Onderzoek noodzaak rol overheid bij opschaling importketens voor waterstof

Opgesteld voor:

Ministerie van Economische Zaken en Klimaat

Ingediend door
Guidehouse Netherlands B.V.
Stadsplateau 15
3521 AZ Utrecht
+31 30 662 3300
guidehouse.com

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Samenvatting voor beleidsmakers

Bij de transitie van het Nederlandse energiesysteem zal waterstof, in aanvulling op electrificatie, een belangrijke rol spelen. Om de Nederlandse en Europese klimaatdoelstellingen te realiseren, industrie te behouden, en om voorzieningszekerheid te bieden is het importeren van waterstof (dragers) noodzakelijk in aanvulling op binnenlandse waterstof productie. Om deze import te realiseren is echter wel nog een versnelde opschaling van de waterstof import waardeketen benodigd.

In deze opdracht is door middel van stakeholder interviews: 1) geïnventariseerd wat huidige barrières zijn die deze keten ervan weerhouden om op te schalen, en; 2) in kaart gebracht wat een adequate rol van de overheid zou zijn, en welke beleidsinstrumenten het meest effectief zouden zijn in het overkomen van de barrières die een overheidsinterventie nodig hebben. Hiervoor zijn 23 partijen geïnterviewd die actief zijn door de gehele waterstof import waardeketen.

Tabel 1 geeft een overzicht van de vier hoofdbarrières die naar voren zijn gekomen. Dit zijn de meest impactvolle barrières, die elk een aggregatie van meerdere ervaren barrières zijn: 1) onzekerheid in lange termijn afname; 2) onzekere visie en beleid en afstemming met buurlanden; 3) onzekere uitwerking van wetgeving, instrumenten en certificatie, en; 4) een mismatch in tijdlijnen van instrumenten en projecten. In de tabel is ook opgenomen op welk deel van de waterstof import waardeketen het zwaartepunt van de impact van de barrière ligt. Hiervoor is de waardeketen verdeeld in drie delen: productie, export & transport (fysieke assets in het exporterende land); handelsstromen (contracten, handelsrelaties); en import & vraag (fysieke assets in Nederland). Ook is een indicatie van het type marktfalen gegeven, waar eventueel overheidsingrijpen door verantwoord kan worden.

Tabel 1: Overzicht van de hoofdbarrières, hun impact per deel van de waardeketen, en het type marktfalen.

Hoofdbarrière	Longlist barrières	Waardeketen impact			Marktfalen
		Productie, export & transport	Handels-stromen	Import & vraag	
1. Onzekerheid in lange termijn afname	- Toekomstige waterstof kosten en prijs zijn onzeker - Onvoldoende leveringszekerheid - Onvoldoende ruimte voor additionele kosten - Waterstofdragers zijn divers en onzeker	Gemiddeld	Gemiddeld	Hoog	Vraag articulatie falen
2. Onzekere visie en beleid, afstemming met buurlanden	- Industriepolitiek en toekomst mogelijkheden onzeker - Afstemming in beleid met buitenland - Gebrek aan veiligheidsruimte voor ammoniak	Laag	Hoog	Hoog	Directiona-liteitsfalen & beleids-coordinatie falen
3. Onzekere uitwerking en implementatie van wetgeving, instrumenten en certificatie	- Energie en gas regulering op waterstof onzeker - Certificatie onduidelijk - Vergunningsprocessen moeilijk	Gemiddeld	Gemiddeld	Hoog	Institutioneel falen (& reflexiteits falen)
4. Mismatch in tijdlijnen van instrumenten en projecten	- Spanning subsidie en project tijdlijnen - Strenge en tijdrovende voorwaarden en aanvraagprocessen - Gebrek aan lange termijn zekerheid van afname	Laag	Gemiddeld	Gemiddeld	(Mild) institutioneel falen

Naast de ervaren barrières, kwam uit de interviews naar voren dat de marktpartijen de overheidsinzet op handelsrelaties en energiediplomatie en de deelname aan het H2Global mechanisme als positief ervaren. Het is dus aan te bevelen om deze voort te zetten.

Om de hoofdbarrières in de opzet van waterstofimporten te verlagen, zijn de volgende vier hoofdaanbevelingen voor de overheid geformuleerd.

Als eerste kan additionele ondersteuning voor waterstofimport het best gefocust worden op de vraagzijde. Een sterke waterstofvraag kan vervolgens de andere delen van de importketen op gang trekken (o.a. doordat producenten lange termijn contracten met afnemers nodig hebben). Aangezien er op dit moment veel onzekerheid heerst aan de vraagzijde (bijvoorbeeld onvoldoende ruimte in de markt voor het compenseren/terugverdienen van extra kosten bij gebruik van hernieuwbare waterstof), kan overheidsingrijpen de vraag op gang helpen.

Ten tweede is het belangrijk beleidsinstrumenten pragmatisch, simpel en flexibel te houden. Aanspraak krijgen tot huidige instrumenten vergt vaak veel tijd, soms al aanzienlijke investeringen, en het voldoen aan vele criteria, allemaal al op een vroeg punt in projectprocessen. Dit maakt dat het lastig is om een importproject gerealiseerd te krijgen. Door in de huidige vroege marktfase voor waterstofimporten een pragmatischere aanpak te kiezen kunnen meer partijen meedoen en kunnen projecten sneller van de grond komen. Overheidsinstrumenten kunnen vervolgens meegroeien met de markt, bijvoorbeeld door in de loop der tijd strengere eisen te gaan stellen.

Ten derde zou het direct gebruik van specifieke waterstofdragers, waar mogelijk, gestimuleerd moeten worden. In het geval van bijvoorbeeld ammoniak import, is het verstandiger om deze ammoniak direct te gebruiken in plaats van het terug kraken naar waterstof. Op deze manier kunnen de kosten lager gehouden worden en kan de op dit moment nog niet volledig volwassen kraaktechnologie vermeden worden.

Als laatst is het voor doorvoermogelijkheden noodzakelijk om waterstof import beleid af te stemmen met ander binnenlands beleid en met importbeleid van buurlanden. Op deze manier kan er voor gezorgd worden dat infrastructurele keuzes elkaar accomoderen.

Bij deze beleidsaanbevelingen worden vier mogelijke beleidsinstrumenten als voorbeeld gegeven: het uitbreiden en versterken van de deelname in H2Global, Carbon Contracts for Difference, opname van importen in lange termijn visies voor energie en industrie, en de implementatie van internationale standaarden. Hierbij ligt een rol voor de overheid en politiek om te bepalen welk beleidsinstrument en budget, gewenst, haalbaar en gepast is om de import waardeketen voor waterstof te versnellen.

1. Introduction

Complementing electrification, hydrogen is expected to play a key role in decarbonizing the Dutch energy system. In order to achieve climate targets, maintain industry and provide security of supply, there is a role for imports of hydrogen (carriers) in addition to domestic hydrogen production. In this regard, a timely development of hydrogen import value chains is required so imports can be delivered to the market in the required volumes and timelines.

1.1 Hydrogen roles & instruments

Achieving the climate goals set by the EU and the Dutch government requires a transition towards a net-zero energy system. To achieve an efficient net-zero future energy system, goals are set for creating and including a well-functioning hydrogen sector. In this future system, hydrogen can fulfil more roles in the energy system and as industrial feedstock, than it does today. These potential new roles include energy system roles, such as long-distance transport of energy (transmission), long-term energy storage, as balancing mechanism between energy markets (e.g. between electricity markets) and as option for decarbonisation of hard-to-abate sectors (e.g. for high temperature heat or feedstock).[1]

The Dutch government currently has multiple instruments in place that support the development of the hydrogen sector (e.g. via IPCEI[2] state-aid approval[3]). For the entire hydrogen sector combined, the monetary value of these instruments adds up to about 10 billion euros.[4] The largest share of these budgets focuses on hydrogen production. On the hydrogen demand side, multiple European policy initiatives are introduced that set obligations for shares of renewable hydrogen to be used. For the industry sector, REDIII sets a target of 42% RFNBO (Renewable Fuels of Non-Biological Origin) contribution to hydrogen use by 2030 and 60% by 2035. Within the transport sector, ReFuelEU Aviation sets RFNBO targets for aviation (gradually increasing from 2025 to 2050), and the REDIII also includes an aim for RFNBO use in the maritime sector (1.2% by 2030). Policy developments that target hydrogen imports are further detailed in Section 2.3.

1.2 Hydrogen import

A well-functioning hydrogen sector contains matching supply and demand sides, regardless of the exact roles and volumes of the future hydrogen sector. Supply of hydrogen could be from domestic production or imports. In recognition of supply diversification and limitations on domestic supply, the Dutch government has acknowledged the need for hydrogen imports in addition to domestic supply. Hydrogen imports supplement the limitations of domestic production, improve diversity of supply and can potentially reduce costs.[5]

Multiple scenario studies conclude that next to domestic hydrogen production in the Netherlands also hydrogen imports will be required. The II3050 system study for example considers 10 to 40 TWh of hydrogen imports for 2035 and 50 to 150 TWh for 2040 (including transit flows).[6] Furthermore, two major ports in the Netherlands (Port of Rotterdam & Port of Amsterdam) have import plans that add up to 5 Mton (±200 TWh_{HHV}) of hydrogen by 2030.[7] The Port of Rotterdam specifically positions itself as a future main European hydrogen import hub, having signed more than 20 agreements regarding

[1] CIEP. 2019.**Van onzichtbare naar meer zichtbare hand**.

[2] Rijksoverheid. 2022. **Zeven grote waterstofprojecten in Nederland krijgen subsidie voor elektrolyse.**

[3] European Commission. 2023. **State aid: Commission approves €246 million Dutch scheme to support renewable hydrogen production**.

[4] NWP. 2023. Confidential.

[5] Letter to parliament, Energiediplomatie en import van waterstof, 2 June 2023

[6] Netbeheer Nederland. 2023. **Het energiesysteem van de toekomst: de II3050-scenario's**.

[7] IEA. 2022. **Northwest European Hydrogen Monitor**.

cooperation on hydrogen routes with international counterparts.[8] On a European level, the REPowerEU package has set the ambition for 2030 to establish hydrogen imports of 10 Mton per year, in parallel with 10 Mton per year domestic production.

