The
Federal Government

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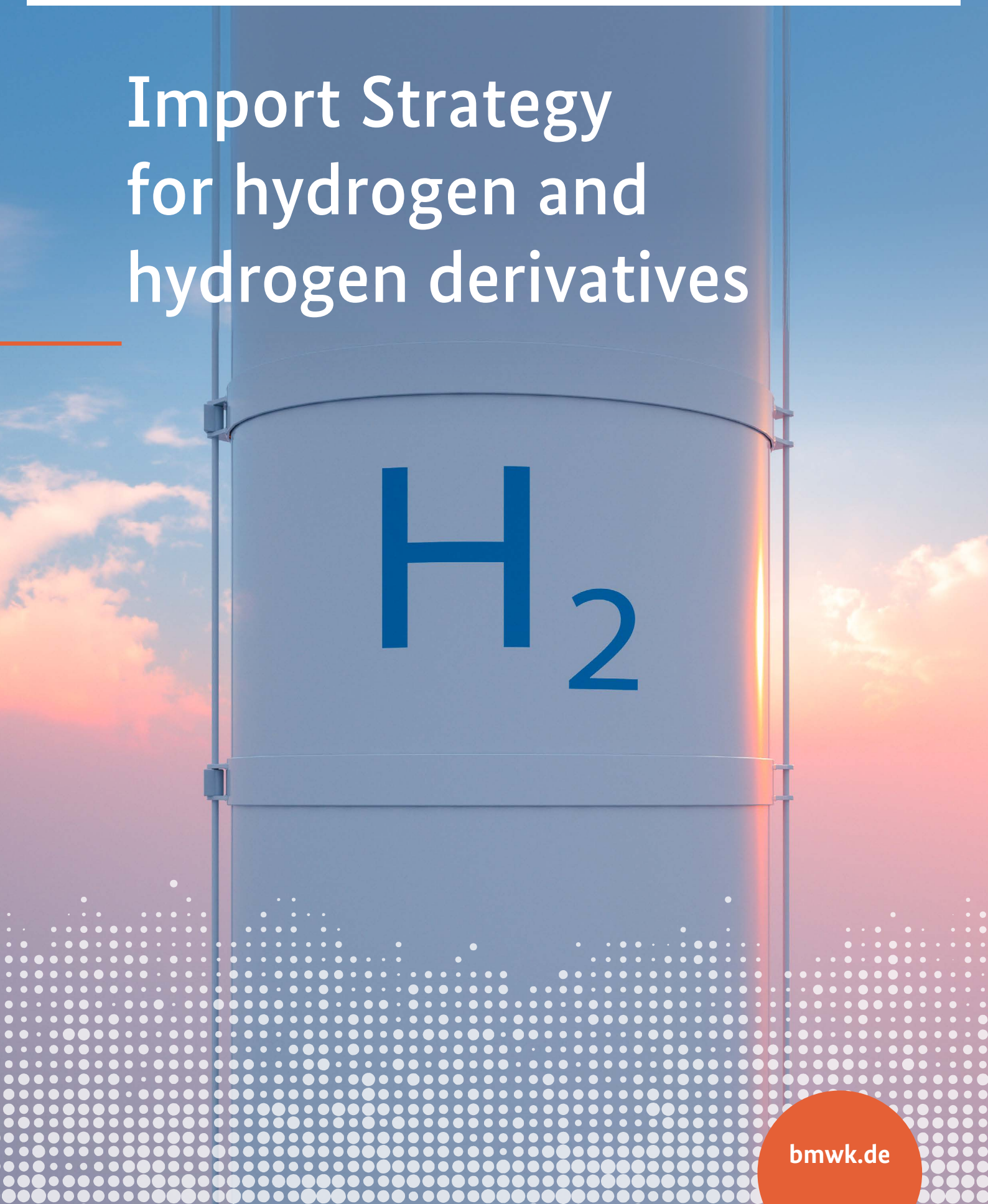
Schlüsselelement
der Energiewende

Import Strategy for hydrogen and hydrogen derivatives



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Summary

In the medium and long terms, imports will account for a large portion of Germany's demand for hydrogen and Germany will be one of the world's largest importers of hydrogen. A resilient, i.e. **sustainable, stable, secure and diversified supply with sufficient quantities of hydrogen and hydrogen derivatives** is in Germany's strategic interest. It is therefore the Federal Government's objective to safeguard a reliable supply with green, permanently sustainable hydrogen and its derivatives. To allow for the necessary swift hydrogen rollout, the Import Strategy also includes coverage of demand by low-carbon hydrogen and its derivatives. This Import Strategy is intended to offer guidance and afford clarity on the overarching objectives and conditions, on Germany's need for imports of hydrogen and its derivatives, and on the establishment of hydrogen partnerships and import routes. It is an integral part of the Federal Government's National Hydrogen Strategy, an updated version of which was adopted by the Federal Government in 2023.

