Hydrogen Policy in the EU: Navigating the Union's Internal Dynamics and Geopolitical Challenges

Yana Zabanova and Rainer Quitzow

Abstract This chapter discusses the evolution of hydrogen policy in the European Union (EU) and related developments in key Member States. It examines the role of the EU as a global policy frontrunner and zooms in on the key measures used by the bloc to promote a hydrogen economy, with a focus on hard-to-abate sectors. It also analyses how the EU's institutional nature as a supranational union of 27 Member States affects its emerging hydrogen sector as compared to other major economies. EU policy-making on hydrogen has been challenged by the bloc's heterogeneity and structural disparities, with Member States having starkly diverging starting points, priorities, and competitive advantages when it comes to the energy transition and green industrial policy. Wealthier and more industrialised Member States have been able to offer generous domestic subsidies for hydrogen, in addition to benefiting from larger amounts of EU-level funding. As a future hydrogen importer, the EU has also put a growing emphasis on hydrogen in its foreign energy and climate policy, even though its hydrogen-related investments in third countries have been relatively limited to date. More recently, the EU, like other major economies, has grappled with the realisation that the green hydrogen economy will take longer to develop than originally anticipated. The persistently high costs of green hydrogen and the difficulties in mobilising demand in key sectors increase the uncertainty about hydrogen's future role in the EU's economy and in international trade.

1 Introduction

Driven by its ambitious climate goals and the need to decarbonise hard-to-abate sectors, the European Union (EU) has prioritised the development of a strong domestic hydrogen economy and an international hydrogen market. The EU's

Y. Zabanova (✉) · R. Quitzow
RIFS Research Institute for Sustainability at GFZ Helmholtz Centre for Geosciences, Potsdam, Germany
e-mail: yana.zabanova@rifs-potsdam.de

R. Quitzow
Technische Universität Berlin, Berlin, Germany

R. Quitzow and Y. Zabanova (eds.), *The Geopolitics of Hydrogen*, Studies in Energy, Resource and Environmental Economics, https://doi.org/10.1007/978-3-031-84022-7_2

Hydrogen Strategy, adopted in July 2020, presents a hydrogen vision as an essential component of the EU's path to net zero and for retaining leadership in clean technologies. Developed in the midst of the global Covid-19 pandemic, the EU Hydrogen Strategy was strongly informed by ideas of green recovery. Further geopolitical shocks, such as Russia's invasion of Ukraine in 2022 and the gas supply crisis, cemented the EU's resolve to decrease its reliance on fossil fuels and to speed up the green transition as a means to boosting energy security. The EU subsequently increased its targets for the production and import of hydrogen, launched domestic production subsidies, and adopted mandatory quotas for industry and transport. Against the background of intensifying international cleantech competition and an emerging global subsidy race, the EU has attempted to invigorate its green industrial policy, adopting the Net-Zero Industry Act in May 2024 (European Commission, n.d.-e).

However, the EU's nature as a supranational actor, with 27 Member States and a division of competencies in key policy areas, sets it apart from other global frontrunners like the USA, Japan, or China. On the one hand, it generates a number of benefits. With a combined population of 448 million people, the EU has a large and attractive single market with unified rules and skilled labour resources—one that can be used to generate demand for green products. The EU's continually developing and expanding Emissions Trading System (EU ETS) is an important pillar with the potential to help incentivise the use of low-emission hydrogen in industry and the maritime sector. ETS revenues are channelled to support innovation and the commercialisation of climate-friendly technologies across Member States, including hydrogen-related applications. With the launch of the European Hydrogen Bank in 2023, this now also includes subsidies for hydrogen production. The bloc also has a developed cross-border gas infrastructure that can be repurposed to carry hydrogen, as well as seaports striving to position themselves as transit hubs for clean fuels.

However, the EU's supranational character also comes with a number of limitations. Its Member States are very diverse in their size, fiscal power, and competitive advantages. Important decisions on the future course of EU policy depend on the EU's ability to reach compromise among the Member States. While the bloc's ambitious climate policy is set at the EU level, energy policy remains largely in the remit of Member States. Reflecting this governance challenge, there are discrepancies between the climate and energy policy defined by the European Commission and the pathways outlined by the Member States. Importantly, the EU's fiscal powers are limited, as it lacks the powers to autonomously raise taxes. The bulk of the EU's seven-year budget, known as the Multi-Annual Financial Framework, comes from Member States' contributions. Absent a major emergency, the bloc is also not allowed to finance its budget by issuing EU-level debt.

In this vein, the EU's hydrogen policy co-exists with the policies developed by proactive Member States, each with a particular starting point and motivation for their engagement. There are those countries that plan to import large amounts of hydrogen, such as Germany, as well as those that aim at becoming exporters, like Spain or Norway (as a member of the European Economic Area), or trading hubs, like the Netherlands or Italy. At the same time, France—a key transit country between the

Iberian Peninsula and Central European countries—is clearly prioritising domestic hydrogen development.

While many of these strategies may be complementary, they also involve major conflicts of interest, raising tensions in EU-level negotiations. Understanding the evolving place of the EU in the global hydrogen economy thus requires an understanding of policies and strategies at the EU level and in important Member States as well as the interplay between these two levels. In the following chapter, we thus frame European hydrogen policy as the confluence of relevant policies and regulations at both levels of governance. We explore how the EU-level policies and processes interact with developments in important Member States and discuss implications for the evolving role of the EU in the broader geopolitics of hydrogen.

This chapter is structured in the following way. First, it describes the EU's strategic vision of a hydrogen economy, its interplay with the priorities and strategies at the Member State level, and the obstacles this vision is facing. Then, it presents key domestic policies in the EU to promote a hydrogen economy, also highlighting policies developed by leading Member States. As the next step, the chapter discusses the external dimension of the EU's hydrogen vision, exploring the bloc's engagement in multilateral governance as well as its efforts to make hydrogen a more prominent component in its bilateral relations as part of the EU's overall external energy and climate policy. The conclusion will summarise the key findings of the chapter.

2 The EU's Strategic Vision for Hydrogen in a Changing Geopolitical Environment

The European Union's hydrogen vision is firmly rooted in the bloc's increasingly stringent climate policy. With the announcement of the landmark European Green Deal in December 2019, the EU officially put itself on the path to becoming the world's first "climate-neutral" continent by 2050. The net-zero goal has since been enshrined in the European Climate Law (2021) and is legally binding. Since then, the EU has adopted an interim target of reducing GHG emissions by 55% by 2030, and a 90% reduction target by 2040 was proposed by the Commission in February 2024 (European Commission, 2024a).

When the EU adopted its "Hydrogen Strategy for a Climate-Neutral Europe" in July 2020, this took place amidst a global wave of interest in clean hydrogen. The bloc followed in the footsteps of key Asia–Pacific economies such as Japan, South Korea, and Australia, which had adopted their strategies in 2017–2019. In Europe, France kicked off the new trend with its 2018 Hydrogen Plan, followed by the Netherlands (April 2020), Norway (May 2020), and Germany (June 2020) (Albrecht et al., 2020, p. 5). By the end of 2024, 20 out of 27 Member States had adopted hydrogen strategies.

The EU Strategy presents hydrogen as essential to reaching Europe's climate goals by helping decarbonise hard-to-abate sectors. It also emphasises the EU's

technological edge in the hydrogen sector and stresses that investment in hydrogen would bring sustainable growth and jobs, especially important in the context of pandemic recovery efforts. In the strategy, the EU made it clear that renewable hydrogen would be prioritised as most compatible with EU goals, yet other types of low-carbon hydrogen would likely be needed as a transitional solution. Finally, the strategy put forward ambitious "strategic objectives": installing "at least" 6 GW of renewable electrolysis capacity domestically by 2024 to produce up to 1 million tonnes of green hydrogen, and as much as 40 GW by 2030 (European Commission, 2020).

Russia's invasion of Ukraine in February 2022 provided an additional impetus to the EU's hydrogen plans. In the REPowerEU package of proposals presented in May 2022, the European Commission laid out a vision of phasing out the EU's dependence on Russian fossil fuels through diversifying suppliers, reducing energy demand, and accelerating the energy transition, including by developing a hydrogen economy. REPowerEU also introduced much more ambitious (albeit non-binding) targets for hydrogen: 10 million tonnes in domestic production by 2030, with an equal amount in imports (European Commission, 2022a).

Since the publication of the EU's hydrogen strategy in 2020, the EU has emerged as the global region with the largest number of announced hydrogen projects. It has adopted important regulatory acts, including a definition of renewable hydrogen, mandates for green hydrogen use in industry and transport, and a set of rules for the future hydrogen infrastructure. The EU and its Member States have allocated tens of billions of euros to support projects along the hydrogen value chain. Finally, hydrogen has become an important focal area in the international outreach by the European Commission and selected Member States.

Despite this increasing momentum, the EU's strategic vision on hydrogen has also encountered a set of challenges. Some of them are rooted in the EU's nature as a supranational entity uniting 27 separate nation states. Others result from the shifting geopolitical realities in Europe and the intensifying global cleantech competition. Internally, charting a common European course on hydrogen has proven complicated. Member States have very different starting points, comparative advantages, and priorities in the hydrogen economy. This has led to disagreements across a number of policy dimensions, resulting in significant delays in adopting key pieces of legislation. There are differences, for instance, on what role low-carbon hydrogen—such as blue hydrogen from natural gas with carbon capture and storage (CCS) or electrolytic hydrogen with nuclear as a power source—should play and how important hydrogen imports should be. There are also clear differences—and oftentimes a mismatch—between the Member States' renewable energy potential and their industrial and innovation capacity. As a result, most hydrogen projects in Europe are clustered in the more industrialised Member States with greater fiscal resources, while lower-income Member States with better renewable energy endowments oftentimes lag behind (Quitzow et al., 2023, pp. 13–14).

The mounting green backlash in many Member States is another prominent challenge. The European energy transition is entering a more difficult and costlier phase, with a growing impact on businesses and households. The farmers' protests that rolled

through several Member States in 2023–2024 featured resistance against the European Green Deal's stricter environmental and climate requirements. In the Netherlands, the outcome of the 2023 parliamentary elections, where the far-right Party of Freedom emerged victorious, has added uncertainty to the country's traditionally robust energy transition policy and its hydrogen development plans. Earlier in Poland and Hungary, persistent democratic deficits led to a row with the European Commission, blocking these countries' access to billions of EUR in pandemic recovery funding, a key source of financing for planned hydrogen-related projects. While the election of former President of the European Council, Donald Tusk, in Poland has put this to rest, the situation persists in Victor Orban's Hungary (Hodgson, 2024).

In addition, hard security challenges for the EU are beginning to compete for attention and resources with the green transition (Eyl-Mazzega and Gherassim, 2024, p. 6). Faced with the prospect of US disengagement from European security under the Trump Administration, the EU is under pressure to substantially increase its defence spending. In early March 2025, the Commission proposed the ReArm Europe Plan, aiming to mobilise up to 800 billion EUR to strengthen Europe's military capabilities.

There is also a growing realisation that a hydrogen economy in Europe will develop more slowly and cost much more than originally hoped for. The EU's original assumptions about "costs, availability, and technical feasibility" of green hydrogen (Graf & Buck, 2024, p. 30) have proven overly optimistic due to the rising costs of inputs such as labour, capital, and technology (Liebreich, 2023). In fact, in 2023–2024, clean hydrogen became more, rather than less, expensive (Martin, 2024b). High costs have negatively affected future customers' willingness to pay, resulting in far fewer offtake contracts than needed to achieve the EU targets. In its comprehensive report published in July 2024, the European Court of Auditors called for a "reality check" for the EU's hydrogen policy (European Court of Auditors, 2024).

As a result of these challenges, progress on the ground has been limited. Of the 7.2 million tonnes of hydrogen consumed in the EU in 2023, 99.7% was produced from fossil fuels (ACER, 2024, p. 4). Electrolyser capacity in operation remains negligible: as of September 2024, it stood at merely 385 MW—a far cry from the EU's now missed 6 GW target for 2024. Existing capacity was spread over 214 plants, meaning that most facilities in question were small-sized (Hydrogen Europe, 2024, p. 20). A lion's share of this electrolyser capacity is located in leading industrialised economies, such as Germany, Spain, Sweden, France, Denmark, and Austria (ACER, 2024, p. 37). Europe still leads the world in the number of announced projects (617 vs. 280 in North America) but is falling behind North America and China in project maturity and committed capacity (Hydrogen Council and McKinsey & Company, 2024, p. 8). In addition, a spate of project cancellations occurred throughout 2024, including several projects that had successfully secured EU or national funding. On the other hand, a number of large green hydrogen projects are moving forward. In July 2024, three projects with a combined capacity of 730 MW—to be implemented by TotalEnergies in the Netherlands and by Shell and EWE AG in Germany—all adopted FIDs, sparking hopes that the ramp-up of the green hydrogen sector was finally picking up speed in Europe (Collins, 2024b).

