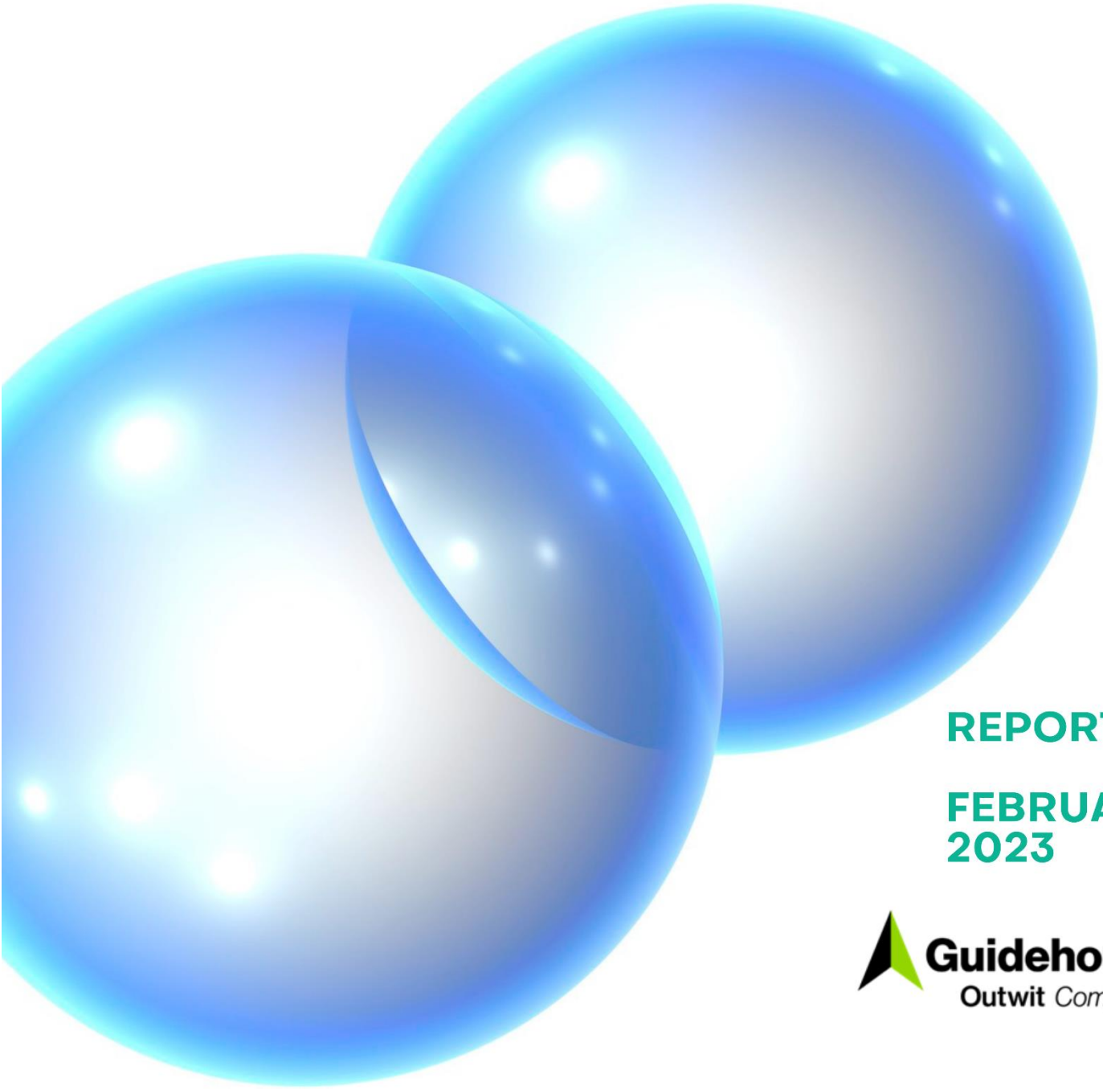
epico
KlimaInnovation

KONRAD ADENAUER STIFTUNG

DESIGN OPTIONS FOR A EUROPEAN HYDROGEN BANK



REPORT

FEBRUARY 2023

Guidehouse
Outwit Complexity

IMPRINT

Design Options for a European Hydrogen Bank

Published by:

EPICO KlimaInnovation
(Energy and Climate Policy and Innovation Council e.V.)
Friedrichstraße 79
10117 Berlin

Konrad-Adenauer-Stiftung e.V.
Klingelhöferstraße 23
10785 Berlin

Guidehouse Germany GmbH
Albrechtstraße 10 c
10117 Berlin

Authors:

Bastian Lotz, Dr. Corinna Klessmann

Steering Group

Dr. Bernd Weber, Sam Williams, Sabina Wölkner, Kevin Oswald

Cite as:

EPICO, KAS and Guidehouse (February 2023). “Design Options for a European Hydrogen Bank”, Berlin and Brussels.

Contents

1. Introduction: What is known about the European Hydrogen Bank? 4
2. Which policy objectives could the European Hydrogen Bank fulfil? 7
3. How could a European Hydrogen Bank function in practice? 11
3.1 Double-sided auctions for supply and demand contracts 11
3.1.1 Description of the instrument 11
3.1.2 Assessment of the instrument 16
3.2 Supply- or demand-side auctions determining market premiums 18
3.2.1 Description of the instrument 18
3.2.2 Assessment of the instrument 22
3.3 Default guarantees for hydrogen producers 23
3.3.1 Description of the instrument 23
3.3.2 Assessment of the instrument 25
3.4 Summary of assessment results 26
4. Conclusions 27
5. References 30

Tables

Table 1. Domestic and imports pillar: Importance of policy objectives 10
Table 2. Assessment: Double-sided auctions for supply and demand contracts 17
Table 3. Assessment: Supply- or demand-side auctions determining market premiums 22
Table 4. Assessment: Default guarantees 25
Table 5. Summary: Assessment of design options under the European Hydrogen Bank 26

Figures

Figure 1. Two-pillar set-up of the European Hydrogen Bank. Own illustration based on European Commission (2022): Competitive Bidding under the Innovation Fund, Stakeholder Consultation. 5
Figure 2. Overview of potential policy objectives for the European Hydrogen Bank. Source: Guidehouse 8
Figure 3. Illustration of double-sided auctions (supply & demand) for hydrogen or its derivatives. Source: Guidehouse 12
Figure 4. Illustration of supply-side auctions determining market premiums for hydrogen or its derivatives. Source: Guidehouse 19
Figure 5. Illustration of demand-side auctions determining market premiums for hydrogen or its derivatives. Source: Guidehouse 19

Boxes

Box 1. German H2Global scheme for international imports of hydrogen-based derivatives 15
Box 2. Assessment approach in this paper 16

Executive Summary

Many were surprised when President of the European Commission Ursula von der Leyen announced the establishment of the European Hydrogen Bank in her State of the Union speech in September 2022. In the speech, she declared that the instrument would be a flagship initiative for the upcoming year and would be endowed with €3 billion from the Innovation Fund to guarantee the purchase of hydrogen. Considering the broader EU policy framework, including the European Hydrogen Strategy, the RePowerEU plan and the Green Deal Industrial Plan, the European Hydrogen Bank's primary objective is to ensure sufficient availability of hydrogen and its derivatives across the EU and kick-start the market uptake of hydrogen production and applications in the EU.

The European Commission currently intends to establish a two-pillar approach to the European Hydrogen Bank. The **domestic pillar** aims at supporting the scale-up of domestic hydrogen production within the EU and will be implemented under the Innovation Fund. Under this pillar, supply-side hydrogen auctions are being discussed. One possible auction option would allocate premium payments, such as fixed premiums, on top of revenues from bilateral offtake agreements. Other instruments including a double-sided auction for both the demand and the supply side would also be feasible.

The **imports pillar** will focus on international imports of primarily hydrogen-based derivatives from outside of the EU. While so far, few concrete design choices have been communicated, the REPowerEU plan specifically links the implementation of the joint purchasing mechanism for hydrogen to the German H2Global scheme intending to draw, among others, from experience with the instrument. If the European Hydrogen Bank were to implement a support instrument like H2Global, the design would follow a double-sided competitive bidding scheme to buy hydrogen or its derivates from producers (supply-side auction) and re-sell it to end users (demand-side auction), thereby determining the gap between the lowest possible offtake prices (on the supply-side) and the highest willingness to pay (on the demand-side).

Assuming the two-pillar set-up outlined above, this report contributes to the current debate around potential design choices for the European Hydrogen Bank. It outlines potential high-level functions and objectives and assesses the relevance of these policy objectives for the domestic and imports pillar. We assess three potential designs (double-sided auctions for supply and demand contracts, supply- or demand-side auctions determining market premiums, and default guarantees for hydrogen producers). For each model, benefits and potential challenges are discussed in terms of how well they perform in achieving the defined policy objectives.

The following table summarizes the assessment results:

Objective	Double-sided auctions for supply and demand contracts	Supply- or demand-side auctions determining market premiums	Default guarantees
Effectiveness	+	0	–
Cost effectiveness	0	+	+
Market orientation	–	+	+
Low Complexity	–	0	0

Considering the results of our assessment, the following design choices for the European Hydrogen Bank are advisable:

Supply-side auctions determining market premiums (e.g., fixed premiums) should be considered for the domestic pillar.
These instruments offer high support cost effectiveness (e.g., no need to reserve excessive budget) and good market orientation (i.e., need to enter into bilateral purchase contracts). They are also effective (i.e., close the funding gap, implicitly match suppliers and offtakers via bilateral agreements) and are stand-alone, i.e., in principle do not require additional instruments to incentivize the domestic market take-up. Compared to double-sided auctions, supply-side auctions are also easier to implement and administer, especially if combined with fixed premiums per unit of hydrogen produced. For the domestic pillar, they provide a sufficient degree of investment security by closing the funding gap, but do not take away all market risks that domestic investors should be able to assume themselves (e.g., marketing, price and default risks), thus providing a certain degree of market integration that can contribute to the development of an EU hydrogen market in the medium term.

For the imports pillar, double-sided auctions for supply and demand contracts may be considered under certain circumstances.
Double-sided auctions may initially be effective for exporting countries with unreliable regulatory frameworks, or high political and delivery risks. They determine and can cover the cost gap between green hydrogen or its derivates and fossil-based alternatives, reduce investment risks (e.g., default and price risks) and match suppliers and offtakers of green hydrogen or its derivatives in the absence of a liquid market. In these contexts, the instrument provides high incentives for continuously making the required hydrogen or hydrogen-based derivative volumes available.

In most cases, supply-side auctions determining market premiums should be considered for the imports pillar.
The instrument avoids some of the downsides of double-sided auctions, and under most circumstances allows for a more efficient use of available public funds and stronger market orientation. To implement double-sided auctions, and despite demonstrating a high degree of effectiveness, substantial funds would have to be reserved for closing the price gap between the longer-term offtake contracts with hydrogen producers and short-term sales contracts with hydrogen consumers, even if this gap is expected to decrease over time. Especially against the background of limited available funding and high initial funding gaps, supply- or demand-side auctions determining market premiums may lead to a more efficient use of EU funds and should thus be considered for the Hydrogen Bank's import pillar.

