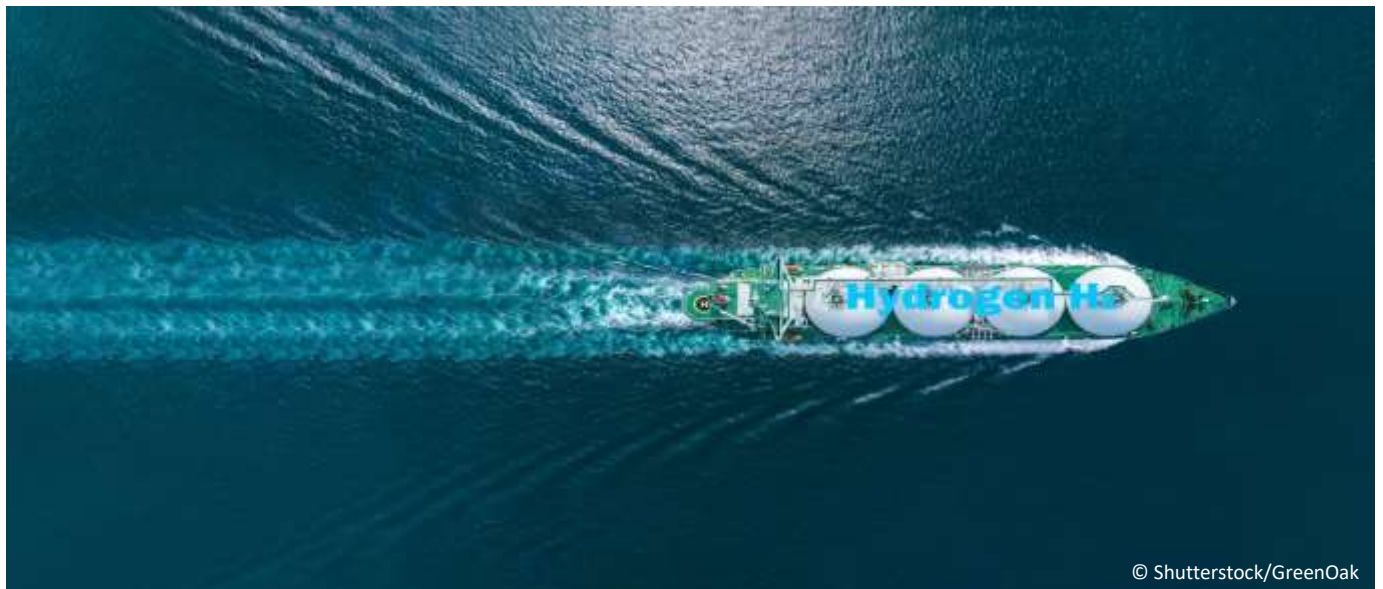


Pillars of a European Hydrogen Import Strategy

Setting the Course for Diversified Hydrogen Sourcing

André Wolf



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Low-emission hydrogen production has become the focus of a global investment race. Countries with significant renewable energy potential have recognized hydrogen not only as a means of phasing out the use of fossil fuels, but also as the basis for a new export model. As a net energy importer, Europe can benefit from this emerging new division of labor. However, to participate in international hydrogen supply chains, the EU must address both internal regulatory barriers and the high costs of cross-regional hydrogen transport in the forthcoming revision of its hydrogen strategy. This cepStudy analyses the policy mix required to establish competitive and stable hydrogen import channels, based on a long-term market simulation for Germany.

- ▶ To avoid over-funding and the unintended creation of new supply risks, policy support for hydrogen imports must be coordinated within the framework of a clearly defined EU-wide strategy. The aim should be to strike a balance between three, at times conflicting, objectives: cost-efficiency, reliability of supply and resilience to supply disruptions.
- ▶ To bridge the initial gap between high import delivery costs and limited domestic willingness-to-pay, the EU should rely on competitive auctions of sales contracts, promoting an EU-wide application of the German H2Global scheme.
- ▶ Dedicated promotion of hydrogen transport infrastructure in third countries is an effective tool to broaden the supply base and thus avoid the creation of new dependencies on single external energy sources. It should be used strategically and centered on locations where transport costs make an essential difference for future market access. These are locations distant to the EU but with a high local renewable energy potential and a solid institutional background.
- ▶ Targeting country risks with public guarantee instruments reduces the need for direct subsidization. However, their widespread application requires the establishment of strict geographical diversification criteria as well as intensified diplomatic engagement with target countries.

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1 Background

In recent years, leadership in low-emission hydrogen production technologies has become a key component of the global technology race. Countries such as China, Australia and Canada are investing heavily in water electrolysis plants and the associated equipment, with the scale of the announced projects steadily increasing. The aim is not merely to reduce the dependence of domestic downstream industries on fossil fuels by developing into a production hub for renewable hydrogen. Rather, it is to secure a position as an interregional energy exporter in a future post-fossil-fuel world. Regions around the world with ambitious decarbonisation targets play a crucial role in implementing these plans as pioneers in low-emission hydrogen technologies. They generate the demand necessary for a fast scaling and for accumulating the experience necessary for making hydrogen technologies competitive with incumbent fossil alternatives.

This fact gives Europe a strategic position within the global hydrogen landscape. Its ambitious climate targets, combined with the limited potential for renewable energy (RE) within its own borders, suggest significant potential for importing climate-friendly energy. This is reflected in the EU's medium-term plans. The REPowerEU plan aims to import 10 million tonnes of renewable hydrogen from third countries by 2030, equivalent to half of the EU's total expected demand.¹ For the transport of energy over long distances, hydrogen and its derivatives, mainly ammonia and methanol, are regarded as one of the most promising long-term solutions. Furthermore, imported hydrogen and hydrogen derivatives can be used directly as raw materials or reducing agents for processes that are difficult to decarbonise in the European steel and chemical industries, thereby avoiding energy losses during reconversion into electricity. By becoming an indispensable driver of demand for future hydrogen exporters, Europe thus has the potential not only to secure its own green transition, but also to help shape future market rules and participate in knowledge networks within a global hydrogen economy.

At present, this vision is still being held back by external and internal barriers to investment. Externally, the high costs of interregional hydrogen transport pose an obstacle to international hydrogen supply chains. This applies in particular to maritime transport, which requires the construction and financing of an entirely new infrastructure (terminals, conversion plants, specialised vessels).² Internally, the EU's strict regulations governing the market introduction of renewable hydrogen present a barrier. This applies in particular to the stringent and complex production requirements (additionality of RE sources, spatial and temporal correlation between RE generation and electrolysis) set out in the legal definition of 'renewable fuels of non-biological origin' (RFNBO).³ As part of the forthcoming review of the European Hydrogen Strategy, the European Commission has announced plans to modernise market rules and the general regulatory approach in order to accelerate market development.

In doing so, it should also address the external barriers to hydrogen imports. This requires dedicated support tools to bridge current cost gaps in a manner that is cost-efficient and promotes competition between hydrogen sources. Such a system must be carefully balanced. Excessive support carries the risk of distorting domestic competition between alternative decarbonisation technologies. In the

¹ European Commission (2022). REPowerEU: affordable, secure and sustainable energy for Europe. Communication COM(2022) 108 final.

² Roland Berger (2021). Hydrogen transportation. The key to unlocking the clean hydrogen economy. Report.

³ European Commission (2023). Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin.

worst-case scenario, this could hold back direct electrification technologies and reduce overall energy efficiency. Furthermore, the aim of promoting the most cost-effective hydrogen sources must be balanced against the need for security of supply, which requires diversification of supply and a particular focus on the reliability of suppliers.

Against this background, this cepStudy analyses the effects and the interplay of three support instruments for promoting external renewable hydrogen supply to Europe: double auctions, grants for investments in transport infrastructure and public insurance against source country political risks. It explicitly models future hydrogen import markets based on the example of Germany. The model addresses three fundamental factors shaping the competitiveness of hydrogen source countries: availability of renewable energy, institutional quality and geographical distance to Europe. It analyses the effects of support instruments on total supply costs, subsidy volumes as well as resilience and reliability of the resulting supply mix. In this way, it illustrates the relevant trade-offs in choosing the policy mix. Based on this, it derives key recommendations for supporting the import pillar in an updated EU hydrogen strategy.

2 International Supply Development

Worldwide, electrolysis capacity has seen exponential growth in recent years. In 2025, installed capacity doubled compared with 2024 and increased more than tenfold compared with the situation five years earlier (see Figure 1).⁴ This trend is accompanied by a similar rise in manufacturing capacity for production equipment such as electrolysis stacks. This boom is primarily attributable to the emergence of new mega-projects. This demonstrates that the development of hydrogen from renewable energy has entered a new phase, evolving from pilot plants towards large-scale solutions for future mass markets.

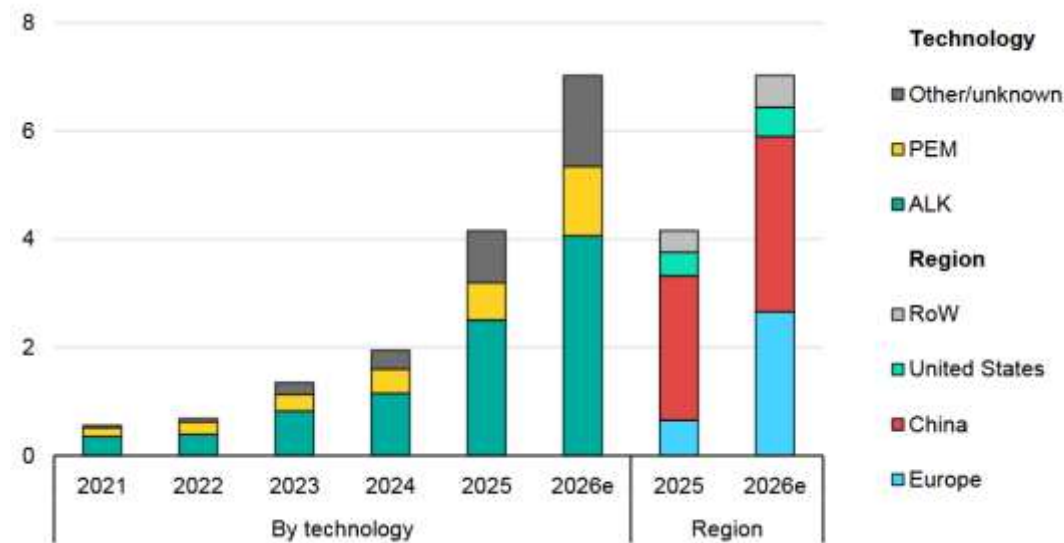
However, the cost of producing hydrogen from renewable energy sources remains a major barrier to the emergence of such markets. Hopes for significant cost reductions through economies of scale have not yet been realized. At the same time, costs vary greatly between production locations, ranging from 3 to 10 US dollars per ton of hydrogen on the global scale.⁵ Current large-scale projects are concentrated in a few regions with ideal production conditions. By comparison, future centers of industrial demand are more geographically dispersed and, in some cases, lie at a considerable distance from promising supply regions. To be financially viable, mega-projects must therefore create sufficient export opportunities. This is also reflected in current national policy strategies. The majority of countries that have published specific hydrogen strategies are pursuing the vision of becoming hydrogen exporters in the future.⁶ To this end, the expansion of infrastructure must go beyond electrolysis and short-distance transport capacity (particularly pipelines) to also include hydrogen conversion plants, export terminals and specialized vessels for the maritime hydrogen trade.⁷ The financing and coordination of the development of such a completely new trade infrastructure presents a major challenge for both the business sector and policymakers in potential export countries.

