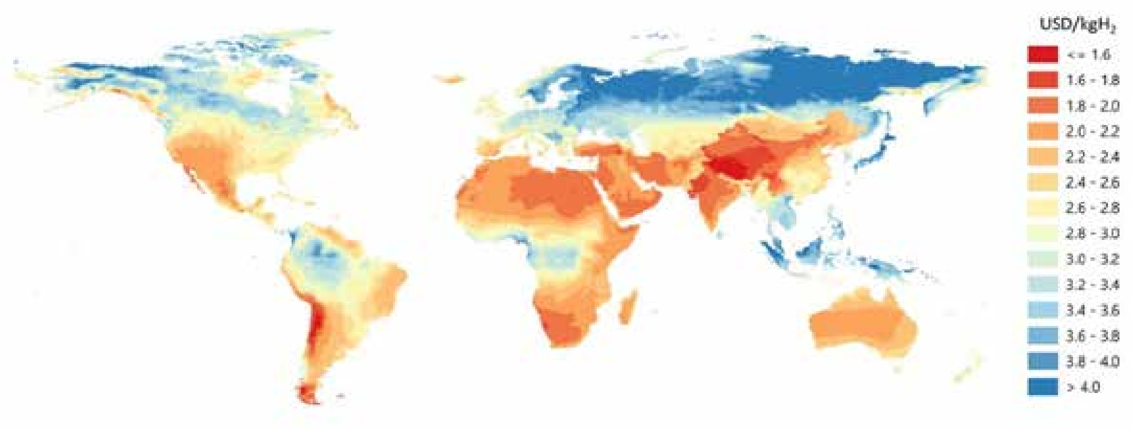
2.1. Geo-economic drivers

Some hydrogen geo-economic drivers are clearly identified in the EU and national strategies, but also in many reports, like hydrogen (green or decarbonised) seen as the new transition fuel, an 'enabler to deploy more variable renewable power in the transition to tomorrow's energy systems'.[27] According to the European Commission's Roadmap Hydrogen and Gas markets Decarbonisation Package, biogas, bio-methane, renewable and decarbonised hydrogen as well as synthetic methane would account for some two thirds of the gaseous fuels in the EU's 2050 energy mix, with fossil gas with CCS accounting for the remainder.

27 IRENA (2019), p. 42.

Other shared features are the aim of promoting the hydrogen sector with industrial and technology policies, and ensuring the sustainability of energy-intensive industries. There are also the economic benefits of creating new value chains and jobs and offering fair transition opportunities to declining sectors and oil and gas exporters.[28] The EU Strategy also highlights that it can create jobs for 'up to 1 million people, directly or indirectly'. The objective to develop both European and Mediterranean hydrogen industrial markets and value chains is also widely considered a relevant driver. Global technological leadership in electrolysers and related technologies, especially regarding competition with China, is also a salient feature in European declarations.

Figure 6. IEA's hydrogen costs from hybrid solar PV and onshore wind systems in the long term (US$/kg$H_2$)



Source: IEA (2019), *The Future of Hydrogen*, IEA, Paris, https://www.iea.org/reports/the-future-of-hydrogen.

Other geo-economic drivers for hydrogen in the Mediterranean are quite clear in the literature.[29] First, as shown in Figure 6 and according to the International Energy Agency (2019), the Mediterranean's abundant solar and wind energy resources mean green hydrogen costs are amongst the lowest in the world in the long term. Costs are especially low in the Iberian Peninsula and in the southern Mediterranean neighbours, and cost reductions in renewables point to levels as much as 15% lower than previously expected. Such reductions result from the deployment of at-scale renewables, especially in regions with high solar irradiation.[30] The strongest cost reductions are expected in locations with optimal resources where renewable auctions continue to break record lows, including Portugal, Spain, Chile, Morocco and the Middle East. Hydrogen is also promising in Turkey due to domestic renewable resources and industry and technology capabilities, but the country is lagging behind in developing a comprehensive strategy.[31]