While globally an estimated 12 Mton of hydrogen could be exported per year (based on project announcements), at this moment more than 80% of that volume has no defined off-taker yet[9]. This shows that even though imports are desired, they are not yet materializing. This indicates a potential need for additional policy support.

1.3 Goal, methodology and structure of this study

The goal of this study is twofold: 1) the first aim is to get a better understanding of the international hydrogen import value chain and specifically what the current barriers are that prevent this chain from upscaling; 2) subsequently, the second aim is to determine the required government role and explore related policy options with respect to these barriers.

The approach started with desktop research, addressing literature and online webpages to establish an overview of current developments in the hydrogen export and import value chain. These findings fed into the stakeholder consultation (in the form of targeted interviews), which is the main information source in this study.

To identify the barriers and policy options in setting up the hydrogen import value chain, a series of interviews with parties active in the different parts of the value chain has been conducted. Twenty-three market parties have been interviewed for this project. Appendix A provides a list of all these stakeholders. Collectively, the interviewed parties cover the entire hydrogen import value chain and include commercial, industry association, non-governmental and academic/research parties. Through both balancing the interviews with parties across the value chain (i.e. avoiding overrepresentation of certain types of parties or certain parts of the value chain) and the number of interviews, a balanced insight in the barriers the parties encounter is safeguarded.

For the interviews a general interview guide was used to provide structure (see 5.3.4Appendix B), which covered the overarching topics of hydrogen import barriers and policy options. However, the interview guide is generic, while different types of stakeholders experience different barriers and perform different activities. Therefore, a semi-structured interview approach was taken, and every interview resulted in a different - stakeholder-specific - focal point.

The following chapter (Chapter 2) describes the hydrogen import value chain and outlines current hydrogen import policy developments. Chapter 3 provides an overview of policy options and defines a theoretical framework for government intervention. Then, Chapter 4 introduces the interview insights regarding current barriers that are experienced by stakeholders in the value chain. Lastly, Chapter 5 specifies policy recommendations that can support in overcoming the identified barriers for hydrogen imports.

[8] IEA. 2022. **Northwest European Hydrogen Monitor**.
[9] IEA. 2022. **Northwest European Hydrogen Monitor**.

2. Hydrogen import value chain

Realisation of hydrogen imports requires the development of a value chain that spans multiple countries. In order to properly assess the development of this value chain, to identify barriers and to propose potential policy instruments, first the required technologies are briefly referred to (Section 2.1). Next, the value chain is introduced and split into three parts as analysis structure (Section 2.2) and lastly an overview of existing policies is presented (Section 2.3).

2.1 Technologies for hydrogen import

There are multiple technology options which can be deployed to realise hydrogen imports. While this project approach is technology agnostic, it is acknowledged that the barriers or impact of policy instruments can differ between the technologies. An assessment of safety, technology readiness, energetic efficiency or costs of the technologies is beyond the scope of this work, and numerous sources are available for this.[10]

The potential hydrogen import technologies within the scope of this project are:

- Ammonia (NH_3): Conversion of hydrogen into ammonia through the Haber-Bosch process with consecutive storage and shipping of liquefied ammonia. Imported ammonia can be directly deployed as feedstock, fuel, or reconverted to pure hydrogen by cracking.

- Liquefied hydrogen (LH_2): Reduction of the volume of pure hydrogen by liquefaction through cooling. Liquid hydrogen can be stored, transported, and regasified once imported.

- Liquid Organic Hydrogen Carriers (LOHCs): LOHCs are carrier molecules to which hydrogen can be bonded (hydrogenation) at the hydrogen production location. The carrier can be stored, transported and hydrogen can be released from the carrier (dehydrogenation) at the desired location. The carrier molecule can be reused in a hydrogenation-dehydrogenation cycle.

- Methanol, synthetic methane, other hydrocarbons: conversion of hydrogen and a carbon source into methanol, synthetic methane or other hydrocarbons, which can be stored, transported, and used as feedstock, fuel or reconverted into hydrogen.

- Pipelines: transmission of (relatively) pure, gaseous hydrogen through pipelines, similar to today's natural gas transmission systems. Current hydrogen import projects in the Netherlands are predominantly considering imports through the four technologies listed above, therefore this analysis applies a similar focus. However, pipeline hydrogen imports are a feasible option and under development. Pipelines are most attractive for intra-European transport, and pursued in for example the European Hydrogen Backbone initiative. National governments can have a great impact in supporting development of cross-border hydrogen pipelines. However, due to long lead times most impact of pipeline imports is expected past 2030, while other import technologies are better placed to for creation of import value chains in the shorter term already.

[10] This includes for example techno-economic analyses by **the EU Joint Research Centre**, the International Energy Agency in the annual **Global Hydrogen Review**, or **health and safety assessments** of transport and storage of hydrogen (carriers).

2.2 Hydrogen import value chain

To realise hydrogen imports, an entire value chain comprising physical assets, business relations, legal arrangements, financial contracts, and certification agreements, needs to be in place (Figure 1).

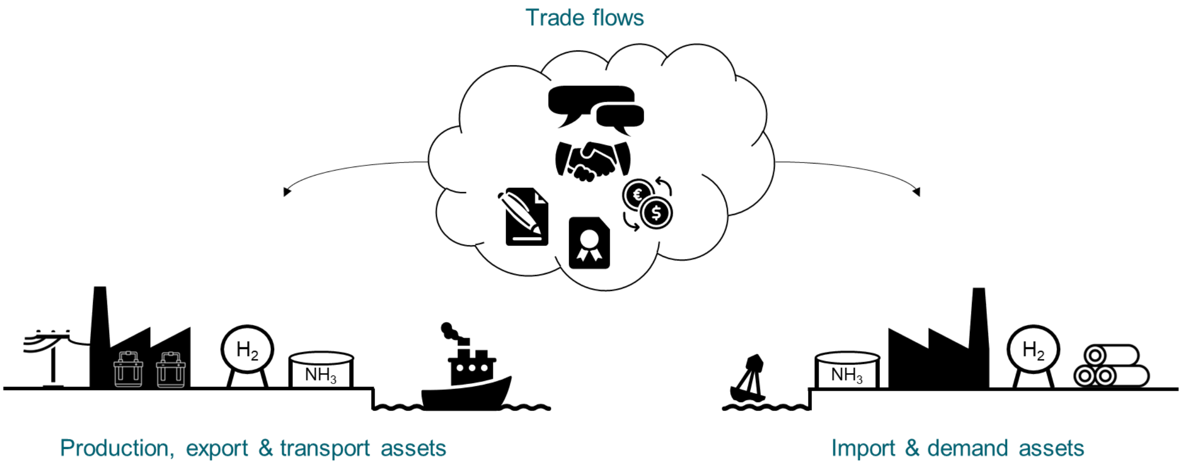


Figure 1 - Hydrogen import value chain

Each component of this value chain is critical, as the functioning of the entire value chain is hindered if one component is missing or dysfunctional. To structure the analysis of the barriers to imports and potential policy instruments for acceleration of the development of this value chain, the value chain is split into three parts, (1) the production, export and transport assets, (2) trade flows and (3) the import and demand assets.

2.2.1 Production, export and transport assets

This part of the value chain comprises all physical installations and transportation assets outside of the Netherlands which are required to supply hydrogen to the Netherlands. This includes for example hydrogen production (electrolysis or low-carbon), conversion facilities (e.g. ammonia plants, hydrogenation plants in case of LOHCs, or liquefaction), storage facilities for hydrogen and hydrogen carriers, export terminals and hydrogen (carrier) vessels.

This part of the value chain is required to ensure sufficient supply of hydrogen to the international market (market liquidity). Barriers to hydrogen import and exports can decrease or delay the build-up of export capacity in third countries. This limits supply and potentially increases prices of imported hydrogen. Build-up of sufficient export and transport capacity is the goal of import policy instruments interacting with this part of the value chain.

Figure 2 - Value chain export assets

2.2.2 Trade flows

The trade flows part of the value chain does not comprise physical assets, but of relationships, agreements, and arrangements. This includes for example trade relationships, securing supply, access to (intellectual) property rights for technology and project site development, financial agreements, and insurance. National policies concerning activities of Dutch businesses in third countries are also included in this part of the value chain. This includes for example the international responsible business conduct requirements.[11] International trade rules and tariffs are included in this part of the value chain as well. Trade can be initiated on the back of pre-existing relationships and business presence, for example in fossil energy, feedstock or product markets. Alternatively, new trade relations can be started through for example matchmaking programs or bidding processes in which the highest bidder can win new contracts.

The proper development of this part of the value chain is required to ensure reliable build-up and operation of the physical assets and direction of a share of the traded volumes towards the Netherlands (security of supply). Barriers in this part of the value chain can result in insufficient investments in the build-up of the other two value chain parts or of direction of traded volumes to countries of destination other than the Netherlands. Governments have a large role to play in providing an international trade environment in which hydrogen trade can flourish. This includes the transitioning of trade rules for hydrogen from feedstock to also regard hydrogen for energy trade.[12] Capturing, directing and maintaining an appropriate level of hydrogen flows towards the Netherlands to ensure security of supply is the goal of import policy instruments interacting with this part of the value chain.

Trade flows

Intangible and financial assets, comprising
- Certification schemes
- Security of supply
- Financial agreements, insurance, etc
- IP and property rights
- International responsible business conduct laws
- International trade rules and tariffs

Figure 3 - Value chain trade flows

2.2.3 Import and demand assets

The import assets part of the value chain comprises physical assets again. Some of these are similar to those required in the export part of the value chain, such as terminals and storage. Others are the reverse to those required in the export part of the value chain, in particular conversion assets for regasification, cracking and dehydrogenation. Additional assets to forward the imported hydrogen to final consumers are required as well, such as connections to pipeline infrastructure or barge transport terminals. Some of these assets require to be purpose-build while others could potentially be converted existing assets.

This part of the value chain is required to ensure feasibility of imports and transit flows. Barriers for import assets could result in insufficient import capacity or a mismatch between import capabilities and the demand location and carrier type (e.g. a scenario in which a demand for gaseous hydrogen exists while ammonia is imported without a cracker for reconversion being available). Enabling the physical import, storage, potential conversion and transmission and distribution to final demand is the goal of import policy instruments focused on this part of the value chain.