Geoeconomically, too, the EU is currently facing a changed situation compared to the years 2019–2020 when its optimistic hydrogen vision was originally formulated. The competitiveness of European industry has suffered under high energy prices. The EU also fears falling behind in the global cleantech race, where heavyweights like China and the USA are increasingly resorting to market-distorting measures. There is a concern that generous subsidy schemes abroad, such as in the US, might lure investment away from Europe, thereby undermining the EU's edge on hydrogen technologies. This begs the question of how adequate the EU's economic governance, premised on the idea of fiscal discipline and public debt and deficit thresholds,[1] is to the challenges of the green transition, which requires large amounts of public investment (Huertas Ruiz & Dura Ferrandis, 2023).

At the same time, following Russia's invasion of Ukraine, the EU is placing a much higher strategic emphasis on diversifying international partnerships and decreasing excessive dependencies on single suppliers. The EU's plans to import hydrogen and derivatives make it attractive as a long-term strategic partner for many prospective hydrogen exporters. The latter include, prominently, countries in the Global South, where the EU and its leading Member States have built a strong reputation as providers of climate finance. The challenge here is to reconcile the EU's hydrogen import aspirations with the growing interest of partner countries to use hydrogen to produce higher value-added industrial goods domestically (UNIDO, IRENA, and IDOS, 2023, p. 23; Cassidy & Quitzow, 2023; Weko et al., 2023). Furthermore, many potential hydrogen suppliers to the EU have fossil-reliant grids and low electricity access rates domestically. Thus, there is a tension between using their renewable energy for hydrogen production for export, and decarbonising their own economies, and expanding access to clean energy.

3 Domestic Hydrogen Policies and Politics

3.1 The Struggle to Define the European Hydrogen Market

Consistent with its strict climate goals, the EU has prioritised renewable hydrogen, produced via electrolysis with renewable power. However, it took the bloc several years to agree on a detailed definition of what qualifies as renewable hydrogen. The prolonged process reflects the divergent positions of key hydrogen stakeholders. Most prominently, France pushed for rules that would confer benefits to its electricity system dominated by nuclear energy—something that was opposed by Germany and Spain. While the German government opposes nuclear energy as a matter of principle, Spain is keen to reap benefits from its abundant renewable resources.

In July 2023, the EU finally adopted delegated acts to the Renewable Energy Directive (RED II), which contain the definition of *renewable gaseous and liquid*

[1] The Maastricht Treaty (1992) introduced debt and deficit thresholds for Member States: gross public debt may not exceed 60% of GDP, while the fiscal deficit is limited at 3%.

fuels of non-biological origin (RNFBOs) as well as a methodology to calculate greenhouse gas emissions savings. RFNBO is the term used in EU legislation to refer to green hydrogen and its derivatives, like green ammonia and green methanol, as well as e-fuels. This stringent definition underpins the EU's binding targets for hydrogen use in the industry and transport sectors in the RED (see following section for details) as well as eligibility for EU support schemes.

To have their hydrogen recognised as a RFNBO, grid-connected renewable hydrogen production facilities will have to comply with three key requirements: *additionality* (making sure that hydrogen is generated with new renewable power facilities, so as not to divert existing renewable energy from other important decarbonisation uses), *temporal correlation* (making sure hydrogen is produced at times where there is renewable energy available in the grid), and *geographic correlation* (referring to the location of the electrolyser vis-à-vis the renewable energy installation). Although there are important exemptions catering to countries with large shares of nuclear power, like France, as well as phase-in periods, these strict rules present a major challenge for investments in renewable hydrogen in the Union. Indeed, in September 2024, Robert Habeck, Germany's then-Minister of Economy and Climate Protection and a major advocate of ambitious climate and energy policies, petitioned the Commission to extend phase-in periods to unlock direly needed investments (Collins, 2024c).

These EU rules are not only critical for the ramp-up of renewable hydrogen in Europe but will also apply to future hydrogen exporters who want to benefit from policy-driven demand in the EU. For this, certification schemes are needed that will take into account the specificities of local power systems. Nevertheless, given the EU's prominent position in the emerging global hydrogen economy, its approach has begun to shape market rules in other countries, signalling the continued relevance of the so-called Brussels effect (Bradford, 2019). In the USA, for instance, companies wishing to benefit from tax credits for hydrogen investments will need to comply with the EU-inspired requirements of additionality, temporal matching, and deliverability (akin to geographic correlation) (Webster & Ruiz Guix, 2024).

Other types of low-carbon hydrogen (e.g. blue hydrogen made from natural gas with CCS or nuclear-based hydrogen) are still awaiting a legal definition. There is a general guideline they must provide at least a 70% reduction in GHG emissions relative to the fossil fuel comparator.[2] In September 2024, the Commission published a draft delegated act to the Hydrogen and Gas Market Directive containing a detailed methodology for calculating GHG emissions savings (European Commission, 2024f). It is expected to be finalised and adopted in 2025. While the EU's existing demand-side mandates clearly prioritise RFNBOs, the slower than expected scale-up of green hydrogen is beginning to raise interest in low-carbon hydrogen as a solution for the transitional period (Holl et al., 2024). The launch of Norway's large-scale CO_2 storage facility in the Barents Sea in September 2024 may improve the prospects of blue hydrogen production in northern Europe (Parkes, 2024b). In addition, the draft delegated act allows the use of grid electricity to produce

[2] This translates into the GHG intensity threshold of 3.38 $kgCO_2eq/kgH_2$.

low-carbon hydrogen, provided the emissions threshold is not exceeded. Currently, grid electricity in Sweden, Norway, and France can already be used to meet these requirements, and Austria and Finland are close as well (Holl et al., 2024, p. 22).

As for Member States, their positions have reflected a far wider range of preferences for hydrogen production pathways from the outset. Some, like Spain with its developed renewable energy potential, clearly prioritise green hydrogen. Others, like Germany, have put an emphasis on green hydrogen but are gradually opening to blue as well (in its July 2024 import strategy Germany stated its readiness to import blue hydrogen in a transitional phase) (BMWK, 2024a). Germany's strong relationship with Norway and the latter's initial interest in supplying Germany with blue hydrogen, along with its readiness to contribute to developing an infrastructure link for such exports, played a role in this regard (however, the planned Norway-Germany hydrogen pipeline project was eventually scrapped in 2024). Many Member States with a large share of fossil fuels in the economy have considered a combination of green and blue hydrogen from the very beginning—these include Italy, Hungary, and Poland. Finally, France, with its large domestic nuclear fleet, occupies a special place in consistently pushing to have nuclear-based hydrogen granted a special status at the European level. In addition, France is the leading European country promoting the exploration of geological (also called native, or white) hydrogen following discoveries of deposits in its Lorraine region.

3.2 Creating Hydrogen Demand: The Limits of EU Regulatory Power

The EU has been ahead of other global competitors in mandating the use of renewable hydrogen and derivatives in industry and transport, including in aviation and maritime shipping (see Table 1). The revised Renewable Energy Directive (RED III) targets a 42% share of renewable hydrogen in industry by 2030 and 60% by 2035[3] as well as 1% in the transport sector by 2030. The EU mandates are addressed to Member States, rather than individual companies, meaning that each Member State is responsible for designing policies and support measures to ensure the targets are met at the national level. Given the persistently high costs of green hydrogen and the production capacity constraints, this will be a steep challenge, and many Member States have failed to take the needed steps towards realising this goal. In addition, for green hydrogen mandates to be successful, they need to be accompanied by measures to stimulate demand for related downstream products, such as green steel or green fertilisers, to allow them to benefit from the green premium (Marcu et al, 2024).

[3] It is possible for Member States to discount the contribution of RFNBOs in industry use by 20% under two conditions: (a) the Member State has contributed to the EU's overall renewable energy target of 42.5% by 2030; and (b) if the share of hydrogen from fossil fuels consumed in the Member State does not exceed 23% in 2030 and 20% in 2035. This caveat has been introduced to give nuclear-based hydrogen a role in industrial decarbonisation.

Table 1 Sectoral green hydrogen demand mandates in the EU

Sector	Legal basis	Targets	Notes
Industry	RED III	RFNBO share: 42% (2030) 60% (2035)	Refers to hydrogen use as a fuel and feedstock Targets can be discounted by 20% in Member States using large volumes of low-emission non-fossil (e.g. nuclear-based) hydrogen
Transport—all modes	RED III	1% RFNBO subtarget (2030) (*within the aggregate 5.5% target for advanced biofuels from waste and residues and RFNBOs*)	Additional incentive: in the aviation and maritime sectors, the energy content from RFNBOs counts 1.5 times twice for achieving mandated emissions reductions targets
Aviation	ReFuel Aviation Regulation	Synthetic fuels share: 1.2% (2030–2031) 2% (2032–2034) 5% (2035) 10% (2040) 15% (2045) 35% (2050)	These are sub-targets within broader SAF blend mandates which apply to fuel suppliers at EU airports Electrolytic hydrogen produced with nuclear power is eligible
Maritime shipping	FuelEU Maritime regulation	*1% (2031)—non-binding* 2% (2034)—binding, if the indicative target for 2031 is not met	Additional incentive for use of RFNBOs: until 2033, GHG savings from the use of e-fuels will be counted twice towards meeting the broader sectoral GHG intensity reduction targets

Source Authors' own compilation based on EU legal acts (RED III, ReFuelEU Aviation, FuelEU Maritime)

The EU is also promoting demand for renewable hydrogen-based fuels in the aviation and maritime sectors with the ReFuelEU and FuelEU Maritime Regulations. Unlike directives (such as RED III), which need to be transposed into national legislation, EU regulations are immediately applicable in all Member States. The ReFuelEU Aviation regulation chooses a decarbonisation pathway with sustainable aviation fuels (SAFs). Today mostly represented by biofuels, SAFs also include synthetic fuels, such as e-kerosene made by combining renewable hydrogen with CO_2. The regulation mandates aviation fuel suppliers in the EU to supply a 2% SAF blend by 2025 and a 6% blend by 2030, which includes 1.2% in hydrogen-based synthetic fuels (see Table 1). The scale of the challenge is enormous: by the end of 2024, the share of SAF in aviation fuel consumption in Europe is expected to be just over 0.6% (Luman et al, 2024). SAFs remain marginal and very expensive, and there are no sufficient production capacities in the EU to meet expected demand (Alexe & Briggs, 2024). Hence, there are growing fears that ReFuelEU will not be able to deliver. While Germany, France, Norway, and Sweden have announced plans to develop SAF (Transport & Environment, 2024), no final investment decisions

had been adopted as of November 2024, and the implementation timeline remains uncertain. As for large-scale e-fuel imports into Europe, they are complicated by investor uncertainty due to the EU's changing regulatory framework, as well as strict European regulations on what counts as a sustainable CO_2 source, making it difficult to produce RFNBO-compliant e-fuels in locations outside of the EU (Marcu et al, 2024).

Additionally, quotas have been formulated for the maritime sector in the FuelEU Maritime Regulation (see Table 1), while the Alternative Fuels Infrastructure Regulation (AFIR) mandates the deployment of hydrogen refuelling infrastructure in urban centres and along major European highways. Similar to RFNBOs and SAF, it is questionable if these targets will be met. The complexity of EU rules coupled with limited EU funding is likely to hamper the needed investments, laying bare the limits of EU regulatory action.

3.3 Financing Investments in Hydrogen Supply and Demand

The EU is only beginning to introduce direct support instruments for hydrogen production and demand that could underpin the ambitious targets and mandates outlined in the previous section. Production subsidies are provided by a specially designed facility called the European Hydrogen Bank (EHB), set up in 2023 and endowed with a budget of 3 billion EUR coming from the Innovation Fund. The EHB is understood as part of the EU's response to the US Inflation Reduction Act, which introduced hydrogen tax credits in the US. However, there are important differences in the scope of funding and eligibility. The EHB has a predetermined budget, while support in the US is theoretically uncapped. Furthermore, in the EU, only successful bidders will receive the subsidy, and in the US, any entity complying with the requirements can benefit from the hydrogen tax credit. Finally, the US scheme is technology-neutral, with the amount of subsidy based on the carbon intensity of hydrogen, whereas the EHB expressly supports renewable hydrogen and its derivatives. (At the same time, Trump's re-election in the US has introduced significant policy uncertainty regarding the future of the IRA hydrogen tax credits).