⁴ IEA (2026a). Global Hydrogen Review 2026. International Energy Agency.

⁵ See IEA (2026a).

⁶ Corbeau, A., Kaswiyanto, R. (2024). What Do National Hydrogen Strategies Tell Us About Potential Future Trade? Center on Global Energy Policy.

⁷ See Roland Berger (2021).

Figure 1: Global evolution of installed electrolysis capacities (in GW)

Source: [IEA \(2026a\)](#)

This situation creates major opportunities for Europe. By supporting the development of international hydrogen trade channels, European energy consumers gain access to renewable energy sources that can be produced on significantly more favorable terms than in Europe. At the same time, scarce domestic renewable resources are conserved for more efficient applications within the context of direct electrification. Jointly funded development of H₂ supply chains with third countries can also lay the foundations for long-term transformation partnerships which, going beyond energy trade, generate new sustainable growth models through knowledge exchange and regulatory cooperation.

The first obstacle on the way is the currently high cost of intercontinental transport of elemental hydrogen (in liquid form) or its derivatives (green ammonia, green methanol). Depending on the distance, these costs can account for more than half of the total delivery costs to Europe.⁸ Secondly, the inadequate institutional environment in many production regions – which are otherwise extremely promising in terms of natural conditions – represents an investment barrier. This concerns both general political stability and the rule of law, as well as the certainty of the specific legal framework for developers of hydrogen projects. Neither of these obstacles can be overcome at the investor level through project management alone. Removing them also promises positive externalities for technological development and political integration that extend beyond the investments themselves. This argues in favor of targeted policy support, for which suitable support instruments need to be developed.

⁸ Galimova, T., Fasihi, M., Bogdanov, D., & Breyer, C. (2023). Impact of international transportation chains on cost of green e-hydrogen: Global cost of hydrogen and consequences for Germany and Finland. *Applied Energy*, 347, 121369.

3 Current Support Framework

3.1 International Hydrogen Partnerships

Besides the EU-internal Clean Hydrogen Partnership⁹, the EU has started to engage in a variety of international hydrogen-related alliances with third countries. Dedicated partnership agreements for hydrogen trade have been signed with Egypt¹⁰, Namibia¹¹, South Africa¹² and Uruguay¹³. These partnerships follow a supply chain approach. Their purpose is not only to incentivize the formation of electrolysis capacities in partner countries but also to set up a transport infrastructure and secure stable supply of qualified workers and mineral raw materials needed for hydrogen production. Moreover, the focus is not exclusively on hydrogen exports, but also on promoting domestic downstream use in partner countries. This caters to the industrial development goals of partners, a prerequisite for establishing partnerships that are stable in the long-term. The implementation of partnerships is embedded in the EU Global Gateway Framework and its associated funding channels (see next section).

In addition, the EU has forged technology-oriented alliances that aim for joint technological leadership in emerging technologies (including renewable hydrogen) such as the India-EU Trade and Technology Council¹⁴ and the cooperation agreement between the EU Clean Hydrogen Partnership and Japan's New Energy and Industrial Technology Development Organisation (NEDO)¹⁵. These alliances focus on knowledge cooperation and the development of common technical standards for hydrogen production and transport. Besides strengthening innovation potential, a main intention of these alliances is to jointly shape the market rules for future international hydrogen trade. In this way, technological pioneering shall be translated into early-mover advantages on emerging hydrogen markets.

Furthermore, specific cooperation agreements have been concluded to develop the infrastructure required for promising hydrogen transport corridors. The prime example of this is the 'Southern Hydrogen Corridor' (SouthH2 Corridor)¹⁶, a multinational initiative aimed at facilitating pipeline-based hydrogen transport from North Africa to Europe. Besides strengthening European energy security, the project is of potentially great strategic importance for the economic development of Algeria and Tunisia, as the prospect of a significant long-term increase in the potential for green exports is expected to boost local investment in renewable energy. For Algeria in particular, as one of Europe's current key suppliers of natural gas¹⁷, such a partnership project offers the prospect of diversifying exports and, in the long term, safeguarding its own energy transition within the framework of a bilateral transition partnership.

⁹ European Union (2026). [Clean Hydrogen Partnership](#).

¹⁰ European Union / Arab Republic of Egypt (2022). Memorandum of understanding on a strategic partnership on renewable hydrogen between the European union and the Arab republic of Egypt.

¹¹ European Union / Republic of Namibia (2022). Memorandum of understanding on a partnership on sustainable raw materials value chains and renewable hydrogen between the European Union and the Republic of Namibia.

¹² European Union / Republic of South Africa (2025). Memorandum of understanding between the government of the Republic of South Africa and the European Union on a Clean Trade and Investment Partnership.

¹³ European Union / Uruguay (2023). Memorandum of Understanding between the European Union and the Oriental Republic of Uruguay on Renewable Energy, Energy Efficiency and Renewable Hydrogen.

¹⁴ European Parliament (2023). [EU-India Trade and Technology Council](#).

¹⁵ European Union (2024). [Clean Hydrogen Partnership signs cooperation agreement with Japan's NEDO](#).

¹⁶ SouthH2 Corridor (2024). [The SouthH2 Corridor project](#).

¹⁷ Reichert, G., Wolf, A. (2025). [Die Energiesicherheit Deutschlands. Analyse im Kontext heutiger Erdgas- und zukünftiger Wasserstoffimporte](#). cepStudie.

3.2 Funding Instruments

EU funding for hydrogen projects is currently scattered across various channels such as the EU innovation Fund, the regional development funds and project-specific support by the European Investment Bank. In 2023, the EU established with the European Hydrogen Bank (EHB) a platform tool for earmarking and channeling different forms of support to hydrogen projects¹⁸. The EHB has both an internal and an external dimension. Currently, direct financial support is limited to an auctioning of fixed premium payments to domestic hydrogen production. In the future, direct support shall be extended to hydrogen imports. The national H2Global Initiative in Germany is likely to serve as a nucleus for this.

The H2Global Initiative provides support to hydrogen import projects through an innovative double auction scheme. In this scheme, foreign hydrogen producers and domestic hydrogen buyers participate in separate price auctions. Both molecular hydrogen and various forms of hydrogen derivatives are auctioned. In the supply auctions, the most cost-effective bid is awarded a long-term supply contract. The import volumes secured in this way are then sold to domestic buyers in a separate auction to the highest bidder. The off-take contracts resulting from this have a shorter term than the exporters' supply contracts. As the production costs of renewable hydrogen in the initial phase are still significantly higher than what buyers are willing to pay, a price differential arises between the two auctions, which is covered by subsidies.¹⁹ In addition to global auctions, regional auctions were also held in the second round of auctions to strengthen the resilience of the hydrogen supply through geographical diversification.²⁰

With the Netherlands, another Member State has already joined the H2Global funding scheme in the second round of auctions. In addition, six further European nations, including France, Spain, Portugal, Austria, Denmark and Finland, have announced plans to provide funding for the initiative. On the potential exporters' side, the H2Global initiative has also succeeded in establishing several cooperation frameworks with promising future hydrogen suppliers such as Australia and Canada²¹.

With the Global Gateway Strategy, the EU has also established a mechanism for supporting infrastructure projects in third countries.²² Within the 'Climate/Energy' priority sector, hydrogen infrastructure projects are also supported as flagship projects. Examples in the current program include a Green Hydrogen & Power-to-X Facility in South Africa and the Clean Energy Solutions project in Namibia.²³ As a funding instrument, Global Gateway relies primarily on resources from the European Fund for Sustainable Development Plus (EFSD+). It utilizes investment guarantees as its primary risk-sharing mechanism to mitigate project risks, combined with grants and loans.²⁴ These financial guarantees act as a safety net for lenders by covering potential losses. This enables private investors and commercial banks to confidently fund high-impact infrastructure in developing and emerging markets. Their objective is to mobilize additional private capital by reducing financial costs. The guarantees are channeled indirectly through development finance institutions.

¹⁸ European Commission (2026a). [European Hydrogen Bank](#).

¹⁹ Hintco (2024). [The H2Global Mechanism](#).

²⁰ Hintco (2025a). [2nd H2Global Auction Round](#).

²¹ Hintco (2025b). [Germany commits EUR 588 million to bilateral H2Global Tenders with Australia and Canada](#).

²² European Commission (2021). The Global Gateway. Joint Communication to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank. JOIN(2021) 30 final.

²³ European Commission (2025). [Global Gateway flagship projects](#).

²⁴ European Commission (2026b). [European Fund for Sustainable Development Plus](#).

To give private companies more direct access to the ‘Global Gateway’ programs and funding, the ‘Global Gateway Investment Hub’ was recently launched as a direct point of contact. It offers companies the opportunity to apply directly for support for their own investment projects in third countries. Proposals are initially assessed by national juries (‘Team National’), and an evaluation is carried out to determine whether national funding is available. The potential support goes beyond guarantees and also includes non-financial aspects such as technical assistance and the facilitation of partnerships.²⁵

3.3 Societal Targets

In choosing the policy mix for incentivizing hydrogen imports, policy-makers must navigate between several potentially conflicting goals. One central criterion is cost efficiency of supply. This refers to the total societal cost of external hydrogen deliveries to Europe, i.e. the costs arising from production, transport and marketization of sustainable hydrogen, including the capital costs of building and maintaining the necessary infrastructure. Minimizing these costs asks for competition-based support instruments that ensure preferred market access for hydrogen sources with the lowest delivery costs. This is however complicated by the fact that current cost rankings are not necessarily a perfect indicator for future ones. For instance, several studies see considerable potential for long-term cost reductions in pipeline and maritime transport of hydrogen, both due to static scale economies in infrastructure and technology improvements in molecule conversion and ship propulsion.²⁶ As a consequence, spatial distance to hydrogen production locations, which is currently a prohibitive factor in many cases, could lose importance in future cost comparisons. An anticipatory support policy that aims at long-run cost minimization should thus consider the role of different cost categories.

Moreover, there are other societal goals to be considered. Through the energy crisis sparked by the outbreak of the Ukraine war, Europe has painfully learned that energy security is a central value on its own. Foremost, diversifying supply sources has proven to be essential to enhance shock resilience and reduce the exposure to external political blackmailing. This wisdom also translates to a future hydrogen economy. Support instruments should thus aim to incentivize a diversification of Europe’s external hydrogen sourcing. This concerns not only the spatial dimension, i.e. diversification of regions of origin and trade routes, but also the technological dimension, i.e. the sector-dependent needs for different hydrogen-based molecules (e.g. green ammonia, methanol, synthetic aviation fuels).

Supply security also requires Europe to consider the reliability of specific suppliers. Currently, third countries in areas like North Africa with significant hydrogen potential and in spatial proximity to the EU are partly characterized by an uncertain regulatory environment and a low degree of general political stability. Regime changes and civil unrest represent a real risk to long-term hydrogen projects. A purely cost-based allocation of investment support through mechanisms like Global Gateway might thus prove a risky support strategy. As internal conflicts can easily spill over to neighboring countries, a diversification strategy alone is an insufficient form of risk management. Diplomacy, continued economic development support and deepened institutional cooperation with source countries are indispensable as well. At the same time, local institutional instability is also an ex-ante cost factor for international investors which aggravates access to funding sources. Indirect financial support through the EU EFSD+ guarantees or dedicated forms of insurance against external policy risks like the investment

²⁵ European Commission (2026c). [Investment hub – Investing with Global Gateway](#).