Default guarantees should be considered as a risk-hedging instrument under the imports pillar to cover difficult to estimate default and delay risks for private purchase contracts involving hydrogen (derivative) imports.
In most circumstances, default guarantees would, at least initially, not be used as a stand-alone instrument. Instead, the instrument would have to be combined with instruments that cover existing funding gaps of green hydrogen production and use. In this context, default guarantees can provide additional investment security and increase the effectiveness of direct support to secure imports from outside of the EU. This may be especially helpful for producers in exporting countries with high default risks that private market participants may not be able to hedge against. Default guarantees could help in this case by tapping into additional import potentials that would otherwise remain unused and secure additional import volumes. In this case, the design of default guarantees should ensure that actors are not incentivized to engage in risky transactions, for which the government would have to assume the costs in case of a default.

Independent of potential support auctions organized under the European Hydrogen Bank, default guarantees can also serve as a parallel, stand-alone support instrument for hydrogen producers without funding needs.
The instrument could therefore contribute to a parallel market-ramp up with limited public intervention facilitating a self-sustaining hydrogen market, both for domestically produced and imported hydrogen and its derivatives.

1. Introduction: What is known about the European Hydrogen Bank?

Many were surprised when President of the European Commission Ursula von der Leyen announced the establishment of the European Hydrogen Bank in her State of the Union speech on 14 September 2022. In her speech, she declared that the instrument would be a flagship initiative for the upcoming year and would be endowed with €3 billion from the Innovation Fund to guarantee the purchase of hydrogen[1]. The speech did not specify a detailed design or policy objectives. However, later statements by high-ranking European Commission officials clarified that the European Hydrogen Bank's goal will be to contribute to the achievement of producing 10 million tonnes of green hydrogen domestically (i.e., within the EU) by 2030, as well as importing an additional 10 million tonnes from outside the EU[2], as laid down in the RePowerEU plan[3].

Considering the broader EU policy framework, including the European Hydrogen Strategy, the RePowerEU plan and the Green Deal Industrial Plan, the European Hydrogen Bank's primary objective is to ensure sufficient availability of hydrogen and its derivatives across the EU and kick-start the market uptake of hydrogen production and applications in the EU.[4] Since existing cost caps between green hydrogen and fossil-based alternatives currently impede the creation of a liquid hydrogen market, the European Hydrogen Bank needs to cover the initial funding gaps to be effective. In this context, an EU-wide approach promises to increase cost effectiveness compared to individual Member State policies. Moreover, the instrument's focus on both domestic production and imports reflects current projections that domestic production may not be sufficient to satisfy total hydrogen demand in Europe[5].

Against this background, the European Commission currently intends to establish a two-pillar approach to the European Hydrogen Bank[6]. One pillar will account for the different design requirements of support schemes incentivising domestic EU-wide production of hydrogen and the other pillar focuses on securing imports of hydrogen or its derivatives (see Figure 1).

The **domestic pillar** aims at supporting the scale-up of domestic hydrogen production within the EU and will be implemented under the Innovation Fund[7]. Under this pillar, supply-side hydrogen auctions are being discussed. One possible auction option would allocate premium payments, such as CfDs or fixed premiums, on top of revenues from bilateral offtake agreements. Other instruments including a double-sided auction for both the demand and the supply side would also be feasible. The introduction of Competitive Bidding Mechanisms (CBM)[8], a new tool for the Innovation Fund in the proposal for the Emissions Trading System (ETS) Directive revision ("Fit for 55"), will cover up to 100% of relevant costs and is needed as a pre-condition to implement the schemes. Once the ETS revision is adopted, the Innovation Fund Delegated Regulation will need to be revised in order to operate CBM and implement the support schemes.[9]

[1] Von der Leyen, Ursula (2022), State of the Union Address 2022

[2] Hydrogeninsight (2022), European Hydrogen Bank will close '100% of the cost gap' between renewable and fossil hydrogen as soon as 2023, but shadow of US tax credit looms

[3] European Commission (2022), REPowerEU Plan, SWD(2022) 230 final

[4] As such, the European Hydrogen Bank seems to correspond, at least partly, to the EU Global Hydrogen Facility (i.e., for imports) announced in the RePowerEU plan that is to be operated as the EU joint purchasing mechanism for hydrogen.

[5] Collins, Leigh (2022), Europe is never going to be capable of producing its own hydrogen in sufficient quantities: EU climate chief, Recharge

[6] European Commission (2022), Competitive Bidding under the Innovation Fund, Stakeholder Consultation

[7] Ibid

[8] Competitive bidding, also called auctioning, refers to a market-based selection of projects or bidders based on lowest bid prices (e.g., a support level) or additional qualitative critiera. With sufficient competition in the auction, auctions ensure that bidders with lowest bid prices or highest scores are awarded.

[9] European Commission (2022), Competitive Bidding under the Innovation Fund, Stakeholder Consultation

According to the provisional political agreement on the ETS revision reached on 18 December 2022, the Innovation Fund will receive additional funding. These funds will come from revenues from auctioning off dedicated allowances that will rise from 450 to 575 million allowances in the period 2020–2030[10]. The agreement states that up to 30% of the allocated funds can be allocated to CBM, and that this share can be increased once up to 50%. In the Green Deal Industrial Plan published in February 2023, the Commission announced a first auction to take place in autumn 2023 allocating fixed premiums for each kg of renewable hydrogen produced and making available an indicative budget of EUR 800 million for this first round[11].

Assuming that the core goal of the European Hydrogen Bank will be to secure the availability of sufficient volumes of hydrogen or its derivatives across the EU, demand-side Carbon Contracts for Difference (CCfDs) are not further considered in the remainder of this paper. While CCfDs can be an effective policy instrument to provide investment security for the switch to low-carbon industry applications, and are mentioned in the RePowerEU plan[12], the instrument is arguably less targeted to support the ramp-up of hydrogen production specifically. Instead, it focuses on demand-side industry sectors that may (e.g., Direct Reduced Iron (DRI) steel) or may not use (e.g., cement) hydrogen as a fuel. Hence, hydrogen production is only incentivized indirectly and depends on additional design choices (e.g., the extent to which hydrogen offtakers can take part in the CCfD scheme). Moreover, the European Commission has communicated in a recent stakeholder consultation that CCfDs are, at least initially, not being considered for implementation under the European Hydrogen Bank[13].

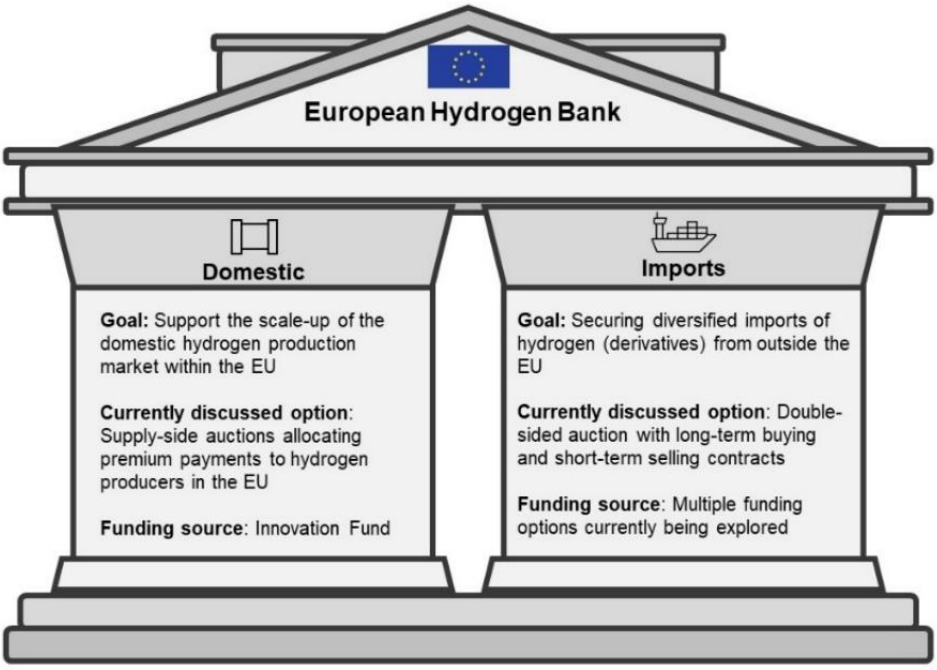


Figure 1. Two-pillar set-up of the European Hydrogen Bank. Own illustration based on European Commission (2022): Competitive Bidding under the Innovation Fund, Stakeholder Consultation.

[10] ICAP (2022), EU reaches landmark provisional agreement on ETS reform and new policies to meet 2030 target

[11] European Commission (2023), A Green Deal Industrial Plan for the Net-Zero Age

[12] "To support hydrogen uptake and electrification in industrial sectors, the Commission will roll out carbon contracts for difference and dedicated REPowerEU windows under the Innovation Fund to support a full switch of the existing hydrogen production in industrial processes from natural gas to renewables and the transition to hydrogen-based production processes in new industrial sectors, such as steel production".

[13] European Commission (2022), Competitive Bidding under the Innovation Fund, Stakeholder Consultation

The **imports pillar** will focus on international imports of primarily hydrogen-based derivatives from outside of the EU[14]. While so far, few concrete design choices have been communicated, the REPowerEU plan specifically links the implementation of the joint purchasing mechanism for hydrogen to the German H2Global scheme (see Box 1) intending to draw, among others, from experience with the instrument[15]. If the European Hydrogen Bank were to implement a support instrument like H2Global, the design would follow a double-sided competitive bidding scheme (see Figure 3) to buy hydrogen or its derivates from producers (supply-side auction) and re-sell it to end users (demand-side auction), thereby determining the gap between the lowest possible offtake prices (on the supply-side) and the highest willingness to pay (on the demand-side). In this set-up, the European Commission or a publicly appointed intermediary would not only cover the determined price gap through a corresponding subsidy but also purchase and re-sell hydrogen or hydrogen-based derivative volumes, thus incurring substantial marketing risks and liabilities compared to a conventional support scheme. This would likely require the build-up of additional administrative capacities and capabilities for the European Commission or an implementing agency or any other publicly installed intermediary to perform its responsibilities under the double-sided auctions scheme.

The broader discussion on imports of hydrogen and hydrogen-based derivatives from outside of the EU, including critical analyses on their general desirability for exporting countries (e.g., risk of displacing renewable electricity production capacity that could have been used to decarbonise direct domestic electricity use, sustainability issues such as water consumption and land use) is outside the scope of this paper. For related assessments we would like to refer to existing studies and contributions, e.g., Bouacida, I. & Berghmans, N. (2022), Piria, R. et al (2022), Heinemann, C. & Mendelevitch, R. (2021), Wietschel, M. et al. (2020)[16].

Assuming the two-pillar set-up outlined above, this paper will contribute to the current debate around potential design choices for the European Hydrogen Bank. The paper first outlines potential high-level functions and objectives the European Hydrogen Bank could fulfil and assesses the relevance of these policy objectives for the domestic and imports pillar, respectively (section 2). Section 3 describes the functioning of three potential designs (double-sided auctions for supply and demand contracts, supply- or demand-side auctions determining market premiums, and default guarantees for hydrogen producers) under the European Hydrogen Bank, both in terms of its planned domestic and imports pillar. For each model, the respective benefits and potential challenges are discussed in terms of how well they perform in achieving the previously defined policy objectives. This assessment allows to derive conclusions and recommendations on a suitable (high-level) design choice for the implementation of European Hydrogen Bank, for both the domestic and the imports pillar, in section 4.