[11] Such as those set by the law for ‘Internationaal Maatschappelijk Verantwoord Ondernemen’ (IMVO).

[12] Issues and considerations regarding international trade rules for hydrogen are for example considered by the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) in a **2022 report**.

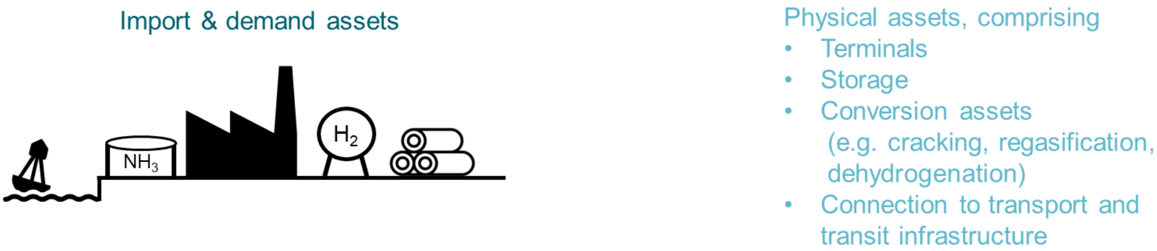


Figure 4 - Value chain import assets

2.3 Current hydrogen import policy developments

Hydrogen imports are a topic under considerable governmental influence and legislative pressure, given the future role of hydrogen in energy imports, global trade rules and tariffs. Additionally, sourcing of hydrogen also occurs from regions with potential sensitivities around water scarcity, renewable electricity scarcity or human rights issues. This could lead to increased regulation of current chemicals or feedstock trade such as ammonia in case this would become regulated as energy trade. Within this context, hydrogen import support and development is already actively pursued by the Dutch governments through various initiatives, policies, and agreements, acting on all three parts of the hydrogen import value chain (Figure 5).

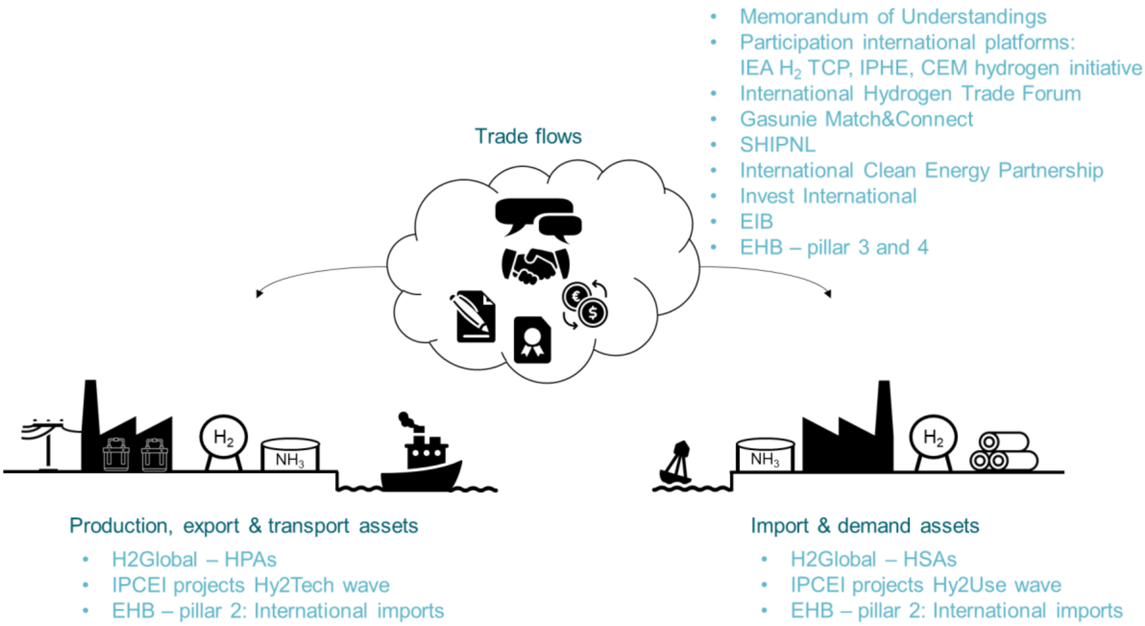


Figure 5 - Hydrogen import support mechanisms and organizations by the Dutch government (direct or indirect) acting on the three parts of the import value chain

Trade flows are strengthened by the government through Memoranda of Understanding (MoUs) on hydrogen with multiple countries (Figure 6). The Dutch government has signed 15 bilateral MoUs, while there are 6 MoUs on hydrogen in place between the EU and third countries. Next to these MoUs on (pan)national level, there is a multitude of MoUs signed by the ports of Rotterdam, Amsterdam, North Sea Port (Zeeland) and Groningen Seaports with commercial parties and (local) governments in exporting countries. Notable examples include the setting up of hydrogen corridors between Bilbao and Masdar to the port of Amsterdam[13] and between Spain and Namibia to the Port of Rotterdam[14].

[13] **MoUs signed** between the port authorities, governments and commercial parties.

[14] **MoUs signed** between the port authorities, governments and commercial parties.

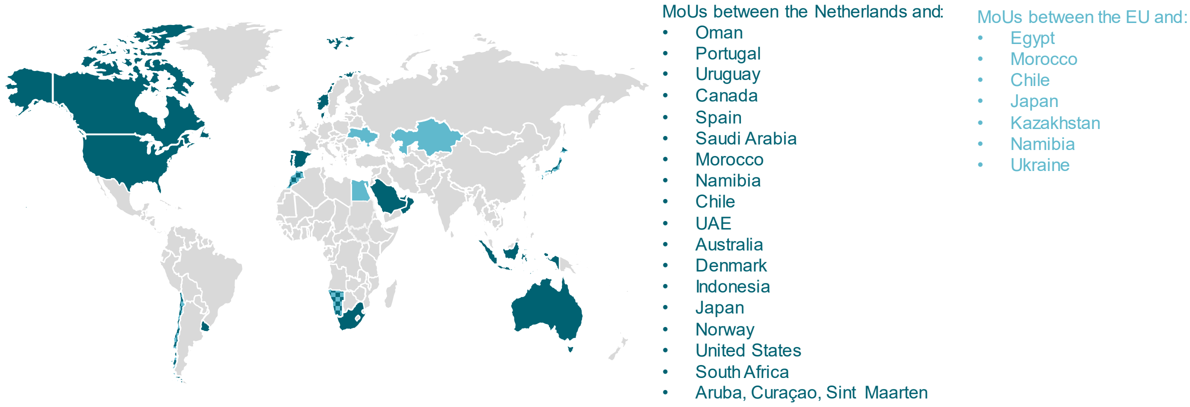


Figure 6 - Memoranda of Understanding on hydrogen[15]

Energy diplomacy and international relations on hydrogen are further strengthened on multiple intergovernmental and trade platforms. This includes participation of the Netherlands on intergovernmental platforms such as the IEA's Hydrogen Technology Collaboration Platform (TCP), the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) or the Clean Energy Ministerial (CEM) Hydrogen Initiative. Amongst others, this has resulted in the creation of a policy development and matchmaking platform for governments in the form of the International Hydrogen Trade Forum.[16]

Additionally, hydrogen imports are boosted through various semi-governmental programmes, (semi-) government agencies and companies in which the state is a stakeholder. This includes the Match&Connect[17] matchmaking platform by Gasunie, the knowledge platform Sustainable Hydrogen Import Programme Netherlands (SHIPNL)[18], promotion of hydrogen trade in the International Clean Energy Partnership[19], and investments through funds created and managed by Invest International[20].

On top of this, multiple policy instruments are created or supported by the Dutch government to accelerate and support hydrogen imports. The most notable instrument to support imports is the EUR 300 million participation of the Netherlands in the H2Global Instrument, which offers both supply and demand side contracts for difference (CfD) through the Hintco subsidiary. Hydrogen suppliers are guaranteed offtake for a fixed price through ten-year Hydrogen Purchase Agreements (HPA), while hydrogen off-takers are guaranteed supply for a fixed price through one-year Hydrogen Service Agreements (HSA).

In addition, the Dutch government has submitted and is supporting multiple hydrogen production, transport and use projects within the EU Important Projects of Common European Interest (IPCEI) framework.[21] When receiving IPCEI status, projects are eligible for increased state support which would otherwise be prohibited under state aid rules.

[15] Sources: **Nationaal Waterstof Programma** (Dutch MoUs), own research (MoUs Aruba, Curacao, Sint Maarten, EU)

[16] **Launch of the International Hydrogen Trade Forum** in July, 2023.

[17] **Match&Connect** is "an online environment where industrial hydrogen stakeholders can meet and find an appropriate supply or demand match".

[18] **SHIPNL** is created withing the National Hydrogen Platform and designed by the Ministry of Economic Affairs and Climate Policy and research organization TNO.

[19] **ICEP promotes hydrogen** trade managed by the Netherlands Enterprise Agency RVO.

[20] Invest International is a joint-venture from the Dutch state and development bank FMO, resulting in e.g. a **hydrogen investment fund aimed at South Africa**.

[21] The first two **IPCEI hydrogen** waves, 'Hy2Tech' and 'Hy2Use', are published. The third 'Hy2Infra' wave is expected end 2023, the fourth 'Hy2Move' beginning of 2024.

3. Policy options

Many tools, instruments and policies are available to policy makers to support hydrogen imports. However, before deploying any of these it is required to reflect on the necessity and justification of government intervention. In this chapter, a theoretical framework to screen on justification of intervention is provided (Section 3.1). This is supplemented with a longlist of potential policy instruments (Section 3.2) and an overview of import policies in neighbouring countries (Section 3.3) to provide context.

3.1 Theoretical framework for government intervention

The development of the hydrogen import value chain is currently not at the pace required to reach the desired capacity. Not achieving a proper hydrogen import value chain would endanger the transformation of the energy system, negatively impacting the realisation of the energy targets and overarching climate policy targets. In innovation policy theory, a new addition to market- and systems failure is that failure of markets to transform themselves to respond to grand societal challenges like climate change can be classified as transformational failure. Similar to market failure and systems failure, such transformational failure justifies government intervention.[22,23] Therefore, from a high-level perspective, accelerating the development of hydrogen import value chains through policy interventions to support reaching energy and climate targets can be justified as it helps avoiding transformational failure (Figure 7).