The Bank's first pilot auction (also referred to as the Innovation Fund hydrogen auction), with a budget of 800 million EUR, was held between November 2023 and February 2024, offering a fixed premium of up to 4.5 EUR/kg to successful bidders. It proved highly popular, attracting 132 bids from hydrogen producers in 17 European countries, led by Spain with 46 bids, Germany with 20, and Norway with 14. Seven green hydrogen projects were selected, poised to receive a total subsidy of 720 million EUR. There were three projects from Spain, two from Portugal, and one each from Finland and Norway, submitting bids for subsidies as low as 0.37 to 0.48 EUR/kg H2 (European Commission, 2024c). Successful projects are required to begin producing renewable hydrogen within five years of signing the grant agreement, i.e. latest in 2029.

The low level of the subsidy requested by successful bidders in the first auction compared to the persistently high costs of green hydrogen production means that offtakers will be expected to shoulder the lion's share of the green premium for renewable hydrogen. While all projects were required to show that they had taken "pre-contractual steps" towards securing offtake with one or more partners for at least 60% of the projected produced volumes, these are not finalised offtake agreements (Directorate-General Climate Action, 2024a). As such, there is still the risk that offtakers might not pay the high costs for the green hydrogen produced. A second round of auctions was launched in December 2024, with a budget of 1.2 billion EUR, including 200 million EUR in dedicated funding for maritime fuels. Following intensive lobbying by the EU electrolyser industry, the auction introduced a special "resilience" criterion, prohibiting applicants from sourcing more than 25% of electrolyser technologies from China (Directorate-General Climate Action, 2024b). (However, India is likely to emerge as a serious contender in electrolyser manufacturing as well). The second auction attracted 61 bids from 11 countries (European Commission, 2025b). A third auction, with a budget of up to 1 billion EUR, is planned for the second half of 2025.

The EHB is also offering a voluntary model called "auctions-as-a-service". It allows Member States to contribute additional national funding to EHB auctions to support bids on their territory that did not make the final cut in the EU-wide selection. The option is meant to promote streamlined, Europe-wide rules for auctions, preventing an excessive national fragmentation of support schemes and cutting costs for individual governments. For the second round of auctions launched in December 2024, Austria, Spain, and Lithuania have earmarked up to 836 million EUR combined in national funding, complementing the auction's budget of 1.2 billion EUR (Martin, 2024c). There is some discussion of Member States using their unspent RRF funds or cohesion funds for this purpose.

In parallel, several Member States are also introducing separate hydrogen support schemes outside of the Innovation Fund auctions (see Table 2). Most Member States focus on promoting domestic hydrogen production, with the notable exception of H2Global, Germany's 4 billion EUR support scheme, which subsidises imports from non-EU countries (but is planning to include European producers in the future auctions). H2Global offers ten-year guaranteed offtake contracts for green hydrogen and derivatives, helping to derisk investments in hydrogen production and supply to the European market. It features double-sided auctions—for international producers on the one end and for European hydrogen offtakers on the other. The price difference is then compensated with funding from the German government.

H2Global's first three auctions—for green ammonia, methanol, and synthetic sustainable aviation fuels (e-SAF)—were held in November 2022 (Parkes, 2023). Fertiglobe, a strategic partnership between Saudi Arabia's ADNOC and the Dutch fertiliser producer OCI, emerged as the winner in the renewable ammonia auction. The company has plans to produce green ammonia in Egypt and has signed a contract with Hintco, the intermediary created for implementing the H2 Global scheme. It aims at supplying up to 19,500 tonnes of green ammonia in 2027, with plans to ramp up this volume to a cumulative 397,000 tonnes by 2033 (Hintco, 2024). By contrast, the

Table 2 Hydrogen production subsidies (operational and planned) in EU Member States

Country	Scheme	Support amount	Details
Contributions to the European Hydrogen Bank auctions ("auctions-as-a-service" model)			
Austria	Direct grants in the framework of the *Hydrogen Support Act (Wasserstoff-Förderungsgesetz)*	820 million EUR	National contribution including 400 million for the second auction beginning in December 2024 plus up to 420 million for the years 2025–2026
Lithuania	Direct grants	36 million	National contribution to the second round of EHB auctions (launched in December 2024), funded out of the Modernisation Fund budget
Spain	Direct grants	400 million EUR	For the second round of EHB auctions (launched in December 2024), to be funded from the national Recovery and Resilience Plan
Other national support schemes			
Denmark	*Power-to-X tender* auction-based fixed-price subsidy	DKK 1.25 billion (ca. 170 million EUR) in 2023	Six projects with 280 MW combined electrolysis capacity were selected, obtaining up to 2 EUR/kg H2 in subsidies
Finland	Direct grants	200 million EUR	Supports investments in production of RFNBOs and the deployment of energy storage with up to 45% of investment costs. Partially funded by the RRF
France	Direct grants for investment costs	900 million EUR	Supports the production of liquid fuels from biomass and renewable hydrogen for use in industrial processes and transport. State aid approved by the Commission in March 2024

(continued)

Table 2 (continued)

Country	Scheme	Support amount	Details
Germany	H2 Global, a double-sided auction scheme for hydrogen producers and offtakers	900 million EUR for the pilot tender and 2.2 billion EUR for the second tender (launched in February 2025)	The German government subsidises the difference between the purchase price and the sales price of hydrogen and derivatives
Italy	Auction-based direct grants	590 million EUR (up to 20 million per project)	Supports renewable hydrogen production in hydrogen valleys throughout Italy
Netherlands	H2 Global double-sided auctions for hydrogen producers and offtakers	300 million EUR	Extension of Germany's H2Global mechanism to cover cooperation with the Netherlands
Netherlands	OWE ("Subsidy scheme for scaling-up fully renewable hydrogen via electrolysis"), an auction-based scheme	2023 selection round: 250 million awarded 2024 selection round: 998 million EUR earmarked	Combines investment grants and operational support
Poland	Auction-based grants	640 million EUR	Programme announced in November 2024; support for RFNBOs and low-carbon hydrogen, as well as for refuelling infrastructure
Portugal	Auction-based contracts for difference	70 million EUR	Supports production of renewable hydrogen and biomethane (70 million EUR each) with ten-year contracts

(continued)

Table 2 (continued)

Country	Scheme	Support amount	Details
Spain	Direct grants	800 million EUR	Supports seven projects that produce hydrogen production projects close to its consumers. Approved by the EU Under the Hy2Use IPCEI scheme
Spain	Direct grants for investment costs	1.2 billion Euros	Investment support for the production of renewable hydrogen in hydrogen clusters, or valleys, with a minimum electrolysis capacity of 100 MW. Fully funded by RRF. State aid approved by the Commission in July 2024

Source Authors' own compilation based on publicly available sources and the European Commission's state aid approval announcements

e-SAF auction has failed to attract any bids, reflecting the lack of production capacity development globally. H2Global's second auction round, with a budget of 2.5 billion EUR (including 300 million EUR in funding contributed by the Netherlands), was launched in February 2025. It features four regional lots (for Africa, Asia, North America, and South America & Oceania), as well as one global lot (Hintco, 2025).

3.4 Developing and Regulating a Hydrogen Infrastructure

To create a functioning hydrogen market in Europe, the EU also needs to develop a cross-border hydrogen transport infrastructure connecting hydrogen producers, industrial consumers, and transit hubs. Such infrastructure would include pipelines, green seaports, and hydrogen storage sites. This would allow, for example, green hydrogen produced in Spain to reach industrial sites in northwest Germany, or the Ports of Rotterdam and Hamburg to become hubs for long-distance imports of green liquid fuels, which can be redistributed to other Member States. In addition, a cross-border CO_2 network would be important as a source of sustainable CO_2 for the production of hydrogen-derived e-fuels. At the moment, there is still no comprehensive plan for a 2050 European net-zero infrastructure, however (Graf & Buck, 2024, p. 23). Instead, there are only Ten-Year Network Development Plans (TYNDPs) issued every two years separately by the electricity and gas network operators, ENTSO-E and ENTSO-G.

An integrated hydrogen infrastructure in Europe would require large-scale investments on the order of tens of billions of euros that public funding alone could not provide. One estimate developed by the Commission puts the costs in the range of 28–38 billion EUR for EU pipelines and 6–11 billion for storage (European Commission, 2022a, p. 7). Another estimate produced by European gas transmission system operators (TSOs) originally put the investment needs for a 53,000 km hydrogen backbone by 2040 at 80 to 143 billion EUR. An update released in November 2023 revised these estimates upwards, citing the rising costs of all components (Martin, 2023). The EU can support the development of a European hydrogen infrastructure in three main ways: by financing selected projects, granting a preferential status to other projects to help them attract other sources of investment, and by creating a clear regulatory framework facilitating investment into the future hydrogen infrastructure.

The EU's strategic investment instrument, the Connecting Europe Facility-Energy (CEF-E), supports intra-European cross-border infrastructure, including hydrogen pipelines and electrolysers. To receive funding from CEF-E, the projects need to be recognised as Projects of Common Interest (PCI).[4] Since 2023, there is also an additional category called Projects of Mutual Interest (PMI), referring to infrastructure links between the EU and neighbouring countries. However, CEF-E has a small budget of only 5.84 billion EUR for the years 2021–2027 for all types of energy infrastructure. In addition to funding, the EU can grant a special status to promising cross-border hydrogen infrastructure projects. This brings the benefits of greater political visibility, preferential treatment (e.g. faster permitting and licensing), and the possibility to receive national subsidies from Member States. The PCI/PMI status confers precisely such advantages. The PCI/PMI list finalised in 2024 is the first to include hydrogen projects: out of 166 projects selected, 65 are hydrogen and electrolyser projects (European Commission, 2023e).

So-called Important Projects of Common European Interest (IPCEI) are another case in point. IPCEI can be proposed by groups of Member States to promote cross-border cooperation and to capitalise on European synergies. They typically bundle tens of individual projects united by a common theme. If accepted by the European Commission, they are exempted from state aid rules and can receive funding support from national governments, which also has the potential to unlock a significant amount of additional private funding. The infrastructure-focused "Hy2Infra" IPCEI approved by the Commission in February 2024 has a record budget of 6.9 billion EUR and bundles 33 projects in seven Member States (France, Germany, Italy, the Netherlands, Poland, Portugal, and Slovakia). These include electrolysers, hydrogen pipelines, H2 storage facilities, and port infrastructure (European Commission, 2024b).

Thirdly, the EU has the important task of developing rules and regulations for the future European network for renewable gases. Clarity on the rules is indispensable

[4] To be recognised as PCI, projects must fulfil the following requirements: have a significant impact on at least two Member States and contribute to promoting market and network integration, enhancing security of supply, promoting energy market competition, and/or contribute to the sustainability transition.

for attracting private investment. This is the focus of the Hydrogen and Decarbonised Gas Package, which entered into force in August 2024. The package introduces a new EU entity to be put in charge of the future network, called the European Network of Network Operators of Hydrogen (ENNOH), which will draw up ten-year hydrogen network development plans starting in 2026. It also increases coordination between hydrogen, electricity, and natural gas networks. The legislation regulates connections and access to the gas grid for renewable and low-carbon gases, establishes a certification system for such gases, and regulates tariff-setting for hydrogen transmission and distribution.

Several Member States are already taking action to develop their hydrogen infrastructure. In the Netherlands, which is positioning itself as a future hydrogen hub for Northwest Europe (Stam et al., 2024), the state-owned company Gasunie began construction of the national hydrogen backbone in October 2023. Germany is following suit with its vision of a 9040 km long core hydrogen grid (*Wasserstoff-Kernnetz*). The pipelines are expected to enter in operation between 2025 and 2032 (BMWK, 2024b). In November 2024, Germany's KfW development bank approved a 24 billion EUR loan for the network construction (KfW, 2024). Germany puts an emphasis on integrating its future network with the rest of Europe, requiring that projects within the *Wasserstoff-Kernnetz* have a PCI or IPCEI status. Spain, too, is planning a national hydrogen backbone, which would include pipelines and storage sites, with the total expected amount of investment estimated at 4.9 billion EUR (Martin, 2024a). Finally, in April 2024, the Danish government reached an agreement with opposition parties to finance a national hydrogen network on the Jutland peninsula, to be constructed by state-owned electricity and gas TSO, Energinet (Collins, 2024a). The planned network also envisions a 340 km pipeline link to Germany, which would enable Denmark to export green hydrogen to its neighbor (Laity, 2025).

There are other examples of cross-border cooperation taking place within the EU. Germany and Belgium have agreed to link their hydrogen networks (Kyllmann, 2023). Spanish, Portuguese, French, and German gas operators have joined efforts to implement the H2Med project, a planned pipeline connecting the Iberian Peninsula with Northwest Europe (H2Med, 2023). MosaHyc is an infrastructure project aiming at creating hydrogen pipelines linking France, Germany, and Luxembourg in the Moselle-Saar region. There is also the AquaDuctus pipeline that aims to bring green hydrogen from North Sea offshore wind farms to German industrial consumers (Buljan, 2023), as well as various electrolyser facilities, hydrogen storage projects, and cross-border hydrogen valleys in Denmark, France, Germany, the Netherlands, Spain, and other countries.