[14] International imports of gaseous hydrogen from neighbouring exporting countries outside of the EU, e.g., from North Africa, may be possible as well but would in this case depend on the availability of the corresponding pipeline infrastructure to transport the procured volumes. For most imports, hydrogen-based derivative volumes such as ammonia, methanol or e-fuels can be assumed, however, due to their ability to be shipped over longer distances without requiring a pipeline infrastructure.

[15] European Commission (2022): REPowerEU Plan, SWD(2022) 230 final

[16] Bouacida, I. & Berghmans, N. (2022): Hydrogen for climate neutrality: conditions for deployment in France and Europe, IDDRI; Piria , R. et al. (2022): Securing hydrogen imports for Germany: Import needs, risks and strategies on the way to climate neutrality, Ariadne; Heinemann, C. & Mendelevitch, R. (2021): Sustainability dimensions of imported hydrogen. Oeko-Institut Working Paper 8/2021, https://www.oeko.de/fileadmin/oekodoc/WP-imported-hydrogen.pdf; Wietschel, M. et al. (2020): Opportunities and challenges when importing green hydrogen and synthesis products, Fraunhofer ISI Policy Brief 03/2020, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2020/policy_brief_hydrogen.pdf;

2. Which policy objectives could the European Hydrogen Bank fulfil?

While the overarching design of the European Hydrogen Bank has been established in public statements by high-ranking European Commission officials, detailed policy objectives remain to be defined. This section attempts to contribute to the ongoing public debate around the detailed design of the European Hydrogen Bank by defining possible policy objectives and their relative importance for the domestic and imports pillar, respectively. The identified objectives later serve as assessment criteria for three design options outlining how the European Hydrogen Bank could function in practice (see section 3).

In general, hydrogen policy instruments should address existing barriers for the market uptake of green hydrogen. In particular, the current cost gap between green hydrogen and fossil-based alternatives implies a non-existent liquid hydrogen market and impedes a market-driven ramp-up of green hydrogen and its derivatives. In this market context, first-movers require long-term planning security in terms of achievable hydrogen offtake prices to invest in hydrogen production facilities. On the demand-side, fixing long-term prices is unattractive. This is because installations that are constructed later would likely be able to sell hydrogen or its derivatives at more favourable conditions due to economies of scale and cost degressions over time. As a result, public support instruments are necessary especially in the early market uptake phase of green hydrogen, to cover expenditures (both CAPEX and OPEX) that, at least initially, cannot be covered through market revenues alone. Moreover, policy instruments can assume certain price and marketing risks that are prohibitive for market participants considering high initial investment insecurities such as unexpected infrastructure and offtake risks, which can be taken over more efficiently by the public support giver.

At the same time, public funds to support the market uptake of green hydrogen should be used as efficiently as possible, and support instruments should not hedge against risks that can be assumed more efficiently by market participants. Moreover, the design and implementation complexity of support instruments for both the support giver and market participants should be proportional and limited to the necessary minimum. In the longer term, a market-driven hydrogen economy facilitated by the ETS and the Carbon Border Adjustment Mechanism (CBAM)[17] should be enabled, which, at its core, requires sufficient willingness to pay for low-carbon hydrogen (derivatives). Initially, this would require support instruments being able to adjust in line with shrinking funding gaps over time before they can be eventually phased out.

Against this background, the following potential policy objectives for the European Hydrogen Bank can be identified, which are summarized in Figure 2 and outlined in more detail below.

A. Effectiveness of green hydrogen ramp-up: The support instrument is effective in that it provides sufficient incentives for continuously and quickly making available the required hydrogen or hydrogen-based derivative volumes (in kg or kWh[18]) in the initial phases of the hydrogen market uptake. For this objective to materialize, the instrument should be able to increase investment security by, inter alia.

(a) closing the funding gap between the cost of producing green hydrogen or its derivatives and the willingness to pay by offtakers (i.e., offtake prices that can be realized currently),

[17] The planned CBAM ensures that CO2-intensive imports are subject to a carbon price which contributes to a level playing field between imports and domestically produced low-carbon hydrogen (deriatives) in Europe. The parallel phase out of free allowances for EU producers and EU importers also implies more price-based incentives to switch to cleaner production processes for all CBAM-covered goods, including for example use of green hydrogen in steel manufacturing

[18] 1 kg of hydrogen contains 33.33 kWh of usable energy.

(b) reducing investment risks in the initial market phase (e.g., price risks, default risks due to non-availability of infrastructure or offtaker/producer default),

(c) matching suppliers and offtakers of green hydrogen or its derivatives in the absence of a liquid market.

Figure 2. Overview of potential policy objectives for the European Hydrogen Bank. Source: Guidehouse

B. Cost effectiveness in reaching green hydrogen ramp-up[19]: The support instrument ensures a cost-effective scale-up of available hydrogen or hydrogen-based derivative volumes (i.e., minimizes € of support per kg of hydrogen or its derivates secured) by

(a) making efficient use of available public funds, i.e., hedges private parties against (unproductive) risks that can be more efficiently assumed by a public authority from an economic perspective (e.g., price or default risks due to infrastructure or failed offtake/production) and avoids overcompensation of support recipients, and

(b) limiting budget uncertainty for the support giver, e.g., the instrument does not require reserving excessive budget amounts to ensure support payments throughout the support period[20].

C. Market orientation: The instrument incentivizes a market-compatible scale up of hydrogen volumes. It does not crowd out private risk hedging instruments and alternative marketing routes outside of the support scheme (e.g., bilateral power purchase agreements (PPA) and hydrogen purchase agreements (HPA)).

[19] Please note that the actual support cost effectiveness of the support instrument will crucially depend on whether (non-repayable support) will be allocated based on a competitive bidding procedure featuring sufficient competition. In this context, the concrete design of the auction strongly impacts whether sufficient competition can be achieved. Since the detailed auction design is not the focus of this paper and against the background of the limited available funding currently allocated to the European Hydrogen Bank, the assessment of support cost effectiveness will primarily address risks that should be assumed by the instrument and which market risks may be more efficiently taken over by market participants themselves.

[20] Note that there is a direct link between the price risks that are assumed by the support scheme, on the one hand, and the budget certainty for the support giver, on the other hand: The lower the price risk for the investor, the higher the budget risk for the support giver, since in this case, the support instrument takes over part of the investors' risks, and vice versa.

D. Low complexity: The instrument entails limited design and implementation complexity for both the public authority and market participants, e.g., it does not require complex and potentially novel contractual arrangements and/or the establishment of dedicated institutions to implement the instrument).

While these policy objectives provide a good basis to assess the suitability of potential policy instruments under the European Hydrogen Bank, their relative importance may differ for support instruments targeting domestic hydrogen production and imports from third countries outside the EU, respectively. For example, an instrument that facilitates matchmaking between demand and supply and hedges investors against default risks may be suitable to secure imports from non-EU countries[21], e.g. to account for the larger distance between producers and offtakers, higher political risks in exporting countries and imported offtake volumes being subject to non-EU regulatory frameworks in the exporting country, as well as the overall higher infrastructure and transport uncertainties for investors (e.g., availability of shipping and import terminals, or, if applicable, cross-border hydrogen pipelines).

However, wide-ranging assumption of market risks by the support giver may not be required to ensure an EU-wide production of hydrogen volumes, where investment and marketing risks (e.g., due to default of producers of offtakers), while still significant especially in the initial market uptake phase, are arguably lower than in the realm of international imports and can thus be more efficiently assumed by private parties. The goal to increase market orientation appears more relevant for instruments incentivizing domestically produced hydrogen volumes compared to international imports. Here, the overarching objective is to establish liquid EU-wide markets for hydrogen and its derivatives in the medium term. In the context of securing international imports, trade relations between producers in exporting countries and EU offtakers will likely continue to be mediated and influenced to a larger degree by state actors, especially due to significant coordination requirements and need to establish and organize the (primarily ship-based) transport routes for derivative imports.

For each of the policy objectives defined above, the following table provides an assessment, including a rationale for this assessment on their importance for the domestic and imports pillars. The policy objectives are labelled as “very important”, “important” and “less important.” This provides an additional qualification and basis for a more nuanced assessment of the suitability of possible design options for the European Hydrogen Bank in section 4, differentiated by its domestic and imports pillar.

[21] This includes primarily ship-based imports of hydrogen-based derivatives such as ammonia or methanol, but may also comprise pipeline-based hydrogen, to the extent that hydrogen pipelines, e.g., connecting North Africa and the EU, are available.

Table 1. Domestic and imports pillar: Importance of policy objectives

Policy objective	Importance		Rationale
	Domestic	Imports	
A. Effectiveness	Important ***Disclaimer:*** *Importance in terms of the degree of publicly provided investment security required*	Very important	While the support instrument needs to provide effective incentives to ensure sufficient hydrogen volumes under both the domestic and the imports pillar, the extent of investment uncertainties and thus the degree of support scheme effectiveness required for the hydrogen scale up differs. Under both pillars, the funding gap needs to be bridged, but securing sufficient imports from outside the EU may require support instruments to address the higher investment insecurities in the international realm compared to the domestic hydrogen scale-up, e.g., to account for the larger distance between producers and offtakers, higher political risks, and offtake volumes being subject to non-EU regulatory frameworks in the exporting country, as well as the generally higher infrastructure and transport uncertainties for investors.
B. Cost effectiveness	Very important	Very important	Against the background of limited EU funds available for the European Hydrogen Bank, cost effectiveness, in terms of ensuring that only unproductive risks for private market participants are assumed by the support scheme, and limiting budget uncertainty for the EU, is a priority under both pillars.
C. Market orientation	Important	Less important	Incentivising a market-friendly scale-up of hydrogen volumes is a suitable and important policy objective for the *domestic pillar*. Here, any support instrument should try to accompany, but certainly not impede, market dynamics on the way towards a developing liquid hydrogen market in the mid-term that would eventually not require any public support instruments. Moreover, market participants may be better placed to hedge against price and default risks in the domestic realm, where overall investment risks may be lower compared to imports from outside the EU. In the context of *international imports*, the assumption is that business relations between producers in exporting countries and EU offtakers will likely continue to be mediated and influenced to a larger degree by state actors in the medium to long term. Hence, market dynamics and thus the need to specifically enable market incentives as part of the support scheme design for imports is considered less important compared to the domestic hydrogen ramp-up
D. Low complexity	Important	Important	The instrument should entail a degree of complexity that is limited to a level necessary and proportionate for the achievement of its goals. This equally applies to both the domestic and the imports pillar.

3. How could a European Hydrogen Bank function in practice?

This section outlines the function of three potential designs of a European Hydrogen Bank, both in terms of its planned domestic and imports pillar. The analysed models are:

- Double-sided auctions for supply and demand contracts (section 3.1),
- Supply- or demand-side auctions determining market premiums (section 3.2), and
- Default guarantees for hydrogen producers (section 3.3)

For each model, the respective benefits and potential challenges are discussed in terms of how well they perform in achieving the previously defined policy objectives. This assessment will allow the reader to understand how the European Hydrogen Bank could function in practice and which functional designs may be most suitable.

While the description of designs will be differentiated by domestic and imports pillar, the assessment in this section is conducted without such differentiation. Whether the design is implemented to procure imported or domestically produced hydrogen or hydrogen-based derivative volumes, we assume that the objectives that one design can fulfil would not differ substantially between both pillars. For example, independent of whether a double-sided tendering mechanism procures volumes domestically or through imports, it entails rather limited market orientation, in principle, since supply and demand volumes are matched by the instrument itself and no bilateral offtake agreements between market participants are required.