A resilient supply with sufficient quantities of hydrogen and its derivatives is necessary to ensure the decarbonisation of the German economy and compliance with Germany's national climate targets. The Import Strategy is to contribute to better security for investments in hydrogen production in Germany's partner countries and for the construction of the necessary import infrastructure, thereby also accelerating the global energy transition. In this way, the Import Strategy opens up major market opportunities for potential exporters of hydrogen and sends a message to the German business community, telling them that there will be a reliable supply with sufficient quantities of hydrogen and its derivatives, which are necessary for the transition to climate-friendly processes. In its implementation of the Import Strategy, the Federal Government will take into account **five dimensions of objectives and impacts:** energy and economic policy, European and neighbourhood policy, foreign and security policy, development policy, climate and environmental policy.

For **2030**, the Federal Government is expecting **demand for hydrogen and derivatives** to have increased to **95-130 TWh**, of which imports are to account for **50-70%.** Demand for hydrogen and hydrogen imports will increase further as the transition of the economy towards climate neutrality progresses: by 2045, it is expected to rise to **360-500 TWh of hydrogen and 200 TWh of hydrogen derivatives**. At present, studies indicate that – especially up to 2030 – this demand will mainly come from the steel industry, basic chemicals and petrochemicals, in mobility and logistics and the power plant sector. Hydrogen and its derivatives will be used to replace fossil fuels and to enable the transition to climate-friendly manufacturing processes.

The Federal Government is supporting a **diversified product portfolio for hydrogen imports**. Apart from molecular hydrogen (i.e. gaseous or liquid hydrogen which is not bound in derivatives), these could include **various hydrogen derivatives** (including ammonia, methanol, naphtha, power-based fuels) and **hydrogen carriers** (such as LOHCs). Each of these products has different characteristics appropriate for different use-cases and comes with its own advantages and challenges that need to be considered as import routes are being established. Hydrogen and its derivatives need to be used efficiently for the relevant technologies to be economically viable. It is therefore necessary to take into account early on that it is particularly cost-effective to **use imported hydrogen derivatives directly, wherever this is possible**. However, a needs-based reconversion of derivatives back to molecular hydrogen will also play an important role.

The Federal Government envisages the **building of import infrastructure for transport by pipeline and ship**, bearing in mind that the use of gas import infrastructure and its reengineering to accommodate hydrogen can result in cost-savings. For **molecular hydrogen, pipelines** are a particularly cost-effective means of transport. These particularly enable hydrogen imports from Europe and its neighbours to Germany. **Transport per ship, railway line or road** is an option mainly for **hydrogen derivatives, carriers and downstream products**. Shipping allows for hydrogen imports from countries that cannot be connected to Germany via pipeline for technical and/or economic reasons. The onshore LNG terminals that are currently in the planning stages are designed to bring hydrogen derivatives on shore when they are no longer used to transport LNG. In the medium term, it is likely that a large portion of Germany's hydrogen imports will be transported via pipelines. For derivatives we can expect that ship-based transport can remain efficient even in the long term, so that it will probably play an important role in the import mix.

The **mix of instruments** deployed in the context of the Import Strategy focuses on different sections of the value chain of the international hydrogen market (upstream, midstream, downstream):

- **Reliable demand in Germany is to be strengthened** so as to send a clear signal for the development of an international market for hydrogen and its derivatives. Demand is to be strengthened by the right framework and through planning security; where necessary, bespoke funding instruments and incentive systems will be established.

- **Supply-side support can be granted in addition to this in cases where this is justified.** This is achieved through relevant funding programmes and guarantee instruments designed to support hydrogen projects in the EU and in third countries.

- For Germany's import needs to be met, it is necessary to enable and support cross-border transports of hydrogen and its derivatives. **To this end, the Federal Government is focusing simultaneously on the construction of both pipeline-based import infrastructure and of import terminals.**

- A reliable international ramp-up of the market for hydrogen and its derivatives also requires **ambitious and workable sustainability standards and transparency regarding the properties of the hydrogen products being traded.** Climate-related product specifications in Germany are rooted in European legislation, particularly the Renewable Energy Directive and the Internal Gas and Hydrogen Market Directive. Beyond this, the Federal Government engages in dialogue with international partners on an equal footing, advocating for ambitious sustainability standards to be agreed, further developed and complied with across the globe.

