NOTES
DE L'IFRI

SEPTEMBER
2022

A Guide to Solve EU's Hydrogen Dilemmas

Center for Energy
& Climate

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ISBN: 979-10-373-0592-3

Cover: © r.classen/Shutterstock.com

How to quote this publication:
Diana-Paula Gherasim, "A Guide to Solve EU's Hydrogen Dilemmas", *Notes de l'Ifri*, Ifri, September 2022.

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Executive Summary

Facing multiple crises, the European Commission (EC), backed by European Union (EU) Member States, has embarked on a pathway to accelerate the decarbonization of the EU energy system, while fostering its resilience and accelerating the roll out of hydrogen and derivative by-products.

A political EU objective of 20 million tonnes (mt) of renewable hydrogen and derivative products (hereafter, H2) by 2030 is the ambition around which several questions are now central: *how* (… to import? to produce domestically? to certify? to transport? to make competitive? to ramp up?) and *what for* (… what product? to be used in which sectors? to decarbonize only or to become a worldwide technology leader, and if so in which segment? to advance together or to gain national advantage?). This note assumes that this target is aimed at setting a momentum while at the same time concrete objectives are being worked out in regulation and legislation. It is indisputable that an unprecedented policy, regulatory, R&D and investment effort is underway in Europe to allow the development of H2, particularly of renewable origin. The goal must be to help the energy transition accelerate in a cost-efficient manner, to ensure the competitiveness of industries and their decarbonization, to support the development of European H2 equipment value chains, and to enable the development of regional, European and international supply chains. Another recent objective is to reduce gas demand, which can happen in the short run through replacing EU ammonia production based on natural gas with green ammonia, and in the longer term, by introducing H2 in the power sector.

H2 regulation issues and areas are multiple, highly complex and fragmented – more than 10 files and communications at the EU level with key negotiations are now underway. This results in a situation of regulatory uncertainty for the burgeoning sector, which can act as a brake for the H2 industry development. The fact that other countries (e.g. US' Inflation Reduction Act) develop ambitions and frameworks to support H2 production and consumption, with several large projects already underway, should be a reminder about the competition lying ahead for securing and leading on decarbonization technologies and standards. While all the pieces must be matched successfully to solve the puzzle, the most critical areas to be addressed concern definitions, incentivizing mechanisms and infrastructure. If the EU is to set international standards and be attractive, it must be clear and convincing. This analysis highlights that the priorities to realize EU's political ambition are now to ensure:

- A clear, reliable and coherent regulatory foundation that allows investments in H2 to start quickly, enhances predictability over the pay-

back periods and supports innovation. Regulatory stability and predictability have been a European competitive advantage until now and the EU should be able to replicate this advantage for the nascent H2 economy. When it comes to the targets set for H2 production and consumption, it must be ensured that direct electrification of end uses is not undermined, hence that the measures are sufficiently well targeted towards those sectors that need hydrogen most, but also, from an energy security perspective, that the domestic production potential is not becoming secondary compared to imports.

- Accelerated permitting to match the needed increase in renewable electricity production and grid expansion, in line with the foreseen H2 production. In its absence (including for H2 infrastructure), reaching the proposed targets on renewable H2 consumption will be either a mission impossible or a race to securing renewable H2 imports outside Europe. This situation shall not be seen as an argument against the principle of additionality, but as an imperative mandating Member States to accelerate permitting for new renewable electricity capacities in line with the EU Renewable Energy Directive, as the most concrete way to support industry to become compliant.
- A targeted infrastructure development based on hydrogen valleys taking shape around clusters of energy-intensive industries, followed by the development of H2 corridors to connect those clusters between them.
- An industrial policy that favors the creation of a full-fledged ecosystem, with mechanisms that support the de-risking of H2 projects, as well as action on diversifying and securing the critical raw materials supplies needed for H2 technologies are essential from an industrial perspective. The EC has been working on increasing the visibility around funding opportunities for H2 projects which shall serve the early movers. At the same time, the EU must remain competitive as an industrial base, hence low carbon, cheap and secure energy is key.
- A functional framework for EU hydrogen diplomacy, based on clear certification methodology for H2 imports, on putting in place a "ring of support for energy decarbonization" in the EU's neighborhood and partner countries, as well as on aligning behind the Energy Platform.

While the EU is working to ramp up H2 supply, demand and value chains, fundamental issues must be considered as they largely remain unanswered while all these pieces of legislation and regulation are being drafted: what volumes of H2 can realistically be produced in the EU in the foreseeable future given the insufficient pace of renewables ramp up, the priorities for coal phase-out, for electrification and rising electricity demand? What are the geopolitical implications of large H2 imports? And ultimately, what is really the no-regret H2 demand and how to guarantee large, secure, low cost H2 supplies where there will be demand in a context of growing global competition for a re-localization of energy-intensive industries?

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Introduction

The European family has a newborn. The controversy is on about its origin, its role and its potential to support the common objectives. Some in the family see him as a magic pill, some as a savior, others insist to ditch him unless its pure origin is proven, while others argue it should be treated no differently than other kids. The European family is arguing so hard that feeding the baby becomes secondary. The newborn dies… This could be EU's hydrogen's story… or not, if instead of arguing, the European family focuses on its immediate duties: a stable environment to thrive in, a step-by-step learning process, the nurturing of a growth ecosystem and the careful inclusion of external factors.

Hydrogen, especially of renewable origin, has been consolidating its position in the EU's energy transition policies and envisaged trajectories, ever since the publication of the European Green Deal, followed by the Hydrogen Strategy for a climate-neutral Europe, and culminating with the Hydrogen Accelerator in the REPowerEU plan from May 2022. EU's ambition in this field is intimidating: 20 mt of renewable H2 by 2030, half produced domestically, half sourced from imports. Political by nature at this stage, this objective has a guiding role, in the context of Russia's invasion of Ukraine which forces the EU to accelerate the phasing out of its dependency on Russian fossil fuels, including by accelerating the energy transition and diversifying its energy supplies. In the longer term, H2 is to play a significant role in the European energy transition as it is estimated that their share in the EU's energy mix in 2050 will stand at 13-14%[1].

Ifri has already been extensively contributing to the debates over the future role of hydrogen in Europe as well as hydrogen strategies of leading economies[2]. At a time when major policy and regulation design and implementation are underway, not least as part of the adoption process of the "Fit for 55" package, this note focuses on what can be reasonably done to achieve the above-mentioned targets with an emphasis on regulation and certification, and what is required to ensure clarity, coherence and coordination so as to allow this nascent industry to develop.

1. "A Hydrogen strategy for a climate-neutral Europe", European Commission, July 2020, available at: ec.europa.eu.
2. See: C. Philibert, "Perspectives on a Hydrogen Strategy for the European Union", *Études de l'Ifri,* Ifri, April 2020; C. Philibert, "After the Hydrogen Bubble Bursts: The Factors Shaping and Possibly Unfolding International Hydrogen Value Chains", *Briefings de l'Ifri*, Ifri, September 17, 2021; M. Nagashima, "Japan's Hydrogen Strategy and Its Economic and Geopolitical Implications", *Études de l'Ifri,* Ifri, October 2018; K. Jianjun Tu, "Prospects of a Hydrogen Economy with Chinese Characteristics", *Études de l'Ifri,* Ifri, October 2020.