To account for the specifics of supporting domestic production and securing international imports under the European Hydrogen Bank, a differentiated assessment of the most suitable design option for the domestic and imports pillar, respectively, will be provided in a final section 4. This assessment will be refined based on the previously identified importance of policy objectives for the domestic and imports pillars to allow for a nuanced assessment of the suitability of possible design options for the European Hydrogen Bank. As a result, the paper transparently lays downs the assumptions to determine the suitability of specific designs.

3.1 Double-sided auctions for supply and demand contracts

3.1.1 *Description of the instrument*

The goal of double-sided auctions for demand and supply contracts is to buy hydrogen or its derivatives from producers and sell it to end users through a (double-sided) auction mechanism that determines the gap between the lowest possible renewable hydrogen/derivative offtake prices (on the supply-side) and the highest willingness to pay for renewable hydrogen/derivative (on the demand-side). The identified price gap between procurement costs and resale revenues is then covered by the support giver. The instrument's overarching purpose is to provide security for renewable hydrogen producers, to invest in new electrolyser capacity, to enable eligible offtakers (e.g., industry) to procure renewable hydrogen for their decarbonisation efforts, e.g., to switch their industrial production processes to renewable hydrogen.

In principle, double-sided auctions under the European Hydrogen Bank would match the cheapest renewable hydrogen or hydrogen-based derivative suppliers

participating in a supply-side auction with eligible offtakers according to their willingness to pay in the demand-side auction. Since bids from both suppliers and offtakers are determined in a competitive bidding process, the lowest bids on the supply-side (covering their OPEX plus transport cost, and potentially CAPEX if not accounted for by ceiling prices) and the highest bids on the demand-side are awarded a hydrogen supply or demand contract. In the context of the European Hydrogen Bank, the European Commission, a Commission implementing agency or a newly established public appointed private entity would auction (long-term) purchase contracts to hydrogen or derivative producers (supply-side auction), sell the previously procured hydrogen or derivative volumes via (short-term) tenders to offtakers (demand-side auction), e.g., to industry customers, and administer and allocate the public funds to cover the price gap between renewable hydrogen or derivative production costs (i.e. the offtake price required by the producer to operate economically) and willingness to pay on the demand-side, as determined in the double-sided auction (see Figure 3).

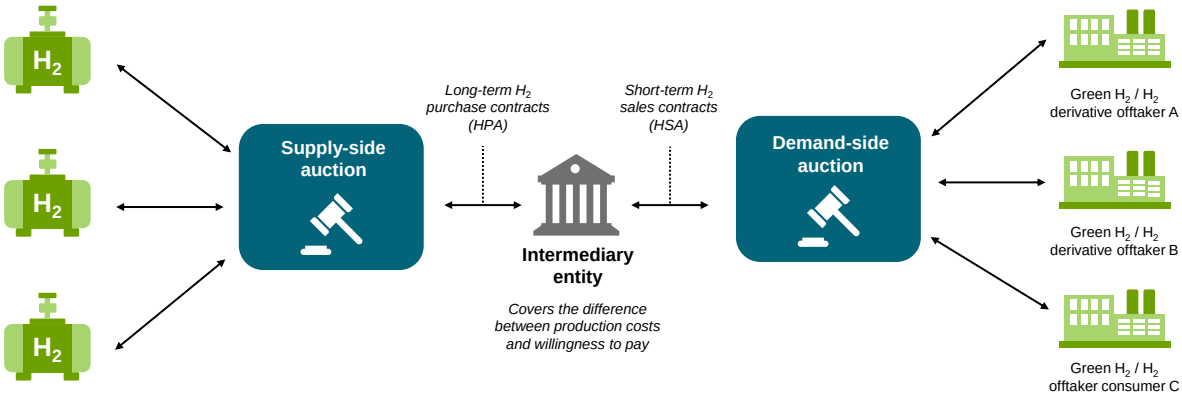


Figure 3. Illustration of double-sided auctions (supply & demand) for hydrogen or its derivatives. Source: Guidehouse

Double-sided auctions imply that the public authority or a publicly appointed intermediary would not only cover the determined price gap through a corresponding support payment but also purchase and re-sell hydrogen or hydrogen-based derivative volumes via purchase contracts with suppliers and sale contracts with offtakers, assuming substantial marketing and price risks compared to a conventional support scheme. In this context, marketing risks relate to the intermediary's responsibility to market the available volumes committed to in long-term contracts with producers via shorter-term sale contracts with offtakers. Price risks could materialize if purchase prices in the shorter-term offtake contracts decrease over time so that the funding gap to be covered by the intermediary increases. Moreover, different contract durations on the demand and the supply side would require the support giver to initially reserve a larger budget than what might be needed eventually, e.g., if the willingness to pay on the demand side increases more than anticipated and support requirements reduce as a result.

Consideration of the instrument for the domestic pillar

Double-sided auctions for the supply- and demand-side are currently discussed primarily in the context of international imports of hydrogen or its derivatives (see next sub-section). However, they can also be used to incentivize domestic production and offtake. In this case, the instrument provides investment security for hydrogen producers in the EU by receiving a guaranteed offtake price for sufficiently long period (e.g., 10 years) and incentivize EU offtakers to invest in green hydrogen applications, e.g., industry investments in key technologies. The

instrument has a clear focus on the scale up of hydrogen on both the demand and the supply side.

Under the condition of sufficient competition, double-sided auctions, in principle, enable a competitive price discovery for green hydrogen on the demand and supply side in the absence of a market price formation via liquid markets. Moreover, the price difference that the intermediary must cover would decrease over time as the production costs for renewable hydrogen are expected to decrease and the willingness to pay on the demand-side is expected to increase (e.g., due to stricter climate regulations and higher ETS prices).

However, only sites close to demand centres (or even electrolysers co-located on the site of the offtaker) would be able to bid competitively in the short term due to the lack of an extensive hydrogen pipeline infrastructure. This is especially true if the European Hydrogen Bank's domestic pillar focuses on securing sufficient volumes of domestically produced gaseous hydrogen (not derivatives). In the medium term and with the existence of such a grid, production sites in various regions could potentially compete in the double-sided auction scheme. However, it is unclear if double-sided auctions would be needed at all at this point, since the existence of a full-fledged hydrogen grid connecting all or most potential offtakers with hydrogen producers, would likely provide the basis for the creation of a functioning liquid hydrogen market. An explicit matching of market participants and formation through the support scheme would likely no longer be required and remaining cost gaps or risks could be covered otherwise (see section 3.2).

It is important to note that high funding requirements may arise in the early market development phase of green hydrogen, especially if the full funding gap is covered by subsidies as foreseen by a double-sided auction scheme. In the short term, the production of renewable hydrogen is still very costly. Additionally, there may not be sufficient competition to drive down the prices in the early market phases. At the same time, the demand for green hydrogen and therefore the willingness to pay by offtakers may be relatively low in the beginning. This could result in a relatively large cost gap between renewable hydrogen production costs and willingness to pay on the demand-side could be relatively.

If the European Hydrogen Bank were to implement a mechanism under which the Commission or an intermediary assumes most marketing and price risks and covers the full funding gap as described above, the relatively scarce available funding of €3 billion may not be used efficiently[22]. Considering the relatively large budget share that must be reserved to cover potential fluctuations and/or defaults by the offtaker or producer and the high initial funding gaps to be expected initially, double-sided auctions would likely result in rather limited hydrogen volumes procured through the mechanism.

Certain additional challenges may arise when implementing EU-wide double-sided hydrogen auctions. In general, double-sided auctions may be subject to varying framework conditions and policy preferences in EU Member States that can have an impact on auction outcomes. For example, support needs for producers in one country may be systematically lower that in another country as a result of lower power sourcing costs that are at least partly influenced by regulatory price components varying across countries. Hydrogen transport costs for any single project would depend on the proximity between hydrogen production and the offtake point, which may lead to structurally differing bid prices and disadvantage decentralized geographical locations. These results may be be acceptable as they would simply reflect the most cost effective option. However, the EU and Member States may have an interest in ensuring a geographically balanced distribution of awarded projects. Levelling out such differences can, in principle, be achieved e.g., via a segmentation of funding rounds or non-price award criteria. However, these

[22] It remains to be specified if the communicated budget refers to the whole European Hydrogen Bank or just the imports pillar, and which timeframe is considered.

design choices may negatively impact competition levels and support cost-effectiveness.

Overall, the EU-wide instrument would likely face conflicting priorities between creating efficient results through aggregation of large production and offtake volumes that enable sufficient competition levels and ensuring national priorities are met (e.g., a sufficiently equal distribution of allocated EU subsidies). Achieving a suitable and acceptable aggregation of offtake and production volumes across EU Member States could remain a challenge.

Consideration of the instrument for the imports pillar

To secure imports of primarily hydrogen-based derivatives from countries with high renewables potential outside of Europe, double-sided auctions can help provide the necessary investment security to producers of hydrogen or its derivatives in exporting countries by providing long-term purchase agreements (e.g., 10 years). Entering into shorter-term hydrogen sales agreements (e.g., 1 to 5 years) with EU offtakers avoids locking in an initially low willingness to pay and, in principle (and depending on the length and frequency of auction rounds), allows to adapt support needs to the shrinking funding gap over time. In the absence of liquid international markets of hydrogen-based derivatives, double-sided auctions – besides closing the cost gap of hydrogen imports with fossil-based alternatives – also entail an in-built mechanism to match offered export volumes and import volumes required by offtakers in the EU.

A double-sided auction scheme to secure imports of derivatives such as ammonia and e-methanol from outside the EU is currently planned as part of the German H2Global scheme (see Box 1). The German Government has indicated that it intends to establish H2Global as a European instrument[23] and chancellor Scholz recently announced that the German Government will endow the instrument with more than €4 billion[24], which would be larger than the budget currently foreseen for the European Hydrogen Bank. Hence, potential interactions between the European Hydrogen Bank's import pillar and H2Global, e.g., the risk of reciprocal cannibalization of offered and requested volumes in the respective auction rounds, should be considered, especially since H2Global is not limited to offtakers in Germany but may in principle be open to offtakers in all EU Member States.

In this context, the H2Global Foundation has emphasized that H2Global may be a readily available instrument that could be used as a set-up for the Global European Hydrogen Facility announced in the RePowerEU plan[25]. Hence, how H2Global and the European Hydrogen Bank will interact in practice and if they could "cannibalize" each other depends on number of factors, including if the EU Hydrogen Bank will implement a similar (double-sided) scheme at all, if H2Global merely serves as a blueprint informing the set-up of a separate scheme on EU level, or if H2Global will be "Europeanized", i.e., assuming the responsibility to support derivative imports for the European Hydrogen Bank.

[23] BMWK (2022), Federal Ministry for Economic Affairs and Climate Action launches first auction procedure for H2Global – €900 million for the purchase of green hydrogen derivatives

[24] Kurmayer, N. (2022), Scholz ups global hydrogen ambitions, dwarfs EU initiative, Euractiv

[25] Van Wijk et al. (2022), How to deliver on the EU Hydrogen Accelerator, H2Global Foundation; H2Global Foundation (2022): H2Global – Idea, Instrument and Intentions, Policy Brief 01/2022

Box 1. German H2Global scheme for international imports of hydrogen-based derivatives

H2Global is Germany's competitive procurement scheme for the import of renewable hydrogen derivatives such as renewable ammonia, methanol, and sustainable aviation fuels (SAF) announced in 2021[26]. The instrument will follow a double-sided auction approach to determine the support gap between the lowest production cost on the supply-side and highest willingness to pay on the demand-side. On the supply-side, the competitive procurement process will result in 10-year hydrogen purchase agreements with non-EU producers. The demand-side will result in short-term hydrogen sales agreements established through annual auctions with EU customers[27]. The purchase and sale contracts for the auctions are managed by an intermediary, HINT.CO (Hydrogen Intermediary Network Company), which is a subsidiary of the H2Global Foundation established by the private sector and backed by the German government.