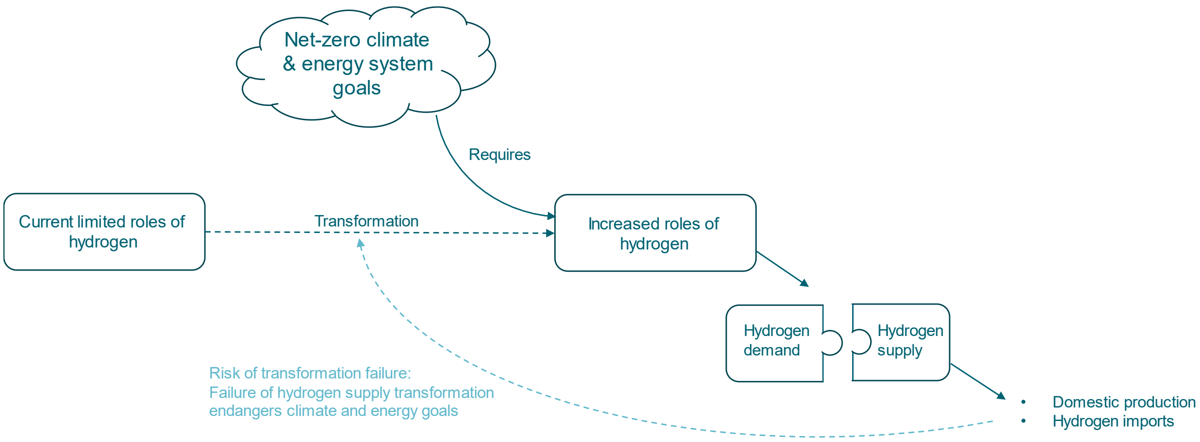


Figure 7 - Potential of transformational failure of underdeveloped hydrogen imports

While this argumentation establishes why policy interventions in the creation of hydrogen import value chains is justified, it does not distinguish between which policy interventions are justified to be implemented. The policy interventions must match the barriers the market parties encounter to help overcome these effectively, as well as be suitable for the current phase of development of the import value chain. At the same time, not all potential barriers warrant intervention in case markets could overcome some barriers themselves, as inefficient spending of public resources and overly distorting markets must be avoided.

For the determination of barriers of creation of hydrogen import value chains, in this analysis a systems perspective is applied. In the value chain (Section 2.2), the different actors and subsystems are interacting to deliver the hydrogen imports. Innovation policy theory argues that from this systems perspective the key barriers for innovation can be determined, on which other frameworks can be

[22] Ministerie van Economische Zaken, **Sturen in een verweven dynamiek**, 2017

[23] Weber and Rohracher, **Legitimizing research, technology and innovation policies for transformative change**, 2012

applied to determine if intervention for these is justified.[24] The arguments of market failure, systems failure and transformational failure can be applied for this (Figure 8).

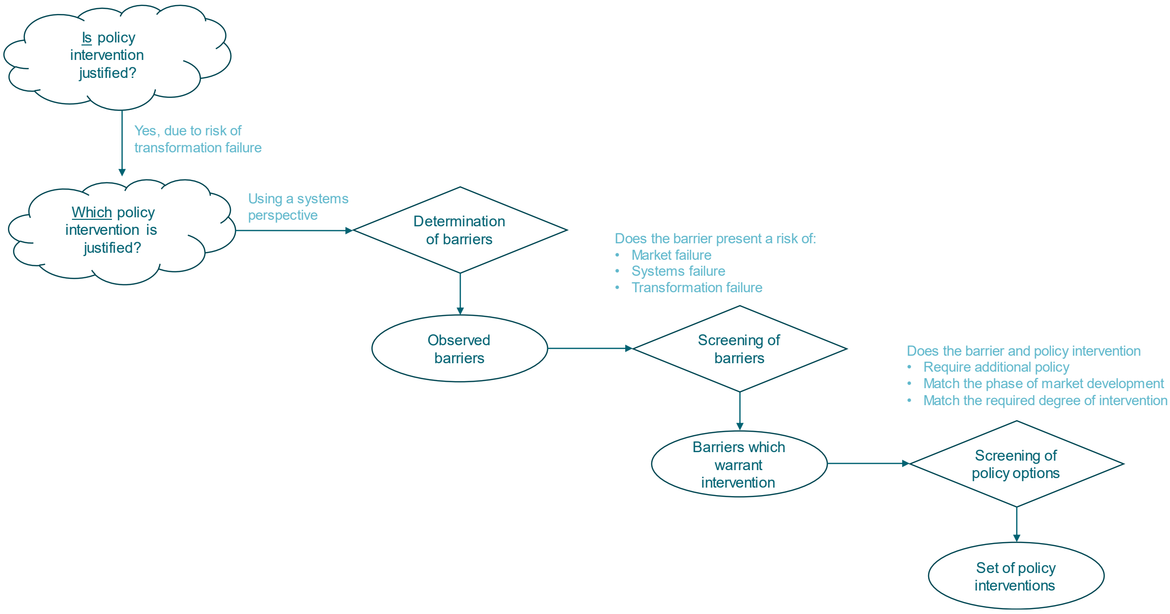


Figure 8 - Screening of observed barriers on justification for policy interventions

Within the frameworks of market, systems and transformative failure, different types and mechanisms of failure can be distinguished (Table 1). These can be used as filters for each barrier to determine if policy intervention is legitimized. If this is the case, the next step is to determine the appropriate policy instrument. To filter on intervention legitimacy, it first must be established if the barrier cannot be addressed with current or expected policies for development of the hydrogen sector, in other words, if additional policy is required. This includes both generic instruments which are agnostic to if the hydrogen is imported or domestically produced, and instruments which are specifically aimed at hydrogen imports. In case additional policy is warranted, the potential new policy instrument should be applicable for the phase of market development of the hydrogen import value chain.[25] For example, what could be efficient instruments for mature markets could be a barrier in the current nascent market of hydrogen imports (and which would then be an institutional failure). For instance, market regulation which is appropriate for mature and liquid markets, could be too strict and suffocating for developing markets. Also, the intended policy instrument must match the required degree of intervention, to prevent unnecessary market distortion.

[24] Dialogic, **Innoveren en ondernemen met beleid**, 2015, Section 2.2

[25] H2Global Stiftung, Policy brief 04/2023, **Hydrogen and market 'ramp-up' – phases and target models**, 2023

Table 1: Overview of failures in the context of transformative change[26]

Failure frameworks	Types of failure	Short description
Market failures	• Information asymmetries • Knowledge spill-over • Externalization of costs • Over-exploition of commons	○ Undersupply of funding for R&D by uncertainty about outcomes and short time horizons of private investors ○ Sub-optimal investment by public good character of knowledge ○ The possibility to externalize costs leads to innovations that can damage the environment or other social agents ○ Over-using of public resources in absence of institutional rules (tradegy of the commons).
Structural system failures	• Infrastructure failure • Institutional failures • Network failure • Capabilities failure	○ Lack of physical and knowledge infrastructures ○ Absence, excess or shortcomings of formal institutions ○ Too stong networks can lead to lock-in, too weak networks can limit interaction and knowledge exchange ○ Lack of appropriate competencies and access to resources
Transformational system failures	• Directionality failure • Demand articulation failure • Policy coordination failure • Reflexivity failure	○ Lack of a shared vision regarding the goal and directoin of the transformation ○ Insufficient anticipation and learning about user needs for uptake, lack of demand-articulation and stimulating signals. ○ Lack of multi-level policy coordination across different systemic levels ○ Insufficient ability of the system to monitor, anticipate and involve actors in processes of self-governance

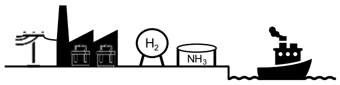
3.2 Longlist policy instruments for intervention

Various types of policy instruments are available to the Dutch government to incentivise specific parts of the hydrogen import value chain. Table 2 presents a wide range of policy instruments that can be operationalised, categorized along the three value chain parts of production, export and transport, trade flows, and import and demand.

Both the export and the import and parts of the value chain can be incentivized by subsidies and CfD’s to mitigate price risks and thereby improve business cases of the supplying as well as off-taking parties. Regular long-term contracts with a fixed price bring about a two-sided price risk. Suppliers have the risk to settle for a too low price, whereas off-takers have the risk to settle for a too high price. A CfD offers more flexibility, by agreeing on a reference price and comparing that with a benchmark price. This mitigates the risk of being unable to capture future price declines for the off-taker, while still supplying price certainty to the supplier. Furthermore, foreign trade and investments could be promoted by providing financial guarantees, while Dutch investment and development banks could also invest in hydrogen export projects abroad. R&D support can be targeted towards hydrogen conversion and transport technologies that are still of insufficient technology readiness level (TRL) or requires scaling up to industrial size (e.g. ammonia cracking, LH2 transport).

[26] Weber and Rohracher, **Legitimizing research, technology and innovation policies for transformative change**, 2012

Table 2: Various policy options per value chain part

 **Production, export & transport**	 **Trade flows**	 **Import & demand**
Supplier CAPEX subsidy	MoU's	Off-taker CAPEX subsidy
Supplier OPEX subsidy	Consortia building	Off-taker OPEX subsidy
Supplier CfD	Matchmaking/trade missions	Off-taker CfD
Investment guarantees	Trading platforms	State participation
Export credit guarantees	Trade insurance (letters of credit, trade credit insurance)	Infrastructure investments (terminal, storage, transport and transit)
Untied loan guarantees		(Aggregated) Joint purchasing
Development bank funding		Demand obligations
Investment bank funding		R&D funding
R&D funding		

**Chapter 4 and 5 will expand on the practical implementation, further detailing, and connection with barriers of the policy options that are deemed most relevant (based on the interview insights).*

With regard to the trade flow value chain part, the Dutch government can use instruments to connect off-takers in the Netherlands and transit destinations (e.g. Germany) with foreign governments and companies that are involved in hydrogen production. Through Memoranda of Understanding, agreements with governments can be initiated, and by use of matchmaking and consortia creation, companies can be connected with each other.