The policy and regulatory setting - Clarity and coherence are urgent and must be there to stay

Hydrogen is addressed in more than 10 legislative files and communications that are being debated at EU level. As shown in the table below, this creates a complex regulatory and policy puzzle. Many aspects of the hydrogen regulatory framework, ranging from definitions to support mechanisms or infrastructure, are included in legislative files which have been recently proposed for revision or have been presented as new initiatives under the European Green Deal. The “Fit for 55” package (REDII, EU-ETS, AFIR, Fuel EU Maritime, ReFuel EU Aviation), the Gas Decarbonisation Package and the recent EU response to the energy crisis –the REPower EU Plan–include relevant elements for the hydrogen industry. Except the TEN-E regulation, whose revised text has entered into force at the end of May 2022, the remaining key legislative files are under negotiation. This results in a situation of regulatory uncertainty for the sector, which, albeit meant to be temporary, can act as a brake for the H2 industry development or lead to large overcosts and miscalculations. The ongoing revision of the Renewable Energy Directive stands out as the catalyst of industry’s concerns due to its implications on the definition and targets for renewable hydrogen.

Table 1: List of key EU policy and legislative files containing provisions on H2

	Legislative file/communication	Provisions (as proposed by the EC in the last revision/recast, currently under negotiation, except for TEN-E)
Definitions	Amendment to the Renewable Energy Directive (REDIII)	Art. 2 (36): renewable fuels of non-biological origin means liquid and gaseous fuels the energy content of which is derived from renewable sources other than biomass (*compared to REDII, the definition in REDIII is extended to RFNBOs in all end-use sectors, not only transport*) Art. 29a (new): RFNBOs can account towards RES targets in RED only if their GHG savings equal at least 70% ➔ the Commission is empowered to adopt a DA to specify the methodology
	Delegated Act on a Union methodology and rules for RFNBOs production	Rules on additionality, as well as temporal and geographical correlation between the production of the renewable electricity used in electrolyzer and the production of the renewable hydrogen (*for now, it is limited to RFNBOs used in transport, but is expected to be extended to all uses given the change in the RFNBOs definition in REDIII. Legislative clarity is needed.)*
	Delegated Act on methodology for assessing GHG emissions savings from RFNBO/RCF	Methodology based on accounting life-cycle emissions of producing RFNBOs. Fossil fuel comparator for RFNBOs set at 94 gCO2eq/MJ
	Directive on common rules for the internal markets in renewable and natural gases and H2	Art. 2 (2) 'renewable gas' means biogas as defined in Article 2, point (28) of Directive 2018/2001, including biomethane, and renewable gaseous fuels part of fuels of non-biological origins ('RFNBOs') as defined in Article 2, point (36) of that Directive' ➔ certification in accordance with art. 29 and 30 of the REDII. (Art. 8.1) Art. 2 (10): 'low-carbon hydrogen' means hydrogen the energy content of which is derived from non-renewable sources, which meets a greenhouse gas emission reduction threshold of 70% ➔ certification methodology to be published by end 2024.
Demand / supply targets	Amendment to the Renewable Energy Directive (REDIII)	Demand-side mandatory targets: • Industry: 50% of RFNBOs out of the total H2 consumption by 2030 (vs. 35% Council vs. European Parliament introducing a 70% target for 2035 vs. European Commission proposing a 78% target in the REPowerEU Communication) • Transport: 2.6% of RFNBOs in transport (vs. European Parliament: 2.6% by 2028 and 5.7% by 2030 (with 1.2% dedicated to maritime sector); Council: 5.2% + making it indicative; vs. European Commission proposing a 5.7% target in REPowerEU)

	Energy Taxation Directive	The lowest minimum rate of €0.15/GJ applies to RFNBOs. Low-carbon hydrogen and related fuels will also benefit from that same rate for a transitional period of 10 years.
	CO2 Standard for new cars and vans	100% emissions-free cars and vans put on the market from 2035, including fuel-cell and other hydrogen-powered vehicles.
	REFuel EU Aviation	Minimum share of 0.7% of "synthetic aviation fuels" in aviation fuels by 2030 and 28% by 2050.
	Fuel EU Maritime	Technology-neutral approach to reducing the GHG intensity of energy used on-board (2% by 2025; 6% by 2030… 75% by 2050). EU Council added a reward factor of 2 (until 1/1/2030) and of 1.5 (for 1/1/2030 – 1/1/2035) for the use of RFNBOs.
Infrastructure	Alternative Fuels Infrastructure Regulation	1 H2 refueling station / every 150 km along the TEN-T core network and in every urban node (vs. EU Council: 1 H2 refueling station / every 200 km)
	Trans-European Network for Transport (TEN-T) Regulation	Requirements for the deployment, across the TEN-T network of the charging and refueling infrastructure needed for alternative transport fuels in line with AFIR.
	Trans-European Network for Energy (TEN-E) Regulation[3]	H2 transport infrastructure and certain types of electrolyzers have been included in the scope of the revised TEN-E Regulation. H2 infrastructure projects must comply with specific criteria such as: significantly contributing to sustainability, including by reducing GHG emissions, by enhancing the deployment of renewable or low carbon H2 (with emphasis on H2 from renewable sources in particular hard-to-abate sectors).
	Regulation on the internal market for renewable and natural gases and H2	Proposal to create a European Network of Network Operators for Hydrogen (ENNOH) to define a non-binding Union-wide ten-year network development plan for H2, targeted at the needs of developing H2 markets. Max. 5% blending of H2 in natural gas networks.
Funding for research, Innovation, Scaling Up	EU Emissions Trading Scheme Directive	• Current EU-ETS benchmark for H2 products refers to steam reforming of hydrocarbon feedstock. The production of hydrogen through electrolysis is not described. In its revision, the EC proposed to review this before the period 2026-2030. • The Innovation Fund (money raised from the auctioning of 450 million ETS allowances over 2020-2030) is open to projects for breakthrough technologies for all energy-intensive industry

3. "Regulation (EU) 2022/869 of the European Parliament and of the Council of 30 May 2022 on Guidelines for Trans-European Energy Infrastructure", available at: eur-lex.europa.eu.

		sectors covered by Annex I to the EU ETS, e.g. electrolyzer manufacturing, H2 production/use. • The Modernisation Fund (revenues based on the auctioning of 2% of the total allowances for 2021-30) can support H2 activities concerning namely the production and use of renewable H2, green H2 fuelled trains/trucks/cars etc.
	REPower EU	In the REPowerEU Communication, the Commission committed to mobilizing EU funding for the deployment of renewable hydrogen (10mt by 2030) under CEF, Cohesion Policy and RRF. A specific REPowerEU window under the InvestEU Advisory Hub will support: • innovative electrification and hydrogen applications in industry • innovative clean tech manufacturing (such as electrolyzers and fuel cells)
International area	EU Energy Platform	The European Council agreed (March 2022) on the creation of a voluntary coordination mechanism for the purchase of gas and hydrogen at EU level. It aims to enhance long-term cooperation with key suppliers including in hydrogen and renewables. In the REPowerEU Communication: • the EC committed to setting up a dedicated work stream on joint renewable hydrogen purchasing under the EU Energy Platform • Green Hydrogen Partnerships: to achieve the 10 mt of renewable hydrogen imports, via 3 major hydrogen import corridors via the Mediterranean, the North Sea area and, as soon as conditions allow, with Ukraine. • Recognition that other forms of fossil-free hydrogen, notably nuclear-based, also play a role in substituting natural gas.