- Also, the Federal Government is planning to diversify the supply of hydrogen and its derivatives to a maximum degree. The Federal Government is doing so by establishing **bilateral and multilateral cooperation formats with a large number of partner countries, regions and international organisations**.

- Targeted research and development will also foster the ramp-up of the international hydrogen market.

1 Introduction

The Federal Government was quick to recognise the importance of hydrogen for a secure and increasingly decarbonised energy and economic system, which is why it adopted a National Hydrogen Strategy in June 2020 (NHS 2020). As the NHS 2020 was in need of adjustment to reflect the higher ambitions in climate action and the new challenges encountered on the energy market, an updated version of the NHS was presented in July 2023 (NHS 2023). This Import Strategy for Hydrogen and Hydrogen Derivatives is an integral and supplemental part of the update of the NHS 2023. It is also part of the regular monitoring of the NHS 2023.

In the medium and long terms, imports will have to account for a large portion of Germany's demand for hydrogen – by 2030, they are likely to contribute 50-70% of Germany's supply. This will make Germany one of the world's largest importers of hydrogen. The Federal Government aims to ensure a secure supply with green, permanently sustainable hydrogen. To allow for the necessary swift hydrogen rollout, , the Import Strategy also includes coverage of demand by low-carbon hydrogen and its derivatives. This is to ensure a reliable supply with sufficient quantities of hydrogen and its derivatives as early as is possible, so that these can be used as a basis to transition to climate-neutral production methods. The NHS restricts direct financial support to the production of green hydrogen and its derivatives. On the demand side, funding for the use of low-carbon hydrogen is also possible, provided that an emissions threshold of approx. 3.4 kg of CO_2-eq./kg H2 set out in the Internal Gas and Hydrogen Market Directive is adhered to. The same principle applies for imports as well.

The over-arching objective of this Import Strategy is to ensure a resilient, i.e. stable, secure, sustainable and diversified supply with sufficient quantities of hydrogen and hydrogen derivatives. This Import Strategy forms a reliable framework for private-sector hydrogen imports to Germany. In this way, it is to afford better security of investments in hydrogen production in Germany's partner countries and in the construction of the necessary import infrastructure.

The Import Strategy is targeted at market players that play a crucial role in realising hydrogen imports to Germany. It is to serve as guidance to producers, project and infrastructure developers, traders of hydrogen and hydrogen derivatives, buyers, financial institutions, grid operators and local stakeholders in the producer countries. Hydrogen offtakers need to be able to rely on a liquid and stable market for hydrogen, whilst also being able to provide the offtake security that is needed for export projects in the partner countries to get off the ground.

The Import Strategy is also intended to give the governments of Germany's partner countries clarity about its needs for imports of hydrogen and its derivatives and about its over-arching objectives in building and expanding hydrogen partnerships, as well as the conditions that apply. Also, the Import Strategy provides some details about selected supportive measures.

2 The policy dimensions of imports of hydrogen and hydrogen derivatives

In its implementation of the Import Strategy, the Federal Government is guided by the following policy dimensions and their objectives (cf. Fig. 1). There are synergies between these, but sometimes also potential for conflict.

Fig. 1: Objectives and effects of the Import Strategy in the various policy dimensions

Source: BMWK

2.1 The dimension of energy and economic policy

The use of hydrogen and hydrogen derivatives as a source of energy and a material feedstock is a key tool for the decarbonisation of the German economy. In principle, hydrogen and its derivatives can be used to decarbonise various sectors. Whether or not hydrogen will actually be used will depend on the quantities that are available and on how much it costs compared with other alternatives. For as long as hydrogen is a limited and expensive resource and source of energy, its use is likely to be predominantly centred on applications where direct electrification is not economically feasible or for which there are no alternative technical solutions to achieve climate neutrality. A quick ramp-up of a liquid market for hydrogen helps ensure that sufficient quantities of much-needed hydrogen become available at a low cost, which will also contribute to our energy security.

It is the Federal Government's view that the use of hydrogen should not be restricted within its individual fields of application. As far as the demand side is concerned, the Federal Government expects that, up to 2030, hydrogen and its derivatives will mainly be used in the industrial sector, for heavy commercial vehicles and increasingly in aviation and shipping. In the electricity sector, gas-fired power plants that can be modified to accommodate hydrogen can play a part in delivering energy security within an electricity system dominated by renewables. Ultimately, it is for the market to decide in what areas and from when it will make good economic sense to use hydrogen and hydrogen derivatives.

For Germany and its economy, the global ramp-up of the hydrogen market also opens up major opportunities in research, development, manufacturing and exports of hydrogen technologies. Through its targeted policies to support research and innovation and to promote foreign trade and investments, the Federal Government is aiming to foster market leadership of German hydrogen technology companies. German technology providers are also available as partners for the global ramp-up of production and transport capacities. The Federal Government wants to further strengthen them in this role.