4 An Emerging EU Industrial Policy: Up to the Task?

As a global actor, the EU has traditionally prioritised free trade, competition, and a rules-based international order. Yet with the rise of protectionist policies globally, as well as with the EU's growing dependency on imports of critical raw materials

and of many net-zero technologies, the bloc has started to rethink its approach to industrial policy. To date, this has consisted primarily in the promotion of research, development, and innovation. Active support for investments in manufacturing has been slow to emerge. However, the war in Ukraine and increasing geoeconomic rivalry are increasing the willingness to consider a more activist green industrial policy, revealing important challenges for its effective design and implementation.

4.1 Supporting Innovative Technologies in the Hydrogen Sector: An Uneven Landscape

One of the strengths of the EU in the hydrogen economy is its strong track record of funding research, development, innovation, and demonstration. The EU and key European Member States have devoted large volumes of funding to this end. At the European level, the leading actor is the EU's Clean Hydrogen Partnership (CHP). It is a prominent public–private partnership uniting three partners: the European Commission, the industrial grouping called Hydrogen Europe, and the research community Hydrogen Europe Research.[5] CHP promotes the development, commercialisation, and scaling of hydrogen technologies and also engages strongly in pre-normative research, i.e. research that aims to inform future standards (Clean Hydrogen Joint Undertaking, 2022). The CHP has been allocated a 1 billion EUR budget for 2021–2027 from the EU's flagship Horizon research funding framework as well as a matching amount from private partners. It has also received an additional 200 million EUR for its work on hydrogen valleys out of the 2022 REPowerEU package.

R&D funding for hydrogen by Member States, especially those with a strong interest in hydrogen, often exceeds the volumes at the EU level. For instance, in 2023 alone, France spent 586 million EUR and Germany 330 million EUR (see Fig. 1). However, for Member States with limited resources of their own, gaining access to EU funding for research and innovation has been a major motivation behind an increased interest in hydrogen.

Demonstration and first commercialisation represent another key area in which the EU is providing support. The EU Innovation Fund, launched in 2020, is one of the world's largest funding programmes for innovative low-carbon technologies, including hydrogen. The fund supports innovative clean technologies that are past the research stage but are not yet bankable. Its budget is made up of revenues from the auctioning of 530 million EU ETS allowances between 2020 and 2030. At a CO_2 price of 75 EUR, this would put it at approximately 40 billion EUR until 2030 (European Commission, n.d.-a). The Fund's focus on new technologies, rather than on large-scale deployment and scaling-up of commercially available technologies, sets it apart from the US's landmark Inflation Reduction Act (2022). Another difference is that in

[5] The CHP is a successor of the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) established in 2002.

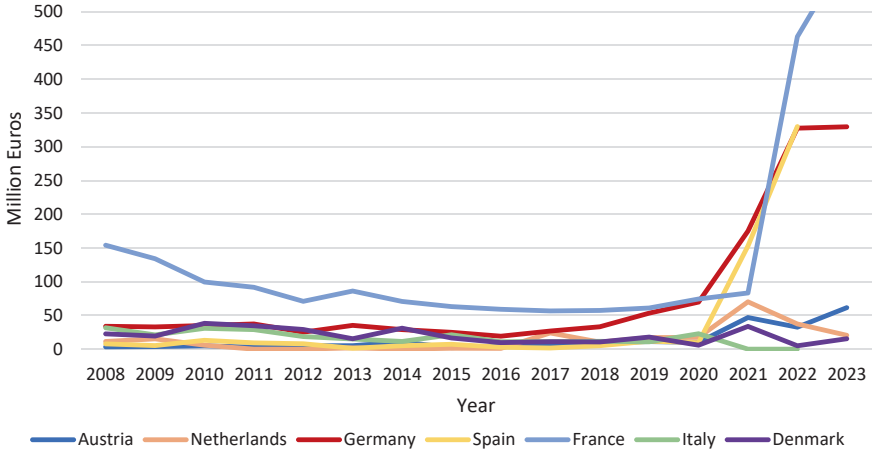

Fig. 1 Public funding for R&D in hydrogen and fuel cells in selected EU Member States, 2008–2023, in million EUR. *Source* Authors, based on IEA (2024)

the US, companies can benefit from support in the form of tax credits for a period of ten years without having to undergo a time-consuming competitive selection process.

Since its inception, the Innovation Fund has issued four large-scale calls, each explicitly targeting hydrogen projects. While the fund is open to all Member States, in practice, the geography of the supported projects reflects existing imbalances in the innovation capacity (see Fig. 2). Lower-income Member States are generally underrepresented (Quitzow et al, 2023). Distribution of funding for hydrogen and electrolyser projects confirms this disparity: of the 2.2 billion EUR in grants that the Innovation Fund awarded in 2020–2023, 74% went to only three countries: Sweden, the Netherlands, and Spain, while Eastern European countries received less than 1% of the total (European Court of Auditors, 2024, pp. 94–95).

Aware of such disparities, the EU set up the *Modernisation Fund* in 2020 with the express goal of supporting the transition to carbon neutrality in lower-income Member States.[6] The Fund's budget relies on the revenues from the auctioning of 2% of EU ETS allowances between 2021 and 2030 as well as additional allowances transferred by beneficiary states. Between 2021 and 2023, the fund disbursed 9.68 billion EUR to eligible Member States to support their green transition (European Commission, 2023g). While hydrogen is listed as a priority area, in practice very few hydrogen projects have been financed so far. One of them is a small green hydrogen production project in Lithuania funded with 2.5 million EUR (Modernisation Fund, n.d.). However, Lithuania is also planning to use its Modernisation Fund budget to contribute national funding to the European Hydrogen Bank's auctions.

[6] Modernisation Fund original members include Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia, which were joined in 2024 by Portugal, Greece, and Slovenia.

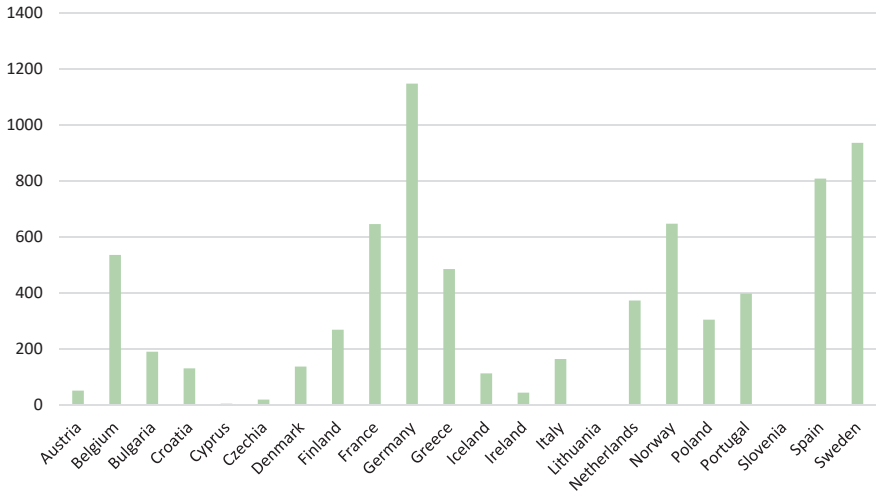

Fig. 2 Innovation Fund grants to member states as of September 2024, million EUR. *Source* Authors, based on the data taken from: Innovation Fund—Portfolio of signed projects. https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/6e4815c8-1f4c-4664-b9ca-8454f77d758d/sheet/bac47ac8-b5c7-4cd1-87ad-9f8d6d238eae/state/analysis

In addition to these EU-level funds, IPCEI, as already mentioned above, are a prominent funding instrument. They are required to involve at least four Member States. Since 2022, there have been four hydrogen IPCEI "waves",[7] with a combined amount of 18.9 billion EUR in public funding and supporting projects along the entire hydrogen value chain (European Commission, n.d.-b). Given that IPCEI are funded through national subsidies, it is unsurprising that companies from the wealthier and more industrialised Member States tend to be overrepresented.

4.2 An Emerging European Agenda in Support of Domestic Manufacturing

The EU has lagged behind other global heavyweights in the manufacturing of clean energy technologies. The European industrial strategy, published in March 2020 and updated in March 2021, identifies the green transition (along with the digital transition) as a priority area. It emphasises the importance of engaging with industry and pursuing "open strategic autonomy", which is to be achieved by diversifying international partnerships, using industrial alliances, and monitoring strategic dependencies (European Commission, n.d.-c).

[7] The four IPCEI include Hy2Tech and Hy2Use approved in 2022, as well as Hy2Infra and Hy2Move approved in 2024.

To engage industry, the EU has set up a Europe-wide Clean Hydrogen Alliance. The alliance has outlined a pipeline of over 750 viable projects for the deployment of low-carbon and renewable hydrogen in Europe. In 2022, it organised a prominent Electrolyser Summit, where the leading European electrolyser companies pledged to increase the manufacturing of electrolysers tenfold to 17.5 GW by 2025 (European Clean Hydrogen Alliance, 2022). The Innovation Fund, too, is increasingly focusing on cleantech manufacturing: in the third and fourth calls, it earmarked 2.1 billion EUR combined for the manufacturing of electrolysers, fuel cells, heat pumps, and energy storage technologies (European Commission, 2022c; 2023d). In particular, the fourth call issued in November 2023 with a record budget of 4 billion EUR aims to "strengthen industrial manufacturing capacity, technology leadership, and supply chain resilience in Europe" (European Commission, 2023d).

Despite these developments, a robust EU-level industrial policy focusing on cleantech manufacturing remains elusive. For one, there is no consensus among Member States on the best approach to green industrial policy in general. While some wealthy Member States like Germany and France actively support national subsidies, others (e.g. the Netherlands or Ireland) would prefer to use such subsidies only sparingly, fearing their potential to distort the level playing field in the EU. Still others, like cost-conscious Austria, Portugal, or Greece, believe in the importance of cheap green technology imports. Finally, the governments in a few Member States, including Hungary and the Czech Republic, simply do not prioritise climate policy to the same extent (Dennison & Engström, 2024).

In any case, funding remains the most basic challenge for developing EU-wide industrial policy. Unlike sovereign nation states, the EU does not levy taxes and cannot borrow on capital markets, absent an emergency of the sort of the Covid-19 pandemic. As alluded to above, EU ETS revenues have become an increasingly prominent source of funding for green industrial policy but are not sufficient in themselves. The Recovery and Resilience Facility (RRF), the main part of the EU's NextGenerationEU pandemic stimulus package, has emerged as another essential source of funding. Based on more than 800 billion EUR in EU-level debt, it is a temporary instrument, however, running out in 2026 (Pisani-Ferry et al, 2023). RRF funds are allocated to and administered by Member States on the basis of their national recovery and resilience plans. At least 37% of RRF funding is required to go to climate-related measures. For many Member States, access to RRF funding served as a strong incentive to consider supporting hydrogen development (some of them for the first time ever). The combined amount, as earmarked in updated Recovery and Resilience Plans, reached 13.6 billion EUR (European Court of Auditors, 2024, p. 93). A large chunk of RRF funds remains unspent, however: by the end of 2023, the Commission had transferred less than 40% of the funds allocated to Member States (Schuman Associates, 2024). The remaining money could help fund hydrogen subsidies and other green transition measures, but only as a short-term fix.

To better position the EU in the global cleantech race, the European Commission proposed the "Green Deal Industrial Plan for the Net-Zero Age" (GDIP) in February 2023, which aims to support the "scaling-up of the EU's manufacturing capacity for the net-zero technologies and products" (European Commission, 2023a). The

Net-Zero Industry Act (NZIA), adopted in May 2024, is the key piece of legislation to meet this goal. To make the EU less dependent on cleantech imports, NZIA sets a domestic manufacturing target of 40% by 2030 for selected "strategic" clean technologies, including electrolysers. If the EU imports more than 50% of a certain category of technologies from a single country, NZIA will require Member States governments to introduce non-price criteria in public procurements tenders, with a weight of 30% (European Commission, n.d.-e). This provision is meant to offer a way to support European manufacturers when they are outpriced by foreign competitors.

NZIA also envisions anti-relocation incentives—such as grants, loans, or tax breaks or, in "exceptional cases", subsidies fully matching those offered by third countries—to help Member States compete with subsidies outside the EU. The NZIA also allows the acceleration of permitting procedures for so-called net-zero strategic projects and envisions upskilling the European labour force by establishing net-zero "academies" (Nicolai & Munchmeier, 2024). Finally, NZIA proposes to establish "Net-Zero Europe Platforms" as a body to coordinate the activities of the Commission and Member States, seek inputs from stakeholders, and ease access to financing.