Source: author's compilation, based on official documents

Particular attention should be paid to ensuring the coherence of other H2-related provisions throughout the interinstitutional negotiations, in order to avoid inconsistencies such as:

- The REDIII proposal[4] underlines that benchmarks should be put in place to incentivize the industry to switch to renewables-based production processes and use of renewable hydrogen. Nevertheless, it is not clear how this provision translates into practice. For instance, currently, the production of hydrogen through electrolysis is not described in the EU-ETS benchmark for H2 products. In this regard, industry alarms that, therefore, an installation that chooses to switch

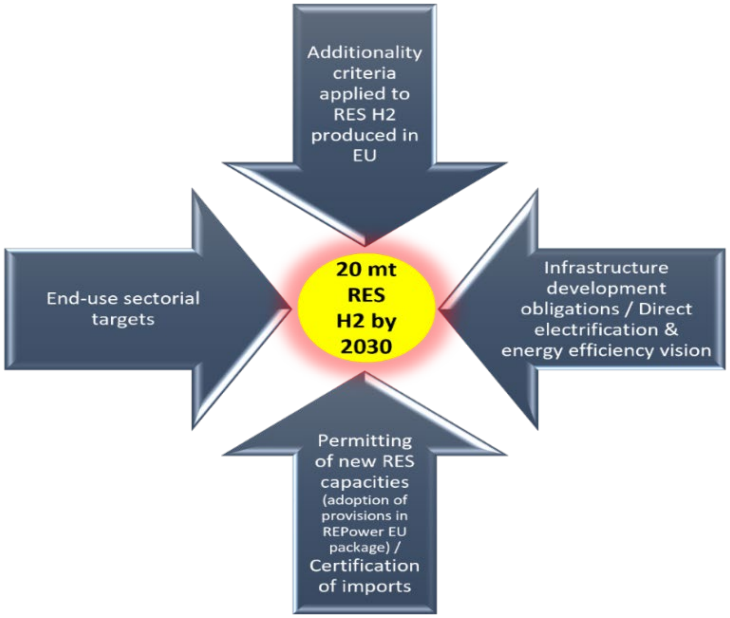
4. European Commission, Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the Promotion of Energy from Renewable Sources, and repealing Council Directive (EU) 2015/652 Amendment to the Renewable Energy Directive, available at: eur-lex.europa.eu.

to renewable or low-carbon H2 would fall out of the EU ETS scope and lose eligibility to free allowances until 2026 (when the revised benchmarks should kick in)[5].

- On several occasions, the EC rightly underlines in its communications that RFNBOs should be used in those sectors that are hard to decarbonize and where direct electrification is not possible. For instance, in the EU Hydrogen Strategy, it is mentioned that "Hydrogen can become in the longer-term an option to decarbonize the aviation and maritime sector, through the production of liquid synthetic kerosene or other synthetic fuels". Yet, the 2.6% RFNBOs target in transport in REDIII proposal does not have a dedicated objective for the maritime and aviation sectors and nor does the FuelEU Maritime proposal. The lack of a truly targeted approach incentivizing the use of H2 in hard-to-decarbonize sectors could lead to an inefficient deployment of H2, at the detriment of direct electrification and energy efficiency.
- A mismatch could arise between end-use targets and corresponding infrastructure development during the negotiations. For instance, in its general approach, the Council keeps the 2.6% RFNBOs target in transport (though making it indicative and adding a multiplier which would make it correspond to 5.2%) but lowers the refueling infrastructure ambition under AFIR by requiring one H2 refueling station every 200 km on the TEN-T core network and in every urban node, instead of the 150 km as proposed by the EC.
- To avoid contradictory signals around targets and means to reach them, countries could make a dedicated effort to estimate what are their needs and ambitions in terms of hydrogen consumption and production by 2030, with a view on 2050, as well as what are the adaptations they need to make in their economies and infrastructure to that end.

5. "Amendments to the European Commission's EU ETS proposal", Eurelectric, December 2021, available at: eurelectric.org.

Figure 1: Key tensions around the realization of the 20 mt RES H2 ambition for 2030



Source: Author

One open discussion point is the inclusion of hydrogen in the list of products targeted by the Carbon Border Adjustment Mechanism (CBAM), which is currently supported by the European Parliament and by some actors in the industrial sector[6]. While the proposed draft Delegated Act on RFNBOs stipulates that the same criteria will be applied to renewable H2 when imported from third countries as for EU-based production, the question is whether there are merits of having a full coverage of H2 imports through their inclusion in the CBAM. Would this be necessary from the perspective of incentivizing third countries to further decarbonize their energy mix or would it further complexify the regulatory framework without major decarbonization gains?

Whereas low-carbon H2 is included in EU's H2 strategy and benefits of a certain level of support (i.e. the proposed revision of the Energy Taxation Directive foresees the lowest minimum taxation rate for it for a period of 10 years; in the REPower EU Communication, the EC recognizes a role notably for nuclear-based H2 in substituting natural gas), overall, EU's focus is on renewable H2, which, for now, it is the only type of H2 with dedicated end-use targets (in the revised RED II). Nevertheless, the complexity and uncertainty around the definition and criteria for what can be labeled as renewable H2 makes it difficult for the market to take bold investment

6. "Industry Joint Letter for the Inclusion of Hydrogen in the Carbon Border Adjustment Mechanism", 29 June 2021, available at: euractiv.com.

decisions[7]. The RED II (art. 27.3, paragraphs 4, 5, 6) provides 3 methods to produce RFNBOs (renewable H2 and its derivates, e.g. ammonia), namely:

- The average share of renewable energy in Member States electricity mixes (past 2 y) ➔ *partial renewable hydrogen*
- The direct connection between renewable electricity generation installations and electrolyzers, respecting additionality criteria and proving (in case of existing connection to the grid) that electricity has not been taken from the grid ➔ *fully renewable hydrogen*
- Grid electricity labeled as 100% renewable as long as supplied through PPAs, respecting requirements of additionality, temporal and geographical correlation ➔ *fully renewable hydrogen*

The controversial "Delegated Act on Additionality"[8] is expected to lay out the framework for what can be labeled as fully renewable hydrogen. The draft proposed by the EC introduces a new possibility for fuel producers to account electricity taken from the grid as fully renewable if the electrolyzer is located in a bidding zone with more than 90% of renewable energy in their power mix in the previous calendar year (which means, for instance, that even in the ambitious scenario of Germany reaching its 80% renewable target by 2030, H2 produced with electricity from the grid cannot be labeled fully renewable H2 by then). Overall, a lot of attention has been placed first and foremost on the criteria of additionality, which effectively asks H2 producers to add new renewable energy capacity to the system to cover for the H2 production. The reason behind such a requirement is sensible. The EC's assumption[9] is that 25% of renewable electricity will be used for H2 production by 2050, in a scenario where H2 would represent 13-14% of EU's energy mix. This is roughly in line with IRENA's assumptions[10] for a 1.5°C scenario where H2 would represent 12% of final energy consumption and 30% of the electricity consumption. If the new needs in electricity for H2 production are not serviced through adding an equivalent amount of new renewable energy capacities but by increasing fossil fuel generation, this would endanger the decarbonization trajectory of the electricity system.