28 Navigant (2019).

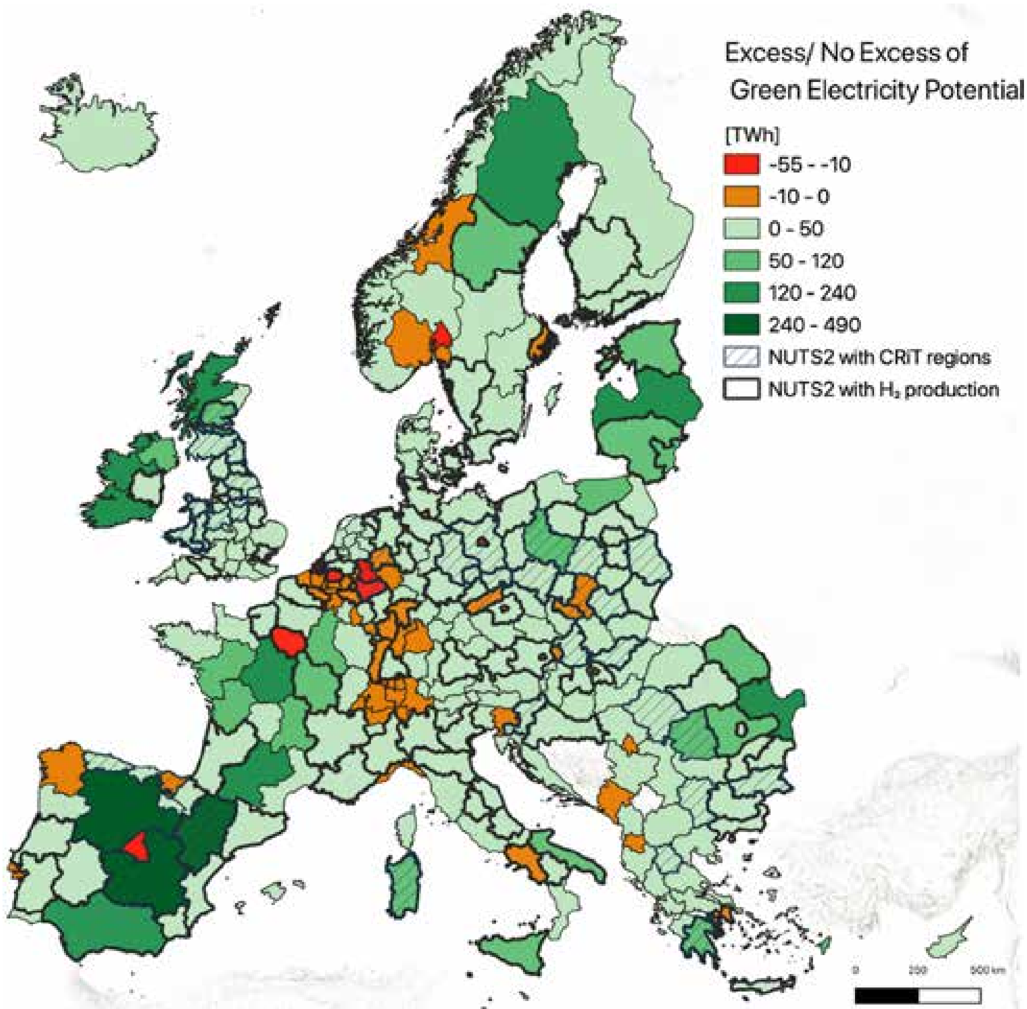
29 See, for instance, RaviKumar Bhagwat & Olczak (2020).

30 McKinsey (2021).

31 Arat *et al.* (2020).

According to some internal industry calculations, 50 GW electrolyser capacity is the 'tipping point' to reach green hydrogen competitiveness, especially when using low-cost dedicated renewables expected at around US$10/MWh by 2030 (for other industry players, however, this price seems too low). Mediterranean countries also rank high in most renewable-related indexes. For instance, the Green Future Index 2021 ranks 76 economies on their progress and commitment towards building a low-carbon future. Within the Mediterranean it includes France (4th) and Spain (18th) among the 20 countries making the greatest progress, followed by Italy (22nd), Morocco (26th), Portugal (30th), Greece (37th), Israel (38th), Egypt (58th), Ukraine (63rd), Turkey (68th) and Algeria (72nd).[32]