H2Global is funded by the Federal Ministry for Economic Affairs and Climate Action (BMWK), and originally approved €900 million in funding in December 2021[28]. The federal government recently announced plans to provide an additional €3.5 billion for further auction rounds to be covered until the year 2036[29].

In December 2022, the first tender procurement procedure for the import of green ammonia into Europe was launched. The tenders for green methanol and e-SAF are expected to follow shortly[30]. A budget of €360 million was allotted for the first round of ammonia[31]. In this initial step, five companies are being sought after by 7 February 2023. These companies will then be invited to submit their bids. The first deliveries of the sustainable hydrogen derivatives are scheduled for the end of 2024 and must arrive via a port in Germany, Belgium, or the Netherlands. The tendering process for offtakers (both in Germany and the EU) is expected to be complete in the beginning of 2024. Once complete, the next stage will require the submission of final bids and the selection of bidders. This is expected to take three-to-five months according to HINT.CO consultants[32].

In general, double-sided auctions to secure imports of primarily hydrogen-based derivatives under the European Hydrogen Bank could provide a certain EU-added value. The aggregation of offtake volumes from different Member States may lower offtake prices compared to an individual national purchase of the nationally required import volumes. Moreover, the European Hydrogen Bank, if implemented as a double-sided procurement mechanism of hydrogen or hydrogen-based derivative volumes from outside the EU, may offer a purchase platform "as a service", especially to smaller EU Member States, implying lower administrative costs compared to a situation where all Member States set up their own purchasing mechanisms.

Besides the overarching downsides already outlined in the previous sub-section (e.g., high complexity and administrative effort, high risks and liabilities for the intermediary, high funding requirements at least initially), it should be noted that double-sided auctions for imports would essentially require a well-developed import and transport infrastructure to guarantee sufficient competition in the auctions. Double-sided auctions for imports are therefore relevant primarily for hydrogen derivatives that can be transported more easily over longer distances

[26] Zawh T. et al. (2022), Facilitating hydrogen imports from non-EU countries, Gas for Climate & Guidehouse
[27] Ibid
[28] BMWK (2021), €900 million for H2Global hydrogen project Minister Habeck: Launch of hydrogen economy market ramp-up
[29] BMWK (2022), Federal Ministry for Economic Affairs and Climate Action launches first auction procedure for H2Global – €900 million for the purchase of green hydrogen derivatives
[30] H2Global Stiftung (2022), 900 million euros for the market ramp-up of green hydrogen
[31] Lohmann, H. (2022), H2-Global startet Beschaffung von grünem Ammoniak. Energate messenger, 08.12.22.
[32] Ibid

without requiring an extensive pipeline transport infrastructure, given that ship- and truck-based transport is possible for derivatives such as ammonia or e-fuels but less economical for gaseous hydrogen.

Nonetheless, contracting gaseous hydrogen import volumes (e.g., from neighbouring regions outside the EU, e.g., North Africa) would be feasible as well if a developed hydrogen pipeline infrastructure exists. However, in this case double-sided auctions would likely not be required in the first place, as the existence of a hydrogen transport infrastructure would likely provide the basis for the creation of a functioning hydrogen market without need to procure such volumes through double-sided tendering. A potential existing funding gap could be covered by market premiums determined in an auction on the demand or the supply-side, while market participants continue to enter bilateral contracts and assume the corresponding risks and liabilities (see section 3.2).

In the more likely case that the European Hydrogen Bank was to implement the instrument primarily to secure imports of hydrogen-based derivatives from non-EU countries, transport from an existing (port) import infrastructure to offtakers would need to be realized (e.g., by truck or rail). Additionally, transport cost distribution between suppliers and offtakers (and how it is reflected in the bid) would have to be determined. Ideally, the transport of volumes procured through the mechanism and resulting delivery risks would be in the responsibility of market participants (e.g., producer until destination port, offtaker from port). Moreover, aggregation of potentially various offtake points needs to be organized by the instrument, which may require a segmentation of funding rounds by the import harbour.

3.1.2 *Assessment of the instrument*

Box 2. Assessment approach in this paper

The assessment for each of the instruments in section 3 is conducted with the help of an evaluation matrix along the previously defined policy objectives. For each instrument, the degree to which these policy objectives can be achieved is scored as follows:

- (+) can be achieved / yes (green colour)
- (0) can be achieved to a certain degree / neutral (orange colour)
- (-) cannot be achieved / no (red colour)

For each score, we provide a concise description and reasoning (i.e., per matrix cell).

Table 2. Assessment: Double-sided auctions for supply and demand contracts

Objective/ Criterion	Assessment
A. Effectiveness	+ In principle, the instrument is effective in that it determines and can cover the cost gap between green hydrogen or its derivates and fossil-based alternatives, reduces investment risks and matches suppliers and offtakers of green hydrogen or its derivatives in the absence of a liquid market. Especially in the initial market phase, the instrument creates high incentives for continuously making the required hydrogen or hydrogen-based derivative volumes available.
B. Cost effectiveness	0 The instrument enables a competitive price discovery for green hydrogen / derivatives on the demand and supply side (under the condition of sufficient competition) and is flexible to adapt to the shrinking price gap between the offtakers' willingness to pay and hydrogen production cost over time. However, the instrument has high funding requirements in the early market development phase, as the full funding gap is covered by subsidies. Furthermore, the instrument involves high risks and liabilities for the support giver to market the procured volumes, since the intermediary would need to re-sell hydrogen and derivative volumes from long-term purchase contracts with producers every time shorter-term sales contracts with offtakers expire. The intermediary would also face significant financials risks if producers or offtakers fell short of their commitments, i.e., having to find new offtakers or producers in case of default, or otherwise cover the resulting financial liabilities. To ensure the public intermediary can honour all its commitments, this also implies that more public funds typically need to be maintained over the period of the long-term supply contract than what may be needed in the end (e.g., due to higher-than-expected willingness to pay from offtakers over time). Especially against the background of the relatively limited funds currently foreseen for the European Hydrogen Bank (€3 bn), double-sided auctions would likely result in rather limited hydrogen volumes procured through the mechanism.
C. Market orientation	– Double-sided auctions create a market for green hydrogen or its derivatives as part of the support scheme. Since marketing and price risks as well as default risks by offtaker or producer are largely taken over by the support giver (no direct contractual relationship between offtaker and producers), private risk hedging instruments and alternative marketing routes outside of the support scheme (e.g., bilateral PPAs and HPAs) are not required. The instrument has very limited market orientation.

D. Low complexity	– The design and implementation of a double-sided tendering instrument relatively high complexity and administrative effort. The intermediary (potentially to be established itself) would design and enter into complex contracts, which would require relevant expertise. It would probably have to build up additional capacities and capabilities to perform its responsibilities under the double-sided auctions scheme. Together with a relatively high administrative effort to set up the overall support scheme, the instrument should only be considered for larger funding volumes.

3.2 Supply- or demand-side auctions determining market premiums

3.2.1 *Description of the instrument*

Currently, and as outlined before, green hydrogen is not competitive compared with fossil-based alternatives and requires financial support to cover the cost gap currently impeding investments in green hydrogen production. Two options to close the cost cap are supply-side and demand-side auctions determining market premiums on top of (bilaterally agreed or, to the extent available in the future, market-based) hydrogen offtake prices.

Supply-side auctions address producers of green hydrogen (i.e., electrolysers) or its derivatives, receiving (upon award) operational support for each unit of hydrogen produced. In a supply-side auction, producers of green hydrogen that require the lowest market premium (i.e., have the lowest production costs) to fulfil a bilateral purchase contract of green hydrogen (HPA) with a chosen offtaker are then selected in a competitive bidding process.

Demand-side auctions address green hydrogen users, such as a steel plant, receiving a premium for each unit of hydrogen consumed that is required to close the funding gap with fossil-based alternatives, i.e., the gap between their willingness to pay and the required offtake price for green hydrogen. Based on a hydrogen purchase agreement with a supplier, the offtaker would determine their bid based on the cost of renewable hydrogen, the cost of incorporating renewable hydrogen into production processes, hydrogen infrastructure/transport costs, and prices of current energy carriers.

In summary, both demand- and supply-side auctions determining market premiums allocate subsidies covering the funding gap, but the support giver (here, the European Commission or an implementing agency as part of the European Hydrogen Bank) would not purchase and sell hydrogen or hydrogen-based derivative volumes itself. Instead, producers would remain responsible to negotiate and enter into bilateral hydrogen purchase contracts and assume the resulting risks and liabilities resulting from these contracts.

Figures 4 and 5 below illustrate the high-level set-up of supply and demand-side hydrogen auctions.

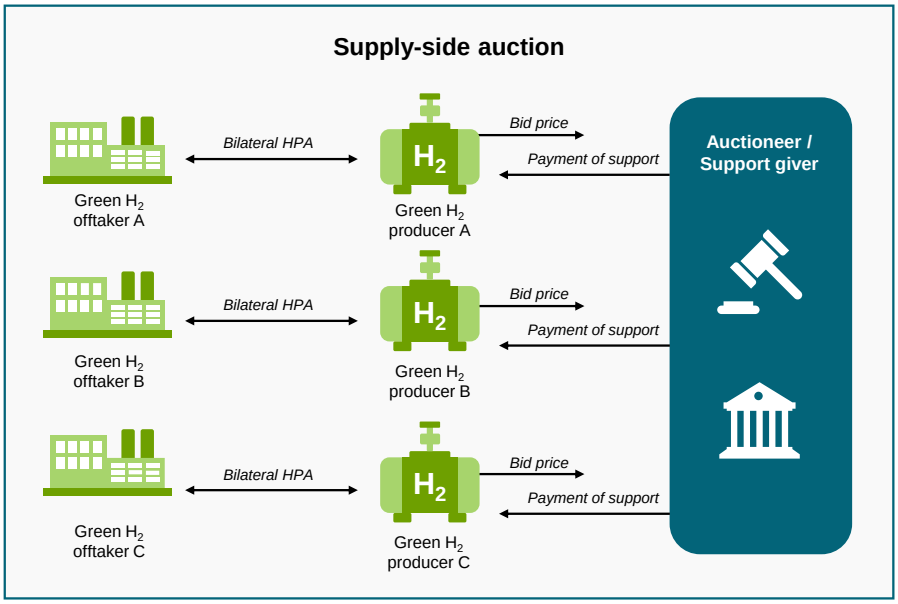


Figure 4. Illustration of supply-side auctions determining market premiums for hydrogen or its derivatives. Source: Guidehouse.