7. "Hydrogen Europe Position Paper. A Regulatory Framework Fit For a European Hydrogen Market", Hydrogen Europe, June 2022, available at: hydrogeneurope.eu.
8. This Delegated Act was proposed as a draft for public feedback by 17th June 2022. Once the Commission adopts the final version, this will enter into force only if neither the Parliament nor the Council object to it within 2 months (extendable once). The proposal cannot be amended by the co-legislators. It should be noted that the ITRE Committee of the European Parliament is proposing to amend the requirements around renewable hydrogen production directly in the Article 27 of the RED, hence the result of the interinstitutional negotiations on RED is key.
9. "A Hydrogen strategy for a climate-neutral Europe", European Commission, July 2020, available at: ec.europa.eu.
10. "Geopolitics of the Energy Transformation – The Hydrogen Factor", IRENA, January 2022, available at: irena.org.

So far, key elements of the debate focused on whether it is justified to differentiate hydrogen from other users of electricity when imposing additionality, as well as temporal and geographical correlation criteria and how strict these should be. The repeated postponement of the delegated act was both a result and a cause of these questions becoming increasingly political and losing sight of one key aspect: investments are unlikely to happen in absence of clear rules for a nascent industry. While rules should be sufficiently strict as to prevent an increase in the carbon intensity of the electricity grid, a gradual strengthening of these based on feedback from first deployments seems a more reasonable approach than over-regulation. Bottomline, the debate around how far such criteria should go seems to be also an expression of a lack of trust in EU Member States' ability to deploy enough renewable energy to cover existing and new demand for decarbonized energy. A truly game-changing and no-regret solution is then accelerating permitting for new renewable energy capacities and the necessary grid development. According to S&P Global Commodity Insights analysis[11], 150 GW of renewable energy capacity is needed to supply the production of 10 Mt of renewable H2 domestically by 2030 (vs. 103 of additional RES foreseen by the EC[12]). At the same time, EU's aim is to also reach a 69% renewable energy share in the power sector[13] by 2030, compared to 37.5% in 2020[14]. Currently, permitting takes between 4 to 6 years[15], despite the fact that the Renewable Energy Directive asks for a maximum two-year period. In May 2022, new legislation was proposed by the EC to facilitate permitting – it is vital that its implementation is taken seriously. In the absence of accelerated permitting but keeping in strict additionality criteria, reaching the proposed targets on RES H2 consumption will be either a mission impossible or a race to securing renewable H2 imports outside Europe. This situation shall not be seen as an argument against additionality, but as an imperative mandating Member States to accelerate permitting for new RES capacities, as the most concrete way to support industry to become compliant. An immediate step to start with is the acceleration of procedures for around 89 GW of renewable energy projects already in pipeline, according to published data[16].

11. "Europe to Need at Least 150 GW of Renewable Power to Meet Green Hydrogen Goal", IHS Markit, June 2022, available at: cleanenergynews.ihsmarkit.com.
12. "Commission Staff Working Document. Implementing the REPowerEU Action Plan: investment needs, Hydrogen accelerator and achieving the biomethane targets", European Commission, May 2022, available at: eur-lex.europa.eu.
13. According to a report by Ember Climate on the European Electricity Review (available at: ember-climate.org), by proposing to increase the RES target to 45% (previously 40%), the REPower EU effectively sets the ambition of 69% of electricity in the EU coming from renewables (previously 65%). In 2021, there were 350GW of installed wind and solar capacities. With REPower EU, the aim is to reach 1102 GW of wind and solar energy installed capacity.
14. "Renewable Energy Statistics", Eurostat, January 2022, available at: ec.europa.eu.
15. "'Power Plant' report", Eurelectric, June 2022, available at: eurelectric.org.
16. "Data Insight: The Permitting Problem for EU Wind Farms", Energy Monitor, April 2022, available at: energymonitor.ai.

It is also important to underline that, currently, the way the compliance of H2 imports with EU rules will be verified is not clear, which may result in future inability to secure enough renewable H2 imports due to the fact that external suppliers cannot be guaranteed that their products will be eligible under (not yet defined) EU rules, or in a situation where H2 imports qualified as renewable by external suppliers are not as virtuous as EU-based H2. This begs the question of a global harmonized certification system for renewable H2, which was extensively studied in a recent report by the World Energy Council and the German Energy Agency that gives an overview of the existing regulations and concludes that "a global certification system will be challenging, as it is unlikely that certain markets, e.g. the European Union, would give up their ambitious criteria (e.g. the renewable electricity criteria according to Art. 27 RED II in the EU) for the sake of a globally harmonized system"[17] . In the absence of harmonization of existing regulations, exporting countries would either need to comply with all existing standards or would need to choose early on their exporting partner, such a situation entailing limited flexibility and potentially new dependencies. The same goes for the certification of low-carbon hydrogen more broadly, which faces also a multiplication of standards globally, as shown by IRENA[18].

All in all, if the EU is serious about achieving the ambition set in the REPowerEU plan of an additional 15 mt of renewable hydrogen–on top of the 5.6 mt already planned under the "Fit for 55" initiative–out of which 10 mt produced domestically, the starting point is to focus on swiftly establishing a clear, coherent and reliable regulatory foundation for the hydrogen economy.

17. "Global Harmonization of Hydrogen Certification. Overview of global regulations and standards for hydrogen certification", World Energy Council, German Energy Agency, January 2022, available at: weltenergierat.de.
18. "Global Hydrogen Trade to Meet the 1.5°C Climate Goal: Part I – Trade outlook for 2050 and way forward", IRENA, 2022, available at: irena.org.

The infrastructure factor – needs, potential and geopolitics

Producing, transporting and supplying 20 mt of renewable H2 by 2030 from both imports (including ammonia) and domestic production will require a sustained development of appropriate infrastructure, inside and outside the EU's borders, from ports to shipping vessels and pipelines. The recently revised Trans-European Network for Energy Regulation (TEN-E) partially responds to this challenge by creating a new type of cross-border infrastructure dedicated to hydrogen. This withholds potential for reinforcing EU's H2 corridors with neighboring countries through setting up Projects of Mutual Interest, a tool which should be further explored.

The REPower EU Plan foresees three major hydrogen import corridors via the Mediterranean, the North Sea area and Ukraine. The map below depicts seven potential H2 corridors in Europe, which are yet to be shaped by the ongoing bilateral agreements and the operationalization of an EU approach to securing H2 supply through the Energy Platform. H2 is expected to flow along the axes North-West, South-East, which could entail new geopolitical arrangements within Europe itself:

- The status of the current EU gas trading hubs as future H2 trading hubs is to be confirmed. While the Port of Rotterdam seems well positioned to secure Netherlands' place as a major H2 hub[19], new hubs are expected to emerge. For instance, Greece might stand out as the preferred hub for H2 imports from North Africa and Middle East, as underlined by the Saudi Arabia Crown Prince, Mohammed bin Salman[20]. This could also entail a situation of competition with EU neighbors like Italy for the "Southern H2 hub" status.
- Due to their considerable renewable energy potential, some EU countries will be in a privileged position as large-scale producers and transit countries (e.g. Spain, Portugal, the Nordics), which could bring substantial revenues to their economies. Improving their connections with the big industry centers in Europe will become essential for ensuring the supply of cheap renewable H2.