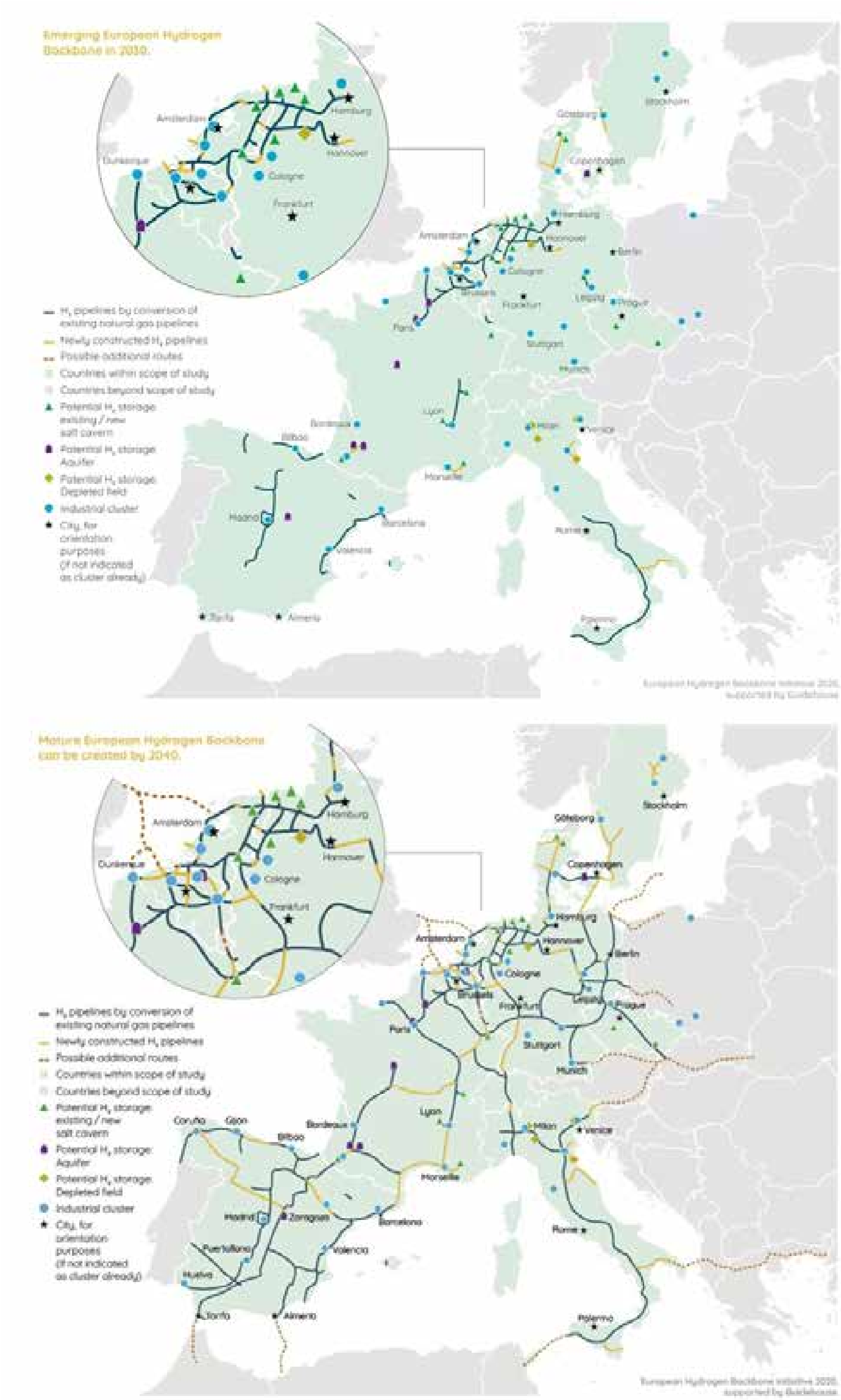
Figure 7. Regions with an excess or deficit of technical potential for green electricity



Source: Kakoulaki *et al*. (2021), https://ars.els-cdn.com/content/image/1-s2.0-S0196890420311766-gr6_lrg.jpg.

32 The Green Future Index, MIT Technology Review Insights, 2021.

Figures 8 & 9. Proposed European hydrogen backbone by 2030 and 2040



Source: European Hydrogen Backbone (TSOs study, referenced as Wang *et al.*, 2020).

European and Mediterranean narratives on exports and imports also reflect the realities of the geographical distribution of European renewable resources. Figure 7 shows the European regions with excess and deficit renewable electricity potentials to cover the total demand and how such imbalances could be matched by transmitting green hydrogen from regions with surplus potential (in green) to those in deficit (red/orange). The countries with the highest surplus green energy potential are Spain and France, followed by Romania and Poland.[33]

Another driver, shared among most European and Mediterranean neighbours, is an established hydrocarbon industry with the know-how to develop large scale hydrogen trade and existing gas infrastructures that can be retrofitted to reduce both hydrogen's uptake and gas's sunken costs. Geographical proximity and relatively low transport costs (when compared with more distant suppliers in the Persian Gulf, Latin America or Australia) were also found to be common drivers for Mediterranean hydrogen exports. A European TSO study proposes a European Hydrogen Backbone for a 'truly European undertaking', connecting hydrogen supply and demand. It requires an estimated total investment of €27-€64 billion based on using 75% of converted natural gas pipelines connected by 25% new pipeline stretches (see Figures 8 and 9).[34]

Green hydrogen imports from southern Mediterranean neighbours are envisaged by some studies to deploy up to 40 GW as soon as 2030, matching the EU's internal target.[35] This goal is recognised by both the EU's Hydrogen Strategy and the 2021 ENP South communication, which identifies hydrogen production as a new Euro-Mediterranean strategic priority. The European gas Transport System Operators (TSOs) promote the development, starting in the mid-2020s, of a hydrogen backbone network that should connect the main production and consumption centres within the EU, and should even allow imports from neighbouring regions like North Africa.