Lastly, the import value chain part can be supported by off-taker subsidies and CfD's, while the Dutch government can also help in joint purchasing of imported hydrogen. State participation in some parts of the value chain could help in accelerating imports, especially in the infrastructure domain (e.g. hydrogen network) where considerable investments are required. Demand can also be assured by obligations, and R&D funding facilitates the further development of technologies that are not yet mature, such as ammonia cracking.

It should be noted that implementing a policy instrument in one part of the value chain also provides certainty to other parts of the value chain. For example, if hydrogen offtake is incentivized, the supply-side has more certainty about its demand (potentially being able to secure long-term offtake agreements), which thus encourages and helps the supply-side as well.

Furthermore, some additional "hydrogen sector wide" incentive options are important to highlight, which are a precondition for market scale-up. Whereas **regulation and certification** around hydrogen cannot be attributed to a specific policy instrument, it is important to clarify these rules and requirements. In this way, market parties throughout the whole value chain can be assured that the renewable or low-carbon hydrogen that they sell or buy is legitimate and compliant with EU legislation. This is partly in the hands of EU policymakers, but also national governments can step in to formulate clear regulatory boundaries and definitions.

3.3 Hydrogen import policies in neighbouring countries

Neighbouring countries have made different decisions regarding their hydrogen import strategies. Whereas Germany is expecting to rely on hydrogen imports for a significant share of their consumption, France focusses on creating a domestic hydrogen value chain and aims for hydrogen autonomy.

Since **Germany**'s potential for domestic hydrogen production is limited compared to their expected demand, the German government expects that they will have to import around 50 - 70% of their expected hydrogen demand in 2030 (total expected German hydrogen demand in 2030 is 95 – 130 TWh).[27] Short-term import is planned to be mainly ship-based, while in terms of carrier, there is a near-term focus on ammonia. Beyond 2025, green methane, synthetic methanol, LOHC and liquid hydrogen could play a role. Also, pipeline-based imports are expected to play an important role after 2030.

In the update of Germany's National Hydrogen Strategy, the following policy measures regarding hydrogen imports are mentioned[28]:

- Participation in IPCEI projects in the field of hydrogen
- Funding instruments (H2Global, PtX fund, H2Upp)
- European collaboration, and in specific instruments such as the European Hydrogen Bank, and European Carbon Contracts for Difference
- Further deepen existing energy and climate partnerships, including the setup of port alliances

Similarly, since **Belgium**'s renewable energy generation potential is smaller than its expected demand, they will also rely on energy imports. Of these imports, hydrogen will play an important role, with an expected import of hydrogen (derivatives) of 20 TWh in 2030 and 200 – 350 TWh in 2050.[29] The federal government aims to position Belgium as an import and transit hub for renewable molecules in Europe.

To achieve this ambition, the federal government set out multiple policy measures in their hydrogen vision and strategy:[30]

- Engage with key partners to open import corridors, amongst others by signing MoU's
- Support infrastructure development
- Organise master classes together with the Belgian Hydrogen Council to establish close relations with export partners
- Investigate complementariness of electricity and hydrogen networks in the North Sea

In contrast, **France**'s hydrogen strategy is not at all based on imports. France aims to develop a domestic hydrogen value chain, in order to become autonomous in the hydrogen domain and prevent dependence on other countries.[31]

[27] German Government. 2023. **National Hydrogen Strategy Update**.

[28] German Government. 2023. **National Hydrogen Strategy Update**

[29] Belgian Government. 2022. **Vision and strategy Hydrogen**.

[30] Belgian Government. 2022. **Vision and strategy Hydrogen**.

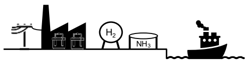
[31] RIFS. June 2023. **France's Hydrogen Strategy**.

4. Identified barriers

During the interviews, a broad set of barriers are identified that currently hamper upscaling of the hydrogen import value chain. The barriers are aggregated into four key barriers which are presented in Section 4.1. Thereafter, Section 4.2 presents the longlist of all identified barriers. Additionally, some aspects were identified which could potentially have been barriers, but which are currently well-addressed by existing policy or governmental actions. These are described in Section 4.3.

Table 3 relates the longlist barriers to the four key barriers and operationalizes the value chain typology and the theoretical framework. In this way, it brings together the barriers, their impact on the value chain, and their associated failure type. Further detailing of these topics is provided in the rest of this chapter.

Table 3: Four key barriers, including their impact on the three value chain parts and the associated failure type.

Key barrier	Combination of longlist barriers	Barrier impact			Failure type
		 **Production, export & transport**	 **Trade flows**	 **Import & demand**	
Demand uncertainty	-Uncertain future hydrogen cost and price -Uncertain timeline in terms of volumes -Insufficient room to compensate cost premiums -Carrier diversity and uncertainty	Medium	Medium	High	Demand articulation failure
Political, policy and alignment uncertainty	-Unclear industry policy vision -Lacking alignment of policies with neighbouring countries -Lacking safety vision on ammonia infrastructure	Low	High	High	Directionality failure & policy coordination failure
Uncertain conditions and implementation of regulation and instruments	-Energy and gas legislation implementation uncertainty -Certification uncertainty -Troublesome permitting process	Medium	Medium	High	Institutional failure (& reflexivity failure)
Instrument and project timeline mismatch	-Tension within financial timeline -Too strict and time-consuming policy instruments -Little long-term offtake certainty	Low	Medium	Medium	(Mild) institutional failure

4.1 Four key barriers to hydrogen import

The insights acquired during the interviews have revealed multiple barriers to hydrogen imports. When considering the different parts of the value chain the interviewed organizations are active in, several of the indicated barriers showed an overlap between different parts of the value chain. In other words, some barriers are obstacles experienced in multiple parts of the value chain. Additionally, some of the identified barriers are similar in topic or scope and can be covered by one overarching barrier.

Based on the value chain part overlap and covering of multiple barriers, in our analysis we have formulated four key barriers that hamper hydrogen imports. The four key barriers are formulated such that collectively, they cover multiple of the identified barriers. In this case, the label of 'key' barrier does not indicate priority over the longlist barriers, but instead implies that government actions that address these four key barriers would be efficient as it would address multiple barriers and aid development of multiple parts of the value chain simultaneously.

In the presentation of the theoretical framework for government intervention (Section 3.1), it has already been established that government intervention in some parts of the hydrogen import value chain can be justified to avoid transformation failure and missing energy and climate targets (Figure 7). In the description of each of the four key barriers following, the screening on failure type and intervention justification (second triangle process in Figure 8) is included.

4.1.1 Demand uncertainty

Looming across the entire hydrogen import value chain, is large uncertainty around demand for imported hydrogen. This uncertainty is multi-faceted and concerns imported hydrogen prices and willingness to pay, the timeline of the expected volumes (and growth) and the type of hydrogen carrier.

- There is large uncertainty in the market around future demand for hydrogen, and the related share for imported hydrogen. In part this is due to **uncertain future hydrogen price development**, with the competition with domestic hydrogen production (and the surrounding uncertainties) as additional complicating factor for imports. Uncertainty around price and willingness to pay is linked to regulation uncertainty (third key barrier, Section 4.1.3).

- In addition to uncertain development of the future hydrogen prices, the **timeline of demand and supply volumes is also uncertain**. The combination of timeline uncertainty around supply, due to the long lead times in creation of hydrogen production and required energy supply in exporting countries, with timeline uncertainty on demand, makes it difficult to create sufficient trust with parties that both demand and supply will match at the right moment. With this, supply and demand uncertainty keep each other in a gridlock. Without secure demand it is difficult to bring import projects to a final investment decision stage, while from the demand side it is hard to provide long-term offtake without security of supply.

- These price and volume uncertainties persist for a large part because at this moment **off-takers do not have sufficient room to compensate any cost premium of sustainable hydrogen**. Whereas they would incur higher costs (compared to the fossil alternative), competition and product prices leave insufficient room to compensate the higher costs of renewable hydrogen.

- Current hydrogen import projects cover all of the hydrogen import technologies (Section 2.1). While this **technology diversity has attractive aspects from a risk mitigation perspective, simultaneously it creates an uncertain environment** for organisations in offtake, transport and storage. One can envision that from the multiple alternatives in the current early market development phase, one or a subset could evolve to be a commodity in a more mature market phase. This creates a risk in adjusting or building production processes and installations fit for a specific hydrogen carrier, increasing demand uncertainty.

The combined effects create a challenging environment for potential off-takers to commit to long-term offtake contracts as well as for potential suppliers to invest in setting up of import capabilities and production. Moreover, both aspects reinforce each other, prolonging and exacerbating this gridlock. The certainty offered by long-term offtake contracts would improve the project bankability for suppliers, while the hydrogen demand would benefit from the lower capital costs and hydrogen costs when project risks are reduced by certainty through long-term offtake.

Demand uncertainty has a high impact on the import and demand part of the value chain, as it directly concerns the demand side (e.g. determining the required hydrogen volumes and carrier). The impact propagates to the production, export and transport part of the value chain, since these need to have long-term offtake contracts (which demand parties currently are not able to support) to be able to get to a FID stage. Trade flows would be impacted as well, since with a limited view on expected volumes and types of carriers, it will be challenging to direct the desired flows of hydrogen to the Netherlands.

Faltering demand for imported hydrogen due to uncertainty can be considered a form of demand articulation failure (Table 1). The uncertainty experienced in the multiple parts of the value chain, hinder companies and organisations in developing clear demands and converting these into (long-term) contracts, offtake and export/import assets. Through this, demand uncertainty can be considered a transformational system failure on which befitting government action can be justified.

4.1.2 Political, policy and alignment uncertainty

The interviews have revealed uncertainty experienced by companies in the import value chain around political developments, support policy and international alignment as a barrier. This barrier is not isolated to hydrogen imports but originates from an uncertain vision for the future position of industry and industrial production in the Netherlands in general. In addition, hydrogen imports cover multiple adjacent topics for which alignment is required but not yet certain.