19. According to the Port of Rotterdam (available at: portofrotterdam.com), by 2050, 18 mt of green hydrogen would be coming to Europe through Rotterdam

20. "We'll Make Greece Europe's Hydrogen Hub, Says Saudi Crown Prince", *Energy News*, July 2022, available at: energynews.biz.

- Some others are likely to produce H2 only for local needs and could be key as transit countries (e.g. France, Bulgaria, Romania, the Baltics). Their credibility in the H2 economy depends on securing the government's commitment to developing new renewable energy capacities (beyond what is needed for grid decarbonization) and building/retrofitting the necessary infrastructure. For the case of France, for instance, the map reveals that the Iberian corridor could take shape via two distinct routes, implying a case where, should France decide not to invest in its interconnections with Spain, the future H2 corridor could be realized via a cooperation between Spain and Italy.
- Key industrial players with constraints on their renewable energy generation capacity, namely Germany, will be net importers or else could experience industry delocalization to match cheap renewable H2 supply. Their industrial policies will need to evolve to offer more support to energy-intensive companies for securing the needed H2 quantities (via the carbon contracts for difference, or joint subsidized purchases through H2Global for example). Depending on the availability and affordability of different types of low-carbon H2, some industries might choose to consume other types of H2 than based on renewable electricity.

Map 1: Map of potential hydrogen corridors

Source: REPowerEU Communication, May 2022.

As a follow-up to the REPowerEU communication, the European Hydrogen Backbone initiative (representing 31 gas infrastructure operators) called on the EC to make the deployment of the H2 corridors a matter of priority[21]. By looking at the ENTSO-G's Hydrogen Project Visualization Platform[22], an actionable way in the short term would rather be to focus on developing the necessary infrastructure based on existing and planned production/supply projects which are concentrated in certain regions of Europe, as depicted by the map made available on the ENTSO-G platform. This means supporting the development of Hydrogen Valleys around clusters of energy-intensive industries which will be submitted to the RFNBOs consumption targets in REDIII. In this sense, it is interesting to note that the REPower EU Communication foresees topping-up Horizon Europe investments on the Joint Hydrogen Undertaking to double the number of Hydrogen Valleys. Europe can then progressively gain visibility over the transmission infrastructure needed and start connecting the H2 demand clusters, to increase their security of supply. Hence a much more targeted approach by 2030 should be explored when it comes to infrastructure development, based on the progressive materialization of the needs.

Finally, given that an important share of the H2 imports is expected to be under the form of ammonia and will be used as such, the development of adequate facilities in the EU's ports is another investment area to be pursued.

Less present in the discussions but equally key when it comes to the future infrastructure needed for ensuring the security of supply of H2 and contributing to boosting the flexibility of the electricity system, the storage of H2 withholds in itself potential geopolitical implications in Europe. One method which is already starting to be deployed is H2 storage in salt caverns, but these are not equally present across Member States, according to available sources[23]. Germany, Netherlands and Denmark stand out for their high potential in salt caverns, Spain, France, Poland and Romania have good potential, while the rest of the European countries see a very limited or even no presence at all of salt formations on their territory. It is thus an open question whether for instance Romania becomes a H2 storage hub in Central-Eastern Europe, as, more than natural endowment, a clear vision and political and financial commitment to such an objective would be needed. Finally, an eventual upcoming EU strategy on storage should consider the issue of H2 storage infrastructure.

21. See "CEOs of 31 European gas infrastructure companies present a pledge to establish hydrogen supply corridors by 2030 to the European Commission at the European Hydrogen Backbone Day event ", European Hydrogen Backbone, June 2022, available at: ehb.eu.
22. See ENTSOG H2 Project Visualization Platform, available at: entsog.eu.
23. Neuman-Esser, Blog "Storing Hydrogen", available at: neuman-esser.de.

The industrial factor – building a fully-fledged ecosystem to capitalize on early public support

In 2019, the Strategic Forum for Important Projects of Common European Interest (IPCEI), a joint body of representatives from Member States and industry, identified Hydrogen Technologies and Systems as one of Europe's key strategic value chains. The strategic character of H2 has thereafter been stressed in a large number of papers and communications and culminated with the RePowerEU's Hydrogen Accelerator ambition.

But can the EU put in place a H2 industry that is competitive globally and supportive of the European wider industrial tissue, in a context of deteriorating public finances, inflation and mounting needs for public spending? If 20 mt of renewable H2 by 2030 is a priority, can Europe use it as a chance to push for reindustrialization, technological leadership on international markets and synergies with other EU sectors? IRENA estimates that, by mid-century, the market potential for electrolyzers could be of $50-60 bn and for fuel cells $21-25 bn[24]. European companies' share of the pie will depend on taking the right actions today to support European technologies and maintain a competitive edge over time.

The industrial and competition policies in the EU have been clearly steered in a favorable direction for the H2 ecosystem by a steady increase in financing, technical assistance and industrial cooperation opportunities. This EU-level mobilization comes in parallel to support from individual Member States, although with different degrees of national-level determination and firepower. According to Hydrogen Europe's first estimates, under the national Recovery and Resilience Plans put forward by Member States, potentially over €50 bn in direct and indirect funding could be made available for the hydrogen industry, out of which €12 bn would be dedicated exclusively to hydrogen, the most ambitious countries being France, Spain, Germany and Italy. These funds must be spent by 2026, which makes them a great booster to the early comers in the industry.

The EU has put in place a wide range of mechanisms to support the development of H2 and has been working on increasing visibility around funding opportunities for H2 projects. The Hydrogen Public Funding Compass[25], a

24. "Geopolitics of the Energy Transformation: The Hydrogen Factor", IRENA, 2022, available at: www.irena.org.
25. See: www.ec.europa.eu.

publicly available platform set up by DG GROW, provides a comprehensive listing of EU funding programs and funds financed by the 2021-2027 long-term EU budget and NextGenerationEU and national funding programs and funds available at EU country level. The table below gives an overview of some of these. Although the total amount that could be eventually allocated to H2 across these different instruments is difficult to estimate, there is clearly an opportunity to be grasped by Central and Eastern European countries that have a privileged access to funds like the Just Transition Fund and the Modernisation Fund.