Despite the many improvements above, NZIA does not provide fresh sources of funding to European industrial policy. In 2022–2023, the Commission floated the idea of creating a European Sovereignty Fund as a Europe-wide industrial policy instrument, but it failed to gain the approval of the Member States. Even the much scaled-down version of the instrument, the Strategic Technology Platform (STEP), has failed to attract the proposed 10 billion EUR in funding. In addition, an ambitious European green industrial policy requires collecting and analysing large amounts of data on issues like technologies, market development, and the business environment. However, the Commission's capacities are already overstretched with current responsibilities in the area of climate and energy policy. There is an acute need for more active and better organised data collection, more analytical staff, and better data infrastructure systems (Jäger, 2024).

Nevertheless, green industrial policy has been identified as one of the central tasks for the new European Commission formed in 2024. In February 2025, the Commission presented its Clean Industrial Deal strategy, aimed at bolstering Europe's industrial competitiveness and resilience–most prominently by bringing down energy prices—while promoting decarbonisation and greater circularity. In line with these priorities, the Strategy focuses primarily on energy-intensive industry and the cleantech sector. The Clean Industrial Deal envisions an Industrial Decarbonisation Accelerator Act, which would speed-up permitting for projects enabling industrial access to energy and climate-friendly technologies, an Industrial Decarbonisation Bank with a budget of up to 100 billion EUR (to be largely funded by EU ETS revenues), and the creation of lead markets for "green" products (European Commission, 2025a). The Clean Industrial Deal draws strongly on the findings of the highly influential September 2024 report *The Future of European Competitiveness* authored by Mario Draghi, former President of the European Central Bank. The Draghi report identifies three main areas of action: closing the innovation gap with the US and China, developing a joint plan for decarbonisation and competitiveness for European industry (including the imperative to lower energy prices), and increasing security

and lowering dependencies. The report estimates the needed amount of investment at up to 800 billion EUR annually and advocates developing a Capital Markets Union to mobilise private investment, as well as using common European debt for financing investment in high-priority sectors at the European level (Draghi, 2024).

4.3 A Shift Towards State Aids: Quick Fix or Erosion of the Single Market?

Given the difficulties of creating a truly European industrial policy, the EU has opted to increase the space for implementing industrial policy measures at the Member State level. According to EU rules, any subsidies (called "state aids") granted by Member States require prior approval by the Commission, due to their potential to distort the single market. IPCEI, discussed above, is a prominent instrument utilising state aids, yet it is also a very selective one. In the wake of the war in Ukraine, the EU has taken significant additional steps to relax its restrictions on state aids, in particular in the area of the green transition.

The most momentous step in this direction has been the European Commission's adoption, in March 2023, of a Temporary Crisis and Transition Framework (TCTF). The TCTF allows state aid for the production and use of renewable hydrogen and derivatives and for industrial decarbonisation more generally. A new focus area includes support for the manufacturing of a wide range of green technologies, including electrolysers. The aid must be granted by December 31, 2025 (European Commission, 2024d). In parallel, the Commission has also revised the General Block Exemption Regulation (GBER). Under GBER, Member States can implement certain aid measures without going through the time-consuming notification and approval procedure. GBER allows Member States to support key sectors for the net-zero transition, including hydrogen, and increases the limits for state aid for undertakings in less-developed regions in the EU (European Commission, n.d.-d). The Clean Industrial Deal unveiled in February 2025, too, has put a stronger focus on mobilising national subsidies. Its proposed Clean Industrial State Aid Framework (CISAF), which is set to replace the TCTF and is expected to run until the end of 2030, envisions a faster approval of state aid measures for renewable energy deployment, industrial decarbonisation, and cleantech manufacturing (European Commission, 2025a).

The loosening of state aid rules has been controversial. A number of Member States—including Central and Eastern European states, but also Belgium, Denmark, Finland, Ireland, the Netherlands, and Sweden—have been concerned about the negative impact on competition and the single market, calling on the Commission to prevent sparking a subsidy race across EU countries (Euractiv, 2023). Indeed, these measures bear additional risks of creating a multi-speed transition, where stronger and larger economies use their resources to support their industry and harness the benefits of decarbonisation, while poorer states fall behind (Quitzow et al., 2023). Available spending data confirms that just a few large Member States have provided

most of the subsidies in the EU. Between March 2022 and June 2023, Member States provided a total of 140.8 billion EUR in state aids to their companies. A lion's share of this amount went to companies in only three Member States: Germany (72.8 billion EUR), Italy (39.2 billion EUR), and Spain (12.1 billion EUR) (Ferraro et al, 2024).

5 EU Hydrogen Policy: External Dimensions

Endowed with comparatively scarce renewable energy resources relative to its decarbonisation needs, the EU has a strategic interest in securing reliable access to renewable hydrogen from abroad. A central priority of the EU's external energy strategy is the development of hydrogen trade. In line with its traditional role as a regulatory power (Bradford, 2019), it aims to establish a "global rules-based and transparent hydrogen market based on EU's experience" (European Commission, 2022b). It also encompasses the development of bilateral hydrogen partnerships, with a particular focus on the European Neighbourhood and Africa, but also other regions like Latin America or Central Asia.

5.1 EU Leadership in Multilateral Hydrogen Governance

The EU has a strong history of multilateral engagement on the energy transition and climate change and has adopted a similar approach in the area of the nascent international hydrogen governance. Today, the EU is an active participant in all multilateral hydrogen governance fora and platforms, supporting the emergence of a functioning international hydrogen market.

One prominent international platform is Mission Innovation, a global intergovernmental forum promoting public–private partnerships for the energy transition. The EU is a co-lead in Mission Innovation's Clean Hydrogen Mission, which promotes R&D and seeks to bring the costs of clean hydrogen to 2 USD per 1 kg by 2030. Moreover, in January 2021, the EU launched the Hydrogen Valley Platform within Mission Innovation, targeting 100 hydrogen valleys globally by 2030. This initiative builds on the EU's efforts to develop hydrogen valleys domestically, also as part of the Clean Hydrogen Partnership (see above). The platform is on track to reaching this target: as of December 2024, there were 98 hydrogen valley projects in 36 countries announced on the platform, with the largest share located in Europe (Clean Hydrogen Partnership, n.d.).

Another forum is the G7, where the EU has signed the Hydrogen Action Pact to promote the use of hydrogen and cooperation on Power-to-X technologies. The EU has also participated in the G20's International Hydrogen Economy Initiative, which seeks to align and harmonise hydrogen standards and certification procedures promote WTO-aligned hydrogen trade and mobilises finance (G20 Energy Ministers, 2023, pp. 15–16). The European Commission is also contracting party to the

International Energy Agency's (IEA) influential Hydrogen Technology Collaboration Programme (Hydrogen TCP) and a member of the Clean Energy Ministerial Hydrogen Initiative (CEM H2I), a voluntary multi-government initiative launched in 2019, also coordinated by the IEA. CEM H2I aims at promoting international collaboration "on policies, programmes, and projects to accelerate the commercial deployment of hydrogen and fuel cell technologies across all sectors of the economy" (IEA, n.d.).

The Commission also participates in the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), established in 2003, which works on accelerating market deployment of hydrogen and fuel cells as well as on policy and regulatory activities. IPHE's work on hydrogen includes analysis of hydrogen production and hydrogen trade rules development. In particular, IPHE has focused on developing a methodology for calculating greenhouse gas emissions associated with different technological pathways of hydrogen production (electrolysis, steam methane reforming with CCS, coal gasification or biomass with CCS, as an industrial byproduct, and others). Tudor Constantinescu of the European Commission was one of the three individuals designing and directing the study, which is expected to contribute to shaping international clean hydrogen standards (IPHE, 2023, p. 11). Different EU Member States have been involved in this work, driven by their own technology preferences. Germany, however, due to its long-held scepticism about CCS, has not been involved in developing a methodology for blue hydrogen.

5.2 Promoting International Trade in Hydrogen and Infrastructure Links

A well-functioning international hydrogen market is strategically important for the EU, offering the bloc a chance to diversify suppliers and procure hydrogen at a competitive cost. Within the EU, the most active Member States advocating for international hydrogen trade has been Germany, which is expected to become the largest hydrogen importer in the EU, with plans to import between 50 and 70% of its future hydrogen demand (BMWK, 2024a). Germany is also the only Member State with a dedicated hydrogen import strategy, although the Netherlands, with its energy-intensive industry, is also expecting a need for hydrogen imports. Moving forward, the Commission is planning to develop a Union strategy for imported and domestically produced hydrogen. Member States are now required to include information on expected imports and exports of RNFBOs in the updates of their National Climate and Energy Plans (NECPs) (European Commission, 2024e). These plans are a key governance tool used by the Commission to coordinate efforts at the Member State and EU level.

Currently, the EU as a bloc does not have a scheme for supporting hydrogen imports, as for now the European Hydrogen Bank can only fund projects in EU ETS countries. However, the Commission has announced an interest in linking Germany's

H2Global scheme (see above) to the European Hydrogen Bank. Other importers, such as Japan, as well as exporters, like Australia, have also signalled their interest in collaboration within H2Global (Parkes, 2024a; see also chapter on Japan in this volume), placing Germany at the forefront of developments in support of international hydrogen trade.

Many other Member States, however, do not plan to import hydrogen at all and do not have initiatives in place to support international trade. Germany's active engagement on promoting hydrogen trade stands in sharp contrast, for instance, to the French position. Concerned with preserving energy sovereignty and promoting domestically produced nuclear-based hydrogen, France has been sceptical about hydrogen imports. As a result, and despite its strong influence in Africa, it has been reluctant to include hydrogen cooperation in its external energy policy, and it initially opposed projects involving the construction of European hydrogen pipelines. Other European countries, most notably Spain and Norway, have their own export ambitions and have little to gain from the development of a global hydrogen market, while most Central and Eastern European countries remain at relatively early stages of hydrogen policy development. They have yet to formulate a clear stance on hydrogen imports. Finally, countries like Sweden plan to produce and use hydrogen domestically, for instance, to produce industrial goods like green steel (Ćetković & Stockburger, 2024; Kilpeläinen et al, 2023).

Consequently, there is still no clearly defined framework for the promotion of external hydrogen trade by the EU. While there are plans to add hydrogen to AggregateEU, the EU's voluntary joint purchasing mechanism for natural gas, the timeline for this remains uncertain. EU-level funding for infrastructure links with third countries is also limited. The main instrument for this purpose is the newly introduced scheme for supporting "Projects of Mutual Interest" (PMI) under CEF-Energy. However, the only hydrogen project in this category—a hydrogen pipeline from Norway to Germany planned by Equinor and RWE (European Commission, 2023f, p.10) was scrapped in September 2024 due to high costs and a lack of demand (Reuters, 2024). The prospects of pipeline infrastructure links to other potential partners, like Ukraine, the UK, or North African countries (Weko et al, 2023, p. 21), are uncertain as well. Nonetheless, some progress has been made on the proposed SoutH2 corridor, meant to bring green hydrogen from Algeria and Tunisia to demand centres in Italy, Austria, and Germany (GasConnect Austria, 2025).

5.3 Bilateral Hydrogen Partnerships: EU and Member State Level

Bilateral energy diplomacy is traditionally not within the mandate of the European Commission but this is beginning to change as the EU realises the need to establish global hydrogen value chains. The 2020 Hydrogen Strategy refers to the need to mainstream hydrogen in the EU's international, regional, and bilateral energy and

diplomacy efforts (European Commission, 2020, Sect. 7), albeit with the primary goal of establishing a global, liquid, rules-based market for hydrogen. With the adoption of hydrogen import targets in REPowerEU in 2022, the EU's growing interest in integrating hydrogen into its international partnerships has become more evident. The EU's external energy engagement strategy adopted in May 2022 highlights the importance of hydrogen partnerships, with a particular emphasis on the EU's Southern and Eastern Neighbourhood as well as a number of countries in sub-Saharan Africa (European Commission, 2022b).

Despite increased engagement by the Commission (Jerzyniak, 2024), leading Member States have remained at the forefront of bilateral hydrogen diplomacy. Germany has been the most proactive in its bilateral outreach. Germany has signed as many as 32 agreements on hydrogen with countries around the globe (Quitzow et al., 2024). This engagement builds seamlessly on Germany's longstanding efforts to project its soft power as an energy transition leader via its growing network of energy partnerships and dialogues (Quitzow & Thielges, 2020). Aside from signing agreements and MoUs, Germany has launched dedicated hydrogen diplomacy offices internationally, focusing in particular on countries dependent on fossil fuels. Under its H2Diplo initiative, Germany has set up offices in Angola, Colombia, Kazakhstan, Kenya, Nigeria, Oman, Saudi Arabia, and Ukraine (Auswärtiges Amt & H2diplo, n.d.).