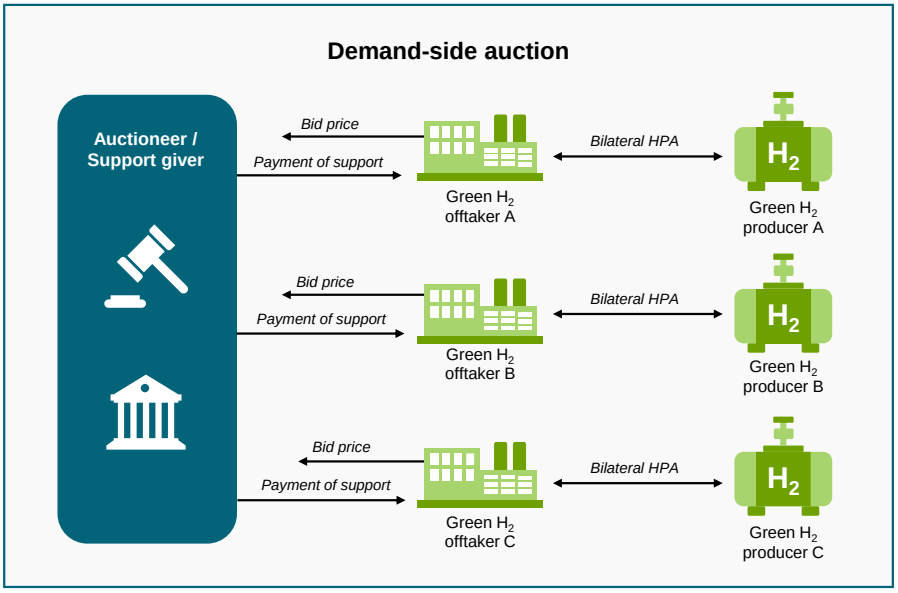


Figure 5. Illustration of demand-side auctions determining market premiums for hydrogen or its derivatives. Source: Guidehouse.

In principle, different market premium types are feasible. Support may be in the form of a fixed premium on top of hydrogen offtake prices, with the fixed premium also serving as the bid price in the auction. Alternatively, the premium may be calculated in reference to an offtake price and therefore cover potential price risks due to potentially fluctuating hydrogen prices[33]. In this case, the so-called Contract-for-Difference (CfD) support payment would be calculated based on a strike price bid in the auction relative to a reference price (support payment if strike price < reference price; payback if strike price > reference price). One of the main challenges related to this are the choice and design of the reference price for the

[33] Note that initially relatively stable hydrogen prices based on longer-term bilateral offtake agreements can be expected, so that price risks may be considered relatively low compared to for example fluctuating electricity wholesale market price developments.

CfD in the absence of an available liquid hydrogen market. In particular, this implies a lack of a readily available reference price index similar to the electricity wholesale price in the case of renewable energy CfDs.

Figure 6 below illustrates the functioning of both fixed premiums and CfDs.

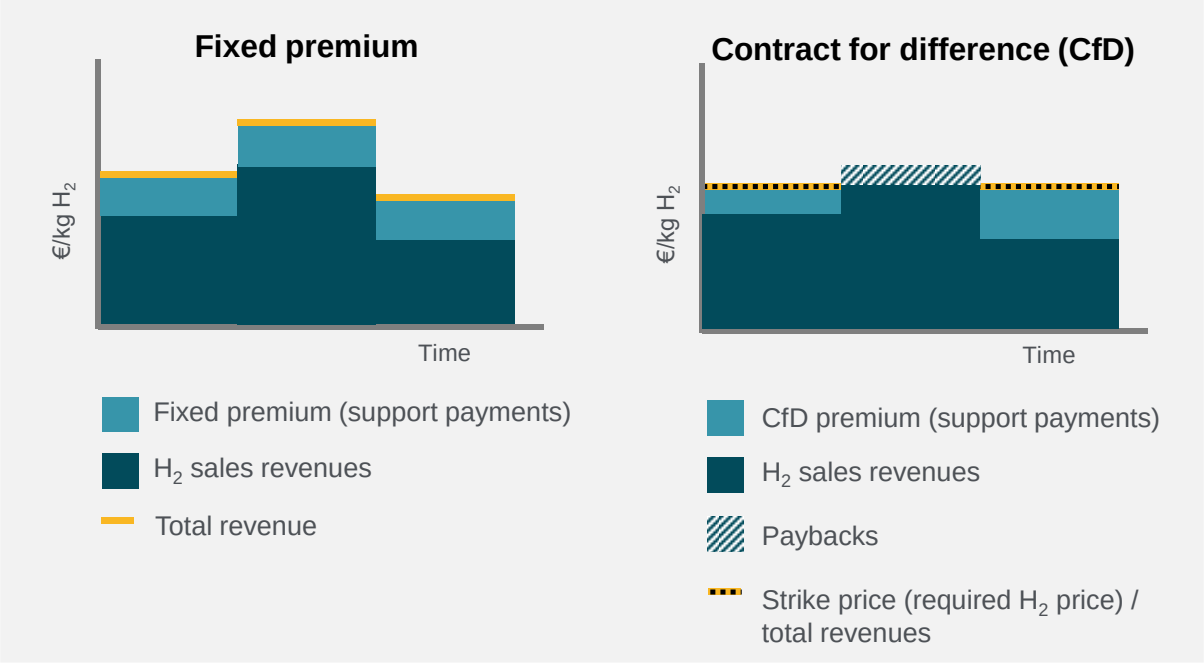


Figure 6. Illustration of fixed premiums and CfDs. Source: Guidehouse.

Consideration of the instrument for the domestic pillar

Before participating in a **supply-side auction** under the domestic pillar, green hydrogen producer within the EU intending to participate in the auction would first have to enter into a non-binding bilateral agreement (e.g., MoU) with an EU offtaker. The producer then takes part in the supply-side auction to compete for a market premium (e.g., a fixed premium). Participation in the auction is limited to other green hydrogen producers located in an EU Member State. Additionally, auction rounds could be segmented by electrolyser location (e.g., region or countries) or offtake point, to account for unavailability of an extensive hydrogen infrastructure and to avoid potential windfall profit due to different cost levels in Member States because of higher renewables resource potential or other factors. However, segmentation of auction rounds may have negative effects in terms of competition levels and thus bid prices.

To steer hydrogen volumes into specific demand sectors with the highest abatement costs and no alternative decarbonisation option (e.g., certain industry sectors such as DRI steel production or the chemical industry), green hydrogen producers in the supply-side auction may be required to demonstrate that produced volumes will be supplied to these sectors (e.g., via the MoU mentioned earlier). However, resulting funding gaps may be higher than without this requirement, primarily due to a potentially higher willingness to pay in other sectors (e.g., transport).

Upon award of the premium in the auction, successful green hydrogen producers enter into a binding bilateral purchase agreement with an EU offtaker and receive a market premium on top of the bilateral offtake price for each unit of hydrogen produced throughout the support period. The required support period for the producer to ensure sufficient investment security may be significantly longer (e.g., 10 years) than the period the offtaker is willing to commit to in the bilateral contract.

In this case, the producer may be required to renegotiate contract terms with the offtaker or find alternative offtakers at specific points in time (e.g., after 5 years).

In a **demand-side auction** under the domestic pillar, EU offtakers with an intention to participate in the auction would first enter into a non-binding bilateral agreement (e.g., MoU) with a green hydrogen producer located in the EU. The EU offtaker takes part in demand-side auction to compete for a market premium. Auction rounds may be segmented by a type of offtaker (e.g., sector such as different windows for transport and industry sectors) to account for different willingness-to-pay in these sectors and avoid adverse effects such as windfall profits for offtakers with a lower willingness to pay and to ensure that the various sectors requiring hydrogen volumes will be awarded.

From a geographic diversity perspective, demand-side auction rounds may be segmented by region or country, e.g., to account for the fact that some Member States may have limited industry offtakers and thus may not be awarded in an open auction round limited to the industry sector but may instead require hydrogen volumes to decarbonize their transport sector. As outlined before, these design choices need to be balanced against the potentially negative effects in terms of lower support cost effectiveness (i.e., higher bid prices). Upon award of the premium in the auction, the EU offtaker enters into a binding bilateral purchase agreement with the green hydrogen producer. The offtaker receives a market premium on top of the bilateral offtake price for each unit of hydrogen taken off throughout the support period to balance out the higher offtake prices bilaterally agreed with the producer.

Consideration of the instrument for the imports pillar

For the **supply-side auction** under the imports pillar, green hydrogen (derivative) producers in exporting countries intending to participate in the auction would first enter into a non-binding bilateral agreement (e.g., MoU) with an EU offtaker, before taking part in a supply-side auction to compete for a market premium. The supply-side auction in this case is limited to other exporting green hydrogen (derivative) producers and should be separated by product type (e.g., hydrogen, ammonia, e-methanol, other e-fuels).

Auction rounds may also be segmented by exporting regions to account for different cost levels and avoid windfall profit, especially if import volumes from various exporting regions are required. Upon award of the premium in the auction, green hydrogen producers then enter into a binding bilateral purchase agreement with an EU offtaker and receive a market premium on top of the bilateral offtake price for each unit of hydrogen or hydrogen-based derivative produced throughout the contract period. As with the supply-side auction for EU producers, the required support period for the producer may be significantly longer (e.g., 10 years) than the period the offtaker is willing to commit to in the bilateral contract, so that multiple purchase agreements may need to be closed or renegotiated throughout the support period.

Before participating in a **demand-side auction** under the imports pillar to secure a market premium, interested EU offtakers would enter into a non-binding bilateral agreement (e.g., MoU) with an exporting green hydrogen producer. The demand-side auction may be limited to only offtakers requiring imports in order to account for potentially higher costs of imported volumes compared to domestically produced hydrogen. As with the supply-side auction, the auction round should be also separated by product type (e.g., hydrogen, ammonia, e-methanol, other e-fuels) and may be additionally segmented by type of offtaker (e.g., sector such as different windows for transport and industry) to account for different willingness-to-pay. Upon award of the premium in the auction, the EU offtaker enters into a binding bilateral purchase agreement with the green hydrogen producer abroad.

3.2.2 Assessment of the instrument

Table 3. Assessment: Supply- or demand-side auctions determining market premiums

Objective/ Criterion	Assessment
A. Effectiveness	0 The instrument is effective in securing sufficient hydrogen or hydrogen-based derivative volumes by closing the funding gap between the cost of producing green hydrogen or its derivatives, on the one hand, and the willingness to pay by offtakers (i.e., offtake prices that can be realized currently), on the other hand. Both supply- and demand-side auctions provide incentives for expanding electrolysis capacities and ensuring green hydrogen is used by industrial sectors to decarbonize, since bilateral agreements between producers and offtakers will be an implicit or explicit pre-condition to participate in the auction. However, supply side auctions may not steer hydrogen volumes to specific hard-to-abate demand sectors. A restriction of offtakers can be included as a prequalification requirement in the auction but monitoring compliance increases complexity and administrative burden for the support giver. Moreover, the instrument does not hedge market participants against certain risks such as default risks due to non-availability of infrastructure or provides an explicit matchmaking function as part of the instrument.
B. Cost effectiveness	+ In principle the auction-based allocation of market premiums (assuming sufficient competition) should minimise € of support per kg of hydrogen or its derivates secured, leading to high support cost effectiveness. However, competition levels in supply-side auctions may be higher and more homogenous compared to demand-side auctions (e.g., few large-scale industrial offtakers with varying willingness to pay may participate), making supply-side auctions the option that can be implemented with less design complexities. Since support is paid per unit of hydrogen produced, governments face a lower risks of incurring support costs without creating the corresponding benefits. Moreover, as market participants need to enter into bilateral purchase agreements, marketing and default risks do not need to be assumed by the support scheme. This avoids having to reserve excessive budget amounts to ensure support payments throughout the support period.[34]

[34] Please note that, depending on the concrete design, premium systems fixing support levels for longer periods (e.g., 10 or 15 years) could negatively impact support costs effectiveness. At the same time, shorter support periods may not provide sufficient investment incentives. Since the detailed support scheme design (e.g., exact premium design and support duration), is not the focus of this paper, this argument is not further considered in the assessment of the instrument.