Table 2: EU funding instruments for H2 projects

EU Instrument	Type of H2 project	Budget
Connecting Europe Facility **Energy**	Cross-border H2 transmission & distribution projects, storage, electrolyzers =/> 100MW; 70% GHG saving requirement	CEF-E total budget (2021-2027) = 5.84bn€ (min. 60% needs to be allocated to climate objectives)
Connecting Europe Facility **Transport**	H2 refueling infrastructure on the TEN-T road and railway networks, dedicated to public transport in urban nodes and to the deployment of H2 alternative fuels for TEN-T maritime and inland ports, inland waterways.	CEF-T total budget (2021-2027) = €25.8 bn€, out of which, the Alternative Fuels Infrastructure Facility (AFIF) for 2021-2023 = 1.575bn€
Cohesion Policy funds (ERDF, CF, REACT-EU)	Hydrogen is not explicitly mentioned, but projects' eligibility to the funding depends on the priorities identified in the national and regional programs	Total ERDF budget = 191bn€ Total CF budget = 43bn€ 30% ERDF and 37% CF targets to support innovation and entrepreneurship in the transition to a climate-neutral economy.
Horizon Europe	Pillar II of Horizon Europe covers the research and innovation partnerships between the Commission, EU countries and industry, among which the most emblematic ones are: - The Clean Hydrogen Partnership (1bn€), with a key 2030 target of producing clean hydrogen at ~€1.5-3/kg and developing hydrogen valleys - The European Partnership for Clean Aviation (735m€) - Clean steel – low-carbon steelmaking	Horizon Europe total budget: 95.5 bn€ (2021-2027)

Innovation Fund	Breakthrough technologies for all energy-intensive industry sectors covered by Annex I to the EU Emission Trading System Directive, including electrolyzer manufacturing and H2 end-use applications. Projects need to demonstrate financial and business maturity.	Estimated total budget of 20bn€ (based mainly on the auctioning of 450 m EU-ETS allowances)
Invest EU	InvestEU could provide repayable support for projects including clean H2 production, supply (at commercial scale), on-site storage, deployment of refueling infrastructure for transport, and critical infrastructure supporting H2 deployment.	The InvestEU Fund could mobilize 372 bn€ of public and private money through an EU budget guarantee of 26.2 bn€
Just Transition Fund	The main purpose of the fund is to alleviate the impact of the energy transition. As such, it supports a wide range of activities, from reskilling to smart and sustainable local mobility, decarbonizing industry etc. Allocation of funds depends on the Just Transition Plans drafted by MSs and approved by the Commission.	JTF total budget = 19.2bn€
LIFE Program – Clean Energy Transition stream	Directed namely at technical assistance, demonstration, 'close-to-market' projects featuring innovative, demonstrative solutions that offer clear environmental and/or climate benefits.	Total budget for 2021-2027 for the Clean Energy Transition stream: 997 m€
Modernisation Fund	Targeted at supporting the 10 lowest-income EU countries in their transition to climate neutrality. The Modernisation Fund can support H2 activities concerning namely the production and use of green hydrogen from renewable electricity; assets like green H2 fuelled trains/ trucks / cars; high-efficiency hydrogen CHP.	Revenues from the auctioning of 2% of the total allowances for 2021-30 under the EU-ETS
The Recovery and Resilience Facility	Activities and projects funded through the RRF depend on every country's Recovery and Resilience Plan. Two flagship areas identified by the Commission are important for H2 projects: - PowerUp: ambition to support the building and sector integration of 6 GW of electrolyzer capacity and production and transportation of 1 million tonnes of renewable hydrogen across the EU by 2025. - Recharge and Refuel, targeting sustainable transport and charging, including hydrogen refueling stations	The RRF will provide up to €337.97 billion in grants and €385.85 billion in loans. 37% of the overall amount needs to be directed to the green transition.

Source: compilation by the author based on official documents.

The latest chapter on this virtuous collaboration between European institutions, Member States and industry was the approval by the EC of up to €5.4 billion of public support by 15 Member States for an Important Project of Common European Interest (IPCEI) in the H2 technology value chain[26], which is estimated to create around 20,000 jobs and includes 41 projects (R&D and first industrial development) undertaken by 35 companies. Some industry voices see this as being the very launch of the European H2 economy. Other H2 IPCEIs are expected to follow[27]. These come on top of the recent revision of the Climate, Energy and Environment Aid Guidelines, the General Block Exemption Regulation, which allow aid for the deployment of renewable energy, including electrolyzers and their components, and could be more easily accessed[28] by projects that have been candidates to the IPCEI status. Finally, the recently amended Temporary Crisis Framework allows for simplified tender procedures that can be quickly implemented in order to support the rollout of renewable energy and the decarbonization of industrial processes, including through electricity-based hydrogen. Given that the window of opportunity is open only until 30 June 2023, it implies that both project developers and governments need to act swiftly to seize it.

The EC has also been working on establishing the basis of EU-wide industrial cooperation, including by setting up the European Clean Hydrogen Alliance as the go-to gate for players in the H2-related sectors, which served as a platform for collecting a pipeline of 750 H2 projects. As a response to the Hydrogen Accelerator, the Alliance issued the Electrolyzer Summit Joint Declaration by which electrolyzers manufacturers in Europe committed to a tenfold increase of their annual electrolyzers manufacturing capacity to 17.5 GW by 2025. Whereas reaching 10 Mt of renewable hydrogen produced domestically means multiplying current electrolysis capacity at least up to 50 times[29] by 2030, the above-mentioned target could prove to be a catalyst for investments in the European market, as well for Member States to review their national hydrogen strategies which currently sum up to about 40 GW of electrolysis capacity by 2030.

All of the above are key elements for de-risking hydrogen projects and their concretization is steering the H2 industry in the right direction. Some key considerations should be kept in sight:

26. "State Aid: Commission approves up to €5.4 billion of public support by fifteen Member States for an Important Project of Common European Interest in the hydrogen technology value chain", Press release, European Commission, July 2022, available at: ec.europa.eu.
27. "Hydrogen: First IPCEI Tranche Approved", Table Europe, July 2022, available at: table.media.
28. According to the European Electrolyzer Summit Joint Declaration (available at: ec.europa.eu).
29. According to the European Electrolyzer Summit Joint Declaration (available at ec.europa.eu), electrolyzer capacity in Europe is around 1.75GW and to produce 10mt of renewable hydrogen would require an installed electrolyzer capacity pf 90-100GW. Other estimates found in the paper "How to deliver on the EU Hydrogen Accelerator" (available at: h2-global.de), endorsed by the H2Global Foundation among others, show that 192GW of electrolyzer capacity will be needed in Europe to achieve the 10mt H2 domestic target (and 158GW abroad).

- International competition is mounting and Europe must learn its lessons from its past industrial setback in the solar PV industry. In 2007[30], the European PV industry accounted for around 30% of the global market for module production, while in 2020, the European share was of only 3% (vs. 95% in Asia)[31]. At the end of 2020, according to the EC, 57% of global investments in electrolyzers were expected to happen in Europe by 2030[32]. While the EU is deploying an extensive panoply of support instruments to seize this reindustrialization opportunity, other countries are stepping up their industrial ambitions. The US Inflation Reduction Act proposes a straightforward incentivizing system for clean H2 production with up to $3/kg tax credit which creates a massive competition to the EU funding and regulatory panorama. If the EU gives itself the means to play the cards of regulatory stability and ecosystem value, risks of being outcompeted in terms of investment attractiveness should be less of a threat. The recent announcement by the EC President[33], concerning the establishment of an EU Hydrogen Bank with a financial support potential of up to €3 bn goes in the direction of more clarity over the availability of funding.
- In its Hydrogen Strategy, the EC estimates that investments needed in the H2 economy by 2050 would fall somewhere between €180 – 470 bn. Private investments will be crucial. Beyond the above-mentioned schemes which are valuable for the early steps, other mechanisms, increasingly based on private financing, need to be explored, ranging from H2 purchase agreements, contracts for difference, to advisory and matchmaking services.
- Critical raw materials need to be secured as many are needed in several H2 technologies, notably PEM electrolyzers, which are expected to increasingly compete with alkaline ones, that are currently predominant in the world and are less exposed to significant materials supply risks[34].