Another active country is the Netherlands, as it pursues its vision of becoming a hydrogen hub for Northwest Europe, building on its strong expertise as a natural gas hub. The government has initiated partnerships with Australia, South Africa, and the Gulf States, including Saudi Arabia and Oman. Moreover, its activities are frequently complemented by engagement from the Port of Rotterdam, which is positioning itself as a major actor in European trade with its international partners (Stam et al., 2024).

Italy is less active at the global scale, but has expanded its traditional engagement with Algeria to hydrogen-related questions, operating largely via its state-owned energy companies, ENI and SNAM. Other countries have been conspicuously absent from bilateral hydrogen diplomacy. Despite its proximity to Morocco, Spain, for instance, has refrained from launching any formalised dialogue with its neighbour, a clear reflection of its own export ambitions. Similarly, France has made the deliberate choice not to engage in an import-oriented hydrogen diplomacy, but has some engagement in support of local hydrogen projects. Instead, leading French energy corporations, like Engie and Total, as well as hydrogen infrastructure companies like HDF Energy, have launched their own outreach, exploring opportunities for hydrogen development in Africa and other regions.

The EU is in the process of finding its place in this emerging landscape of hydrogen diplomacy (see Table 3). It has launched partnership agreements with a number of potential exporters globally. In many cases though, these agreements are mere indicators of the EU's interest in cooperation and do not come equipped with a budget. To bridge this funding gap, the Commission is increasingly pursuing its so-called Team Europe approach, a prominent element within its Global Gateway Strategy. This aims at the coordination of European efforts under the leadership of the Commission. Team Europe pools the resources of the EU, interested Member

States, and European financial institutions such as the European Investment Bank, the EBRD, or KfW (European Commission, 2021). In addition, the Clean Industrial Deal proposed by the Commission in February 2025 includes plans for so-called "Clean Trade and Investment Partnerships" (CTIPs) which would align EU external action with its industrial policy and resilience objectives. CTIPs are expected to diversify the EU's supply chains and expand the bloc's access to critical raw materials, clean energy and clean technologies (European Commission, 2025a).

So far, Team Europe has launched hydrogen-related initiatives in Africa and Latin America. In Africa, the European Commission has announced support for a hydrogen power plant in Morocco and green hydrogen production in Namibia (Team Europe, 2024a). According to a joint declaration signed with the Namibian government, the European Investment Bank (EIB) will potentially provide a loan of up to €500 m to finance renewable hydrogen and renewable energy investments (European Investment Bank, 2022). Another partner is Mauritania: in October 2023, the EU launched a Team Europe Initiative in the country, with the goal of supporting its ambition to become a green hydrogen hub. The initiative is expected to fund capacity building and green energy infrastructure, as well as promote job creation and help put in place an appropriate "legal and fiscal framework" (Shumkov, 2023). However, the funding for Mauritania has not been determined yet. Finally, in September 2024, the EU announced it would provide two grants worth 34 million EUR to South Africa to support the development of green hydrogen industry and infrastructure (Laity, 2024; EEAS, 2024).

In Latin America and the Caribbean, the EU is planning to support the production of green hydrogen in Chile, Colombia, Uruguay, Argentina, Panama, and Barbados (Team Europe, 2024b). In Chile, Team Europe has announced a Renewable Hydrogen Funding Platform for with 200 million EUR in financing from the European Investment Bank (EIB) and the German development bank KfW. In Brazil, part of a 2 billion Euro Team Europe Initiative is supposed to support a large-scale green hydrogen project. This would involve the construction of a 10 GW green hydrogen and ammonia production facility in the Brazilian state of Piaui, to be shipped to industrial offtakers in southeastern Europe (European Commission, 2023c).

Overall, the Commission's financial commitments have been relatively slow to materialise, representing a mismatch with the EU's ambitious import targets. The EIB's expanding hydrogen-related funding activities represent one vehicle that might begin to fill this gap. The bank has recently launched a line of funding for hydrogen projects in third countries. The EIB manages the Green Hydrogen Fund set up by the EU in 2021 to provide technical assistance and strategic advice on hydrogen to third states, with a 25 million EUR budget. With the new German contribution of 434 million EUR (Collins, 2023), the fund will be able to provide investment grants to developing countries to implement hydrogen-related initiatives and projects. In cooperation with EIB and other European development banks, the EU also hopes to leverage large-scale private sector resources for hydrogen investment, as envisioned in its Global Gateway initiative. However, experience has shown that leveraging private sector investment with the help of EU funds in partner countries has had limited success (Prontera & Quitzow, 2023).

Table 3 EU and Team Europe agreements containing a focus on hydrogen

Date	Partner country or regional bloc	Agreement name or type
May 2021	Japan	EU-Japan Green Alliance
May 2022	Gulf Cooperation Council	Strategic Partnership with the Gulf
October 2022	Morocco	EU-Morocco Green Partnership
November 2022 (MoU) October 2023 (Roadmap to the MoU for 2023–2025)	Namibia	Memorandum of understanding and establishing a strategic partnership on sustainable raw materials value chains and renewable hydrogen under global gateway Team Europe: EU, EIB, Germany, Netherlands, France, and Finland
November 2022	Kazakhstan	Memorandum of understanding between the EU and Kazakhstan on a strategic partnership in the fields of raw materials, batteries, and renewable hydrogen
November 2022	Egypt	Memorandum of understanding on the EU-Egypt Renewable Hydrogen Partnership
December 2022	Japan	Memorandum of understanding on Hydrogen
February 2023	Ukraine	Memorandum of understanding between the European Union and Ukraine on a Strategic Partnership on Biomethane, Hydrogen, and other Synthetic Gases
April 2023	Norway	EU-Norway Green Alliance
May 2023	South Korea	European Union—Republic of Korea Green Partnership
June 2023	Chile	Team Europe Initiative for the Development of Renewable Hydrogen in Chile. Participants: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Netherlands, Portugal, Spain, Sweden + European Commission, EIB, KfW
July 2023	Tunisia	Memorandum of understanding on a strategic and global partnership between the European Union and Tunisia
July 2023	Argentina	Memorandum of understanding on cooperation related to energy between the European Union and the Argentine Republic
July 2023	Uruguay	Memorandum between the EU and Uruguay on cooperation on renewable energy, energy efficiency, and renewable hydrogen

(continued)

Table 3 (continued)

Date	Partner country or regional bloc	Agreement name or type
October 2023	Mauritania	Team Europe Initiative to develop green hydrogen in Mauritania and accelerate its energy transition Participants: European Commission, France, Germany, Spain, and the European Investment Bank
November 2023	Canada	EU-Canada Green Alliance

Source Authors' own elaboration based on the Commission's documents

Notably, the EU has not engaged very proactively with the Gulf monarchies of Saudi Arabia, Oman, and the UAE, which have exhibited keen interest in becoming early hydrogen suppliers. Despite the EU's 2022 "Strategic Partnership with the Gulf Cooperation Council" (GCC), which emphasised the region's role as a potential supplier of renewable hydrogen to Europe, the level of engagement on the EU level has remained largely declarative (Bianco, 2023). This may be due to the heterogeneity of interests and positions both within the EU and the GCC blocs, making bilateral partnerships at the national level easier to implement compared to bloc-level engagement (Dienstbier & Ertl, 2023). For now, GCC countries are predominantly looking at Asia, which is already the main market for their fossil fuel exports, as the destination for their future hydrogen exports as well (Dienstbier & Ertl, 2023, p. 47).

In parallel, the EU has also undertaken efforts to develop cooperation with international hydrogen frontrunners, both those with export ambitions and those expected to emerge as importers. In the aftermath of Russia's invasion of Ukraine in 2022, the EU has intensified its cooperation efforts with Canada, which is a potentially large hydrogen producer. The European Commission and the Canadian Government set up a special working group on the green transition and liquefied natural gas (LNG). This aims at "lay[ing] the foundation for the development of reliable hydrogen supply chain between Canada and the EU as well as to develop common approaches to standards and the certification of hydrogen" (European Commission, 2023b). Yet the current absence of an LNG or hydrogen gas export infrastructure between Canada and the EU pushes these plans into a remote future. As for the USA, despite the latter's ambitious hydrogen production plans supported by the Inflation Reduction Act, hydrogen has not been at the forefront of various bilateral cooperation initiatives between the EU and the US. The EU has also launched cooperation with fellow prospective hydrogen importers in Asia such as Japan and South Korea, yet there have been few activities on this front so far. In general, efforts at cooperation between prospective hydrogen importers have been very limited. A situation where they compete for a limited supply of clean hydrogen in the future is therefore not unlikely.

6 Conclusion

The European Union and selected Member States have played a pioneering role in promoting a clean hydrogen economy. The EU has been developing a detailed regulatory framework for hydrogen, which assigns a priority to renewable hydrogen and has a tangible impact on policy discussions in other parts of the world. Starting in 2030, the EU is mandating the use of renewable hydrogen and its derivatives in industry and transport. With the launch of the European Hydrogen Bank in November 2023, the EU is now also offering hydrogen production subsidies, which are complemented by national-level support schemes in many Member States.

Yet the EU's vision is coming to grips with the challenging internal dynamics and the new geopolitical realities, leading to adjusted expectations. Defining a common European course on hydrogen has proven complicated, given the very different starting positions, priorities, and fiscal resources of Member States. There are growing fears about the weakening competitiveness of European industry vis-à-vis other global players. Cost reductions for clean hydrogen have lagged far behind initial forecasts, with repercussions for demand-side developments. These factors help explain the low number of final investment decisions (FIDs) in the hydrogen sector in Europe. Other pressing priorities, such as defence spending, are beginning to compete for attention and resources with the green transition as well. More generally, there is a growing concern in the EU that its fiscally conservative system of economic governance is ill-suited to address the mounting geopolitical challenges the bloc is facing today, which require large amounts of public investments.

In the face of the accelerating global subsidy race, the EU, due to its fiscal limitations and institutional setup, has been unable to agree on a large EU-wide green industrial policy support scheme. Instead, it has relaxed its strict rules on granting subsidies at Member State level. Predictably, a few Member States with larger fiscal resources have accounted for a lion's share of all subsidies granted, which poses a risk to the integrity of the EU's prized single market. A "Clean Industrial Deal" to boost competitiveness has been identified as the chief priority of the new European Commission formed in December 2024 but achieving its goals will require massive amounts of private and public investment and likely institutional reform.

Internationally, the EU has been actively involved in various multilateral hydrogen governance mechanisms aimed at promoting an international hydrogen market, developing common standards, and popularising hydrogen valleys. In addition, the EU's explicit acknowledgement of its future need for hydrogen imports has sparked the interest of potential exporters worldwide. These include both established energy producers like the Gulf States but also low- and middle-income economies in Africa and Latin America with large but still underexploited renewable energy potentials. Following the examples of proactive Member States such as Germany or the Netherlands, the EU is beginning to intensify its international outreach on hydrogen as well. Its connectivity initiative, the Global Gateway, is putting a growing emphasis on hydrogen as an important element in EU partnerships, even though the financing of such measures often remains uncertain. Within this context, the EIB is also likely

to play a more prominent role in hydrogen partnerships in the future. A key challenge will be how to develop a strategy for the effective coordination of EU and Member State initiatives. The EU's Team Europe approach provides such a framework in principle but remains at an early stage in terms of practical implementation. Rather, for the time being, Germany's very active engagement strategy remains the more visible and tangible in terms of its financial envelope.

That said, the EU's expected dependency on hydrogen imports makes it more attractive as a long-term strategic partner for future hydrogen exporters. As the EU works on shaping diversified and resilient green value chains for hydrogen, one of the key challenges is to promote inclusive partnerships with the Global South that contribute to local socioeconomic development and decarbonisation. Done right, such partnerships could bring benefits and local acceptance on both sides, with positive impact for the global climate efforts as well. Moreover, such partnerships might be stepping stones for broader economic partnerships within a net-zero economy. In this vein, the EU's need to collaborate might also prove an asset as the EU seeks to build broader networks and alliances.

Acknowledgements Research for this chapter was financially supported by the German Federal Foreign Office within the framework of the project "Geopolitics of the Energy Transformation – Implications of an International Hydrogen Economy" (GET Hydrogen), funding reference number AA4521G125.

References

ACER—European Union Agency for the Cooperation of Energy Regulators. (2024). European hydrogen markets 2024 Market Monitoring Report. https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER_2024_MMR_Hydrogen_Markets.pdf

Albrecht, U., Bünger, U., Michalski, J., Raksha, T., Wurster, R., & Zerhusen, J. (2020). *International hydrogen strategies: A study commissioned by and in cooperation with the World Energy Council Germany*. World Energy Council Germany.