- Hydrogen demand is hampered by the **uncertain position of industrial production in the Netherlands**. The interviews revealed that multiple stakeholders experience a lack of a clear long-term vision for the role of the industry in the Netherlands. This hampers potential import demand, as off-takers are not certain there is sufficient political support for their sector or production. Long-term demand contracts cannot be provided if there is a lack of trust in future support for the production process and production site. This should be regarded in context of a wider societal and political discussion around the future of industrial production in the Netherlands, and developments around industrial policy and the development of a 'National Programme Sustainable Industry'.[32]

- Hydrogen imports and transits interact with multiple topics on which alignment is required to achieve a well-functioning value chain. This comprises both alignment within the Netherlands, as with neighbouring countries. **Within the Netherlands, the terminals, storage and transport of hydrogen carriers, require clearing with risk and safety legislation**. Risk and safety management falls within the responsibilities of the Ministry of Infrastructure and Water Management, and current policies have been aimed at reducing ammonia transports. Additionally, a barrier when considering transit flows of hydrogen carriers is the **mismatch which seems to emerge between the Netherlands and neighbouring countries in preferred routes and modalities** (e.g. railroad, waterway/barge, pipeline). Bilateral alignment on this is required, as in a worst-case scenario it could lead to a corridor with a dead end at the border.

Both aspects result in uncertainty experienced by organisations in the value chain on the political acceptance and legislative and permitting viability of proposed import or transit projects. In worst case, the uncertainty for example could result in investments in assets with a short lifetime due to political pressures, or into transit assets which do not match those required in the neighbouring countries. One example of this is risk of an emerging mismatch in preference for ammonia transport by pipeline in the Netherlands, while Germany is pursuing ammonia transport via railroad. This risk is

[32] '**Nationaal Programma Verduurzaming Industrie**'

identified by multiple market parties, however as the ammonia market and policies are still under development the risk assessment appears to still differentiate.

Political, policy and alignment uncertainty, including with respect to neighbouring countries, mainly impact the trade flow and import and demand value chain parts. This is as an unclear vision of future industry in the Netherlands impacts the hydrogen demand (volumes and carrier type). Misalignment of policies with neighbouring countries impacts the development of the infrastructure required for transit flows.

The two aspects can be considered two different failure types for transformative change; directionality and policy coordination failure respectively. The uncertain position of industrial production is a form of directionality failure, as there is insufficient steering on the desired direction of development. The second aspect, coordination with the relevant policies and stakeholders, is an example of policy coordination failure. Both types are forms of transformational system failure, again justifying government intervention.

4.1.3 Uncertain conditions and implementation of regulation and instruments

In the current early market phase of hydrogen and hydrogen imports, much of the required regulation and many of the policy instruments are still under development. Though this is in part inherent to the early market phase, the uncertainty around the exact conditions and implementations create a difficult basis for project investment decisions.

- New energy and gas regulation is still under development on both EU and Dutch levels. **The position and regulation of hydrogen within this is still unclear**. There is uncertainty in the market on the degree of applicability of the gas and energy regulatory framework in the upcoming EU hydrogen and decarbonised gas market package (mature market phase) on hydrogen (early market phase).

- Certification of imported hydrogen as RFNBO or renewable is important for import projects, as it increases demand and enables price premiums. However, **the exact conditions for certification are complex and still partly unclear**. For imports specifically, the potential emissions during transport and the requirement for certified production outside of the country of hydrogen use and potentially the EU, are additional complicating factors.

- **Permitting procedures and subsidy applications are long in duration, time-consuming, and complex**. This reduces the attractiveness of instruments and creates uncertainty in the market with regard to the chances of receiving subsidies and permits. The interviews revealed decreased interest in available support due to this. Additionally, some high upfront investments in subsidy and permit applications can only be justified by large organisations. This reduces attractiveness and opportunities for small and medium size projects and organisations.

These aspects increase the challenge to bring hydrogen import projects to FID stage[33]. For example, potential loss of eligibility as RFNBO or 'green' hydrogen credits as criteria, increases project risks as it would imply missing price premiums or not be of interest for certain users. As another example, hydrogen transport is inherently linked to imports, however unclear transport emission accounting hinders the development of transport assets and the finalisation of import projects. Unclear limits to evaporative or boil-off losses and fuel emissions, make it uncertain if it is required to design and use for example hybrid, zero-emission fuel, renewable fuel, or (fuel cell) electric transport solutions.

Uncertain conditions and implementation of regulation and instruments impacts all parts of the value chain. Especially uncertainties around certification impact all involved parties, as each is not certain yet the produced, transported and consumed hydrogen will be accounted as renewable. For the import and demand value chain specifically, also other regulatory uncertainties are present (e.g. permitting, decarbonised gas package implementation), which leads to this key barrier having an especially high impact on this is part of the value chain.

[33] FID: Final Investment Decision.

The first two aspects, where the absence and uncertainty in regulation is hindering import development, are examples of institutional shortcomings, which is a failure type withing system failure (Table 1). The third aspect of long and complex procedures and applications could be considered institutional failure as well, or potentially as reflexivity failure in case one considers the policy flexibility has already been shortcoming to address this. With this, the key barrier would categorize as structural system failure and potentially transformational system failure as well. Both can be used as argument for government intervention.

4.1.4 Instrument and project timeline mismatch

Experienced along the import value chain, are **mismatches in the timelines of current policy instruments and project planning**. These mismatches complicate the coordination between for example project financing, permit application and final investment decision and thus hinder project progress.

Subsidy criteria can for example include demands to (being close to) having secured project finance, before a subsidy can be granted. However, achieving this project status can be difficult without (a perspective on) granting of subsidies. Another example are criteria for projects to have secured environmental permits before subsidies are granted. In project planning the securement of non-revokable environmental permits is often planned for a late project stage (partly due to the long timelines for permitting procedures), close to FID.

The mismatch in instrument and project timeline currently impacts the import & demand side most, mainly because current import subsidy schemes are focussed on assets which are based in the Netherlands. Potentially this mismatch could endanger attracting trade flows to the Netherlands, as parties might redirect their trade flows to countries where they can get easier access to subsidies.

Shortcomings in policy instruments are a mild form of institutional failure, as the legislation is not as effective as intended in creating a favorable environment for innovation (in this case stimulating imports). This failure type categorizes as structural system failure, which argues for government intervention.

4.2 Longlist of observed barriers

The four key barriers that are mentioned above, each are a combination of multiple barriers that came forward in the interviews. Furthermore, several other barriers came to light which are important to note, although they are no key barrier. Table 4 shows a categorised overview of these barriers, including brief description.

Table 4: Longlist of observed barriers

Barrier category	Barrier	Description
Demand	Uncertain future hydrogen cost and price	- Future prices of hydrogen are still uncertain, this keeps off-takers hesitant to settle for prices that they currently deem as too high. - For hydrogen importers, the competition with (partly subsidized) domestic hydrogen production is also relevant to consider in terms of price competitiveness.
	Uncertain timeline in terms of volumes	- Timelines of hydrogen demand volumes are uncertain, making it difficult for exporting stakeholders to reach the stage of final investment decisions - Timelines of hydrogen supply volumes are uncertain, making it difficult for off-takers to convert processes and provide long-term offtake contracts

	Insufficient room to compensate cost premiums	- Off-takers do not have sufficient incentives to choose for renewable hydrogen. Whereas they would incur higher costs (compared to the fossil alternative), there is insufficient room to compensate the price premiums for renewable products.
	Carrier diversity and uncertainty	- Industry feels uncertain for which sectors and activities there is sustained political and societal support in the Netherlands, and which hydrogen carrier is required for the desired activities. - It is also still uncertain which carrier will be most cost-efficient to be used in import value chains, in case of converting to gaseous, pure hydrogen for final demand.
Policy (alignment)	Unclear industry policy vision	- Industry feels uncertain for which sectors and activities there is sustained political and societal support in the Netherlands in the future. This lack of political support hampers demand commitments for hydrogen of the potential off-takers (i.e. as long as there is uncertainty of the future viability, investment in hydrogen-fueled or -feedstock industrial production will lag).
	Lacking alignment of policies with neighbouring countries	- Alignment of policies with neighbouring countries is lacking, especially in terms of required / desired hydrogen carriers and transport modalities for hydrogen transit.
	Lacking safety vision on ammonia infrastructure	- For ammonia, different regulations apply compared to (gaseous) hydrogen / natural gas since ammonia is currently mainly used as a chemical feedstock. - Current ammonia policies are aimed at reducing the ammonia transport in the Netherlands. This creates uncertainty with regard to the future of ammonia transits through the Netherlands.
Regulation	Energy and gas legislation implementation uncertainty	- It is still uncertain how certain elements of the energy and gas legislation will be implemented, for example with regard to what will and what will not be regulated (e.g. terminals, crackers), andwith regard to vertical integration possibilities.
	Certification uncertainty	- Relatively complex certification rules need to be aligned with countries outside the EU - It is still uncertain how the certification would look like in practice, who would be the certifying stakeholders, etc. - This certification uncertainty leads to the potential risk that other parts of the world - where certification is less strict – would attract the first hydrogen exports - It is especially unclear how emissions during transport should be accounted for
	Troublesome permitting process	- Permitting processes are slow and take a long time - Safety requirements do not reflect new fuel specific characteristics, but are copy pasted from other (conventional) fuels
	Limited nitrogen emissions space ('Stikstofruimte')	- The nitrogen crisis in the Netherlands impacts almost all projects that require construction work, including projects / assets related to hydrogen imports.
Current support schemes	Tension within financial timeline	- Most subsidies only want to award projects that have already (almost) reached financial closure, but projects can only reach that stage when having certainty with regard to subsidy allocation.