2.2 The dimension of European and neighbourhood policy

For the Import Strategy to be successful, greater cooperation within the EU and with the countries neighbouring the EU (e.g. Norway, the UK, North African countries) is of great importance. A focus here is placed on tapping low-cost potential for hydrogen production as effectively as possible and on building durable import relations.

In addition to deepened cooperation, the swift construction of a pipeline-based, trans-European hydrogen network is of the essence. This is to connect up the most important centres of production, import and use of hydrogen within the EU and allow for the distribution of hydrogen produced within the EU or imported from third countries. The Federal Government is a pioneer on this, creating a hydrogen core network as a basis for the trans-European hydrogen network that will increase the level of planning security for

all stakeholders involved within the country and abroad. It is a key objective of the Federal Government to ensure that the trans-European hydrogen network is connected to the EU neighbours and to ports within the EU.

Germany and the EU have developed and set a clear framework for hydrogen that is to support the market ramp-up and contribute to regulatory and investment certainty. The work to deliver the elements that still missing, such as the necessary specifications of the certification requirements, is under way and given high priority. In this way, Germany and the EU are taking on a leading role in the development of the international market. At EU and international level, the Federal Government is advocating that the relevant rules should be developed further as a joint effort, so that they can also be established in international trade. Throughout the work in these rules, care is being taken to equally take into account the interests of producers and customers of hydrogen and hydrogen derivatives.

Beyond this, the Federal Government is working to achieve a coordinated ramp-up of the EU hydrogen market and a coherent implementation of the EU regulatory framework on hydrogen. The Federal Government also believes it has a responsibility to support the market ramp-up in smaller EU Member States. A closely coordinated European market ramp-up will contribute to the objective of a liquid global market for hydrogen and hydrogen derivatives, on the basis of rules, standards and certification systems that are recognised internationally.

2.3 The dimension of foreign and security policy

Germany's National Security Strategy stipulates that critical dependencies on energy imports are to be avoided/eliminated in this world of increasing systemic rivalry and technological competition. The Import Strategy also serves the objective of strengthening energy security through the establishment of diversified import routes for hydrogen and hydrogen derivatives, which is also resilient against disruptions of supply. The same applies to technologies and upstream products connected to this, including critical raw materials. Value and supply chains fall within the responsibility of companies. At the same time, the Federal Government will keep an eye on the geopolitical framework, the need for supplies and the competitive situation German companies find themselves in and will remain in dialogue with German companies and associations on these matters.

There is a large number of countries that have good potential for producing hydrogen and hydrogen derivatives and could act as suppliers – a fact that makes it easier to establish a diversified import portfolio. For exporters of fossil fuels, this also opens up new opportunities to switch their supply relations to hydrogen and to tap into a forward-looking market. Existing and new climate and energy partnerships can strengthen hydrogen import projects and deepen trade relations to both countries' benefit. By the same token, cooperation on hydrogen – a resource that is set to gain importance in the future – can also benefit Germany's wider bilateral cooperation with many countries.

The Federal Government will also ensure that immobile infrastructure like pipelines will not generate dependency on individual suppliers, which is why Germany is in favour of creating a trans-European hydrogen network and opening up ship-based import routes for hydrogen derivatives, carriers and liquefied hydrogen. Attention will also be given to the protection of this critical infrastructure and to securing free trade routes. International cooperation on the ramp-up of the hydrogen market is to contribute to a values-based, socially just ecological transition that generates peace, stability and sustainable prosperity instead of new dependencies and inequality.

2.4 The dimension of development policy

Given the necessity for building new value chains and infrastructure, there is a chance to design the ramp-up of the hydrogen market pragmatically and as a part of a socially just and sustainable energy transition in the supplier countries and the importing countries. Germany supports developing countries and emerging economies on their paths towards decarbonised, sustainable and reliable energy systems and does so particularly through existing energy, climate, development and hydrogen partnerships and bilateral and multilateral Just Energy Transition Partnerships (JETPs). The establishment of hydrogen markets is also an opportunity for the creation of local value chains and skilled jobs. For partner countries currently exporting fossil fuels, the transition to hydrogen is an opportunity for economic diversification.

Because of this, the Federal Government is offering holistic cooperation that serves the UN Sustainable Development Goals (SDGs), i.e. is aimed at value creation in the partner countries benefitting from Germany's development cooperation and at improving living conditions there (including access to energy and drinking water). Within international forums and existing and new hydrogen partnerships, the Federal Government will support the establishment of and compliance with joint ambitious and workable sustainability standards and criteria and work to update and harmonise these where necessary and within the holistic meaning of the SDGs (e.g. with regard to energy and water consumption, the rights of indigenous populations, land use, resource-efficiency, health and safety at work, local participation). This will always be done as part of a constructive dialogue with our partners and on an equal footing.