Alexe, P., & Briggs, P. (2024, February 21). Why REFuel EU may not work. *Bird & Bird.* https://www.twobirds.com/en/insights/2024/global/why-refuel-eu-may-not-work

Auswärtiges Amt & H2-Diplo. (n.d.). *More About H2-Diplo.* https://h2diplo.de/en/

Bianco, C. (2023, May 23). The EU's Strategic Partnership with the Gulf: One Year On. Brussels International Center. https://www.bic-rhr.com/research/eus-strategic-partnershipgulf-one-year

BMWK. (2024a, July). *Import Strategy for hydrogen and hydrogen derivatives.* https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/importstrategy-hydrogen.pdf?__blob=publicationFile&v=7

BMWK. (2024b, October 22). Wasserstoff-Kernnetz genehmigt – der Aufbau der Zukunftsinfrastruktur kann beginnen. https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2024/10/20241022-wasserstoff-kernnetz.html

Bradford, A. (2019). *The Brussels effect: How the European Union rules the world*. Oxford University Press.

Buljan, A. (2023, January 24). P*artners apply for 'Project of Common Interest' status for aquaductus green hydrogen pipeline*. OffshoreWIND.Biz. Retrieved 3 June 2024, from https://www.offshorewind.biz/2023/01/24/partners-apply-for-project-of-common-interest-status-for-aquaductus-green-hydrogen-pipeline/

Cassidy, C., & Quitzow, R. (2023). Green development in South Africa and Namibia. Opportunities and Challenges for International Cooperation. *RIFS Study.* RIFS.

Ćetković, S., & Stockburger, J. (2024). Hydrogen strategy of Sweden: Unpacking the multiple drivers and potential barriers to hydrogen development. In R. Quitzow & Y. Zabanova (Eds.) *The Geopolitics of hydrogen. Studies in energy, resource and environmental economics.* Springer, Cham. https://doi.org/10.1007/978-3-031-59515-8_10

Clean Hydrogen Joint Undertaking. (2022). *Strategic research and innovation Agenda 2021–2027.* https://www.clean-hydrogen.europa.eu/system/files/2022-02/Clean%20Hydrogen%20JU%20SRIA%20-%20approved%20by%20GB%20-%20clean%20for%20publication%20%28ID%2013246486%29.pdf

Clean Hydrogen Partnership. (n.d.). *Mission Innovation Hydrogen Valley Platform.* Retrieved 6 Sept 2024, from: https://h2v.eu

Collins, L. (2023, December 20). EIB to start providing grants for green hydrogen production in developing countries after Germany adds €434m to fund. *Hydrogen Insight.* https://www.hydrogeninsight.com/policy/exclusive-eib-to-start-providing-grants-for-green-hydrogen-production-in-developing-countries-after-germany-adds-434m-to-fund/2-1-1574531

Collins, L. (2024a, April 5). Denmark agrees to finance hydrogen pipeline network—If sector meets five conditions. *Hydrogen Insight*. https://www.hydrogeninsight.com/policy/denmark-agrees-to-finance-hydrogen-pipeline-network-if-sector-meets-five-conditions/2-1-1622183

Collins, L. (2024b, July 29). Analysis with FIDs taken on three major green hydrogen projects last week, is the European sector finally taking off? *Hydrogen insight*. https://www.hydrogeninsight.com/analysis/analysis-with-fids-taken-on-three-major-green-hydrogen-projects-last-week-is-the-european-sector-finally-taking-off-/2-1-1683651

Collins, L. (2024c, September 20). Germany wants EU to postpone controversial additionality rules 'so green hydrogen can be produced more cheaply'. *Hydrogen Insight.* https://www.hydrogeninsight.com/policy/germany-wants-eu-to-postpone-controversial-additionality-rules-so-green-hydrogen-can-be-produced-more-cheaply/2-1-1712665

Hintco. (2025, February 19). Hintco starts second H2Global tender worth EUR 2.5 billion. https://www.hintco.eu/news/hintco-starts-second-h2global-auction-worth-eur-25-billion

Dennison, S., & Engström, M. (2024). Eco-nomics: A green industrial policy for the next European Commission. *Policy Brief. European Council on Foreign Relation*s. https://ecfr.eu/publication/eco-nomics-a-green-industrial-policy-for-the-next-european-commission/

Dienstbier, P., & Ertl, V. (2023). Große Pläne, kleine Fortschritte. EU-Energiepartnerschaften mit dem Golf. *Auslandsinformationen.* Konrad Adenauer Stiftung.

Directorate-General Climate Action. (2024a). *Innovation Fund 2023 Auction: Frequently Asked Questions.* https://climate.ec.europa.eu/document/download/19f8a164-0d64-436d-81f7-1117559f0822_en?filename=policy_innovation_fund_binding_qna_auction_en3.pdf

Directorate-General Climate Action. (2024b). *Innovation Fund IF24 Auction: Terms and Conditions.* https://climate.ec.europa.eu/document/download/b996825e-cd36-44c1-895d-a780062f626d_en?filename=policy_funding_innovation_fund_if24_auction_tc_en.pdf

Draghi, M. (2024, September 17). *Address by Mr. Draghi—Presentation of the report on the Future of European competitiveness—European Parliament—Strasbourg*—17 September 2024. https://commission.europa.eu/document/download/fcbc7ada-213b-4679-83f7-69a4c2127a25_en?filename=Address%20by%20Mario%20Draghi%20at%20the%20Presentation%20of%20the%20report%20on%20the%20future%20of%20European%20competitiveness.pdf

EEAS—European External Action Service. (2024, September 9). *Global Gateway: European Union supports South Africa's Green Hydrogen ambitions.* https://www.eeas.europa.eu/sites/default/files/documents/2024/Media%20Announcement%20by%20EU%20on%20Grant%20funding%20for%20SA%20Green%20Hydrogen%20.pdf

Euractiv. (2023). Eleven EU countries urge 'great caution' in loosening state aid rules. https://www.euractiv.com/section/economy-jobs/news/eleven-eu-countries-urgegreat-caution-in-loosening-state-aid-rules/

European Clean Hydrogen Alliance. (2022). *European Electrolyser Summit Joint Declaration.* Brussels, 5 May 2022. https://ec.europa.eu/docsroom/documents/50014/attachments/1/translations/en/renditions/native

European Commission. (n.d.-a). *What is the Innovation Fund?* https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/what-innovation-fund_en#:~:text=The%20Innovation%20Fund's%20total%20funding,of%20€75%2FtCO2

European Commission. (n.d.-b). *Approved Integrated Important Projects of Common European Interest (IPCEI).* https://competition-policy.ec.europa.eu/state-aid/ipcei/approved-ipceis_en

European Commission (n.d.-c). *European Industrial Strategy*. Retrieved 03 June 2024, from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en#:~:text=On%2011%20May%202021%2C%20the,resilient%20and%20globally%20competitive%20economy

European Commission (n.d.-d). *State aid Regulations: General Block Exemption Regulation.* https://competition-policy.ec.europa.eu/state-aid/legislation/regulations_en

European Commission. (n.d.-e). *The Net-Zero Industry Act: Accelerating the transition to climate neutrality.* https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en#:~:text=The%20Act%20sets%20a%20goal,for%20CO2%20storage%20services.

European Commission. (2020). *A hydrogen strategy for climate-neutral Europe.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301.

European Commission. (2021, December 1). *Global Gateway: Up to €300 billion for the European Union's strategy to boost sustainable links around the world*. Retrieved 03 June 2024, from https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6433

European Commission. (2022a). *REPowerEU Plan* (COM/2022/230 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483

European Commission. (2022b, May 18). *EU external energy engagement in a changing world* (JOIN(2022) 23 final). https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX%3A52022JC0023

European Commission. (2022c, November 3). *Commission invests €3 billion in innovative clean tech projects to deliver on REPowerEU and accelerate Europe's energy independence from Russian fossil fuels.* https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6489

European Commission (2023a, February 1). *The Green Deal Industrial Plan: Putting Europe's net-zero industry in the lead*. Retrieved 03 June 2024, from https://ec.europa.eu/commission/presscorner/detail/en/ip_23_510

European Commission. (2023b, March 7). *Joint press release on Canada-EU relations.* https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1486

European Commission. (2023c, November 20). *Keynote speech by President von der Leyen at the European Hydrogen Week 2023, via video message.* https://ec.europa.eu/commission/presscorner/detail/en/speech_23_5907

European Commission. (2023d, November 23). *Commission opens €4 billion call for proposals for net-zero technologies under the Innovation Fund*. https://ec.europa.eu/commission/presscorner/detail/en/IP_23_5948

European Commission. (2023e, November 28). *Commission proposes 166 cross-border energy projects for EU support to help deliver the European Green Deal*. Retrieved 03 June 2024, from https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6047

European Commission. (2023f). *Annex to the COMMISSION DELEGATED REGULATION (EU) …/... amending Regulation (EU) No 2022/869 of the European Parliament and of the Council*

as regards the Union list of projects of common interest and projects of mutual interest. https://energy.ec.europa.eu/system/files/2023-11/Annex%20PCI%20PMI%20list.pdf

European Commission. (2023g, December). *EU invests an additional €2 billion of emissions trading revenues in clean energy infrastructure projects in Member States via the Modernisation Fund.* Retrieved 03 June 2024, from https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6644

European Commission. (2024a, February 6). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Securing our future Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2024%3A63%3AFIN

European Commission. (2024b, February 15). Commission approves up to €6.9 billion of State aid by seven Member States for the third Important Project of Common European Interest in the hydrogen value chain. https://ec.europa.eu/commission/presscorner/detail/en/ip_24_789

European Commission. (2024c, April 19). *European Hydrogen Bank auction provides €720 million for renewable hydrogen production in Europe.* https://ec.europa.eu/commission/presscorner/detail/en/ip_24_2333

European Commission. (2024d, May 2). Consolidated text: Communication from the Commission. Temporary Crisis and Transition Framework for State Aid measures to support the economy following the aggression against Ukraine by Russia. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02023XC0317%2801%29-20240502

European Commission. (2024e, September 2). Communication from the Commission. Guidance on the targets for the consumption of renewable fuels of non-biological origin in the industry and transport sectors laid down in Articles 22a, 22b and 25 of Directive (EU) 2018/2001 on the promotion of energy from renewable sources, as amended by Directive (EU) 2023/2413. https://energy.ec.europa.eu/document/download/0c574279-b71d-4aa0-9403-daf9ea5a8491_en?filename=C_2024_5042_1_EN_ACT_part1_v8.pdf

European Commission. (2024f). *Methodology to determine the greenhouse gas (GHG) emission savings of low-carbon fuels.* https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14303-Methodology-to-determine-the-greenhouse-gas-GHG-emission-savings-of-low-carbon-fuels_en

European Commission. (2025a). *Clean Industrial Deal: A plan for EU competitiveness and decarbonisation.* https://commission.europa.eu/topics/eu-competitiveness/clean-industrial-deal_en

European Commission. (2025b, March 7). *Oversubscribed European Hydrogen Bank auction receives 61 bids for Innovation Fund support, including 8 maritime projects.* https://climate.ec.europa.eu/news-your-voice/news/over-subscribed-european-hydrogen-bank-auction-receives-61-bids-innovation-fund-support-including-8-2025-03-07_en

European Commission (2025c, February 26). Questions and answers on the Clean Industrial Deal. https://ec.europa.eu/commission/presscorner/detail/en/qanda_25_551

European Investment Bank. (2022, November 16). EIB to support green energy in Namibia. https://www.eib.org/en/press/speeches/cop27-namibia-mou-hoyer

Eyl-Mazzega, M.A., & Gherassim, D.P. (2024). How Can the Green Deal Adapt to a Brutal World? *Ifri Studies,* Ifri.