²⁶ See Roland Berger (2021).

guarantees in Germany can help mobilizing private capital in such regions, but might conflict with supply security goals without proper guardrails.

In total, navigating between the different societal goals associated with hydrogen trading asks for a well-balanced mix of policies. How to achieve this balance is not obvious, as the effects and risks of different support instruments highly depend on the future global hydrogen landscape, i.e. the evolution of capacities and costs at different production locations. In the following, the trade-offs of different policy variants are investigated based on a market simulation for the example of the hydrogen import market in Germany.

4 Policy Analysis

4.1 Modelling Scenario

The goal is to analyze how different policy support measures influence the cost competitiveness and spatial patterns of future hydrogen imports. To this end, the German import market for renewable hydrogen is considered. This choice is made both due to its function as a significant hydrogen demand sink and its pioneering role in promoting hydrogen imports (see Section 3).

Potential external hydrogen supply is modelled as the sum of supply from single hydrogen production projects that appear over time. While the total number and size of projects that emerge each modelling period is considered fixed, the project locations are determined by a stochastic process. Host countries of the projects are selected from the set of third countries which have implemented dedicated hydrogen strategies. The probability that a new project is located in a specific country is determined by the relative size of the country's suitable land area for renewable energy generation. The specific location within the respective country is then determined as a random spot within the suitable land area, with locations having a very low combined PV and wind power potential (the bottom 10% in each country) being excluded. This stochastic process reflects the fundamental uncertainty of German stakeholders on how political ambitions and concrete investment plans in single third countries will evolve. Projects are assumed to exhibit a standardized output capacity (in MW hydrogen), determined as the global median of projects currently planned for the time after 2030. Each period new projects are drawn from the distribution until the total added capacity of new projects reaches a threshold. The threshold is determined based on forecasted period-to-period changes in installed electrolysis capacity outside Europe. It represents the theoretical maximum of additional hydrogen supply by third countries that could be channeled in a period to Germany.

Projects are modelled to involve local renewable energy generation, electrolysis and subsequent transport of produced hydrogen to Germany. As renewable energy sources, two potential technologies are compared: PV and onshore wind. Dependent on the natural production conditions, relative efficiencies of these two technologies are location-specific. In each case, the technology is applied that delivers the lowest estimated region-specific hydrogen supply costs. In modelling the cost of hydrogen exports to Germany, two potential transport technologies are considered: H₂ pipelines and transport of liquified hydrogen by ship. The comparatively cheap pipeline transport is only assumed to be possible for countries with existing gas pipeline connections to Europe. For the remaining countries, hydrogen transport has to occur via specialized hydrogen vessels.

CAPEX and OPEX in electrolysis are assumed to be identical across countries, following studies like Galimova et al. (2023). Unit CAPEX in hydrogen transport only vary with spatial distance, by modelling a daily percentage loss of hydrogen during transport. Moreover, following Egli et al. (2025)²⁷, country variety in the financing costs of investments is introduced. Discount rates of project costs and revenues are modelled based on a standard Weighted Average Costs of Capital (WACC) approach. Expected returns on equity and the lending rate of debt are adjusted for project-specific risks, including a country risk component. The risk-free component is drawn from a uniform distribution, reflecting uncertainty on the future evolution of the general interest environment. The risk components considered in discount rate calculation differ by policy support scenario (see below).

The sum of the costs of electricity generation, electrolysis and exporting per ton of hydrogen produced is defined as the Levelized Cost of Hydrogen Deliveries (LCOHD). They mark the minimum hydrogen price expectation of a project operator in order to be willing to sell their hydrogen to Germany. The project-specific LCOHDs are ranked and, together with the size of projects, determine the supply curve for the German hydrogen import market in a period.

German demand is represented by an exogenous, time-dependent demand curve. The demand curve is constructed based on assumptions on future sectoral volume needs and sector-specific willingness-to-pay, adopted from forecasts on hydrogen deployment and future H₂ parity prices in the literature (see below). Since the overall scale and timing of future renewable hydrogen deployment is subject to significant uncertainty, a low-demand and a high-demand scenario are distinguished, marking the boundaries of plausible demand evolution. The extent to which this demand will be met by EU-internal supply is likewise difficult to predict. It both depends on the general investment climate for electrolysis in Europe and the relative scale of the German market. We assume a 50% coverage by hydrogen production inside the EU, adopting the EU-wide expectations of the European Commission in the REPowerEU Plan.

Model periods are divided into five-year-intervals, with new supply and demand projects being implemented at the start of each period. Precisely, the periods 2031-2035, 2036-2040 and 2041-2045 are considered. The import market is assumed to be organized in the form of two-side auctions, reflecting the basic mechanism of the H2Global-initiative (see Subsection 3.2). Third country project developers compete in supply auctions based on their LCOHDs. They are offered long-term contracts with a length of 15 years, to provide sufficient sales security for financing the infrastructure investments. Domestic demand sectors compete in separate demand auctions based on their willingness-to-pay, with contracts lasting only one modelling period to provide flexibility. The auctions have the form of competitive pay-as-bid auctions. A central agency acts as a buyer of hydrogen in the supply auctions and as a seller in the subsequent demand auctions. The total volume of hydrogen bought and sold each period is determined by the total level of domestic demand across sectors. Any potential financial gap between purchase costs and revenues of the agency is compensated by the state. Effectively, this implies that market participants receive an implicit public subsidy per kWh of hydrogen delivered compared to the scenario of unregulated direct marketing²⁸

²⁷ Egli, F., Schneider, F., Leonard, A., Halloran, C., Salmon, N., Schmidt, T., & Hirmer, S. (2025). Mapping the cost competitiveness of African green hydrogen imports to Europe. *Nature Energy*, 1-12.

²⁸ In our modelling, we abstract from the auction-specific economic and technical contract conditions set by H2Global, in particular the current discrepancy in contract lengths between supply and demand auctions. Therefore, the subsequent

Model simulations consist of taking a large number of draws ($n = 10000$) from the described probability distributions, constructing the resulting supply and demand curves and determining the auction results for each draw in each period. As a final step, period-specific probability distributions for import costs, public support payments and market shares of export countries are calculated.

4.2 Policy Options

The modelling framework described above is used to compare the implications of three different policy options for supporting hydrogen imports to Germany. The first option (“Baseline Scenario”) is exclusive support through publicly subsidized two-side auctions. The level of resulting support payments is equal to the difference between total supply costs and total willingness-to-pay for the auctioned quantity of hydrogen.²⁹

From an investor perspective, this support scheme represents a state-backed take-or-pay contract that almost completely secures project developers against revenue risks (demand risk, price risk) during the contract period. The residual revenue risk is the risk of the aggregator defaulting on its payment obligations. Since these payment obligations are completely guaranteed by the state, this risk component is equal to the sovereign default spread of Germany.

At the same time, the support scheme does not shield project developers against project-specific risks, i.e. the risk that a project will not be timely implemented or is forced to stop operating prematurely. This risk category can be subdivided into technological risks, i.e. risks related to the lack of experience with and/or immaturity of the technology, and political risks. The technological risk related to hydrogen production and transport is assumed to be global and expressed by adding a technology premium to the discount rate, following the approach by Egli et al. (2025).³⁰ Political risks can relate to the instability of regulatory conditions, fears of expropriation and forced shutdown due to wars or civil unrest. They are closely connected with a host country’s political stability and regulatory quality. In the following, this is expressed by a country-specific political risk premium added to the discount rate. The political risk premium is obtained by subtracting the host country’s sovereign default spread from its overall country risk premium. The latter is a standard metric to quantify the risk evaluation of political and solvency-related country characteristics. By subtracting the sovereign default spread, the solvency-related aspect is eliminated.

The second option complements the auction scheme by dedicated infrastructure support to project developers. It takes the form of grants financed by the German state budget that cover a fixed percentage of the project CAPEX associated with the export infrastructure, i.e. pipelines, hydrogen vessels, liquefaction plants and export terminals. The purpose is to provide targeted support to overcome financing hurdles for infrastructure capacity-building in areas with significant capital requirements and/or financing costs.

The third option complements the auction scheme by a publicly backed insurance mechanism against political country risks. It provides partial loss coverage to project developers in scenarios of project

results should not be understood as cost simulations for the current support scheme, but as a general analysis of technology-induced cost gaps.

²⁹ In our model, we do not make any assumptions on the geographical distribution of project ownership. From the perspective of Germany, some projects could take the form of outward FDI. Hence, public support costs may not be equalized with value transfers to other countries.

³⁰ See Egli et al. (2025).

default due to expropriation, wars, social unrest or significant changes to host country hydrogen policies. It thus mirrors the instrument of investment guarantees already institutionalized in Germany's foreign trade and investment promotion.³¹ The public insurance is assumed to be provided for free. The scheme is modelled as a percentage reduction of the political risk premium, which is equal to the percentage loss coverage of the insurance. This results in a lower project discount rate. It thus reduces the LCOHD by lowering the risk-related financing costs. Unlike the other two support instruments, this form of support does not immediately result in public transfer payments. However, the fact that the German state absorbs parts of the project risk represents a transfer of economic value to project developers. It can be expressed in monetary terms in the form of the Gross Grant Equivalent (GGE).³²

The Appendix provides the formulas for calculating country-specific LCOHD in each of the three policy scenarios.

4.3 Data

The list of third countries with national hydrogen strategies in place is adopted from the IEA.³³ Suitable land area for large-scale renewable energy development in these countries is approximated by applying multiple exclusion criteria to total land area in GIS mapping. Land area is excluded that is too steep (slope grade > 5%)³⁴, covered with forests, wildlife habitats or cities³⁵, or possesses high-quality agricultural soil (soil classes 1 and 2 from the HWSD³⁶).

The volume of new electrolysis capacity announcements for the five-year model periods after 2030 is assumed to equal expected absolute capacity growth of projects for the period 2026-2030, thus assuming a turn to linear capacity growth after the currently exponential initial growth phase. Based on announced projects listed in the IEA Hydrogen Projects Database, expected added electrolysis capacity at the global level in 2026-2030 amounts to 516 GW input capacity.³⁷ This implies a long-term growth that roughly matches the 2050 capacity goal of the IEA Net-Zero Scenario. The expected capacity contribution of projects located outside the European Economic Area amounts to 226.7 GW in 2026-2030. Project size in the model is determined as the median project size of this project cohort (130 MW input capacity). Together, this determines the total number of external project announcements drawn in each modelling period.

Data for estimating the location-specific costs of PV and wind energy generation are combined from several sources. Capacity factors for PV of suitable areas within each supplier country are taken from the Global Solar Atlas³⁸, capacity factors for wind energy from the Global Wind Atlas³⁹. Estimates of CAPEX and OPEX of electricity generation and electrolysis as well as equipment lifetime are taken from Galimova et al. (2023). Transport distances, fuel consumption and infrastructure costs for hydrogen transport by ship and pipeline were adopted from EWI (2024)⁴⁰ and Galimova et al. (2023). Electricity

³¹ BMW (2026). Investitionsgarantien Halbjahresbericht 2026. Bundesministerium für Wirtschaft und Energie.

³² <https://www.lexxion.eu/en/stateaidpost/the-gross-grant-equivalent-of-state-aid-in-public-guarantees/>

³³ See IEA (2026a).