Germany can support the creation of a hydrogen market, in particular in developing countries and emerging economies, by offering economic and technological partnership involving exports of innovative hydrogen technologies, help with training and further training of local skilled labour, and thereby the creation of climate-neutral value chains in potential export countries. German companies are already involved in many of the emergent hydrogen export projects abroad.

2.5 The dimension of climate and environmental policy

By adopting the Paris Agreement, the international community has committed to a 1.5-degrees path that is designed to contain the risks of the climate crisis and implement a global transition towards a climate-neutral economic and social system. The Federal Government's Strategy on Climate Foreign Policy also mandates the creation of an international hydrogen market and the establishment of hydrogen import relations as a prerequisite for Germany to remain a centre of industry.

The international, European and German climate and energy targets and their translation into European and national law set the climate-policy framework for the European market ramp-up. However, the dynamic increase in hydrogen production and demand incentivised by these targets must not have negative repercussions on the global energy transition and on sustainable development within the meaning of the SDGs. In this context, it is also important to avoid false incentives for investments in fossil energy (fossil lock-ins), which is why the transition and possibilities for reengineering to hydrogen and its derivatives should be taken into consideration from the beginning in such investments. As export projects are set up in third countries, considerable consideration should therefore be given to aspects such as the project's contribution to national climate strategies in accordance with Nationally Determined Contributions (NDCs) and to long-term strategies, and to factors such as resource-efficiency, the security of infrastructure and environmental compatibility. This applies in addition to the other policy dimensions. The Federal Government is actively working to promote compliance with ambitious thresholds for greenhouse gas emissions and environmental, safety and security and social standards.

The production of various hydrogen derivatives requires not only hydrogen, but also carbon. Not least with regard to imports of hydrogen derivatives, it therefore makes sense to increase the availability of sustainable carbon and ensure its circular use. The German Carbon Management Strategy will make a contribution to this.

3 Demand and framework for imports of hydrogen and hydrogen derivatives

In Germany, demand for hydrogen and hydrogen derivatives will grow by a significant margin. Hydrogen derivatives is a term subsuming a multitude of hydrogen-based products, each with its own distinctive characteristics, fields of applications, and its advantages and challenges during conversion, transport and use.

3.1 Demand for imports of hydrogen and hydrogen derivatives in relevant applications

In its NHS 2023, the Federal Government estimated that Germany's demand for hydrogen and its derivatives will reach between 95 to 130 TWh by 2030. To meet this demand, 10 GW of domestic electrolyser capacity is to be added. In addition to this, some 50-70% of the demand (45-90 TWh) will have to be covered by imports. The Federal Ministry for Economic Affairs and Climate Action estimates in its interim report on the Systems Development Strategy that the share of imports will continue to grow after 2030, with demand reaching 360-500 TWh of hydrogen and some 200 TWh of synthetic hydrocarbons and other hydrogen derivatives by 2045. Any forecasts of demand are, however, characterised by many points of uncertainty that are subject to a host of dynamically developing factors (e.g. price development, availability of hydrogen, infrastructure development, etc.), and these uncertainties increase over time. Depending on how the market develops, actual needs can turn out higher or lower than the spans cited above. Nevertheless, there is a robust outcome that spans all scenarios and forecasts: demand for hydrogen and its derivatives is set to massively increase and with this comes a very high need for imports.

Based on the information that is currently available, this demand will mainly arise in the fields of application listed below. They will result from the replacement of fossil energy on the one hand and from additional needs through new production processes on the other (e.g. direct reduced iron, Fischer-Tropsch, methanol synthesis). Concrete forecasts of demand for the fields of application described below can be found in the relevant literature, e.g. the long-term scenarios published by the Federal Ministry for Economic Affairs and Climate Action or the analyses conducted by the National Hydrogen Council.

At present, the **steel industry** does not use hydrogen; blast furnaces are usually powered by coking coal. For iron and steel to be produced emissions-free, the blast furnaces of today will be replaced with direct reduction iron (DRI) installations. In these installations, hydrogen is used to produce sponge iron, which can then be used to manufacture steel products. With the transition to DRI installations, demand for hydrogen in the German steel industry will rise successively and massively up to 2045.