The TSOs' European Hydrogen backbone does not consider imports in detail but includes green hydrogen infrastructure corridors from North Africa, the North Sea (Norway and the UK), Ukraine and Greece, and possibly from Russia from 2040 onwards. As with natural gas, hydrogen pipeline transport is seen as the most efficient option for large quantities over long distances, compared with shipping alternatives in the form of liquid hydrogen, ammonia or organic liquid carriers. The cost estimates for new hydrogen gas pipelines as well as the adaptation of the existing network would mean that seaborne transport will be relegated to situations where there is no other alternative.[36] Nevertheless, other industry players also consider the option of exporting through hydrogen carriers, especially synthetic fuels. These would be especially well suited for intra-European exchanges in the short term and could complement a more modest or gradual pipeline network development. Synthetic fuels or e-fuels could also facilitate the logistics of EU imports from Mediterranean neighbours in the longer term (and even the short term for countries like Morocco).[37]

33 Kakoulaki *et al.* (2021).

34 Wang *et al.* (2020).

35 Van Wijk & Chatzimarkakis (2020).

36 TSOs study, referenced as Wang *et al.* (2020).

37 This paper focuses on hydrogen gas and does not further analyses the conversion of hydrogen to LOHC, e-fuels, methanol or ammonia, which according to oil industry sources greatly simplifies hydrogen logistics between countries and offers a new perspective that should be taken into account.

An Agora Energiewende study finds that future green hydrogen costs will be quite similar in North Africa and Spain. It concludes that Spain's hydrogen exports will outcompete assumed Algerian exports in both the Italian and German markets but be outcompeted by blue hydrogen exports from the Netherlands. It also assesses the viability of a green hydrogen corridor transiting from Spain to South-Eastern France.[38] Mixing hydrogen into existing natural gas pipelines (blending) is the cheapest way of supplying hydrogen from North Africa, but existing capacity is far smaller than North Africa's renewable potential.[39] The limited percentage of blending (around 10%) makes it not a long-term strategy to supply hydrogen but rather a short-term way to scale up the production of electrolysers and reduce their costs. By contrast, another study predicts that sufficient variable renewable electricity will be installed in Europe to produce green hydrogen and does not includes imports in its modelling.[40] A recent Bruegel report also considers that under 'IEA assumptions of current costs it seems hard to make a case for imports of hydrogen from solar energy from North Africa'.[41]

2.2. Geo-economic barriers

While the existing techno-economic literature offers low-cost figures, demand is driven by prices, which depend upon many more elements than just production costs. For instance, techno-economic studies highlight the viability of renewable electricity exchanges within the EU and with Mediterranean neighbours. But in spite of having the technology and EU support, European renewable electricity trade remains limited, partly because of the lack of electricity interconnections to export the southern European renewable surplus. And it is negligible with Southern neighbours, where exchanges are only taking place between Spain and Morocco due to the absence of interconnections.[42]

Regarding hydrogen, demand will depend among other things on the number of uses and sectors that are promoted and the level of support, on building interconnections and promoting market integration, and on whether new regulatory and governance mechanisms could be introduced.[43] For instance, the projections for the use of hydrogen range between around 25%[44] to 10%[45] of the EU's total final energy consumption by 2050. The European gas industry has asked for greater political certainty and clear decarbonisation targets for natural gas consumption in Europe to mobilise and attract investments.[46] Together with regulatory vacuums, the lack of intra-EU and Euro-Mediterranean interconnections risks having the regional hydrogen market developing in a fragmented manner. This will replicate

38 Agora Energiewende (2021).

39 Timmerberg & Kaltschmitt (2019).

40 DNV-GL (2020).

41 McWilliams & Zachmann (2021), p. 6-7.

42 Escribano *et al.* (2019).

43 To some stakeholders, however, the European regulatory framework constitutes no barrier, given the ongoing work to update it and the fact that the inclusion of hydrogen is one of its primary purposes, ranking high in the European energy regulatory agenda.

44 Hydrogen Europe (2019).

45 Shell (2020).

46 Eurogas & EBA (2020).

the lack of integration that has afflicted natural gas with new obstacles, this time to green hydrogen exports.

The lack of institutional and industrial absorption capacity may also act as barriers. For instance, one 2021 ENP communication flagship project consists in supporting Algeria to exploit its solar and wind energy potential and make progress in energy transition. It is difficult to foresee how Algeria could manage to attract (and manage) the investments to embark in the energy transition when it currently struggles to do so in the established natural gas sector. As is the case in other Middle East and North African countries oil and gas producers, Mediterranean hydrocarbon exporters lack an integrated policy approach to confront the twin challenge of increasing renewables into their energy mix and reforming the power sector to attract investment.[47]

Other economic barriers relate to carbon pricing. While the 2021 ENP South communication advocates supporting carbon pricing initiatives, the fact is that no Southern neighbour (not even Israel) has a carbon pricing scheme. Ukraine is the only non-EU European country with a scheduled ETS legislation, while in Turkey carbon pricing is still under consideration.[48] As a result, Mediterranean neighbours will have to be subjected to carbon border adjustments, which are expected by 2023 in sectors relevant to them, like chemicals and fertilisers.[49] Electricity exports will be also subjected to border carbon adjustments and there is no reason why hydrogen would not be levied in the future in the absence of a carbon pricing mechanism extending to Mediterranean neighbours. Nevertheless, gas industry sources consider it premature to point it out as a barrier, mainly because it is a problem that has not yet been posed with regard to hydrogen.