	No level playing field across carriers / transport modes	- LH_2 is not included in subsidies or other incentive mechanisms - Maritime transport corridors of hydrogen carriers as a whole are not labelled as ‘critical infrastructure’, excluding the transportation assets in the value chain from subsidies. Compared to import via pipeline which are labelled as ‘critical infrastructure’, this is not a level playing field
	Too strict and time-consuming policy instruments	- Often significant investments are required upfront, for only being eligible for a subsidy, with having no view on winning chances yet. Such upfront investments are especially challenging for smaller organizations, which as a result are prone to be excluded. - Subsidy arrangements often have specific timeline whereas value chains that are currently being built have much uncertainty. Due to delays in the chain a subsidy request or even allocation can run out of time.
	Little long-term offtake certainty	- Current policies (e.g. H2Global CfD’s) provide offtake contracts with too short timelines for off-takers. Currently contract timeline is 1 year, while off-takers need longer term contracts to be able to commit.
	Limited budgets	- In order to scale up the value chain, large scale projects are needed to develop significant volumes of hydrogen imports. Large sums of money are required to support this, as investment costs of large installations are high, or alternativelly, as covering the cost gap between current hydrogen market prices and imported hydrogen costs on these large volumes amounts to large sums.
Technology	Ammonia cracking not yet market ready at scale	- Ammonia crackers are not yet commercially available at the required scale
Infrastructure	Uncertainties with regard to hydrogen backbone development	- Various uncertainties exist with regard to the development of a hydrogen backbone in the Netherlands, for example: development timeline, off-taker connection costs, tariffs, total capacities and volumes
Financial	High financing costs in specific countries	- Development of projects in countries with low financial ratings can bring about high financing costs, which will be included in the price of the produced hydrogen

4.3 Four aspects not regarded as barriers

The interviews have also revealed aspects on which the current policies, instruments and political support is well-developed or well-running, and actively decreasing the barriers in setting up import value chains. Four notable topics are identified in this.

4.3.1 Matchmaking, amongst others through energy diplomacy

The efforts of the Dutch government in matchmaking are regarded positive and useful by the interviewed organisations. This includes the setting up of memoranda of understanding, the active planning and conduction of trade missions in cooperation with commercial organisations and the active development of matchmaking platforms. The interviews indicate that these efforts are effective in decreasing the barriers for connecting potential suppliers and off-takers. Continuation of these matchmaking efforts would be regarded as positive by the interviewed parties, as it aids market parties of all sizes to find and connect with potential suppliers and transporters. While some would be able to do this without the governmental efforts, especially for parties who are not custom to operate on a global market government help would reduce the required effort, time and costs.

4.3.2 Technology readiness

Absent within the key barriers identified during the interviews is the availability and readiness levels of hydrogen import technologies. It should be noted this does not imply no technology development is still required, but rather that the interviewed organizations regard technology development as a manageable concern and not the most urgent or key barrier.

Hydrogen carriers such as ammonia and LOHC can be deployed based on existing technology or even existing infrastructure. The interviews indicate that most technology challenges are in scaling up and reducing costs, which to large extend could be sorted out by the market building on sufficient demand for imports. However, as technology development, scale-up and cost reductions affect import costs, technology does impact the competitive position of imports against domestically produced hydrogen.

4.3.3 Positive perspective on development of hydrogen (carrier) supply

Though plenty of barriers exist for the import of hydrogen and hydrogen carriers, the majority of the interviews have revealed sufficient general trust and opportunities for the supply of hydrogen and hydrogen carriers in exporting countries. The market sentiment indicates that once hydrogen demand volumes increase and certainty on long-term offtake improves, the production capacity will be able to follow this growth.

4.3.4 Build-up of import terminals and storage

The interviews have revealed a certain trust within the hydrogen import value chain, that the build-up of import terminal and storage capacity will likely not be the limiting factor for imports. Import terminals and storage capacity can be expanded in phases, responsive to the market demands and increasing certainty on volumes and type of hydrogen carriers. This is in part due to the fact that for companies active in this part of the value chain, responding to these market uncertainties is common to their business models and similar to current markets and activities. However, uncertainties in for example ammonia transit flows (see Section 5.2.4) can have an impact on the business case of such terminal and storage facilities.

5. Potential policies and market interventions

By combining the identified barriers with the longlist of policy options (Section 3.2) and with insights into and suggestions for policy options that came forward in the interviews, recommendations for policies and market interventions can be distilled for accelerating the hydrogen import value chain. Part of these recommendations consider building on and continuing current policies and efforts, whereas another part considers additional policies and interventions.

5.1 Recommendations - policy efforts that should be continued

Several efforts that the Dutch government is currently undertaking were experienced as positive by the interviewed stakeholders. Apart from proposing new policy interventions we therefore also want to highlight what is already going well. Namely, it is also important to receive feedback on which interventions work properly and should be continued.

Firstly, the Dutch government's support in matchmaking, amongst others through energy diplomacy, is experienced as positive by most market parties (see Section 4.3.1). Stakeholders mention that these efforts are helpful to connect supply and demand. Hence, the energy diplomacy approach, including trade missions in cooperation with commercial organisations and the setting up of matchmaking platforms should be continued.

Secondly, the announced participation of the Dutch government in the H2Global mechanism, is also regarded positively. The fact that the mechanism covers CfDs for supply and demand of hydrogen improves certainty in terms of prices and volumes. Still, a few improvements could be made to the mechanism, these are discussed in Section 5.3.1.

5.2 Recommendations - policy efforts that should be altered or introduced

In the interviews, multiple adjustments to current policies and support mechanisms as well as policy interventions that could be newly introduced were discussed. The four main policy recommendations are described below in Sections 5.2.1 to 5.2.4. Additionally, Section 5.2.5 highlight possible tensions and political choices that are inherent to some of the recommended policy interventions.

5.2.1 Focus (additional) support on demand side

Since there is currently no market yet for renewable hydrogen, prices are uncertain, and liquidity is absent. As a result, off-takers cannot know what reasonable prices are and as such are hesitant to commit to long-term contracts. In parallel, hydrogen producers need long-term offtake contracts in order to get access to financing. During the interviews most stakeholders agreed that this chicken-egg problem can best be solved by supporting the demand side, as this would pull along the rest of the value chain, whereas supporting the hydrogen production side only would not automatically also create demand in the Netherlands.

The demand side needs certainty in terms of hydrogen price and in terms of volume (security of supply). At the same time, off-takers' main concern is to remain competitive. As such, most off-takers need support to overcome the price difference between use of renewable hydrogen (carrier) and the fossil fuel alternative. The current market environment namely does not provide sufficient incentives to use renewable hydrogen. Moreover, a sufficiently long timespan of certainty is required. A CfD mechanism was often mentioned as suitable scheme, considering that the scheme would cover multiple years on the offtake side (not just one year, as the H2Global mechanism currently does). A CfD scheme for a longer period could offer short-term price certainty for off-takers, while the government can hedge itself against spending unlimited amounts of money for the long-term. If the price of the renewable hydrogen would go down (or the fossil fuel reference up), the required government funding would decrease over time and could potentially become negative, resulting in an income for the government instead of a cost. An interesting form of such CfD scheme that was mentioned several times during the interviews is the 'Carbon Contracts for Difference' funding program that the German government is developing.[34] It would be interesting to investigate the potential of a similar mechanism in the Dutch context. Section 5.3.2 elaborates more on this concept.

Implementing a variation of a CfD scheme for hydrogen demand in the Netherlands could be an example of clear (targeted) industrial policy. This could incentivize industries to stay operational in the Netherlands, and as such stimulate and provide certainty of hydrogen demand. A good overview of all applicable subsidies and support should however be kept, to reduce the risk of multiple sector or value chain support instruments adding up to unintended over-subsidising.

5.2.2 Keep policies and support schemes pragmatic, simple, and flexible

Many of the current policies and support schemes that aim to stimulate hydrogen imports, require the fulfilment of lots of specific criteria, already in early stages of the process where receiving support is still very uncertain. For example, stakeholders mentioned that for some projects environmental permits need to be acquired already before being eligible to be granted a subsidy. Since such permitting processes can be time-intensive and require upfront investments this is currently experienced as a barrier. By making support schemes simpler and more pragmatic, fewer burdens would be present for stakeholders to set up relevant projects and the speed of application procedures can be increased.

Furthermore, flexibility of support schemes should also be increased. This can be achieved by maintaining a level playing field between various technologies and by loosening subsidy demands on project timelines. For example, LH2 technology is excluded from H2Global, creating a disadvantage compared to ammonia and LOHC. Project timeline demands in current subsidy schemes can be restrictive as they require operations to start in very optimistic timelines, so any potential delays could result in loosing subsidy eligibility. By levelling the playing field and using a more pragmatic approach to delays for new and upscaled technologies, the policies and support schemes can be made more attractive to stakeholders that want to develop relevant projects in the hydrogen import value chain.

In the context of attractiveness of support schemes, stakeholders often made the comparison with the Inflation Reduction Act (IRA) support that the government of the Unites States has introduced. The simplicity and certainty of receival of grants is experienced as an attractive manner to set up a support scheme. Multiple stakeholders were in favour of such a 'qualifying subsidy' type (where a company is certain to receive support in case they fulfil certain specific requirements). It should be noted that budgetary restrictions evidently put limits on the proportions of such a qualifying subsidy.

5.2.3 Promote direct use of a hydrogen carrier where possible

Most stakeholders agree that where direct use of a hydrogen carrier is possible, this is preferred. In this way, several of the mentioned barriers can be avoided or lowered. Namely, conversion losses and their impacts on the price of the hydrogen can be prevented. For ammonia specifically, if the reconversion step back to hydrogen through cracking can be left out, the technological immaturity barrier of the cracking process can be prevented as well. From this point of view, starting the import of hydrogen carriers with carriers that can be directly used (e.g. ammonia), and which can directly contribute to decarbonizing specific end-uses would be preferred.

5.2.4 Align import policies with other domestic policies and with hydrogen import policies of neighbouring countries

In general, aligning Dutch policies with policies of neighbouring countries can enhance collaboration and trade. Seeking to achieve alignment between countries in terms of hydrogen carrier and transportation modality, it would be good to consider that from the Dutch port perspective Port of Amsterdam focuses on non-ammonia hydrogen carriers, while ammonia terminals are already present (and more are planned) in the Port of Rotterdam. It can be expected that at least some amount of domestic and hinterland demand for green ammonia will arise in the future. In terms of

[34] See: BMWK. 2023. **https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2023/06/20230605-start-of-the-carbon-contracts-for-difference-funding-programme.html**

ammonia transit infrastructure, then it could make sense to take Rotterdam as a starting point and use the Delta-Rhine corridor (via pipeline) to start building ammonia pipeline infrastructure and facilitate such transit flows. This specific case should be well aligned with German policies and desires, so that the flow at the border can smoothly continue towards German end-consumers.