30. "Global Market Outlook for Photovoltaics 2013-2017", EPIA, graph page 49, available at: globalccsinstitute.com.
31. "Photovoltaics Report", Fraunhofer ISE, updated: 24 February 2022, available at: ise.fraunhofer.de.
32. "A Hydrogen strategy for a climate-neutral Europe", European Commission, July 2020, available at: ec.europa.eu.
33. "2022 State of the Union Address by President von der Leyen", European Commission, September 2022, available at: ec.europa.eu.
34. S. Kieme, T. Smolinka, F. Lehner, J. Full, A. Sauer, R. Miehe, "Critical Materials for Water Electrolyzers at the Example of the Energy Transition in Germany", International Journal of Energy Research, January 2021, 45:9914–9935, available at: https://doi.org/10.1002/er.6487.

The international factor – the difficult task of speaking with one voice

"Hydrogen diplomacy" is today more of a Member State matter than an EU one. The EC has the intention to turn the race for securing green H2 supply into a European exercise through its newly established Energy Platform. Succeeding in such an enterprise requires showing the benefits of joint purchase, overcoming national reflexes of supply hoarding, and mainstreaming internationally the European standards and certification for renewable H2. This is a tight rope to walk, more so as securing 10 Mt of green H2 supply for Europe needs to go hand in hand with improving the quality of life and accelerating the grid decarbonization of partner countries. This means that the renewable H2 imports ambition should be matched with the appropriate decarbonization incentives/safeguards for the energy supply in the partnering countries.

Germany leads the plethora of EU states signing Memorandums of Understanding (MoU) on H2 (as illustrated in the table below), which should come as no surprise, given that, out of the 9 bn€ dedicated to putting in practice its Hydrogen Strategy, Germany allocates 2 bn€ to international partnerships on green H2, out of which 900 m€ are to be implemented by its national platform H2Global. The table below delivers a series of insights:

- Germany has a well-structured approach to H2 diplomacy. It features a dedicated budget, a central platform, high-level engagement, dedicated representation in certain countries ("Hydrogen offices") and a comprehensive set of aspects considered in its agreements (technologies, skills, R&D, etc.). Decisively, German companies have the technologies and Germany commits to importing the products in large volumes.
- In the context of the energy crisis, other EU Member States have accelerated their outreach actions and started securing some form of cooperation on H2 with the same partners as Germany. This practice of bilateral agreements could turn out to be counterproductive. The "*first come, first served*" principle would ultimately play against those EU countries which lag behind on establishing their own H2 outreach strategy. Most importantly, there is a risk that EU may lose credibility over its capacity to speak with one voice internationally on energy issues, as well as to harness synergies and economies of scale based on the internal market and the European external action service.

- Beyond securing green H2 supply for European countries, these cooperation agreements withhold industrial and technological opportunities for EU-based energy companies. As shown in the table, some MoUs are followed by EU companies being awarded local projects/the opportunity to sell their technologies.
- Finally, whereas there is limited information with respect to the volumes that will be made available under these agreements, their growing number and focus on renewable hydrogen suggest a growing global movement. But other types of H2 (e.g. blue, turquoise, pink) could also be part of the equation, according to some agreements. As mentioned in the first section of this paper, the question of certification and verification of H2 import is key and should be clarified as quickly as possible.

Table 3: Selection of bilateral "hydrogen diplomacy" examples between EU Member States and non-EEA countries

EU Country	Partner country	Date	Cooperation Agreement
Germany	Japan	June 2019	Energy Partnership to exchange on innovation, digitization and flexibility in the field of renewable energies, grid modernization and the use of hydrogen. April 2022 – meeting of the Hydrogen Working Group to discuss challenges and opportunities when it comes to building regional and international hydrogen supply chains.
Germany	Morocco	June 2020	Green Hydrogen Cooperation agreement - Power-to-X project - Research platform on Power-to-X - Knowledge transfer & skills partnership with the Institute for Research in Solar Energy and New Energies
Germany	Australia	November 2020	MoU to create a joint feasibility study into a supply chain for renewable hydrogen
France	India	January 2021	MoU on R&D projects in the field of renewables and H2, including skilling aspects, know-how and technology transfers and exchange of information June 2022: TotalEnergies and the Indian company Adani deal to produce 1mt/y of green H2
Portugal	Morocco	February 2021	MoU aiming at developing partnerships in the H2 sector between the economic stakeholders of the two countries.
Germany	Canada	March 2021 & August 2022	Energy Partnership, including cooperation on H2. Canada aims to become of the world's 3 largest H2 producers by 2050. In August 2022, Germany and Canada signed a joint declaration of intent, labeled by the Canadian

			Prime Minister: "Canada-Germany hydrogen alliance". According to which the two countries will establish a "transatlantic Canada-Germany supply corridor" and start exporting H2 by 2025
Germany	Saudi Arabia	March 2021	MoU on German-Saudi H2 cooperation - December 2021: Thyssenkrupp agreement with Saudi Arabia to supply and install a 2GW-plus electrolysis plant to produce green H2
Germany	Australia	June 2021	Australia-Germany Hydrogen Accord with the ambition "*to produce the cheapest green hydrogen in the world*" via 3 initiatives: - HyGate initiative (research, demonstration) - Collaboration in Australian Hydrogen Hubs (selected regions where H2 users and exporters are collocated) to reduce H2 producing costs under 2$/kg - Facilitating renewable H2 trade between Australia and Germany, based on H2Global
Germany	Chile	June 2021	Agreement for the Promotion of Green H2 - creation of a task force as part of the Energy-Partnership Chile-Alemania to identify viable green H2 projects - facilitate the development of supply chains abroad - share knowledge and experiences on regulatory and security processes - promote the development of low-carbon emission's certification programs - joint research, pilot and demonstration projects.
Germany	Namibia	August 2021	Joint Communiqué of Intent - Germany to provide up to 40m€ in funding to Namibia. German assumption: 1kg of H2 from Namibia will cost between 1.5-2€, hence the most competitive price in the world - feasibility study: explore the potential of a green H2 industry, including seawater desalination technologies, possibilities of H2 export to Germany. - pilot projects for green H2 production and transport - Exchange programs for students and experts and scholarships for Namibian students
France	Canada	August 2021	Canada-France Climate and Environment Partnership 2021-2022, including dialogue on low-carbon H2 production and storage.