Finally,[50] there are also uncertainties regarding the economic impact of other European norms regarding, for instance, the implementation of the EU taxonomy and its Do No Significant Harm (DNSH) provisions, which include the thresholds that need to be met in order for hydrogen manufacturing to be aligned with the taxonomy.[51] However, it will be a Delegated Act (DA) published by the European Commission, which is being debated at the time of writing,[52] that will establish the legal criteria to be met for an activity to be considered

47 Poudineh *et al.* (2021).

48 World Bank (2020).

49 European Parliament (2020).

50 These two final remarks were proposed by Lara Lázaro.

51 The thresholds were as follows: 'direct CO_2 emissions from manufacturing of hydrogen: 0.95 tCO2e/t Hydrogen; electricity use for hydrogen produced by electrolysis is at or lower than 50 MWh/t Hydrogen; average carbon intensity of the electricity produced that is used for hydrogen manufacturing is at or below 100 gCO_2e/kWh (Taxonomy threshold for electricity production, subject to periodical update)'. EU Technical Expert Group on Sustainable Finance (2019).

52 EC (2020a).

as contributing to climate mitigation, adaptation and to abide by DNSH requirements.[53] Added to the mitigation screening criteria are the adaptation screening criteria to minimise the impact of climate on these activities.[54] The current debates[55] and political divides in the European Parliament on the approval of the taxonomy's Delegated Act are an additional source of uncertainty.[56] At present, however, the gas industry is confident that their cleanest hydrogen production technologies are compatible with the thresholds discussed.

A further source of uncertainty in the future development of an H_2 market is the expected finalisation of the implementation guidelines of the Paris Agreement. Recent discussions have suggested that both articles 6.2 and 6.4 of the agreement could help develop hydrogen markets,[57] especially as countries' climate commitments embrace net zero targets by 2050 or soon thereafter. It has been suggested that Japan's Joint Crediting Mechanism, which is a bilateral carbon trading mechanism, could serve as a pilot for market mechanisms under article 6 and hence as a testbed for green hydrogen exports under the Paris Agreement.[58] Nothing has been agreed at the time of writing and hence the lack of implementation guidelines for market and non-market mechanisms could arguably be considered a current barrier to further the development of an H_2 market.

In short, Mediterranean hydrogen markets make sense on economic grounds, with many drivers supporting their development, first at an EU level, and from neighbouring countries in the longer term. Nevertheless, demand uncertainties remain regarding prices, inclusiveness of support measures (eg, cross-border support), the adoption of adequate standards and regulatory frameworks (including carbon pricing), and shade and sector covering. While the recent increase in CO_2 prices may foster the commercial competitiveness of green hydrogen, there is consensus that support measures would be needed to promote its deployment. This also raises the issue of a lack of inclusiveness were a member State to introduce some kind of support mechanism for any particular hydrogen industry branch that is not accessible to other countries.

53 At present, Annex I to the Commission's Delegated Regulation Supplementing Regulation (EU) 2020/852 on mitigation includes: the manufacture of hydrogen electrolysis technologies. For hydrogen manufacture it requires compliance 'with the life cycle GHG emissions savings requirement of 80 % relative to a fossil fuel comparator of 94g CO2e/MJ [resulting in 2.256 tCO_2eq/tH_2]'. Construction and operation of hydrogen storage facilities are also included. Construction and operation of hydrogen networks and repurposing and retrofitting of gas networks are included as long as their main purpose is integrating H_2 and other low-carbon gases in distribution networks. Hydrogen refuelling infrastructure for personal mobility and for low-carbon water and airborne transport would also be included. EC (2020b).

54 EC (2020c).

55 For a critical analysis from civil society on the draft Delegated Act of the Taxonomy see T&E (2020)..

56 Simon (2021).

57 Michaelowa *et al.* (2020).

58 Michaelowa & Butzengeiger (2019).

3 H_2 Med: geopolitical barriers and drivers

This section starts with the geopolitical barriers facing hydrogen in the Mediterranean to close on a more optimistic view with the drivers that might foster its development. Figure 10 summarises both of them, including sustainability and climate as geopolitical drivers/barriers because of its human and ecological security implications for the entire Euro-Mediterranean region.[59]

Figure 10. H_2 Med geopolitical drivers and barriers

Geopolitical drivers	Geopolitical barriers
- Green Deal & climate diplomacy	- Conflicting geopolitical & energy security narratives
- H_2 as cooperation policy	- Renewable mercantilism
- Strategic autonomy	- Green colonialism
- New interdependencies	- Managing geopolitical risks
- Lifeline to oil and gas exporters	- New dependencies & vulnerabilities
- Climate change mitigation	- Energy resource's governance
- Green soft power	- Applying sustainability criteria
- Sustainability	- Avoiding geopolitical lock-ins
- H_2 as the new Euro-Mediterranean strategic priority	- Political economy shifts in O&G exporters

Note: sustainability and climate are included as geopolitical drivers/barriers because of its human and ecological security implications.
Source: literature review and stakeholder consultations.