³⁴ USGS (2018). [USGS EROS Archive - Digital Elevation - Global 30 Arc-Second Elevation \(GTOPO30\)](#). U.S. Geological Survey.

³⁵ esa (2026). [World Cover V2 2021](#). European Space Agency.

³⁶ HWSD (2026). [Harmonized World Soil Database](#).

³⁷ IEA (2026b). [Hydrogen Production and Infrastructure Projects Database](#). International Energy Agency.

³⁸ World Bank/Solargis (2026). [Global Solar Atlas](#).

³⁹ World Bank/DTU (2026). [Global Wind Atlas](#).

⁴⁰ EWI (2024). [EWI Global PtX Cost Tool 2.0](#). Energiewirtschaftliches Institut an der Universität zu Köln e.V.

used for hydrogen liquefaction and pipeline compression is assumed to stem from the same source as electricity in electrolysis. The ship is assumed to run on boil-off gas.

The country-specific financial indicators sovereign default spread and country risk premium are specified as the most recent values of the database of Damodaran (2026).⁴¹ The risk-free interest rate is varied within a corridor between 2% and 5% following Egli et al. (2025).

Data on future German sectoral hydrogen demand is taken from the latest long-term projections by the National Hydrogen Council, using the forecast ranges for each period as levels for the low-demand and the high-demand scenario, respectively.⁴² Future sectoral willingness-to-pay for hydrogen is obtained from recent estimations by Zheng et al. (2026)⁴³ and Ziemsky et al. (2026).⁴⁴ The complete table with global parameter values and parameter sources is found in the Appendix.

4.4 Results

4.4.1 Pure Auction Scheme

First, the range of differences in hydrogen supply costs among the countries of origin is presented. Table 1 lists the third countries with the highest and lowest average values of LCOHD for the first and for the last modelling period. It shows strong cost discrepancies that are both rooted in production and transport costs. In the most recent simulation period, Morocco and Azerbaijan stand out with the lowest LCOHD. In both cases, this is due to the combination of fairly low production costs and very low transport costs. The significance of transport costs becomes even more apparent when looking at the countries with the highest LCOHD, which all exhibit transport costs that make up way more than 50% of the LCOHD. Beside spatial distance to Germany, the relatively high costs of the liquefaction technology are a significant cost driver. The countries with the three lowest LCOHD all benefit from the ability to circumvent these costs due to their pipeline connection. In the period ten years later, learning effects in electricity production, electrolysis and hydrogen transport are expected to reduce the LCOHD to a relevant extent. The cost ranking of countries is not expected to change significantly, mainly because learning effects are assumed to be global in nature. In particular, spatial distance continues to be a major cost barrier to export competitiveness for many countries.

⁴¹ Damodaran, A. (2026). [Country Default Spreads and Risk Premiums](#).

⁴² NWR (2026). Wasserstoffbedarfe: Eine Einordnung in den realpolitischen Rahmen. Informations- und Grundlagenpapier. Nationaler Wasserstoffrat Deutschland.

⁴³ Zheng, L., Eckstein, J., & Eichhammer, W. (2026). Deriving industrial hydrogen demand curves in Germany and China: The implications of carbon pricing instruments. *International Journal of Hydrogen Energy*, 197, 152705.

⁴⁴ Ziemsky, V., Pichlmaier, S., & Gyetko, M. (2026). Bridging the financial gap: Analysis of parity prices and policy instruments for green hydrogen applications in hard-to-abate sectors in Germany. *Next Energy*, 11, 100610.

Table 1: Ranking of third countries by expected LCOHD to Germany (country averages)

Period 2031-2035								
Lowest LCOHD (EUR /MWh H ₂)				Highest LCOHD (EUR /MWh H ₂)				
Rank	Country	Production	Transport	LCOHD	Country	Production	Transport	LCOHD
1	Morocco	39.45	54.23	93.68	Sri Lanka	77.79	146.13	223.92
2	Azerbaijan	47.21	59.60	106.80	Ecuador	84.69	136.34	221.03
3	Algeria	55.00	64.00	119.00	Bolivia	76.25	142.52	218.77
4	Chile	28.32	94.40	122.72	Costa Rica	64.54	102.93	167.46
5	United Kingdom	37.84	91.52	129.36	Japan	67.55	98.72	166.27
6	Canada	39.60	90.98	130.57	Malaysia	67.22	98.95	166.17
7	New Zealand	36.98	94.42	131.40	Paraguay	64.38	101.41	165.79
8	Colombia	34.38	98.47	132.84	Indonesia	64.18	101.59	165.77
9	United States	42.56	92.12	134.69	Singapore	70.59	95.01	165.60
10	Oman	42.41	100.64	143.06	Argentina	42.55	122.46	165.01

Period 2041-45								
Lowest LCOHD (EUR /MWh H ₂)				Highest LCOHD (EUR /MWh H ₂)				
Rank	Country	Production	Transport	LCOHD	Country	Production	Transport	LCOHD
1	Morocco	32.88	33.12	66.01	Sri Lanka	60.37	140.18	200.55
2	Azerbaijan	39.34	36.43	75.77	Ecuador	66.11	130.07	196.17
3	Algeria	39.54	38.98	78.52	Bolivia	51.40	138.88	190.28
4	Chile	23.59	92.91	116.50	Argentina	35.53	120.47	156.00
5	Kazakhstan	39.10	78.62	117.72	Costa Rica	42.92	99.94	142.87
6	United States	32.15	88.52	120.67	Indonesia	42.60	98.64	141.24
7	United Kingdom	31.52	89.84	121.36	Paraguay	42.76	98.45	141.21
8	Canada	32.97	89.29	122.26	Namibia	33.84	107.23	141.07
9	New Zealand	30.79	92.78	123.58	Malaysia	44.55	95.93	140.48
10	Colombia	28.65	96.81	125.46	Japan	44.72	95.70	140.42

Source: own calculations

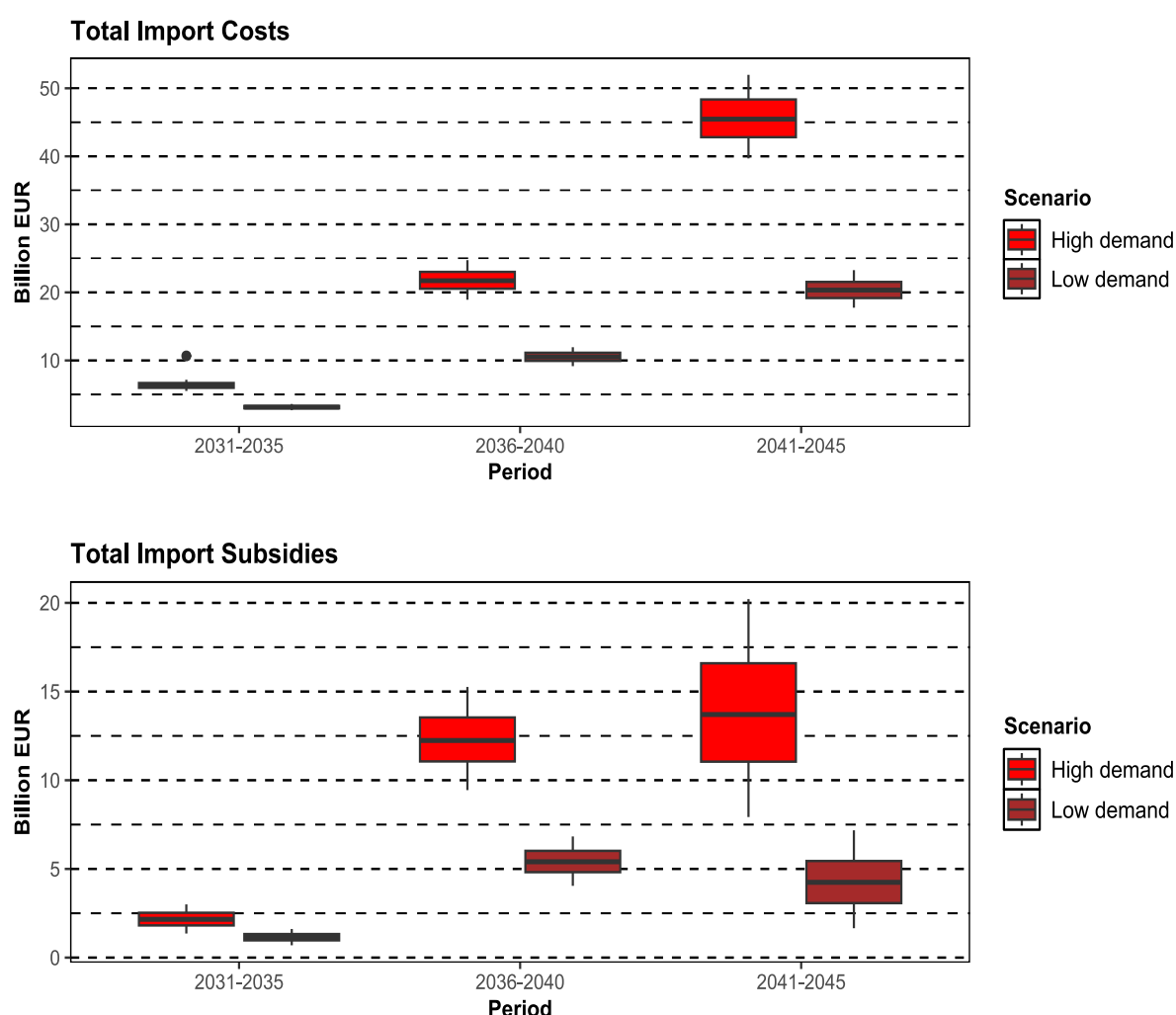
Figure 2 shows the distribution of hydrogen import costs and the required public compensation by period. In the period 2031-35, average import costs amount to 3.4 billion EUR in the low demand scenario and 6.8 billion EUR in the high demand scenario. During this period, the estimated LCOHD of even the most competitive supplier countries still exceed the expected willingness-to-pay of the domestic core hydrogen users steel and chemical industry. The resulting payment gap requires subsidies to finance the auction scheme in a scenario-dependent magnitude of 0.8 to 3.5 billion EUR. Moreover, imports during this period are geographically heavily concentrated. In the low demand scenario, Algeria as the country with the far biggest area of suitable land among the competitive suppliers reaches an average market share of 54% (see Figure 3). This is followed by Morocco (39%) and Azerbaijan (8%). External hydrogen sourcing thus initially relies on only three suppliers, with the two dominant suppliers both located in the politically unstable Northern African region. In the high demand scenario, the size-related dominance of Algeria is even more pronounced (average share of 71%). Chile and Canada enter the scene as additional suppliers, but the bulk of hydrogen comes from North Africa.