C. Market orientation	+ In summary, both demand- and supply-side auctions determining market premiums allocate subsidies covering the funding gap, but the support counterparty (here, the European Commission or an implementing agency as part of the European Hydrogen Bank) would not purchase and sell hydrogen or hydrogen-based derivative volumes itself. Instead, producers would remain responsible to negotiate and enter into bilateral hydrogen purchase contracts and assume the resulting risks and liabilities resulting from these contracts. While operating support influences and subsidies in general always influence operating decisions, market orientation can be considered relatively high.
D. Low Complexity	0 Both supply- and demand-side auctions determining market premiums, especially in case the latter are designed as fixed premiums not requiring a reference market price, are relatively simple to implement. In particular, the instruments do not require the support giver to enter into complex and potentially novel contractual arrangements and/or the establishment of dedicated institutions to implement the instrument. At the same time, the instrument implies a regular disbursement of support payments (e.g., monthly or quarterly), and potentially requires the build-up of additional resources to design and implement such a scheme.

3.3 Default guarantees for hydrogen producers

3.3.1 *Description of the instrument*

Default guarantees hedge against risks related to potential default events in take-or-pay contracts for hydrogen or its derivatives that are outside the control of the hydrogen producer[35]. This includes in particular risks related to:

- the completion of import or transport infrastructure (e.g., pipelines and/or terminals),
- transportation (e.g., ship-based or pipeline based),
- default by the hydrogen offtaker, such as an industrial plant (e.g., due to bankruptcy, delay in commissioning the industrial installation, shutdown of the project).

In case of a default event, the default guarantee allows the producer to be compensated for being unable to sell the hydrogen produced (or any of its derivative) or at a lower price than initially agreed. The resulting loss is compensated by the guarantee. The risk of production loss, on the other hand, remains with the hydrogen producer, as it is a calculable business risk that can be efficiently assumed by the producer. Similarly, the price risk in terms of potentially fluctuating hydrogen offtake prices is not covered by this instrument, and

[35] This instrument was introduced in Klessmann, C. et al. (2022), Policy Paper. Wasserstoff-Importstrategie für den Markthochlauf. Policy Accelorator for Climate Innovation 2022. EPICO Klimainnovation & KAS

guarantees are not able to close the cost gap between green hydrogen and fossil-based alternatives. If necessary, default guarantees may, however, be combined with other support instruments able to assume such price risks and/or cover the funding gap (e.g., double-sided auctions or supply- or demand-side auctions determining market premiums – see previous sections).

The financial guarantee should be provided by a public authority, in this case the European Commission, an appointed implementing agency or the European Investment Bank (EIB). This ensures that default guarantees on the part of the customers towards the producer are backed by a public authority, so that the producer is not exposed to any credit risk towards the customers. The calculation of import guarantee fees could be based on the approach of Hermes export guarantees (expense, term, risk)[36].

Securing the offtaker against a potential default (e.g., if a planned pipeline does not become available on time) is conceivable as well, since the buyer of hydrogen or its derivatives will often have to bear high investment costs for converting its (industrial) production processes. However, while reducing the infrastructure risk can significantly increase the attractiveness of hydrogen purchase contracts, the supplier and/or buyer would, in principle, bear the supply volume risk, and the producer, on the other hand, should not be entitled to make use of guarantees in case of self-inflicted default events, as this falls under his (productive) entrepreneurial risk.

Consideration of the instrument for the domestic pillar

While default guarantees have so far been primarily considered in the context of securing imports of hydrogen or its derivatives (i.e., as import guarantees for hydrogen producers in exporting countries), the instrument, in principle, is conceivable as well in the context of de-risking investments in production facilities located in the EU for the domestic production and offtake of hydrogen. Here, default guarantees can play a role in de-risking hydrogen purchase contracts between EU producers and offtakers of hydrogen or its derivatives against specific relevant default events outside the control of the producer and/or the offtaker.

Potential default events to be secured for the domestic production of hydrogen may relate to the non-availability of the required pipeline infrastructure at the time the hydrogen offtake event(s) are set to take place according to the offtake contract. Guarantees could thus provide investment security for the build out of electrolyser capacities, as they take away certain infrastructure risks from private suppliers and offtakers of hydrogen, which is often outside of their control. This enables contractual parties to bet on pipeline-based delivery of hydrogen in the early market phase, while incurring a reduced delivery risk compared to a situation without such guarantees. As a result, guarantees may eventually contribute to accelerating the system-friendly location of electrolysers close to production centres of green electricity that in many cases may be located far away from (industrial) offtake centres, thus requiring the respective infrastructure to connect hydrogen producers and offtakers.

Beyond these specific risks, default guarantees are also able to hedge producers against defaults by the hydrogen offtaker, for example in case the industrial installation is not able to purchase the contractually agreed offtake volumes due to bankruptcy, delay in commissioning or abandonment of the industrial plant.

Consideration of the instrument for the imports pillar

In the context of securing imports from exporting countries outside of the EU, default guarantees for hydrogen (derivative) producers in exporting countries can cover difficult to estimate default and delay risks for private purchase contracts

[36] BMWK (2022), Exportkreditgarantien (sogenannte Hermesdeckungen)

(e.g., delays in commissioning of the required import infrastructure such as import terminals, or the availability of required shipping transport capacities).

Since investors in hydrogen production facilities selling volumes to offtakers in the EU are de-risked to a certain degree, default guarantees can provide competitive advantages over other importing countries, increase planning security for producers in exporting countries, thus contributing to secure the required import amounts for EU Member States. Moreover, the instrument can create a level playing field for EU customers who, besides domestically produced volumes of hydrogen or its derivatives, will also remain dependent on imports, but at the same time will have to compete, for example, with (state-owned) groups abroad with typically higher credit ratings due to, for example, high investments in the conversion of their sites. More generally, default guarantees therefore provide investment security for the required production and export infrastructure abroad and can help accelerate and leverage market activation.

3.3.2 *Assessment of the instrument*

Table 4. Assessment: Default guarantees

Objective/ Criterion	Assessment
A. Effectiveness	– Default guarantees are a support instrument that enable a reduction of investment risks for producers with respect to default risks that are outside their own control, e.g., availability of infrastructure or offtaker/producer default. However, they are not able to close the funding gap between the cost of producing green hydrogen or its derivatives, and the willingness to pay by potential offtakers. They also do not match suppliers and offtakers of green hydrogen in the absence of a liquid market. As a result, default guarantees as a stand-alone instrument would likely not provide sufficient incentives for continuously making available the required hydrogen or hydrogen-based derivative volumes in the EU if implemented as part of the European Hydrogen Bank. In order to be more effective in this regard, they would thus need to be combined with additional support instruments such as double-sided auctions or supply- or demand-side auctions determining market premiums.
B. Cost effectiveness	+ In principle, default guarantees are an efficient support instrument in that they can leverage the hydrogen scale-up by reducing (unproductive) risks outside the direct control of the hydrogen producer. They also entail limited budget uncertainty and little risk of overcompensation for the support giver since payments only arise in case of an actual default event. The primary risk-hedging effect leading to a reduction of financing costs for the investor results from the initial security provided by the public authority. However, the design of default guarantee should ensure that actors are not incentivized to engage in risky transactions, with the government assuming costs in case of a default.

C. Market orientation	+ As a de-risking instrument for bilateral contracts between market participants, default guarantees, in principle, do not provide subsidies or cover price risks. Therefore, the instrument does not distort market price signals or influences decisions of market participants to close bilateral PPAs and HPAs. Market orientation of the instrument can thus be considered high.
D. Low Complexity	0 Compared to the other instruments, default guarantees are relatively straightforward in their design (potentially drawing from established experience with export guarantees) and as a de-risking instrument do not require a regular disbursement of support payments. At the same time, they require the build out of dedicated capacities at the relevant implementing institution to determine default cases and execute guarantees in case of an applicable default event. Especially for imports and varying framework conditions in exporting countries, monitoring, and detecting eligible default events could be relatively complex in some cases.

3.4 Summary of assessment results

The following table provides a summary of the assessment results.

Table 5. Summary: Assessment of design options under the European Hydrogen Bank

Objective	Double-sided auctions for supply and demand contracts	Supply- or demand-side auctions determining market premiums	Default guarantees
Effectiveness	+	0	–
Cost effectiveness	0	+	+
Market orientation	–	+	+
Low Complexity	–	0	0

4. Conclusions

In the initial market ramp-up, public support will be needed to kick-start the uptake of green hydrogen and its derivatives in order to bridge the substantial funding gaps between the production costs and the offtakers' willingness to pay. Support instruments may also be needed to address the significant investment uncertainties in the absence of a liquid market and an extensive transport infrastructure.

At the same time, the degree to which support schemes protect against market risks and cover funding gaps should be proportionate and should ideally be reduced over time as green hydrogen markets become more mature, market uncertainties decrease, and support needs become less marked. Moreover, private market participants should only be hedged against unproductive risks that a public authority can assume more efficiently from an economic perspective to ensure an efficient use of scarce EU funds. This will help prevent over-subsidization. In the longer term, a market-driven hydrogen economy facilitated by the ETS and the CBAM is desirable.[37]

As there are limited EU funds expected, support instruments implemented as part of the European Hydrogen Bank under both the domestic and imports pillar should provide effective incentives for the ramp-up of green hydrogen and its derivatives by bridging the funding gap and providing sufficient investment security. Additionally, support instruments should not take away market risks from private parties so that they can hedge themselves (e.g., through entering bilateral hydrogen purchase contracts). Hedging only the most prominent risks would allow the European Hydrogen Bank to maximize the volumes of green hydrogen, or its derivatives secured through the instrument (i.e., to increase support cost effectiveness per € spent).

Against this background and the results of the previous assessment, the following design choices for the European Hydrogen Bank are advisable:

Supply-side auctions determining market premiums (e.g., fixed premiums) should be considered for the domestic pillar[38]. These instruments offer high support cost effectiveness (e.g., no need to reserve excessive budget) and good market orientation (i.e., need to enter into bilateral contracts). They are also effective (i.e., close the funding gap, implicitly match suppliers and offtakers via bilateral agreements) and are stand-alone, i.e., in principle do not require additional instruments to incentivize the domestic market take-up. Compared to double-sided auctions, supply-side auctions are also easier to implement and administer, especially if combined with fixed premiums per unit of hydrogen produced. For the domestic pillar, they provide a sufficient degree of investment security by closing the funding gap, but do not take away all market risks that domestic investors should be able to assume themselves (e.g., marketing, price and default risks), thus providing a certain degree of market integration that can contribute to the development of an EU hydrogen market in the medium term.

Double-sided auctions offer a higher effectiveness by taking away substantial risks from market participants and providing additional investment security (e.g., by assuming market and default risks). However, in the domestic realm, these risks could also be assumed by market participants themselves, even in the initial market

[37] The planned CBAM ensures that CO2-intensive imports are subject to a carbon price which contributes to a level playing field between imports and domestically produced low-carbon hydrogen (deriatives) in Europe. The parallel phase out of free allowances for EU producers and EU importers also implies more price-based incentives to switch to cleaner production processes for all CBAM-covered goods, incl. use of green hydrogen in steel manufacturing.