The **basic chemicals and petrochemicals industry** already produces hydrogen locally through steam reforming along established process routes. This hydrogen is then directly used as a chemical feedstock. A need for substitution will mainly arise in the field of petrochemicals whose production is currently based on naphtha and steamcracking. In future, hydrogen will be used on its own as a fuel gas for high-temperature processes and in combination with carbon dioxide to serve as a basic chemical for the production of various derivatives in (petro-)chemical processes. As a result, demand for hydrogen for (petro-)chemical processes will have multiplied by 2045.

At present, international **shipping** operates mainly on the basis of fossil fuels that are derived from crude oil (and in a few cases natural gas). The bulk of Germany's merchant fleet consists of large vessels such as container vessels or bulk carriers. Apart from fully electric batteries, electricity-based fuels can also serve as a key lever for the decarbonisation of German shipping. As far as internationally freight shipping is concerned, potential candidates being discussed include ammonia, methanol and liquid hydrogen. Due to long investment cycles required to replace vessels' propulsion systems, a large demand for various hydrogen derivatives is not to be expected before the medium or long term.

Decarbonising **aviation** requires the replacement of traditional fossil-based kerosene with sustainable aviation fuels (SAFs), including eKerosene. In its power-to-liquid roadmap, the Federal Government mentions the use of at least 200,000 tonnes (equivalent of approx. 2.4 TWh) of eKerosene as a realistic target for 2030. Due to the various possible manufacturing paths for SAFs it is difficult to make a final forecast of demand for eKerosene. Overall, however, demand for hydrogen in this field is also expected to rise to a high level by 2045.

In **heavy-goods transport** (heavy commercial vehicles), hydrogen and fuel cell technology will complement other alternative drives. In view of the CO_2 emission reduction targets and measures such as the CO_2-based truck toll, growing demand for hydrogen is also expected to emerge in the field of heavy-goods transport by 2030.

At present, **the power stations delivering intermediate and peak loads** and **CHP installations** used for the generation of electricity are mainly fuelled with natural gas (and in some cases hard coal). This demand is to be gradually substituted. Together with other efficient flexibility or storage options, hydrogen power plants will, in future, be able to provide additional electricity in times of high demand and low supply from renewables. This can cover short term peaks and seasonal supply shortages. The Power Plat Security Act and the capacity mechanism were designed by the Federal Government not least with the intention of incentivising H_2-ready gas-fired power stations that will use hydrogen in the future. However, future demand from the power plant sector might vary, especially depending on the speed of the expansion of wind energy and PV installations.

According to the information available to the Federal Government at present, demand for hydrogen in distributed **heat generation**, for light commercial vehicles and cars will be rather moderate up to 2030, due to more low-cost alternatives. The necessary framework for hydrogen use in centralised and distributed heating has been created by adoption of the Heat Planning Act and the most recent amendment of the Buildings Energy Act. As part of their heat planning process, municipalities can decide to designate hydrogen network areas or else to use synthetic methane. This also includes the option of using hydrogen for district heating.

At present, **process heat** is overwhelmingly generated from fossil fuels. Apart from applications in the steel and (petro-)chemical industries, process heat is also needed for basic materials (cement, lime, glass and paper), forming technology, hardening and electroplating, foundry technology, aluminium, copper, ceramics and brick and tiles. At present, it is difficult to predict the extent to which hydrogen will be used for the CO_2-neutral generation of process heat (instead of electrification or biomass).

3.2 The role and importance of derivatives compared to those of molecular hydrogen

Apart from molecular hydrogen (i.e. gaseous or liquid hydrogen which is not bound in derivatives), these could include various hydrogen derivatives, carriers and downstream products. Each of these has its own distinctive chemical and physical characteristics that come with different advantages and challenges (cf. Table 1). Due to the specific advantages and challenges of each hydrogen derivative, the Federal Government will support imports of a diverse product range.

3.2.1 Current and future demand for hydrogen derivatives

At present, the Federal Government is expecting demand for various hydrogen derivatives to increase to approx. 200 TWh in 2045. The most important hydrogen derivatives that are already widely used by the industrial sector are ammonia, methanol and naphtha.

Ammonia is a basic compound used by the chemical industry – at present mainly for the production of fertilisers. Today, some 3 million tonnes of ammonia are in use in Germany every year. In structural terms, the German ammonia market is characterised by a mixture of domestic production and imports. As new types of use (e.g. ammonia as a shipping fuel) are developed in addition to the existing ones (especially fertiliser production), a considerable increase in demand can be expected.

Methanol is already being put to a wide range of applications, especially as a basic chemical and, in a pure or diluted form, as a fuel. Approx. 1 million tonnes of methanol per year are currently being used in Germany. Across the globe, more than 171 million tonnes of methanol are produced every year, making it one of the most common basic organic chemicals. Substitution of what is currently a fossil-based molecule combined with new fields of application (e.g. as an alternative shipping fuel) will result in even much higher demand for methanol.