In the subsequent period 2035-2040, the rising willingness-to-pay and the learning-induced cost reductions in hydrogen production and transport narrow the gap between supply costs and demand. However, the effect of this development on public compensation needs is clearly overshadowed by the overall increase in hydrogen import volumes. Subsidy payments reach an average level of 6.1

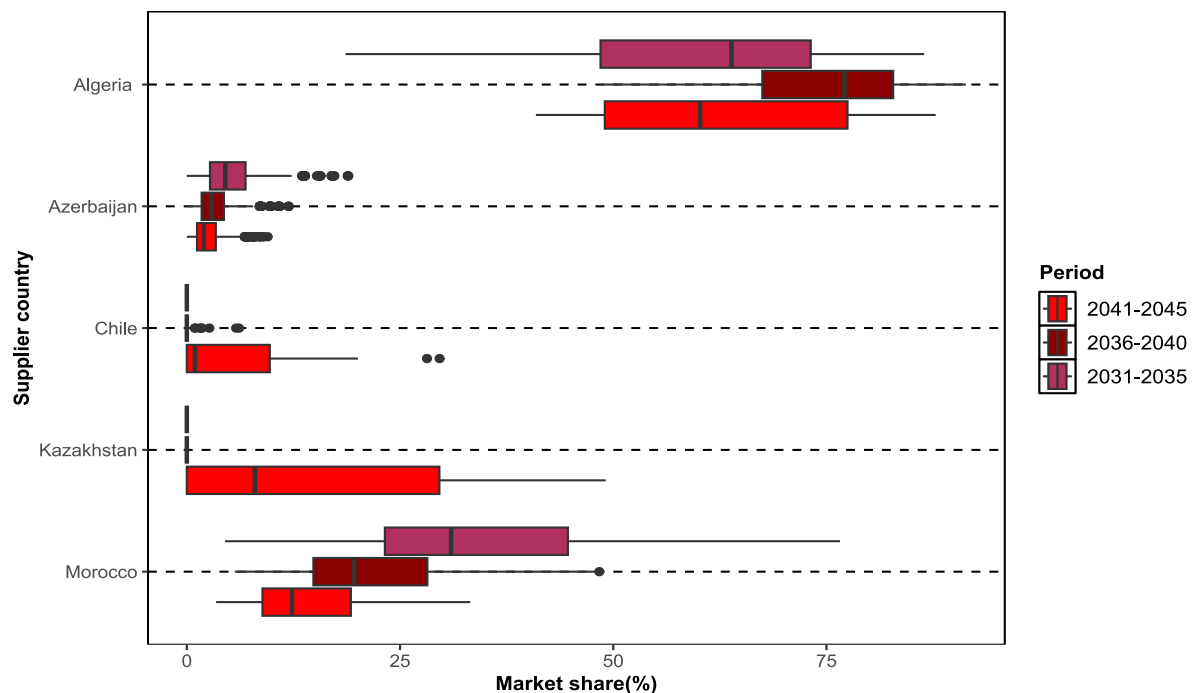
billion EUR in the low demand scenario and 12.3 billion EUR in the high demand scenario. Only in the period 2041-2045, compensation needs of new projects would turn negative, i.e. a double auction scheme would generate positive rents in reselling hydrogen from new projects. However, the continued need to sell high-cost hydrogen from old projects initiated in the first modelling period implies that subsidy costs in this last period still remain high.

The import market growth is not necessarily accompanied by a diversification of supplier countries. Under pessimistic demand expectations, supply is projected to remain geographically highly concentrated. This is mainly due to the high physical supply potential of Algeria, absorbing the demand increase. Under the more optimistic demand outlook, a slight diversification trend is observed, with Algeria however maintaining a dominant market position even in the time after 2040 (see Figure 3).

Figure 2: Evolution of hydrogen import costs and import subsidies



Source: own calculations

Figure 3: Market shares of supply countries among new projects (high demand scenario)

Source: own calculations

4.4.2 Infrastructure Support

A lower CAPEX burden on infrastructure reduces the unit fixed costs of hydrogen transport and thus implies smaller economic damage from hydrogen losses during transport. These losses occur continuously and are thus directly dependent on transport distance. As a consequence, indiscriminatory grants to transport infrastructure CAPEX can affect the cost ranking of hydrogen source countries in favor of countries in larger distance to Germany. Table 2 compares the ranking of countries with lowest LCOHD for different levels of CAPEX support. It shows that infrastructure support entails significant cost reductions for hydrogen deliveries from all potential export countries. The cost ranking is only affected to a minor degree. Effects are stronger in the first modelling period, due to the still relatively high level of infrastructure costs in the earlier stages of importing. In particular, Chile as a large-distance supplier is benefiting heavily, while Algeria loses the competitive edge of its proximity.

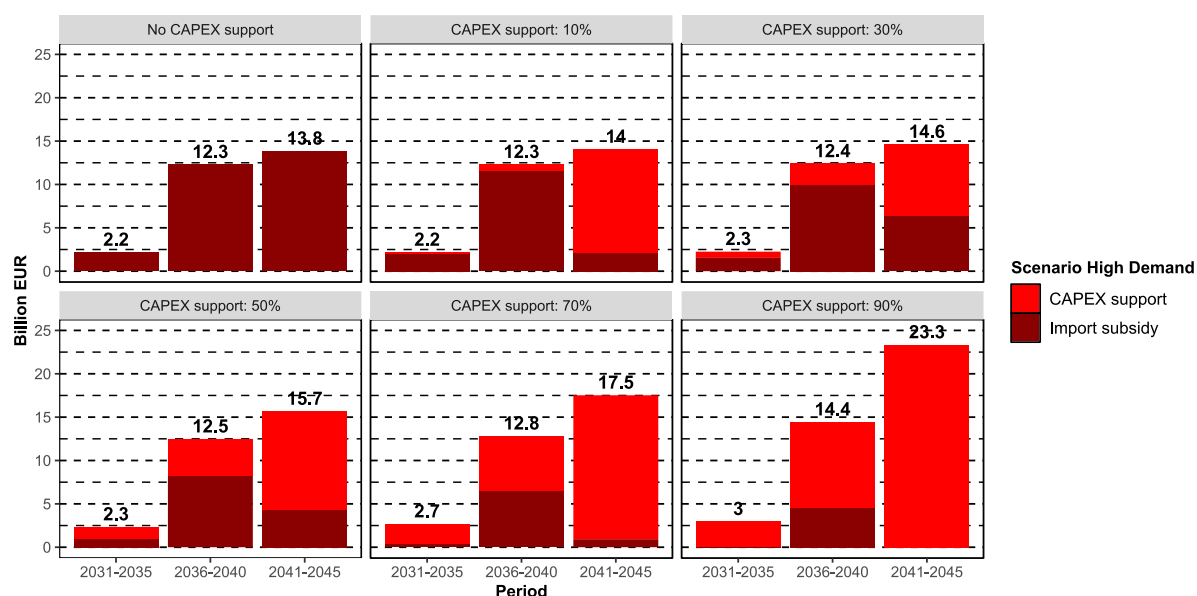
The introduction of dedicated infrastructure support reduces the need for direct import subsidies provided through the double auction scheme. However, by affecting the LCOHD ranking of supplier countries, it also impairs the scheme's ability to select the most cost-efficient suppliers. Hence, it is not neutral with respect to the overall fiscal burden. Figure 4 shows for the high-demand scenario that the fiscal consequences of this bias are highly time-dependent. In the period 2031-2035, providing moderate levels of infrastructure support does not significantly alter expected support payments. The infrastructure burden is almost neutralized by the reduced need to compensate price gaps in the double auctions. With very high levels of CAPEX support, the auction scheme already becomes obsolete during this period. In the subsequent period 2036-2040, higher domestic willingness-to-pay and lower hydrogen production costs reduce the need to support new projects. Unlike the auction subsidies, fixed CAPEX support does not automatically adjust to the changed circumstances. Focusing on CAPEX instruments thus renders the support framework unnecessarily expensive in later stages of market development. Results for the low-demand scenario show a qualitatively similar picture.

Table 2: Third countries with lowest LCOHD (country averages) by level of infrastructure support

Period 2031-2035						
No CAPEX support			50% CAPEX Support		70% CAPEX Support	
Rank	Country	LCOHD (€/MWh)	Country	LCOHD (€/MWh)	Country	LCOHD (€/MWh)
1	Morocco	93.68	Morocco	75.84	Morocco	68.70
2	Azerbaijan	106.80	Azerbaijan	87.04	Chile	72.77
3	Algeria	119.00	Chile	87.04	Azerbaijan	79.13
4	Chile	122.72	United Kingdom	94.52	Colombia	79.51
5	United Kingdom	129.36	Colombia	94.75	United Kingdom	80.58

Period 2041-2045						
No CAPEX support			50% CAPEX Support		70% CAPEX Support	
Rank	Country	LCOHD (€/MWh)	Country	LCOHD (€/MWh)	Country	LCOHD (€/MWh)
1	Morocco	66.01	Morocco	55.09	Morocco	50.73
2	Azerbaijan	75.77	Algeria	61.12	Algeria	54.16
3	Algeria	78.52	Azerbaijan	63.67	Azerbaijan	58.83
4	Chile	116.50	Chile	82.02	Chile	68.22
5	Kazakhstan	117.72	United States	84.91	United States	70.60

Source: own calculations

Figure 4: Expected public support payments (high demand scenario)

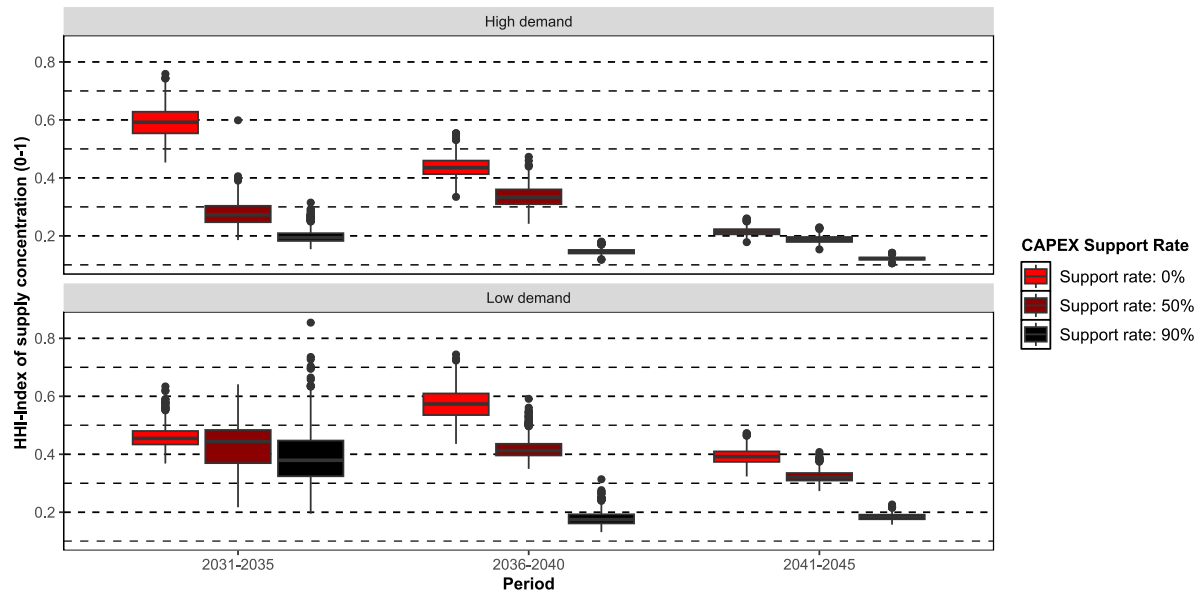
Source: own calculations

Besides cost efficiency, infrastructure support can also affect the other meaningful targets of a future European Hydrogen Import Strategy: resilience and reliability of supply. Figure 5 shows value ranges of geographical supply concentration for different demand scenarios and periods, measured based on the Herfindahl–Hirschman Index (HHI).⁴⁵ A high HHI indicates a low level of supply diversification and thus potentially a low degree of resilience towards disruptions of single supply channels. In general, the HHI is declining over time (see Figure 5). Increased domestic demand and learning-induced cost reductions reduce the market entry barriers for more and more supplier countries. Moreover, under both optimistic and pessimistic demand conditions, infrastructure support lowers expected HHI levels

⁴⁵ Rhoades, S. A. (1993). The herfindahl-hirschman index. Fed. Res. Bull., 79, 188.

in all periods. The effect is strongly related to a reduced market dominance of Algeria. With an infrastructure CAPEX support rate of 50%, the expected market share of Algeria in the period 2031-2035 only amounts to 37% in the high-demand scenario, compared to 73% without CAPEX support.