[38] Supply-side auctions allow a more direct focus on the build-out of electrolyzer capacities compared to demand-side auctions, and may potentially lead to higher competition levels than demand-side auctions (e.g., few large-scale actors participating in the auctions if limited to industry offtakers). Demand-side auctions are conceptually similar to supply-side auctions in that they allocate support to close the funding gap for green hydrogen (either on the demand- or the supply-side). Therefore, we have discussed supply- and demand-side auctions jointly in section 3. In this final section, we only refer to supply-side auctions as the currently discussed option under the European Hydrogen Bank, but demand-side auctions would in principle be feasible as well.

phases. To implement double-sided auctions substantial funds would have to be reserved for closing the price gap between the longer-term offtake contracts with hydrogen producers and short-term sales contracts with hydrogen consumers, even if this gap is expected to decrease over time. Especially against the background of limited available funding and high initial funding gaps, supply- or demand-side auctions determining market premiums may lead to a more efficient use of EU funds and should thus be considered for the European Hydrogen Bank.

For the imports pillar, double-sided auctions for supply and demand contracts[39] may be considered under certain circumstances. Producers in exporting countries and their offtakers in the EU face higher risks than domestic producers. In particular, default risks for the import of green hydrogen (derivative) volumes are arguably more pronounced compared to the domestic hydrogen production. This is due to larger distance between producers and offtakers, higher political risks in exporting countries, and imported offtake volumes being subject to non-EU regulatory frameworks, as well as the generally higher infrastructure and transport uncertainties for investors (e.g., availability of shipping and import terminals, or, if applicable, cross-border hydrogen pipelines).

As a result, double-sided auctions may initially be especially effective for exporting countries with unreliable regulatory frameworks, or high political and delivery risks, in that they determine and can cover the cost gap between green hydrogen or its derivates and fossil-based alternatives, reduce investment risks (e.g., default and price risks) and match suppliers and offtakers of green hydrogen or its derivatives in the absence of a liquid market. In these contexts, the instrument provides high incentives for continuously making the required hydrogen or hydrogen-based derivative volumes available. In particular, marketing, price, and default risks by the offtaker or producer are largely assumed by the support giver (e.g., no direct contractual relationship between offtaker and producers). However, this also means the instrument can have a complex design, be challenging to implement, and have low market orientation. Overall, double-sided auctions requires that the public intermediary must play a large role, and private risk hedging instruments and alternative marketing routes outside of the support scheme (e.g., bilateral PPAs and HPAs) are not required.

In most cases, supply- side auctions determining market premiums should be considered for the imports pillar. The instrument avoids some of the downsides of double-sided auctions, and under most circumstances allows for a more efficient use of available public funds and stronger market orientation.

Supply-side auctions avoid the high risks and liabilities for the support giver to market the procured volumes, since the intermediary would need to re-sell hydrogen and derivative volumes from long-term purchase contracts with producers, every time shorter-term sales contracts with offtakers expire. The intermediary would also face significant financial risks if producers or offtakers fell short of their commitments, i.e., having to find new offtakers or producers in case of default, or otherwise cover the resulting financial liabilities. To ensure the public intermediary can honour all its commitments, typically more public funds need to be maintained over the period of the long-term supply contract than what may be needed in the end (e.g., due to higher-than-expected willingness to pay from offtakers over time).

The relatively limited funds currently expected for the European Hydrogen Bank (€3 billion) would likely result in limited hydrogen volumes procured through double-sided auctions. Assuming sufficient competition, supply-side auctions determining market premiums minimise euros of support per kg of hydrogen or its derivates secured and can lead to higher cost-effectiveness, while enabling stronger market orientation compared to double-sided auctions. As market participants need to enter into bilateral purchase agreements, marketing and default risks do not need to be assumed by the support scheme. This avoids having to reserve excessive

[39] Please note that double-sided auctions may follow the model of the German H2Global scheme and could classify as a "Europeanization" of the instrument. For more details, see section 3.1.1.

budget amounts to ensure support payments throughout the support period. Moreover, supply-side auctions can, in principle, be designed to prioritize the use of hydrogen by specific (hard-to-abate) demand-sectors, e.g., via corresponding prequalification requirements for bidders.

Default guarantees should be considered as a risk-hedging instrument under the imports pillar to cover difficult to estimate default and delay risks for private purchase contracts involving hydrogen (derivative) imports. In most circumstances, default guarantees would, at least initially, not be used as a stand-alone instrument. Instead, the instrument would have to be combined with instruments that cover existing funding gaps of green hydrogen production and use, such as supply- or demand-side auctions allocating market premiums. In this context, default guarantees can provide additional investment security and increase the effectiveness of direct support to secure imports from outside of the EU. This may be especially helpful for producers in exporting countries with high default risks that private market participants may not be able to hedge against. Default guarantees could help in this case by tapping into additional import potentials that would otherwise remain unused and secure additional import volumes. In this case, the design of default guarantees should ensure that actors are not incentivized to engage in risky transactions, for which the government would have to assume the costs in case of a default.

Independent of potential support auctions organized under the European Hydrogen Bank, default guarantees can also serve as a parallel, stand-alone support instrument for hydrogen producers without funding needs. The instrument could therefore contribute to a parallel market-ramp up with limited public intervention facilitating a self-sustaining hydrogen market, both for domestically produced and imported hydrogen and its derivatives.

5. References

BMWK (2022), Exportkreditgarantien (sogenannte Hermesdeckungen) . Available at: https://www.bmwk.de/Redaktion/DE/Artikel/Aussenwirtschaft/export-kreditgarantien.html, accessed on 7 February 2023.

BMWK (2022), Federal Ministry for Economic Affairs and Climate Action launches first auction procedure for H2Global – €900 million for the purchase of green hydrogen derivatives. Available at: https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2022/12/20221208-federal-ministry-for-economic-affairs-and-climate-action-launches-first-auction-procedure-for-h2global.html, accessed on 7 February 2023.

BMWK (2021), €900 million for H2Global hydrogen project Minister Habeck: Launch of hydrogen economy market ramp-up. Available at: https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2021/12/20211223-900-million-euro-for-h2global-hydrogen-project.html, accessed on 7 February 2023.

Bouacida, Ines and Berghmans, Nicolas (2022), Hydrogen for climate neutrality: conditions for deployment in France and Europe, IDDRI. Available at: https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Etude/202201-ST0222-hydrogen.pdf, accessed on 7 February 2023.

Collins, Leigh (2022), 'Europe is never going to be capable of producing its own hydrogen in sufficient quantities': EU climate chief, Recharge. Available at: https://www.rechargenews.com/energy-transition/europe-is-never-going-to-be-capable-of-producing-its-own-hydrogen-in-sufficient-quantities-eu-climate-chief/2-1-1212963, accessed on 7 February 2023.

European Commission (2023), A Green Deal Industrial Plan for the Net-Zero Age. Available at: https://commission.europa.eu/system/files/2023-02/COM_2023_62_2_EN_ACT_A%20Green%20Deal%20Industrial%20Plan%20for%20the%20Net-Zero%20Age.pdf, accessed on 7 February 2023.

European Commission (2022), Competitive Bidding under the Innovation Fund, Stakeholder Consultation. Available at: https://climate.ec.europa.eu/system/files/2022-11/event_20221121_workshop_presentations_en.pdf, accessed on 7 February 2023.

European Commission (2022), REPowerEU Plan, SWD(2022) 230 final. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0001.02/DOC_1&format=PDF, accessed on 7 February 2023.

European Commission (2020), A hydrogen strategy for a climate-neutral Europe. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0301&from=EN, accessed on 7 February 2023.

ICAP (2022), EU reaches landmark provisional agreement on ETS reform and new policies to meet 2030 target. Available at: https://icapcarbonaction.com/en/news/eu-reaches-landmark-provisional-agreement-ets-reform-and-new-policies-meet-2030-target#:~:text=On%2018%20December%202022%2C%20the,reform%20of%20the%20EU%20ETS, accessed on 7 February 2023.

H2Global Stiftung (2022), 900 million euros for the market ramp-up of green hydrogen. Available at: https://www.h2global-stiftung.com/post/900-million-eur-market-ramp-up-green-hydrogen, accessed on 7 February 2023.

Heinemann, Christoph. and Mendelevitch, Roman (2021), Sustainability dimensions of imported hydrogen. Oeko-Institut Working Paper 8/2021. Available at: https://www.oeko.de/fileadmin/oekodoc/WP-imported-hydrogen.pdf, accessed on 7 February 2023.

Hydrogeninsight (2022), European Hydrogen Bank will close '100% of the cost gap' between renewable and fossil hydrogen as soon as 2023, but shadow of US tax credit looms. Available at: https://www.hydrogeninsight.com/policy/european-hydrogen-bank-will-close-100-of-the-cost-gap-between-renewable-and-fossil-hydrogen-as-soon-as-2023-but-shadow-of-us-tax-credit-looms/2-1-1341703, accessed on 7 February 2023.

Kurmayer, Nikolaus (2022), Scholz ups global hydrogen ambitions, dwarfs EU initiative, Euractiv. Available at: https://www.euractiv.com/section/energy-environment/news/scholz-ups-global-hydrogen-ambitions-dwarfs-eu-initiative/, accessed on 7 February 2023.

Lohmann, Heiko (2022): H2-Global startet Beschaffung von grünem Ammoniak. Energate messenger, 8 December 2022, accessed on 7 February 2023.

Piria, Raffaele, Jens Honnen, Benjamin Pfluger, Falko Ueckerdt, and Adrian Odenweller (2022), Securing hydrogen imports for Germany: Import needs, risks and strategies on the way to climate neutrality, Ariadne. Available at: https://ariadneprojekt.de/media/2022/03/Ariadne-Analysis_Securing-hydrogen-imports_February2022.pdf.

Van Wijk Ad, Kristen Westphal, and Jan Frederik Braun (2022), How to deliver on the EU Hydrogen Accelerator, H2Global Foundation. Available at: http://files.h2-global.de/H2Global_How-to-deliver-on-the-EU-Hydrogen-Accelerator.pdf, accessed on 7 February 2023.

H2Global Foundation (2022), H2Global – Idea, Instrument and Intentions, Policy Brief 01/2022. Available at: http://files.h2-global.de/H2Global-Stiftung-Policy-Brief-01_2022-DE.pdf, accessed on 7 February 2023.

Von der Leyen, Ursula (2022), State of the Union Address 2022. Available at: https://state-of-the-union.ec.europa.eu/system/files/2022-09/SOTEU_2022_Address_EN.pdf, accessed on 7 February 2023.

Wietschel, Martin, Anke Bekk, Barbara Breitschopf, Inga Boie, Jakob Edler, Wolfgang Eichhammer, Marian Klobasa, Frank Marscheider-Weidemann, Patrick Plötz, Frank Sensfuß, Daniel Thorpe, and Rainer Walz (2020), Opportunities and challenges when importing green hydrogen and synthesis products, Fraunhofer ISI Policy Brief 03/2020. Available at: https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2020/policy_brief_hydrogen.pdf, accessed on 7 February 2023.

Zawh Tareq, Jaap Peterse, Matthias Schimmel, and Jan Cihlar (2022), Facilitating hydrogen imports from non-EU countries, Gas for Climate and Guidehouse. Available at: https://gasforclimate2050.eu/wp-content/uploads/2022/10/2022_Facilitating_hydrogen_imports_from_non-EU_countries.pdf, accessed on 7 February 2023.