Germany	Nigeria	November 2021	The first of Germany's Hydrogen Offices[35] was opened in Abuja to enable the establishment of a German-Nigerian "*network of decision-makers, experts and companies from both countries and to offer expert advice on the opportunities and challenges posed by the hydrogen economy*"[36].
Belgium	Oman	September 2021	MoU focusing especially on: - the green Hydrogen Sultanate anchor project "Hyport Duqm", building a 250 - 500 MW green hydrogen factory in the first phase (start operation in 2026). - the implementation of standards for green certification and the interaction between universities, scientific research institutes and the private sector of both countries.
Belgium	Namibia	November 2021	MoU on cooperation in the field of green hydrogen.
Belgium (Port of Antwerp and Zeebrugge)	Chile	November 2021	MoU between the two Belgian ports and the Chilean Ministry of Energy to develop the flow of green H2 from Chile to Western Europe, including through establishing the logistics chain.
Germany	Ukraine	January 2022	German Foreign Minister Annalena Baerbock announced Germany's intention to open a hydrogen diplomacy office in Ukraine
Germany	Saudi Arabia	February 2022	Germany opened a Hydrogen Office (2nd after the one in Nigeria) to encourage reflections on the impact of the transformation of the energy sector and networking among experts, companies and decision-makers.
Netherlands	Canada	February 2022	MoU on "*cementing' hydrogen's role in building a cleaner net-zero future*"
Netherlands	United Arab Emirates	March 2022	The MoU focuses on cooperation in the field of production, transportation and application of clean H2 and related fuels and feedstock
Austria	United Arab Emirates	March 2022	The MoU implies a joint roadmap for accelerating H2 use and a framework for collaboration and exchange across the entire H2 chain (production, storage, conversion, transport, trade, re-conversion, utilization of clean hydrogen, manufacturing, R&D)

35. According to available information at: giz.de, the German Agency for International Cooperation was commissioned a project of creating Hydrogen Diplomacy Offices to promote political dialogue on energy with countries exporting fossil fuels (such as Nigeria, Angola, Saudi Arabia) and raise awareness about rising demand for green hydrogen.
36. "Hydrogen diplomacy: Germany opens Hydrogen Office in Nigeria", German Federal Foreign Office, November 2021, available at: auswaertiges-amt.de.

Germany	India	May 2022	German-Indian cooperation agreement: - establish a task force to promote the creation of a close network between the government, industry and research institutes of both countries - joint measures to support the market ramp-up of green H2 - exchanging know-how on H2 regulation, norming, safety procedures and sustainability criteria
Germany	Angola	June 2022	A "H2 diplo" Cabinet was established in Angola in April 2022[37]. MoU Between the Angolan state energy company Sonangol and two German companies, Gauff Engineering and Conjuncta: - to build a factory to produce around 280,000 tons of green ammonia for export starting in 2024.
Italy	Saudi Arabia	June 2022	Italian Ambassador to Saudi Arabia confirmed Italy's interest for a long-term partnership with a "*future source of hydrogen such as the Kingdom*"[38]
Germany	Egypt	July 2022	Green Hydrogen Partnership. to be noted: - Siemens will 100 - 200 MW electrolysis capacity in the framework of a partnership with the Egyptian Electricity Holding Company (EEHC). - The Egyptian Natural Gas Holding Company (EGAS) signed a MoU with Wintershall Dea to prepare studies on blue and turquoise H2 production in Egypt
France	Saudi Arabia	July 2022	Agreement to cooperate on renewable energy, including hydrogen.
France	United Arab Emirates	July 2022	Strategic energy cooperation agreement on investments by both countries in hydrogen, renewable and nuclear energy
Greece	Saudi Arabia	July 2022	MoU with ambition to make Greece a green H2 hub for Europe and to develop an electricity interconnection to transfer electricity to Greece and Europe.
EU	Namibia	Upcoming	Potential MoU on minerals and green hydrogen to be signed at COP27[39].

Source: Compilation by the author based on data collected from articles & declarations (non-exhaustive).

37. "Germany and Angola Advance with a Joint Project in the Area of Green Hydrogen", Ver Angola, March 2022, available at: verangola.net.
38. "Italy looks forward to Long-Term Partnership with Saudi Arabia in Green Hydrogen", Fuel Cells Works, June 2022, available at: fuelcellsworks.com.
39. "EU, Namibia Plan MoU on Green Hydrogen – report", Renewables Now, July 2022, available at: renewablesnow.com.

The EU recently started to envisage a common approach to hydrogen diplomacy through a European Global Hydrogen Facility dedicated to purchasing H2, which should be part of the EU Energy Platform[40] and built on the models provided by the Germany's H2Global Platform and by the Euratom Supply Agency. The EC intends to develop Green Hydrogen Partnerships around the world through the Energy Platform, with a first one to be established with Egypt, as part of a wider Mediterranean Green Hydrogen Partnership[41]. The success of a European approach to securing H2 imports will depend on factors such as:

- Regulatory clarity: while based on the first table presented in this paper, one could agree that the EU H2 regulatory framework is probably the most advanced worldwide, but also a highly complex one. The EU will either need to convince suppliers from third countries to adopt its standards or to engage in an exercise of global harmonization of definitions and criteria for renewable and low-carbon H2. The question is whether the EU will be able to do one or the other in a sufficiently timely manner to secure the needed quantities.
- The impact of renewable H2 production on the grid decarbonization and electrification of H2 exporting countries: if Europe aims to match future domestic H2 production with imports of renewable H2, it is its responsibility to create a club of support for energy decarbonization. EU's neighbouring countries and its key partners around the world should be targeted. Within such a club, the EU would back ambitious decarbonization policies, promote clean direct electrification of economies and their industries' decarbonization, by offering technical and financial support. In this sense, a question to be asked is whether EU can and should take a more targeted approach to its international funding.

Overall, there are several questions and reflections to be addressed around this new form of European cooperation on hydrogen imports:

- What is the value added in acting under the European flag for a Member State like Germany or France that are already able to secure H2 deals with key future exporters and increase the market share of their own technology-exporting companies?
- Will the EU manage to convince the world to focus on renewable hydrogen production based on high sustainability standards instead of focusing on the best, cheapest available option?
- How will the EU be in capacity to control the H2 production standards in partner countries? What is the risk for EU and the world if its H2 certification system is too complex to be adopted?

40. The EU Energy Platform which was created as part of the response to the Russian aggression in Ukraine and the energy crisis it entailed. Participation to the EU Energy Platform is open to the Energy Community members (Western Balkans, Ukraine, Moldova and Georgia) and its Advisory Group will include industry representatives. Available at: ec.europa.eu.

41. "EU external energy engagement in a changing world", European Commission, May 2022, available at: eur-lex.europa.eu.

Conclusion

Remaining issues that have not been closely looked at in this paper will add to the debate. The *EU Hydrogen and decarbonized gas market* package will continue to nourish intense debates around the necessity of a dedicated European Network of Network Operators for Hydrogen, unbundling, the pertinence of blending H2 in natural gas networks or the necessity of targets on low-carbon hydrogen. Difficult choices are hence ahead for the EU when it comes to hydrogen development in times of an ever more acute energy and climate crisis. The EU will have to advance in spite of the many unknowns in today's hydrogen sector. The other option is to sink under the weight of its own ambitions and constraints. Clear and stable regulation is what the industry needs and what the EU can deliver. It is true that the EU has a considerable normative power worldwide to capitalize on and, as such, it is right to aim for a perfect regulatory framework. But while the EU is fighting over how perfect it should be, the rest of the world might decide that "good enough" is just enough to start with… elsewhere.

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