Figure 5: Distribution of HHI of supply countries for different levels of CAPEX support



Source: own calculations

By changing the supply mix, CAPEX support also alters the exposure of German hydrogen imports to political source country risks. An indicator for this is the average political risk premium of supplier countries. Without CAPEX support, the average premium associated with the long-term portfolio of suppliers amounts to 0.75% in the low-demand and 0.58% in the high-demand scenario (see Table 3). When being weighted by the countries' expected supply shares, the expected premium is significantly higher, mostly due to the high political risks associated with the dominant supplier country Algeria. By comparison, the average political risk premium of EU27 countries amounts to only 0.4%. Hence, besides diversifying supply sources, support to infrastructure CAPEX is also predicted to reduce political import risks. Specifically, this is due to its ability to improve the cost competitiveness of the politically stable, but geographically distant countries Canada and Chile.

Table 3: Political risk premiums of supplier countries (supply mix in period 2041-2045)

Scenario: low demand			
	CAPEX support: 0%	CAPEX support: 50%	CAPEX support: 90%
Maximal partner-specific risk premium	2.58%	2.58%	2.58%
Minimal partner-specific risk premium	0.00%	0.00%	0.00%
Mean risk premium partners (unweighted)	0.75%	0.66%	0.68%
Mean risk premium partners (weighted)	1.80%	1.57%	1.12%
Scenario high: demand			
	CAPEX support: 0%	CAPEX support: 50%	CAPEX support: 90%
Maximal partner-specific risk premium	2.58%	2.58%	3.33%
Minimal partner-specific risk premium	0.00%	0.00%	0.00%
Mean risk premium partners (unweighted)	0.58%	0.72%	0.97%
Mean risk premium partners (weighted)	1.28%	1.14%	0.90%

Source: own calculations

4.4.3 Political Risk Insurance

Backing investor risks associated with hydrogen source countries by public budgets improves the financing conditions for hydrogen capacities abroad. Lower financing costs imply a smaller CAPEX contribution to the LCOHD. Similar to CAPEX support, a public risk insurance instrument can thus be expected to reduce total import costs. Indeed, assuming a complete backing of the political risk component, expected import costs in the period 2031-2035 are lowered by 0.2 billion EUR compared to a situation without state support in the low-demand scenario and by 0.4 billion EUR in the high-demand scenario. At the same time, a crucial difference to CAPEX support is that public guarantee schemes like this do not immediately entail a payment burden to public budgets, but instead a long-term risk. It thus represents a mechanism to trade current public costs against risks and to shift the fiscal consequences of import capacity promotion to later periods. Adding such an instrument to the policy mix can thus also contribute to a cost distribution that is fairer in intertemporal terms.

At the same time, interactions with other support instruments must be carefully managed. This is shown in Table 4. Introducing a political risk insurance reduces the known long-term total subsidy payments, since less direct import support is needed. However, when being coupled with infrastructure CAPEX support, the risk insurance raises CAPEX support payments in some scenarios, slightly undermining the desired impact on total subsidy payments. In sum, the total value of state support (subsidy payments plus value of public risk insurance) is expected to rise by adding risk insurance. Hence, the reduction in required subsidy payments is coupled with a higher overall fiscal burden.

Table 4: Political risk insurance and hydrogen support costs in the period 2041-2045 (Bn EUR)

Scenario: low demand			
	CAPEX support: 0%	CAPEX support: 50%	CAPEX support: 90%
Without risk insurance			
CAPEX support	0.00	3.95	9.18
Import subsidy	4.27	0.78	0.00
Total subsidy payments	4.27	4.73	9.18
Value political risk insurance (GGE)	0.00	0.00	0.00
Total state support	4.27	4.73	9.18
With risk insurance			
CAPEX support	0.00	3.99	7.64
Import subsidy	2.83	0.34	0.00
Total subsidy payments	2.83	4.33	7.64
Value political risk insurance (GGE)	3.05	2.84	1.92
Total state support	5.88	7.17	9.55
Scenario: high demand			
	CAPEX support: 0%	CAPEX support: 50%	CAPEX support: 90%
Without risk insurance			
CAPEX support	0.00	11.36	23.33
Import subsidy	13.84	4.30	0.00
Total subsidy payments	13.84	15.66	23.33
Value political risk insurance (GGE)	0.00	0.00	0.00
Total state support	13.84	15.66	23.33
With risk insurance			
CAPEX support	0.00	13.16	23.88
Import subsidy	11.36	3.77	0.00
Total subsidy payments	11.36	16.93	23.88
Value political risk insurance (GGE)	8.05	5.34	3.31
Total state support	19.41	22.28	27.11

Source: own calculations

In addition to the fiscal dimension, a political risk insurance should also be evaluated based on its contribution to import resilience and reliability. Table 5 shows the impact of support policies on long-term supply concentration and political risk levels of supplier countries. As to be expected, providing political risk insurance raises the average political risk level of import supply, since high-risk source countries benefits the most in their competitiveness from such an instrument. The impact of a political risk insurance on supply concentration is less clearcut and highly scenario-dependent. It tends to work against diversification when being coupled with high levels of infrastructure CAPEX support. This is because political risk insurance disadvantages some politically stable supplier countries located at a greater distance to Germany, particularly Canada and Chile, which undermines the spatial diversion effect of infrastructure funding (See Section 4.4.2).

Table 5: Impact of political risk insurance on import resilience and reliability in the period 2041-2045

Scenario: low demand			
	CAPEX support: 0%	CAPEX support: 50%	CAPEX support: 90%
Without risk insurance			
Mean risk premium partners (weighted)	1.80%	1.57%	1.12%
Mean HHI supply concentration (0-1)	0.39	0.32	0.18
With risk insurance			
Mean risk premium partners (weighted)	1.84%	2.14%	2.20%
Mean HHI supply concentration (0-1)	0.41	0.31	0.30
Scenario: high demand			
	CAPEX support: 0%	CAPEX support: 50%	CAPEX support: 90%
Without risk insurance			
Mean risk premium partners (weighted)	1.28%	1.14%	0.90%
Mean HHI supply concentration (0-1)	0.21	0.19	0.12
With risk insurance			
Mean risk premium partners (weighted)	1.96%	1.85%	1.87%
Mean HHI supply concentration (0-1)	0.21	0.15	0.15

Source: own calculations

4.5 Discussion

The preceding analysis has highlighted both the benefits and the risks of different support strategies for hydrogen imports. First, it shows that building up import capacity at the pace anticipated by current policy plans in Germany is likely to be a very costly undertaking. Ensuring market security and cost recovery for foreign investors requires substantial public subsidies. Despite shrinking production costs, these tend to increase over time due to growing domestic hydrogen demand, particularly in optimistic demand scenarios. Hence, curbing import subsidies through threshold criteria and a balanced mix of policy instruments should be a key priority in policy design.

At the same time, support policies should not be exclusively viewed through the fiscal lens. Resilience and reliability of external hydrogen supply are other key features to be considered, given the strong dependence of certain demand sectors on H₂ technologies. The analysis shows that support instruments targeting specific cost barriers tend to alter geographic supply patterns. In particular, support for infrastructure investments in the form of earmarked grants for investments in liquefaction plants, ships, and regasification facilities reduces a key cost disadvantage associated with geographically distant supplier countries. This serves two purposes. First, it reduces dependence on dominant nearby suppliers, foremost among them Algeria. Second, by integrating politically stable but geographically distant supplier countries such as Canada and Chile into the German import market, it lowers the overall level of political risk associated with Germany's future supply mix. The downside is a general increase in subsidy payments, as distance-based support measures distort competition among suppliers in the import market.

To reduce public spending pressure, it is worth exploring the complementary use of indirect forms of government protection, such as guarantee instruments. Public risk adoption improves the financing conditions for private investors and leads to a reduction in import costs by lowering the risk-adjusted discount rates for future revenues. To minimize moral hazard risks, government guarantees should be limited exclusively to risks that lie outside the individual investor's sphere of influence and are difficult

to diversify through market instruments. Political country-of-origin risks are a sensible target in this regard. The analysis shows that offering government insurance against such political risks reduces the need for direct subsidy payments. The likely drawback of such a measure is a general increase in country-specific import risks.

In this way, the analysis also highlights the trade-offs between the objectives of a cost-effective, resilient, and reliable supply (see Section 3.3). While the use of a variety of support instruments that affect different cost components does not eliminate these conflicts, it does improve policymakers' ability to balance conflicting objectives. This is particularly relevant because a purely economic cost perspective on hydrogen imports may prove short-sighted in the long term. For example, targeted support for supply from politically aligned but initially costly source countries holds particular long-term potential for forging close ties through technological and regulatory cooperation. This, in turn, can prove to minimize costs in the long term by creating an environment for shared learning, standardization, and the establishment of common market rules.

It must be emphasized that the analysis is based on some simplifications that may affect specific results. One of these is the assumption that the dual-auction model for promoting imports is limited solely by import volumes. In real-world programs such as H2Global, upside risks associated with import subsidies are mitigated by budget caps. However, strict budget constraints can imply that an underfunded program fails to meet the supply targets, which then requires additional financial support from other sources. Moreover, global capacity development is likely to follow rather an exponential than a linear trajectory. Absolute long-term supply costs are thus likely to be overestimated, as a larger share of projects will emerge after cost reductions have materialized.

Furthermore, the analysis assumes that there are no export restrictions on the part of the countries of origin. In reality, many source country governments will likely aim to promote the domestic use of local hydrogen production as a tool for general industrial promotion and value chain upgrading. In particular, this concerns developing economies with comparative advantages in renewable energy generation. This may mean that European importers must pay a premium on top of the LCOHD to compensate investors for lost financial benefits from domestic hydrogen sales.

Finally, the analysis assumes that future economies of scale in hydrogen production and infrastructure are global in nature and exogenous. As a result, the actual impact of a comprehensive German import support program on global hydrogen development may be underestimated. If, alternatively, German importers were able to effectively stimulate technological learning and accelerate future cost reductions, long-term import costs could turn out to be significantly lower than expected. The impact of such policy-driven technological improvements on supply diversification will depend heavily on their geographic scope.

5 Recommendations for a European Hydrogen Strategy

While being focused on Germany, the numerical analysis has produced insights that are relevant also for the European level. These can be summarized in the following four fields of action, which should be central elements of the import pillar of the upcoming EU hydrogen strategy.