Naphtha is another important basic chemical. Today, it is mainly used in steam crackers, where it is added to basic chemicals to make plastics and other materials. At present, Germany uses some 11.7 million tonnes of naphtha and other petroleum derivatives every year. By 2045, demand for Fischer-Tropsch naphtha could rise considerably.

In future, relevant quantities of **electricity-based fuels** (e.g. eKerosene) will also be used in addition to the hydrogen derivatives listed above. Importing **synthetic methane (SNG)** or dimethylether (DME) is an option, provided that the carbon cycle is closed on balance if viewed across the entire value chain.

As an alternative to hydrogen derivatives, liquid or solid carriers, such as **liquid organic hydrogen carriers (LOHCs)** or metal hydrides can also play a role, given their capacity to facilitate the transport and storage of molecular hydrogen.

Table 1: Role and characteristics of different hydrogen products and carriers

Hydrogen product/carrier	Potential fields of application	Advantages	Key obstacles	Time to implementation
Molecular hydrogen	Iron and steel production, power plants, heavy-goods transports, process heat, space heating (fuel cells)	No synthesis required High efficiency of pipeline-bound gaseous hydrogen transport	Potential lack of public acceptance, particularly of new pipeline projects Insufficient shipping and liquefaction capacities so far High energy requirements for shipping compared to pipelines	**Short to medium term** Conversion and construction of pipelines **Medium to long term** Liquefied hydrogen by ship
Ammonia	Basic chemicals and petrochemicals, shipping, carrier for molecular hydrogen	Simple extraction of the nitrogen required from air Advantageous transport properties Trade in ammonia already established. Infrastructure for import and use already available in Germany	Large-scale ammonia crackers are in the planning stages, but not yet available Environmental hazards caused by nitrogen oxides/ toxicity	**Short term** Ammonia transport by ship
Methanol	Basic chemicals and petrochemicals, shipping	Advantageous transport properties; liquid at ambient temperatures Trade in methanol already established. Infrastructure for import and use already available in Germany	Sustainable carbon (cycle) required (yet to be developed) Large-scale DAC installation not yet available	**Short term** Methanol transport by ship
Dimethyl ether (DME)	Chemical and pharmaceutical industries, diesel engines, carrier for molecular hydrogen	Advantageous transport properties Higher volumetric energy density than methanol or ammonia	Risks delaying investments in and construction of alternative infrastructure Reconversion to hydrogen not available (yet) Sustainable carbon/cycle) required (yet to be developed)	**Medium term** Transport by ship
Fischer-Tropsch products (e.g. naphtha, eKerosene)	Basic chemicals and petrochemicals, aviation and shipping	Advantageous transport properties Materials characteristics identical with fossil product Use of existing petroleum infrastructure for transport, distribution and consumption	Low efficiency rate compared to ammonia or methanol synthesis Sustainable carbon/cycle) required (yet to be developed) Large-scale DAC installation not yet available	**Short to medium term** Transport by ship
Synthetic methane (SNG)	To replace natural gas (e.g. steel, chemicals, power plants, space heating)	Materials characteristics identical with fossil product Use of existing natural gas infrastructure for transport, distribution and consumption	Risks delaying investments in and construction of alternative infrastructure (e.g. hydrogen core network, DRI installations) Sustainable carbon/cycle) required (yet to be developed) Large-scale SNG installations not yet operational	**Short term** SNG transport per pipeline for natural gas Transport of liquefied SNG per ship
Liquid Organic Hydrogen Carriers (LOHCs)	Carriers for molecular hydrogen	Use of existing petroleum infrastructure for transport and distribution	Very expensive at present Hydration, dehydration and production installations for carriers not yet in existence Environmental hazards	**Medium to long term** LOHC transport by ship

3.2.2 The role of hydrogen derivatives in the Import Strategy

Hydrogen derivatives make it possible to chemically bind molecular hydrogen, making it easier to transport and store over longer distances and for a longer time. However, using imported hydrogen derivatives directly wherever possible is more energy-efficient and tends to be more cost-effective. Where it is impossible to domestically produce sufficient quantities of hydrogen or import them via hydrogen pipelines, the process of reconverting derivatives into molecular hydrogen can also play an important role. It is true that such reconversion results in significant losses of energy and therefore entails costs. However, in future this will partially be compensated by the lower costs of production in the exporting countries. The reconversion of derivatives containing carbon, including methanol, naphtha and eKerosene, also releases carbon dioxide. The Federal Government is advocating for solutions that ensure that sustainable carbon is permanently kept within the cycle (CCU) or is once again captured and permanently stored at the end of the product's lifecycle (CCS). The details of this will be set out in the Federal Government's Carbon Management Strategy that is currently being drawn up.