3.1. Geopolitical barriers

Within the EU, as shown in the geo-economic analysis above, partially conflicting hydrogen pathways and geopolitical and energy security approaches may constitute geopolitical barriers hampering intra-European hydrogen market integration. Closed or semi-closed intra-European hydrogen markets in the 2030-40 horizon, or with Mediterranean neighbours beyond that date, risk ending up with a new renewable mercantilism. This in turn could erode renewable cooperation and deployment within Europe and, in the medium to long terms, also in the Mediterranean neighbourhood.

Hydrogen also presents intrinsic geopolitical risks to energy security, but with a reduced geographical scope when compared with natural gas due to a significant contribution from European production. The latter reduces vulnerability by reducing import dependence, whereas the benefits of geographical diversification depend upon the geopolitical risk profile

59 Escribano & Lázaro (2020).

of the new suppliers. Hydrogen also entails new dependencies and vulnerabilities. Some of them have industrial implications, for instance, competition with Chinese electrolyser production. Others imply the risk of research and development lags, like patents in related technologies and their market implementation. To our knowledge, no comprehensive geopolitical analysis of the hydrogen value chain has yet been conducted.

Regarding the Mediterranean, geopolitics are very different across its northern and southern shores. In Mediterranean Europe, solar and wind potential is high and geopolitical barriers mainly refer to differing nuances in national approaches. Geopolitical risks to energy security and sustainability are low, and conflicts are limited to the issue of interconnections and market access. By contrast, in the Mediterranean neighbourhood the geopolitical risk is much higher although it greatly varies across countries.

For instance, the failure of the Desertec initiative and the Mediterranean Solar Plan can be explained by both economic and geopolitical miscalculations, but it is undeniable that the wave of unrest that shocked the region in the aftermath of the so-called Arab Spring greatly increased the perceived energy security risks.[60] In the Mediterranean neighbourhood, geopolitical risks constitute a serious barrier for any investment, especially so when considering new ones, like renewable generation plants, electrolysers and transport infrastructures. This includes the renewable and future hydrogen sectors and neighbours that would in principle comply with economic criteria and most sustainability criteria too.[61]

In the longer term, repurposing existing gas pipelines will imply renewing existing gas trade geographical patterns with suppliers like Algeria, but will also allow transit countries like Morocco, Tunisia or Turkey to access European markets. In this regard, while geopolitical hydrogen futures point to a reduced geographical scope, intra-EU and Euro-Mediterranean interdependencies might well increase instead.[62] There are concerns that this could mean exchanging European energy dependence from petrostates to a new class of electro-states (which may or not coincide).[63]

These concerns also raise the issue of weak resource governance in some Mediterranean countries, which adds to geopolitical risk and conflicts with the EU's stated values.[64] While there is consensus that renewables are less likely to incur into resource curse dynamics than oil and gas, a lack of clear resource governance criteria may affect geopolitical sustainability. Concerns over 'green hydrogen colonialism' also constitute geopolitical barriers related to poor resource governance.[65]

60 Carafa & Escribano (2017).

61 Escribano (2019).

62 Liakopoulou

63 Bordoff (2020).

64 For instance, there is evidence that the current EU's oil and gas import pattern is not fully aligned with its own principles regarding the good governance of natural resources (Escribano *et al.*, 2020).

65 See Scita *et al.* (2020) and Showers (2014).

Similar dilemmas arise regarding the implementation of sustainability criteria, included here as another driver related to the EU's external action. It has been proposed that a comprehensive sustainability standard must have positive effects on at least six Sustainable Development Goals, in particular SDG 6 (clean water), SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure), SDG 12 (responsible consumption and production) and SDG 13 (climate action).[66]

Complying with all of them entails a significant challenge for many Mediterranean neighbours affected by different combinations of water scarcity, environmental stress, increasing domestic electricity demand, high-carbon power mixes, failing natural resource governance, highly subsidised energy and power sectors, high vulnerability to climate change, and ample room to improve their climate ambition and policies. Water scarcity is especially constraining. Besides conflicting with SDG 6, it implies desalinisation and therefore higher costs and life cycle carbon assessments. Nevertheless, it has also been argued that desalination would allow synergies in the energy-water nexus, with green hydrogen plants becoming anchor off-takers for desalination plants.[67]

This adds to the carbon geopolitics implied in incentivising neighbours to adopt carbon pricing mechanisms in order not to be subjected to border carbon adjustments. Or to avoid geopolitical lock-ins when building infrastructures with countries not having the prospects to develop carbon pricing mechanisms or ready to align with sustainability or good resource-governance criteria. In the Eastern Mediterranean this applies, for instance, to the proposals of new pipelines and export infrastructures. When being criticised for lack of alignment with the EU's Green Deal, the defenders of the EastMed pipeline project running from Israeli and Cypriot offshore gas fields argue that it could be easily repurposed to hydrogen.