5.1 Promote Market Development Through Cross-National Double Auctions

Double auctions are an efficient instrument for bridging the initial gap between international hydrogen supply costs and domestic willingness-to-pay. For emerging technologies like renewable hydrogen, they are superior to traditional forms of investment support like grants and subsidized loans, due to their ability of providing sales security and enabling coordination in early stages of market formation. This makes them an import anchor for diversified hydrogen sourcing and the formation of competitive hydrogen markets. Nevertheless, under the expected trajectories of cost and demand development, double auction schemes for hydrogen imports are likely to require substantial long-term state aid. To secure a broad funding base and better coordinate European demand, cross-border cooperation in implementing double auction schemes is essential. This can be most easily achieved by accelerating the current internationalization process of the established German H2Global platform, including the continued integration of third countries with high export potential. To avoid overfunding and an excessive dissemination of hydrogen solutions to inefficient applications, auctions budgets should be regularly adjusted to updated demand forecasts.

5.2 Coordinate External H₂ Infrastructure Promotion

Dedicated promotion of hydrogen transport infrastructure in third countries is an effective tool to broaden the supply base and avoid the creation of new dependencies on single external energy sources. However, without proper coordination, its complementary use together with support schemes like hydrogen auctions has some pitfalls. Without criteria avoiding double funding, infrastructure support can distort the competition in auction-based formats, which impairs the cost efficiency of overall import promotion. With strict prohibition of double funding, as is currently the regular practice, promising production pathways can be excluded from the long-term sales security necessary for capacity-building. The solution is a more strategic use of infrastructure spending. The spatial allocation of financial means should neither occur in a scattered way nor be compromised by non-economic goals like development diplomacy. Instead, it should be centered on locations where transport costs make the essential difference for future market access. These are locations with a significant distance malus in relation to the EU but a high local renewable energy potential and a solid institutional background.

5.3 Ensure Diversified Use of Guarantee Instruments

Many potentially competitive hydrogen supplier countries are characterized by significant political risk. Targeting such country risks with dedicated guarantee instruments not only reduces financing-related barriers to market access. It also reduces the need for a direct subsidization of projects in high-risk countries and thus lowers public spending needs in ramping up hydrogen imports. EU investors should be granted transparent and non-discriminatory access to such instruments when undertaking hydrogen projects in third countries. The establishment of the Global Gateway Investment Hub (see Section 3.2) is an important step in this direction but requires strong cooperation between the managing national institutions to become a meaningful steering instrument. At the same time, the dangers of a more widespread use of this support instrument for external hydrogen projects must be kept in check. This concerns the threat of a strong future supply reliance on high-risk countries and a burdening of the EU budget with uncontrollable and hard-to-quantify long-term risks. Responsible risk management requires the establishment of clear geographical diversification criteria for the allocation of public guarantees as well as intensified political engagement with target countries.

5.4 Implement Monitoring Tools for External Policy and Market Risks

Managing the diversity of risks related to external hydrogen sourcing also requires reliable assessment tools. The EU should develop a dedicated risk monitoring framework for emerging international hydrogen supply chains. It should cover both global and region-specific risks. At the global level, the general technology development should be monitored, including the evolution of technologies for hydrogen production, transport and downstream processing, as well as the distribution of associated intellectual property rights. At the regional level, the framework should screen the regulatory development and the general political stability of source countries. Local environmental risks related to hydrogen sourcing such as freshwater scarcity should be examined as well. Moreover, the framework should cover risks related to the manufacturing of hydrogen production equipment such as the sourcing of hard-to-substitute electrolysis metals like platinum or titanium. Results of risk monitoring should be summarized in reports and form the basis for regular updates of the EU sourcing strategy, foremost the design and requirements of import support schemes of the European Hydrogen Bank and the promotion of external infrastructure development through Global Gateway.

6 Conclusion

Given its relatively low potential for renewable energy by global standards, Europe is likely to remain a net energy importer even in a fossil-free future. Sustainably produced hydrogen and its derivatives will be the most important energy carriers for future intercontinental energy transport. As investment in global electrolysis capacity gains momentum and the costs of maritime hydrogen transport fall, the prospect of international supply chains for renewable hydrogen has become more realistic.

For several reasons, Europe should aim to play an active part in this global dynamic. Firstly, imports of renewable hydrogen provide the necessary input for the decarbonization of the hard-to-abate steel and chemicals sectors, without having to sacrifice scarce domestic renewable energy for electrolysis. Secondly, participation in international supply chains enables Europe to help shape the regulatory frameworks and technical standards in the emerging international hydrogen markets, a prerequisite for (re)gaining leadership in clean technologies. Thirdly, given the increasing importance of infrastructure control, international cooperation in building up hydrogen capacity offers considerable potential for positive spillovers to geopolitical power goals.

To avoid over-funding and the unintended creation of new supply risks, policy support for hydrogen imports must be coordinated within the framework of a clearly defined EU-wide strategy. The aim should be to strike a balance between three, at times conflicting, objectives: cost-efficiency, reliability of supply and resilience to supply disruptions. Cost-efficiency requires support mechanisms that foster cost-based competition between hydrogen sources and aim to mitigate the cost implications of investment risks that are difficult to diversify. Reliability of supply requires support mechanisms that take into account the regulatory quality and political stability of the countries of origin and involve enhanced political cooperation. Resilience to supply disruptions requires support mechanisms that strengthen the EU's responsiveness, primarily through incentives to diversify suppliers.

Based on a scenario modelling of future competition among hydrogen imports to Germany, this study examines how a combination of various support mechanisms is likely to affect the supply mix and the associated policy objectives in the medium to long term. The modelling takes into account three fundamental factors for the future competitiveness of source countries: renewable energy potential,

institutional quality and geographical distance. Firstly, the results suggest that building up import capacity at the pace envisaged by current policy plans is likely to require substantial financial support, even in the long term. This makes the widespread use of competition-oriented, market-shaping support mechanisms, such as dual auctions, all the more important at this stage.

Secondly, the complementary use of CAPEX support to transport infrastructure is shown to contribute to a diversification of the supply base. As a positive side effect, the greater weight of country-specific financing costs shifts the supply mix towards source countries with lower political risk. Finally, the provision of public guarantees against policy-related investment risks significantly reduces the direct fiscal burden of import promotion. However, to prevent an accumulation of country-specific risks in public budgets, a widespread application of such guarantees requires strict diversification guidelines.

7 Appendix

7.1 Formulas for Calculating the Location-specific LCOHD

1. Levelized cost of electricity (LCOE) for electrolysis:

$$LCOE_{rt}^{Wind} = \frac{(CAPEX_t^{Wind} \cdot crf_r^{Wind} + OPEX_t^{Wind})}{crf_r^{Wind} \cdot 8760}$$

$$LCOE_{rt}^{PV} = \frac{(CAPEX_t^{PV} \cdot crf_r^{PV} + OPEX_t^{PV})}{crf_r^{PV} \cdot 8760}$$

$$crf_r^{Wind} = \frac{WACC_r \cdot (1 + WACC_r)^{T^{Wind}}}{(1 + WACC_r)^{T^{Wind}} - 1}$$

$$crf_r^{PV} = \frac{WACC_r \cdot (1 + WACC_r)^{T^{PV}}}{(1 + WACC_r)^{T^{PV}} - 1}$$

2. Levelized cost of electrolytically produced hydrogen (LCOH):

$$LCOH_{rt}^{Wind} = \left(\frac{(CAPEX_t^{H2prod} \cdot crf_r^{H2prod} + OPEX_t^{H2prod})}{crf_r^{Wind} \cdot 8760} + LCOE_{rt}^{Wind} \right) / EFF_t^{H2prod}$$

$$LCOH_{rt}^{PV} = \left(\frac{(CAPEX_t^{H2prod} \cdot crf_r^{H2prod} + OPEX_t^{H2prod})}{crf_r^{PV} \cdot 8760} + LCOE_{rt}^{PV} \right) / EFF_t^{H2prod}$$

$$crf_r^{H2prod} = \frac{WACC_r \cdot (1 + WACC_r)^{T^{H2prod}}}{(1 + WACC_r)^{T^{H2prod}} - 1}$$

$$LCOH_{rt} = \min. \{ LCOH_{rt}^{Wind}; LCOH_{rt}^{PV} \}$$

3. Levelized cost of hydrogen transport (LCOHT):

3.1 Transport by pipeline:

$$UnitCost_{rt}^{Pipe_onshore} = CAPEX_t^{Pipeonshore} \cdot crf_r^{Pipeonshore} + OPEX_t^{Pipeonshore} + EL_t^{Pipeonshore}$$

$$UnitCost_{rt}^{Pipe_offshore} = CAPEX_t^{Pipeoffshore} \cdot crf_r^{Pipeoffshore} + OPEX_t^{Pipeoffshore} + EL_t^{Pipeoffshore}$$

$$crf_r^{Pipeonshore} = \frac{WACC_r \cdot (1 + WACC_r)^{T^{Pipeonshore}}}{(1 + WACC_r)^{T^{Pipeonshore}} - 1}$$

$$crf_r^{Pipeoffshore} = \frac{WACC_r \cdot (1 + WACC_r)^{T^{Pipeoffshore}}}{(1 + WACC_r)^{T^{Pipeoffshore}} - 1}$$

$$LCOHT_{rt}^{Pipeline} = \frac{\left(Dist_r^{Pipe_{onshore}} \cdot UnitCost_{rt}^{Pipe_{onshore}} + Dist_r^{Pipe_{offshore}} \cdot UnitCost_{rt}^{Pipe_{offshore}} \right)}{(1 - Loss^{Pipe}) \left(Dist_r^{Pipe_{onshore}} + Dist_r^{Pipe_{offshore}} \right)}$$

3.2 Transport by ship (liquefaction technology):

$$UnitCost_{rt}^{H2_{liq}} = \left(CAPEX_t^{H2_{liq}} \cdot crf_r^{H2_{liq}} + OPEX_t^{H2_{liq}} + EL_t^{H2_{liq}} \right) / EFF_t^{H2_{liq}}$$

$$UnitCost_{rt}^{H2_{gas}} = CAPEX_t^{H2_{gas}} \cdot crf_r^{H2_{gas}} + OPEX_t^{H2_{gas}}$$

$$UnitCost_{rt}^{Ship} = CAPEX_t^{Ship} \cdot crf_r^{Ship} + OPEX_t^{Ship}$$

$$crf_r^{H2_{liq}} = \frac{WACC_r \cdot (1 + WACC_r)^{T^{H2_{liq}}}}{(1 + WACC_r)^{T^{H2_{liq}}} - 1}$$

$$crf_r^{H2_{gas}} = \frac{WACC_r \cdot (1 + WACC_r)^{T^{H2_{gas}}}}{(1 + WACC_r)^{T^{H2_{gas}}} - 1}$$

$$crf_r^{Ship} = \frac{WACC_r \cdot (1 + WACC_r)^{T^{Ship}}}{(1 + WACC_r)^{T^{Ship}} - 1}$$

$$LCHT_{rt}^{Shipping} = \frac{\left(UnitCost_{rt}^{H2_{liq}} + UnitCost_{rt}^{Ship} \right)}{(1 - Loss^{Ship}) \left(\frac{Dist_r^{Ship}}{Speed^{Ship}} \right)} + UnitCost_{rt}^{H2_{gas}}$$

$$LCOHT_{rt} = \min. \{ LCOHT_{rt}^{Pipeline}; LCOHT_{rt}^{Shipping} \}$$

4. Levelized cost of hydrogen delivery (LCOHD):

$$LCOHD_{rt} = LCOH_{rt} + LCOHT_{rt}$$

5. Country-specific weighted average cost of capital (WACC):

$$WACC_r = r^{base} + sds_{de} + crp_r - sds_r \text{ (without political risk insurance)}$$