At the same time, policies within the Netherlands should be well aligned. Current ammonia policies are aimed at reducing ammonia transport in the Netherlands. This creates uncertainty about the future of ammonia transits through the Netherlands. Therefore, the Dutch government should coordinate a common vision across Ministries with regard to ammonia transportation and associated safety risks[35]. Additionally, also for other carriers such as LH_2 and LOHCs safety regulations should account for fuel specific characteristics, instead of copy pasting logic and regulations that are based on developed fuels and infrastructures such as natural gas.

Next to domestic coordination on safety topics, also other hydrogen related policies should be aligned with import policies. Especially alignment with domestic hydrogen production is important, as domestic production and imports are both relevant and needed but compete with one another.

5.2.5 Tension between policy interventions

When putting the multiple policy recommendations next to each other, some internal contradictions might seem present. There seems to be a tension between some policy interventions, most notably between the recommendation to keep policies and support schemes flexible (Section 5.2.2) and the recommendation to provide certainty by offering directions through decision making, for example in the alignment of Dutch domestic and international policies (Section 5.2.4).

Finding a balance between flexibility and directional certainty is challenging, but not impossible. In order to find this balance, it is most important to decide on a couple of key starting points. These can create a firm and common base on which parties can develop their business cases and import scenarios. This can for example be a statement whether and when open-access infrastructure or conversion facilities will be available in the future. In parallel, for broader instruments a level playing field between hydrogen carriers can still be maintained, to facilitate flexibility and allow other hydrogen carriers (and related infrastructures) to participate and develop.

Additionally, an improved insight into the eventual demand for each hydrogen carrier (in the Netherlands and hinterland countries) could provide support in finding such balance and for example assist in decision-making with regard to infrastructure. This would be a topic for further research.

5.3 Examples of specific policy interventions

A longlist of current specific policy instruments is available for operationalization of the policy recommendations (Table 2). From this longlist, here we highlight three specific tools and options which could be effective and efficient in addressing the observed key barriers.

5.3.1 Expand and strengthen H2Global

The H2Global instrument is a flagship hydrogen support instrument for governments and is generally perceived positive by the hydrogen sector. Nonetheless, the instrument could be more effective in addressing some of the identified barriers, for example through three changes in the conditions and budget.

- Broadening the scope of the hydrogen carriers that are included in the mechanism would enhance a level playing field between carriers. Liquid hydrogen imports are currently not covered in the instrument, while this could be technically feasible.

[35] For a detailed study on the safety of hydrogen carriers (including ammonia) see: Berenschot, Arcadis, TNO, 2023. **Omgevingsveiligheid van toekomstige stromen waterstofrijke energiedragers**

- Increase the duration of the hydrogen service agreements (HSA), the contracts on the hydrogen offtake side, to increase security of supply for off-takers. This increased security of supply can enable off-takers to (re)build their production processes around hydrogen. However, a **split in duration of price and supply** could be included in the contract. Within a longer-term contract (e.g. 10 year), a price can be set via the bidding process for only the first part of the contract duration (e.g. 3 years). After this, the price could be renegotiated or indexed to for example hydrogen market prices or a combination of alternative 'grey' hydrogen and ETS prices. With this split in contractual duration, the risk of changing market prices for off-takers can be managed (i.e. avoid off-takers being bound to a long-term, fixed price contract while the hydrogen market price available to competitors is lower).

- Facilitating creation of an import value chain with sufficient flexibility and liquidity requires multiple parties active in long-term, high-volume hydrogen import projects. The budgets required to support these through H2Global, would quickly eclipse the existing available budget. To illustrate this, the order of magnitude budget implication of supporting 150 kton/year hydrogen import has been outlined in Table 5. This represents about 10% of current hydrogen production and demand in industry in the Netherlands.[36] This order of magnitude calculation shows that if support of large-scale hydrogen imports is desired, considerable budget increases for H2Global are required.

Table 5: Order of magnitude budget calculation for hydrogen import support

Value	Unit	Cost/price/budget	Comment
4.2	€/kg	Renewable hydrogen marginal production cost	Based on HYCLICX green best 50% marginal cost average for August 2023
2.5	€/kg	Blue hydrogen alternative	Based on HYCLICX blue cost average for August 2023
2	€/kg	Import and conversion cost premium compared to domestic production	Estimate by authors, highly depending on production costs, transport costs and achievable economies of scale and technology development and improvement
4.7	**€/kg**	**Cost gap imported hydrogen over domestic production blue hydrogen**	
150	kton / year	Hydrogen import	Example for this order of magnitude calculation
~550	**Million € / year**	**(Order of magnitude) support required to bridge the cost gap of 150 kton/year hydrogen imports**	

5.3.2 Carbon contracts for difference as operational expenditure support

An alternative and more indirect policy instrument to overcome operational expenditure price differences between hydrogen and alternative (fossil) energy sources, is the use of carbon contracts for difference. With this, the cost gap of deploying low-emissions production routes not reflected in product prices can be supported. For example, it could cover the increased costs of utilizing hydrogen to produce green steel, where the market valuation of green steel falls short. Through this, a carbon contract for difference can accelerate hydrogen demand, benefitting hydrogen imports as well as domestic hydrogen production.

However, deployment of a carbon contract for difference is only an indirect way of stimulating hydrogen imports, and it should be viewed in context of wider industry policy and other low-carbon

[36] TNO. 2020. The Dutch hydrogen balance, and the current and future representation of hydrogen in the energy statistics. p.12-14

production routes. Both are beyond the scope of this research, and more consideration is required for a proper assessment of the societal, economic and environmental impacts.

5.3.3 Include imports within long-term vision for energy and industry

An explicit vision for the role of hydrogen imports in the future energy system, along with expression of which sectors and industrial activities will receive support in offtake of this hydrogen, is an opportunity to strengthen and restore trust in the viability of industry in the Netherlands. This would both promote demand certainty and reduce political uncertainty, two of the key barriers. As the 'Nationaal Plan Energiesysteem' and the 'Nationaal Plan Verduurzaming Industrie' are still under development, these offer strong and credible opportunities to create such a vision. In parallel to these national options, continued support for strong industrial and hydrogen policy in EU context is important. Even though the impact of the Dutch government in such an international context can be lower, this could be compensated by larger market impacts of EU legislation and directives.

5.3.4 Implement international certification rules and schemes

The uncertainty in the market on applicable rules and certification for renewable hydrogen credits can be reduced by standards and regulation. As these are already under development, continued support to develop and adopt these as quickly as possible is recommendable. This requires action on multiple levels:

- On EU level, the definition and adoption of conditions and standards for hydrogen in RFNBO and REDIII legislation would provide much required clarity. With the conditions known and in place, importers can set up the assets such that they would comply. Some fundamental choices can be made with regard to the design of export assets, such as for example: the fuel, maximum allowable evaporative emissions, and the type of ship propulsion.

- On international level, the development of international standards helps to provide an international market. One example is the development of an ISO standard for emission accounting, for which an emissions accounting methodology developed by IPHE will play a crucial role.[37]

[37] IPHE, **Metholdology for determining GHG emissions associated with production, conversion and transport of hydrogen** (2023)

Appendix A. Interview list

Representatives of the following companies, organisations and institutions have been interviewed in the context of this project:

Air Liquide

Anthony Veder

Cepsa

CIEP

Enertrag

European Investment Bank

Fertiberia

Gasunie

Groningen Seaports

HyCC

NLHydrogen

Port of Amsterdam

Port of Rotterdam

RWE

E.on

Shell

SkyNRG

Tata Steel

Utrecht University

VOPAK

VOTOB

Evos

Zenith Energy

Appendix B. Interview guide

The following interview guide has been used during the stakeholder interviews. As the majority of interviewees was Dutch, most interviews have been conducted in the Dutch language and the guide has been set up accordingly.

Introductie

Guidehouse is door het ministerie van EZK gevraagd om in kaart te brengen welke beleidsinterventies noodzakelijk zijn om de **importketen voor duurzame waterstof en waterstofdragers** naar Nederland (versneld) op gang te brengen, vanuit de gedachte dat deze import nodig is om de klimaatdoelen te halen en om aantrekkelijk te blijven als industriële vestigingsplaats.

Om de mogelijke **beleidsinstrumenten** zo goed mogelijk aan te laten sluiten bij de behoeftes en autonome mogelijkheden voor het importeren van waterstof in de markt, is Guidehouse door EZK gevraagd via een reeks interviews met marktpartijen de ervaren **barrières** te onderzoeken.

Barrières

Tegen welke barrières lopen bedrijven aan als ze waterstof(dragers) willen importeren?

Per barrière:

- Wat is de barrière?
- Wat is de impact van deze barrière?
- Op welke actoren heeft deze barrière betrekking?
- Is de barrière relevant voor specifieke (sub-)sectoren en type bedrijven (start-ups, consortia, etc)
- Wat voor type barrière is het?
- Is de verwachting dat deze barrière door de markt opgelost kan worden of is overheidsingrijpen noodzakelijk?

Welke ontwikkelingen zouden moeten plaatsvinden in de sector voordat het technisch en bedrijfseconomisch haalbaar is om waterstof te importeren?

Beleidsmogelijkheden

Welke beleidsmogelijkheden heeft EZK om deze barrières voor waterstofimport te verlagen?

Per barrière: Welke beleidsinterventies zijn het meest geschikt om deze barrière op te lossen?

- Financiële steun (bijv. een investeringssubsidie, specifieke CAPEX of OPEX steun, hoe verhoudt dit zich tot bestaand generieke beprijzing, normering en subsidiering, welke CAPEX en OPEX is specifiek van toepassing op import?)
- Coördinatie (bijv. het bij elkaar brengen van vraag en aanbod, matchmaking, certifcatie, etc)
- Het wegnemen van (investerings)risico (bijv. een garantiestelling, importkredietverzekering, prijsgaranties, etc)
- Inzet van een nationale deelneming om gestandaardiseerde waterstof "producten" in Nederland/Europa aan te bieden (bijv. H2Global)