As with the proposal of the EuroAsian and EuroAfrican electricity interconnections, this narrative tends to ignore the above-mentioned carbon-related barriers.[68] It also disregards the geopolitics of anchoring new long-term energy projects in potentially unstable regions where rivalries abound and might intensify due to the energy transition. Other problematic combination arises where abundant solar and wind resources collide with water scarcity and resource governance and human rights concerns. The European Commission has already announced that it will seek to establish 'proper' rules to trade hydrogen with countries like Morocco and Ukraine.[69]

The recent spat between Morocco and Germany (allegedly over Berlin's stance on the Western Sahara) shows the limits of cooperation agreements in cushioning political differences when higher geopolitical prizes are at stake.[70] In Egypt renewable potential coexists with oil and gas production and domestic subsidisation, and authoritarian governance with lagging

66 Wietschel *et al.* (2020).

67 RaviKumar Bhagwat & Olczak (2020).

68 EMBER (2020).

69 Kate Abnett & Vera Eckert (2020), 'EU wants rules on hydrogen trade with partners – bloc's energy chief', Reuters, 5/X/2020, https://www.reuters.com/article/germany-eu-energy-ministers-idUSL8N2GW3V6.

70 DW (2021), 'Morocco cuts contact with German embassy', 2/III/2021, https://www.dw.com/en/morocco-cuts-contact-with-german-embassy-reports/a-56741809?maca=en-Twitter-sharing.

climate policies. Finally, the energy transition implies shifting political economy balances within Mediterranean oil and gas producers, whose incumbents may resist change and obstruct the deployment of renewables.

3.2. Geopolitical drivers

Hydrogen geopolitical drivers in European strategies range from European Green Deal and Climate diplomacy to hydrogen as an opportunity for cooperation policies with partners and other third countries. Achieving the EU's climate neutrality in 2050 brings the challenge of developing green H_2 at a commercial scale, because it plays a key role as a substitute for natural gas. As with geo-economic drivers, H_2 European strategies already identify several geopolitical drivers for hydrogen. Hydrogen diplomacy (agreements, memorandums, cooperation and stakeholders' networks and meetings, etc…) is expected to result in geopolitical de-risking.[71] Hydrogen is also seen as a tool to improve the EU's strategic autonomy and energy security. Most EU hydrogen strategies also identify reducing energy and technological dependence, and increasing supplier, technology and value chain diversification as important strategic drivers for hydrogen.

Some of hydrogen's geopolitical benefits may be derived from the new interdependencies script. As an example, H_2 hubs may substitute gas hubs (admittedly at a smaller scale) and replicate to some extent their geopolitical relevance. This might also offer a 'lifeline' to oil and gas exporters, which could go either through temporarily including blue hydrogen or supporting their gradual transition from oil and gas towards green hydrogen. Russia is considering these and other different hydrogen pathways to first complement and progressively substitute (or decarbonise) its gas exports to the EU.[72]

However, the 'lifeline' script has several limitations, starting with a narrow window of opportunity. Secondly, it challenges the sustainability criteria both under its version of renewables as a way of supplying domestic demand and of freeing fossil resources for exports; or the opposite strategy of exporting surplus renewables while using hydrocarbons in domestic power mixes. In any case, new hydrogen interdependence patterns offer opportunities to both incumbent natural gas players and green energy entrants. H_2 being considered the EU's new Mediterranean strategic priority also sends a clear message helping to turn hydrogen into a focal point of the energy transition in the EU, and increasingly so in its neighbourhood.

Another driver is the (green) soft power of offering an appealing and clear green hydrogen market model, including credible prospects for the long-term integration of Mediterranean neighbours. Hydrogen also brings the soft power of becoming an energy transition companion country or region, in the sense of providing despatchability to neighbours or absorbing its renewable surplus. This also includes accompanying neighbours with mutually beneficial technical, technological and industrial cooperation. But the strongest drivers seem to be climate change mitigation and sustainability goals. There is a wide consensus that,

71 Westphal *et al.* (2020); Wietschel *et al.* (2020).

72 Mitrova *et al.* (2019).

whatever the scale of deployment and market size, hydrogen is needed to achieve the EU's carbon neutrality objective. It could also help Mediterranean neighbours comply with their climate targets and face the high climate change risks foreseen for the region.

As a whole, the mapping of hydrogen's geopolitical drivers and barriers shows the dilemmas for European external action in this field and how geopolitics will continue to play a relevant role. Some elements might be interpreted as both powerful drivers and barriers, for instance different approaches to climate and sustainability or the tension between new dependencies and interdependencies. Similar to the decarbonisation merit order proposed in the previous section, a geopolitical merit order may be devised that is compatible with the time horizons considered by stakeholders: intra-EU market development and exchanges first, then imports from those neighbours where drivers clearly compensate existing barriers, or the latter might be realistically overcome. The final question is what 'low-cost' Mediterranean hydrogen really means, for instance in terms of human rights or the environment, and to the extent to which such costs should be factored in through geopolitical and sustainability criteria.