European Court of Auditors. (2024). *The EU's industrial policy on renewable hydrogen: Legal framework has been mostly adopted—time for a reality check.* Special Report. https://www.eca.europa.eu/ECAPublications/SR-2024-11/SR-2024-11_EN.pdf

Ferraro, S., Cannas, G., & Van de Casteele, K. (2024). The use of crisis State aid measures in response to the Russian invasion of Ukraine (until end-June 2023). *Competition State Aid Brief,* Issue 1/2024, February 2024. https://competition-policy.ec.europa.eu/document/download/22938d94-beaa-44bf-97ca-8a1785ca1a1c_en?filename=state_aid_brief_1_2024_kdam24001enn_ukraine.pdf

GasConnect Austria. (2025, January 22). *SoutH2 Corridor: Five States signed Declaration of Intent*. https://www.gasconnect.at/en/recent/news/south2-corridor-fuenf-staatenunterzeichnen-absichtserklaerung-in-rom

Graf, A., & Buck, M. (2024). *EU policies for climate neutrality in the decisive decade: 20 initiatives to advance solidarity, competitiveness and sovereignty.* https://www.agora-energiewende.org/fileadmin/Projekte/2023/2023-05_EU_Big_Picture_2040/A-EW_318_EU_Big_Picture_2024_WEB.pdf

G20 Energy Ministers. (2023). *G20 energy transitions ministers' meeting outcome document and chair's summary*. https://www.g20.org/content/dam/gtwenty/gtwenty_new/document/G20_Energy_Transitions_Ministers%E2%80%99_Meeting_Outcome_Document_and_Chair%E2%80%99s_Summary.pdf

Hintco. (2024). *Hintco and Fertiglobe sign landmark renewable ammonia supply contract*. https://www.hintco.eu/news/bmwk-1-tender-lot-1-signing-ceremony-fertiglobe

Hodgson, R. (2024, January 15). Poland's new government commits to join EU 'fight' against climate change. *Euronews*. https://www.euronews.com/green/2024/01/15/polands-new-government-commits-to-join-eu-fight-against-climate-change

Holl, M., Buck, M., Dossche, V., Deutsch, M., & Janke, L. (2024). Low-carbon hydrogen in the EU. Towards a robust definition in view of costs, trade and climate protection. *Agora Energiewende and Agora Industry.*

Huertas Ruiz, A., & Dura Ferrandis, E. (2023, September 2023). The Social Dimension of the EU's Economic Governance Review. *Euractiv*. Retrieved 03 June 2024, from https://www.euractiv.com/section/economy-jobs/opinion/the-social-dimension-of-the-eus-economic-governance-review/

Hydrogen Council & McKinsey & Company (2024, September). *Hydrogen Insights 2024*. https://hydrogencouncil.com/wp-content/uploads/2024/09/Hydrogen-Insights-2024.pdf

Hydrogen Europe (2024). *Clean Hydrogen Monitor 2024*. https://hydrogeneurope.eu/wp-content/uploads/2024/11/Clean_Hydrogen_Monitor_11-2024_V2_DIGITAL_draft3-1.pdf

H2Med. (2023, November 2023). *The H2med project adopted by the European Commission on the list of Projects of Common Interest (PCI).* Retrieved 03 June 2024, from https://h2medproject.com/the-h2med-project-adopted-by-the-europeancommission-on-the-list-of-projects-of-commoninterest-pci/

IEA. (n.d.). CEM Hydrogen initiative. *International Energy Agency*. Retrieved 03 June 2024. From https://www.iea.org/programmes/cem-hydrogen-initiative

IEA. (2024, October). *Energy Technology RD&D Budgets: Tracking trends in spending by energy technology in IEA countries back to 1974.* https://www.iea.org/data-and-statistics/data-product/energy-technology-rd-and-d-budget-database-2

IPHE. (2023). Methodology for determining the greenhouse gas emissions associated with the production of hydrogen.

Jäger, P. (2024). Flying blind? Why EU administrations need better data and analytical capacities. *Policy Brief.* Jacques Delors Centre, Hertie School. https://www.delorscentre.eu/en/publications/detail/publication/flying-blind-why-eu-administrations-need-better-data-and-analytical-capacities#:~:text=Given%20that%20vertical%20government%20interventions1,to%20properly%20analyse%20this%20data.

Jerzyniak, T. (2024). The EU De-Risking of energy dependencies: Towards a new clean energy geopolitical Order? *Politics and Governance, 12*. https://doi.org/10.17645/pag.8285.

KfW. (2024, November 27). *New milestone for the hydrogen strategy: KfW supports network development*. https://www.kfw.de/About-KfW/Newsroom/Latest-News/Pressemitteilungen-Details_830720.html

Kilpeläinen, S., Quitzow, R., & Tsoumpa, M. (2023). *Hydrogen in the Nordics: Drivers of European Cooperation?*. Bonn: Friedrich-Ebert-Stiftung. https://library.fes.de/pdf-files/a-p-b/20629.pdf

Kyllmann, C. (2023, February 15). *Germany and Belgium to link hydrogen networks, double LNG transit and explore second interconnector.* Clean Energy Wire. Retrieved 03 June 2024, from https://www.cleanenergywire.org/news/germany-and-belgium-link-hydrogen-networks-double-lng-transit-and-explore-second-interconnector#:~:text=In%20a%20joint%20statement%2C%20the,the%20goal%20of%20doubling%20transit

Laity, E. (2024, September 10). EU grants South Africa €32m for green hydrogen development. *H2View*. https://www.h2-view.com/story/eu-grants-south-africa-e32m-for-green-hydrogen-development/2114648.article/

Laity, E. (2025, January 31). Denmark fast-tracks hydrogen pipeline with lowered capacity booking requirement. *H2 View*. https://www.h2-view.com/story/denmark-fast-trackshydrogen-pipeline-with-lowered-capacity-booking-requirement/2120864.article/

Liebreich, M. (2023, December 13). Clean Hydrogen's Missing Trillions. *BloombergNEF*. Retrieved 03 June 2024, from https://about.bnef.com/blog/liebreich-clean-hydrogens-missing-trillions/

Luman, R., Geijer, T., Zhang., C. & Patterson, W. (2024, September 25). Europe leads the way on SAF, but airlines are struggling to hit targets. *ING THINK economic and financial analysis.* https://think.ing.com/articles/europe-leads-the-saf-journey-but-faces-slack-as-well-hold/

Marcu, A., Imbault, O., Cavallera, C., Patonia, A., Quitzow, R., Eicke, L., & Zabanova, Y. (2024). *Reflection note: Incentivising hydrogen demand: Critical challenges and opportunities for EU policy*. Roundtable on climate change and sustainable transitions. Oxford Institute for Energy Studies, and Research Institute for Sustainability Potsdam. https://ercst.org/incentivising-hydrogen-demand-critical-challenges-and-opportunities-for-eu-policy/

Martin, P. (2023, November 24). Europe's 'hydrogen backbone' of cross-border pipelines will cost billions more euros than initial estimates. *Hydrogen Insight.* https://www.hydrogeninsight.com/production/europes-hydrogen-backbone-of-cross-border-pipelines-will-cost-billions-more-euros-than-initial-estimates/2-1-1560429

Martin, P. (2024a, July 31). Spain gives provisional green light for Enagás to build cross-border hydrogen pipelines with Portugal and France. *Hydrogen Insight.* https://www.hydrogeninsight.com/policy/spain-gives-provisional-green-light-for-enag-s-to-build-cross-border-hydrogen-pipelines-with-portugal-and-france/2-1-1684860

Martin, P. (2024b, September 3). 'We are not sure green hydrogen cost will fall to €5/kg any time soon': senior German government official. *Hydrogen Insight.* https://www.hydrogeninsight.com/production/we-are-not-sure-green-hydrogen-cost-will-fall-to-5-kg-any-time-soon-senior-german-government-official/2-1-1703134

Martin, P. (2024c, November 18). Spain, Lithuania, and Austria commit funds to European Hydrogen Bank's 'Auctions-as-a-Service' scheme. *Hydrogen Insight.* https://www.hydrogeninsight.com/policy/spain-lithuania-and-austria-commit-funds-to-european-hydrogen-banks-auctions-as-a-service-scheme/2-1-1740926

Modernisation Fund. (n.d.). *Investment. List of confirmed and recommended investment proposals*. https://modernisationfund.eu/investments-2/

Nicolai, S., & Munchmeyer, M. (2024, April 15). An EU industry fit for net zero. *EUI Florence School of Regulation*. Retrieved 03 June 2024, from: https://fsr.eui.eu/an-eu-industry-fit-for-net-zero/

Parkes, R. (2023, October 20). H2Global floats timeframe to announce winners of massive €900m hydrogen auctions—and confirms extra funding. *Hydrogen Insight*. Retrieved 03 June 2024, from https://www.hydrogeninsight.com/policy/h2global-floats-timeframe-to-announce-winners-of-massive-900m-hydrogen-auctions-and-confirms-extra-funding/2-1-1538752

Parkes, R. (2024a, January 25). Australia poised to jointly fund a €400m H2Global green hydrogen subsidy auction with German government. *Hydrogen Insight*. Retrieved 03 June 2024, from https://www.hydrogeninsight.com/production/australia-poised-to-jointly-fund-a-400m-h2global-green-hydrogen-subsidy-auction-with-german-government/2-1-1588281

Parkes, R. (2024b, September 27). Boost for blue hydrogen as Equinor opens world's first cross-border carbon storage facility. *Hydrogen Insight*. https://www.hydrogeninsight.com/production/boost-for-blue-hydrogen-as-equinor-opens-world-s-first-cross-border-carbon-storage-facility/2-1-1716523

Pisani-Ferry, J., Tagliapietra, S., & Zachmann, G. (2023). A new governance framework to safeguard the European Green Deal (No. 18/2023). *Bruegel Policy Brief*. https://www.bruegel.org/sites/default/files/2023-09/PB%2018%202023_1.pdf

Prontera, A., & Quitzow, R. (2023). Catalytic power Europe: Blended finance in European external action. *JCMS: Journal of Common Market Studies, 61*(4), 988–1006. https://doi.org/10.1111/jcms.13442

Quitzow, R., Nunez, A., & Marian, A. (2024). Positioning Germany in an international hydrogen economy: A policy review. *Energy Strategy Reviews, 53*. https://doi.org/10.1016/j.esr.2024.101361

Quitzow, R., & Thielges, S. (2020). The German energy transition as soft power. *Review of International Political Economy*. https://doi.org/10.1080/09692290.2020.1813190

Quitzow, R., Triki, A., Wachsmuth, J., Garcia, J. F., Kramer, N., & Lux, B. (2023). Mobilizing Europe's Full Hydrogen Potential: Entry-Points for Action by the EU and its Member States. *HYPAT Discussion Paper No 5/2023*. Fraunhofer ISI (Ed.), Karlsruhe. https://hypat.de/hypat-wAssets/docs/new/publications/Hypat-Discussion-Paper-05_2023-Mobilizing-Europe-s-Full-Hydrogen-Potential.pdf

Reuters. (2024, September 21). *Norway's Equinor scraps plans to export blue hydrogen to Germany*. https://www.reuters.com/business/energy/norways-equinor-scraps-plans-export-blue-hydrogen-germany-2024-09-20/

Schuman Associates. (2024, March 20). *Over €1 trillion to be spent by 2029: Recovery and Resilience Facility & Cohesion Policy funds.* Retrieved 03 June 2024, from https://www.schumanassociates.com/newsroom/over-1-trillion-euro-to-be-spent-by-2029-recovery-and-resilience-facility-and-cohesion-policy-funds.

Shumkov, I. (2023, October 25). *EU launches new initiative to develop green hydrogen in Mauritania. Renewables Now.* Retrieved 03 June 2024, from https://renewablesnow.com/news/eu-launches-new-initiative-to-developgreen-hydrogen-in-mauritania-837706/

Stam, R., van der Linde, C., & Stapersma, P. (2024). Hydrogen Policy in the Netherlands: Laying the foundations for a scalable hydrogen value chain. In R. Quitzow & Y. Zabanova (Eds.), *The geopolitics of hydrogen volume 1: European strategies in global perspective* (pp. 165–189). Springer.

Team Europe. (2024a, May). *EU-Africa flagship projects (Global Gateway Projects).* https://international-partnerships.ec.europa.eu/document/download/ed505ccf-18ef-4fe9-816b-587d28f10633_en?filename=infographics-global-gateway-flagship-projects-2023-2024-eu-africa_en.pdf

Team Europe. (2024b, May). *EU-Latin America and the Caribbean flagship projects*. https://international-partnerships.ec.europa.eu/document/download/026adfa5-40fb-405a-bd43-6ee6dbbd80f1_en?filename=infographics-global-gateway-flagship-projects-2023-2024-eu-lac_en.pdf&prefLang=de

Transport and Environment. (2024, January 24). *E-fuels for planes: with 45 projects, is the EU on track to meet its targets?* Retrieved 03 2024, from https://www.transportenvironment.org/articles/e-fuels-for-planes-with-45-projects-is-the-eu-on-track-to-meet-its-targets/

UNIDO, IRENA & IDOS (2023). *Green Hydrogen for Sustainable Industrial Development. A Policy Toolkit for Developing Countries.* https://www.unido.org/sites/default/files/files/2024-02/Green%20hydrogen%20for%20Sustainable%20Industrial%20Development%20A%20Policy%20Toolkit%20for%20Developing%20Countries.pdf

Weko, S., Farrand, A., Fakoussa, D., & Quitzow, R. (2023). The Politics of Green Hydrogen Cooperation. *RIFS Study.* RIFS. https://doi.org/10.48481/rifs.2023.031

Webster, J., & Ruiz Guix, P. (2024). Toward harmonizing transatlantic hydrogen policies: Understanding the gaps. *Atlantic Council*. https://www.atlanticcouncil.org/blogs/energysource/toward-harmonizing-transatlantic-hydrogen-policies-understanding-the-gaps/