$$WACC_r = r^{base} + sds_{de} \text{ (with political risk insurance)}$$

7.2 Symbols

Symbol	Meaning	Symbol	Meaning
Electricity production			
$CAPEX_t^{Wind}$	Capital expenditures for wind power plants per kW capacity	$CAPEX_t^{PV}$	Capital expenditures for PV power plants per kW capacity
cf_r^{Wind}	Capacity factor for wind power plant	cf_r^{PV}	Capacity factor for PV power plant
crf_r^{Wind}	Capital recovery factor for wind power plants	crf_r^{PV}	Capital recovery factor for PV power plants
$OPEX_t^{Wind}$	Operational expenditures for wind power plants per kW capacity and year	$OPEX_t^{PV}$	Operational expenditures for PV power plants per kW capacity and year
Electrolytical hydrogen production			
$CAPEX_t^{H2_{prod}}$	Capital expenditures for electrolysis plants per kW capacity	$EFF_t^{H2_{prod}}$	Conversion efficiency in electrolysis (%)
$crf_r^{H2_{prod}}$	Capital recovery factor for electrolysis plants	$OPEX_t^{H2_{prod}}$	Operational expenditures for electrolysis plants per kW capacity and year
Hydrogen transport by pipeline			
$CAPEX_t^{Pipe_{onshore}}$	Capital expenditures for hydrogen onshore pipelines per kW capacity and km	$CAPEX_t^{Pipe_{offshore}}$	Capital expenditures for hydrogen offshore pipelines per kW capacity and km
$crf_r^{Pipe_{onshore}}$	Capital recovery factor for hydrogen onshore pipelines	$crf_r^{Pipe_{offshore}}$	Capital recovery factor for hydrogen offshore pipelines
$Dist_r^{Pipe_{onshore}}$	Distance of necessary hydrogen onshore pipelines in km	$Dist_r^{Pipe_{offshore}}$	Distance of necessary hydrogen offshore pipelines in km
$EL_t^{Pipe_{onshore}}$	Electricity consumption of hydrogen onshore pipelines per kW capacity, km and year	$EL_t^{Pipe_{offshore}}$	Electricity consumption of hydrogen offshore pipelines per kW capacity, km and year
$OPEX_t^{Pipe_{onshore}}$	Operational expenditures for hydrogen onshore pipelines per kW capacity, km and year	$OPEX_t^{Pipe_{offshore}}$	Operational expenditures for hydrogen offshore pipelines per kW capacity, km and year
$Loss^{Pipe}$	Percentage hydrogen losses in pipeline transport per km	-	-
Hydrogen transport by ship			
$CAPEX_t^{H2_{liq}}$	Capital expenditures for H2 liquefaction facility and export terminal per kWh hydrogen	$CAPEX_t^{H2_{gas}}$	Capital expenditures for H2 regasification facility and import terminal per kWh hydrogen
$crf_r^{H2_{liq}}$	Capital recovery factor for H2 liquefaction facility	$crf_r^{H2_{gas}}$	Capital recovery factor for H2 regasification facility
$EL_t^{H2_{liq}}$	Electricity consumption of H2 liquefaction facility and export terminal per kWh hydrogen and year	$EL_t^{H2_{gas}}$	Electricity consumption of H2 regasification facility and import terminal per kWh hydrogen and year
$OPEX_t^{H2_{liq}}$	Operational expenditures for H2 liquefaction facility and export terminal per kWh hydrogen and year	$OPEX_t^{H2_{gas}}$	Operational expenditures for H2 regasification facility per kWh and import terminal hydrogen and year
$EFF_t^{H2_{liq}}$	Conversion efficiency of H2 liquefaction (%)	$CAPEX_t^{Ship}$	Capital expenditures for hydrogen transport vessel per kW capacity
$Dist_r^{Ship}$	Shipping distance in km	crf_r^{Ship}	Capital recovery factor for hydrogen transport vessel
$Loss^{Ship}$	Boil-off losses of hydrogen in shipping per km	$OPEX_t^{Ship}$	Operational expenditures for hydrogen transport vessel per kWh hydrogen and year
$Speed^{Ship}$	Average speed of vessel in km/day		
General environment			
crp_r	Country risk premium of supplier country (%)	r^{base}	Risk-free base interest rate (%)
sds_{de}	Sovereign default spread of Germany (%)	sds_r	Sovereign default spread of supplier country (%)
T	Lifetime of respective technology in years	-	-

7.3 Data Sources

	Value in period			
Parameter	2031-2035	2036-2040	2041-2045	Source(s)
Electricity production				
$CAPEX_t^{Wind}$	1025.00 EUR/kW	999.00 EUR/kW	973.00 EUR/kW	Galimova et al. (2023)
cf_r^{Wind}	Location-specific	Location-specific	Location-specific	World Bank / DTU (2026)
T^{Wind}	30 years	30 years	30 years	Galimova et al. (2023)
$OPEX_t^{Wind}$	2.0 % of CAPEX	2.0 % of CAPEX	2.0 % of CAPEX	Galimova et al. (2023)
$CAPEX_t^{PV}$	407.00 EUR/kW	358.50 EUR/kW	310.00 EUR/kW	Galimova et al. (2023)
cf_r^{PV}	Location-specific	Location-specific	Location-specific	World Bank / Solargis (2026).
T^{PV}	35 years	40 years	40 years	Galimova et al. (2023)
$OPEX_t^{PV}$	2% of CAPEX	2% of CAPEX	2% of CAPEX	Galimova et al. (2023)
Electrolytical hydrogen production				
$CAPEX_t^{H2prod}$	326.00 EUR/kW	268.50 EUR/kW	211.00 EUR/kW	Galimova et al. (2023)
EFF_t^{H2prod}	62.50 %	63.75 %	65.00 %	Galimova et al. (2023)
$OPEX_t^{H2prod}$	3.5 % of CAPEX	3.5 % of CAPEX	3.5 % of CAPEX	Galimova et al. (2023)
T^{H2prod}	30 years	30 years	30 years	Galimova et al. (2023)
Hydrogen transport by pipeline				
$CAPEX_t^{Pipe_{onshore}}$	0.99 EUR/(kW*km)	0.80 EUR/(kW*km)	0.60 EUR/(kW*km)	Galimova et al. (2023)
$Dist_r^{Pipe_{onshore}}$	Location-specific	Location-specific	Location-specific	EWI (2024)
$EL_t^{Pipe_{onshore}}$	0.027 kWh/(kW*km)	0.027 kWh/(kW*km)	0.021 kWh/(kW*km)	Galimova et al. (2023)
$OPEX_t^{Pipe_{onshore}}$	5.0 % of CAPEX	5.0 % of CAPEX	5.0 % of CAPEX	Galimova et al. (2023)
$T^{Pipe_{onshore}}$	40 years	40 years	40 years	Galimova et al. (2023)
$CAPEX_t^{Pipe_{offshore}}$	1.38 EUR/(kW*km)	1.11 EUR/(kW*km)	0.84 EUR/(kW*km)	Galimova et al. (2023)
$Dist_r^{Pipe_{offshore}}$	Location-specific	Location-specific	Location-specific	EWI (2024)
$EL_t^{Pipe_{offshore}}$	0.027 kWh/(kW*km)	0.027 kWh/(kW*km)	0.021 kWh/(kW*km)	Galimova et al. (2023)

$OPEX_t^{Pipe_{offshore}}$	5.0 % of CAPEX	5.0 % of CAPEX	5.0 % of CAPEX	Galimova et al. (2023)
$T^{Pipe_{offshore}}$	40 years	40 years	40 years	Galimova et al. (2023)
$Loss^{Pipe}$	0.1 %	0.1 %	0.1 %	Galimova et al. (2023)
Hydrogen transport by ship				
$CAPEX_t^{H2_{liq}}$	0.07 EUR/kWh _{H2}	0.07 EUR/kWh _{H2}	0.07 EUR/kWh _{H2}	Galimova et al. (2023)
$EL_t^{H2_{liq}}$	0.274 kWh/ kWh _{H2}	0.259 kWh/ kWh _{H2}	0.244 kWh/ kWh _{H2}	Galimova et al. (2023)
$OPEX_t^{H2_{liq}}$	4.0 % of CAPEX	4.0 % of CAPEX	4.0 % of CAPEX	Galimova et al. (2023)
$EFF_t^{H2_{liq}}$	93.80 %	93.80 %	93.80 %	Galimova et al. (2023)
$T^{H2_{liq}}$	30 years	30 years	30 years	Galimova et al. (2023)
$CAPEX_t^{H2_{gas}}$	0.01 EUR/kWh _{H2}	0.01 EUR/kWh _{H2}	0.01 EUR/kWh _{H2}	Galimova et al. (2023)
$OPEX_t^{H2_{gas}}$	4.0 % of CAPEX	4.0 % of CAPEX	4.0 % of CAPEX	Galimova et al. (2023)
$T^{H2_{gas}}$	30 years	30 years	30 years	Galimova et al. (2023)
$CAPEX_t^{Ship}$	1.02 EUR/kWh _{H2}	1.02 EUR/kWh _{H2}	1.02 EUR/kWh _{H2}	Galimova et al. (2023)
$OPEX_t^{Ship}$	2.0 % of CAPEX	2.0 % of CAPEX	2.0 % of CAPEX	Galimova et al. (2023)
$T^{H2_{ship}}$	30 years	30 years	30 years	Galimova et al. (2023)
$Dist_r^{Ship}$	Location-specific	Location-specific	Location-specific	EWI (2024)
$Loss^{Ship}$	0.2 %	0.2 %	0.2 %	Galimova et al. (2023)
$Speed^{Ship}$	600 km/day	600 km/day	600 km/day	EWI (2024)
General environment				
crp_r	Location-specific	Location-specific	Location-specific	Damodaran (2026)
r^{base}	2 % - 5 % (random draw)	2 % - 5 % (random draw)	2 % - 5 % (random draw)	Egli et al. (2025)
sds_{de}	0.21 %	0.21 %	0.21 %	Damodaran (2026)
sds_r	Location-specific	Location-specific	Location-specific	Damodaran (2026)
Domestic demand				
Domestic hydrogen demand: low-demand scenario	60 TWh	155 TWh	275 TWh	NWR (2026)
Domestic hydrogen demand: high-demand scenario	115 TWh	295 TWh	555 TWh	NWR (2026)

Willingness-to-pay: Chemicals	54.05 EUR / MWh	63.06 EUR / MWh	72.07 EUR / MWh	Zheng et al. (2026); Ziemsy et al. (2026)
Willingness-to-pay: Steel	24.02 EUR / MWh	33.03 EUR / MWh	42.04 EUR / MWh	Zheng et al. (2026); Ziemsy et al. (2026)
Willingness-to-pay: Other industry	63.06 EUR / MWh	66.07 EUR / MWh	69.07 EUR / MWh	Zheng et al. (2026); Ziemsy et al. (2026)
Willingness-to-pay: Aviation	78.07 EUR / MWh	81.08 EUR / MWh	84.08 EUR / MWh	Zheng et al. (2026); Ziemsy et al. (2026)
Willingness-to-pay: Shipping	15.02 EUR / MWh	15.02 EUR / MWh	15.02 EUR / MWh	Zheng et al. (2026); Ziemsy et al. (2026)
Willingness-to-pay: Trucks	414.41 EUR / MWh	453.45 EUR / MWh	492.49 EUR / MWh	Zheng et al. (2026); Ziemsy et al. (2026)

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