Finally, compared with past initiatives, like Desertec or the Mediterranean Solar Plan, economic drivers such as the fall of renewable generation costs or the increase in carbon prices might have improved, but new barriers like carbon border adjustments are likely to add to the perpetuation of gas-like geopolitics. From a geopolitical perspective, divergences between EU member States' strategies are still prevailing but are further complicated by broader carbon geopolitics. More importantly, the geopolitical situation in the Mediterranean neighbourhood has continued to deteriorate. Currently the number of eligible countries to benefit (even in the long run) from a substantial set of drivers pushing hydrogen while not being affected by unsurmountable barriers seems quite limited.

Conclusions

This Policy Paper is devoted to the geo-economic and geopolitical drivers and barriers faced by an integrated European and Euro-Mediterranean hydrogen market. The paper analyses first the geo-economic and geopolitical narratives underlying the EU, Dutch, French, German, Portuguese and Spanish hydrogen strategies, as well as the main traits of other countries' strategies and roadmaps. It then explores the geo-economics and geopolitical drivers and barriers of hydrogen in the Mediterranean identified by these strategies and the existing academic, think-tank and grey literature, completing the results with stakeholder consultations. This concluding section summarises the results and reflects on the combination of elements that could accelerate the uptake of an integrated Euro-Mediterranean hydrogen market:

1. In spite of the European enthusiasm for hydrogen and its international prospects acting as a clear driver, the inconsistency between some external elements in European hydrogen strategies also implies geo-economic and geopolitical barriers. Different approaches to green, blue and pink hydrogen are the most salient obstacles, but emphasis on self-sufficient narratives versus import/export complementarities are equally worrying. Developing an integrated European hydrogen market and ensuring unrestricted cross-border trade as stated by the EU's Hydrogen Strategy is a priority in order to be able to match member States' export potential and import needs, but also for cost-effective European decarbonisation.

2. Several geo-economic drivers support Mediterranean hydrogen market development. Abundant renewable resources, existing infrastructures and relatively low transport costs are expected to make green hydrogen competitive during the present decade. Intra-European trade is being considered from 2025-30, and imports from neighbouring countries from 2040 onwards. However, uncertainties remain regarding prices, the coverage, magnitude and extent of support measures (eg, whether they will include cross-border support, both within the EU and with neighbours), the adequacy of regulatory frameworks and its interaction with carbon pricing.

3. While perhaps at a smaller scale and scope, geopolitics will continue to play a relevant role in any future hydrogen market, especially in designing the contours of an eventual Euro-Mediterranean hydrogen space. Mediterranean geopolitics offer both powerful drivers and barriers regarding energy security, sustainability, governance and foreign policy goals. As with geo-economics, a geopolitical merit order would prioritise European integration and exchanges before promoting cooperation with those neighbours where geopolitical drivers clearly overcompensate barriers. In any case, European hydrogen strategies in the Mediterranean (and elsewhere) should include clear geopolitical and sustainability criteria.

4. From this preliminary assessment of Mediterranean hydrogen markets' drivers and barriers, a combination of drivers potentially able to overcome identified barriers could include some of the following elements:

    - A careful management of expectations and further research to reduce the uncertainties surrounding the economics and geopolitics of hydrogen in the Mediterranean.
    - Green differentiation: both Mediterranean geo-economic and geopolitical drivers tend to favour green hydrogen.
    - European integration: the development of an integrated European green hydrogen market requires South-North infrastructure corridors.
    - Industrial inclusiveness: ensuring that national or EU support schemes, as well as industrial cooperation are open to all member States.
    - Promoting cooperation with Mediterranean neighbours to establish governance mechanisms based upon clear and transparent sustainable criteria.
    - Exploring the transitional narrative with Mediterranean oil and gas producers while asserting the EU's attachment to sustainability.

Finally, reducing current uncertainties on the magnitude and extent to which drivers and barriers interact requires refining public policies and more research on its cross-border design. Besides implementing clear and supportive policy pathways, it is key to extend research to the international economics and politics of hydrogen and its linkages, addressing emerging issues like carbon geo-economics and geopolitics or how to implement sustainability criteria. This research itself could be extended to quantify and qualify the identified drivers and barriers (and trying to devise new ones), for instance through questionnaires or semi-structured interviews with stakeholders. It could also contribute to develop geopolitically sustainable criteria for Mediterranean neighbours (or other partners) interested in developing hydrogen and integrating with European markets. International hydrogen markets are coming and not much is known yet about their possible geographical contours, governance or risks. It is high time to prepare for their future geopolitical implications.

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