Imports of hydrogen and hydrogen derivatives are subject to specific safety requirements. These can be specified on the basis of existing requirements for the technical handling of different hydrogen derivatives (e.g. coating requirements for tanks, safety requirements for the transport of ammonia, etc.).

3.3 Transport options

The Federal Government envisages to build import infrastructure for pipeline-bound and maritime transport in parallel, bearing in mind that the use of gas import infrastructure and its potential reengineering to accommodate hydrogen may result in cost-savings that improve the economic viability of hydrogen projects. In the medium term, it is likely that a large proportion of Germany's hydrogen imports will be transported via pipelines, provided that – as is assumed to be the case for the typical distances across the North Sea, Baltic Sea and the Mediterranean – these import routes are cheaper and more environmentally-friendly than maritime transport and that the resulting cost savings make up for potentially higher production costs. For hydrogen derivatives we can expect that shipping can remain efficient even in the long term, so that it will probably play an important role in the import mix.

3.3.1 Pipelines and transport networks

A pipeline-bound hydrogen infrastructure allows for a cost-effective transport of molecular hydrogen from Europe and its neighbouring countries to Germany – without the need for conversion that would result in energy losses. In addition to new pipelines, reengineering of natural gas pipelines, where it is technically feasible and compatible with gas security, can have various advantages over the construction of new pipelines, e.g. lower costs, resource-efficiency etc.

The construction of a pipeline infrastructure poses a major financial challenge to future hydrogen network operators, particularly during the initial phase when there will be few users. This is why the Federal Government gives priority to the financ-

ing and swift construction of hydrogen pipelines and the repurposing of long-distance natural gas pipelines. In a first step, a hydrogen core network is being planned in Germany. Because of cost and efficiency advantages, a close connection of this core network to the trans-European hydrogen network is envisaged from the very beginning. Interconnectors, i.e. cross-border links between neighbouring networks, are a physical requirement for the construction of a trans-European hydrogen pipeline network.

Apart from the expansion of the pipeline system, storage facilities for hydrogen and hydrogen derivatives are also part of the expansion of the national hydrogen network. Feeding hydrogen into and out of these storage facilities allows for the constant supply of large-scale hydrogen users, even at times of low production or fluctuating import quantities or prices. Apart from its storage in underground facilities or caverns, hydrogen can also be stored in the form of its derivatives.

3.3.2 Shipping

Shipping of liquid hydrogen, liquid or solid carriers or derivatives allows for hydrogen imports from world regions that cannot be connected to Germany per pipeline for technical or economic reasons. In this way, hydrogen or its derivatives can be shipped to Germany's sea ports or the ports of neighbouring EU Member States equipped with the relevant infrastructure (particularly Amsterdam, Rotterdam, Antwerp). The Federal Government expects that, in the long term, imports of fossil fuels via the ports will fall and be replaced with imports of hydrogen derivatives. This transition requires the construction or reengineering of import terminals. In addition to this, sustainable transport routes in the form of **green corridors** are to be established. Green corridors are certain shipping routes that are emissions-free from start to finish, including the fuelling infrastructure and the vessels themselves.

Ammonia transport per ship is already established internationally. However, scaling up of this international trade in ammonia requires the construction of additional import terminals and transport vessels. In Germany, several projects of this kind are currently in the planning stages and are to be concluded before 2030 (e.g. in Hamburg, Wilhelmshaven, Brunsbüttel and, in future, Rostock). If ammonia is not to be used directly as a derivative, but as a carrier for molecular hydrogen, crackers need to be established to split up the compound. Because of this, projects for import terminals and for crackers are being planned and implemented parallel to one another. Once isolated, the hydrogen can then be used locally by the industrial sector or fed into the hydrogen core network for transport. This, however, comes with energy losses due to the conversion. As with ammonia, **shipping of methanol** is also a tried and tested process. Here, too, transports cost energy and result in energy losses. **LOHCs** are similar to fossil fuels, allowing for a swift adaptation. At present, it is as yet unclear whether and to what extent the **shipping of liquid hydrogen** to Germany will be economically competitive; this is due to high energy losses and its low volumetric energy density during transport.

3.3.3 Other transport options

Transport by truck, railway or the inland waterways allows for the supply of hydrogen and its derivatives to small and medium-sized users that are not connected to the hydrogen core network directly. To avoid reconversion costs, these transport options are mainly suitable for users of derivatives. Also, in the short term, they allow for initial imports to be transported from the ports to consumers.

4 Measures for the ramp-up of imports of hydrogen and hydrogen derivatives

The Federal Government defined and has since further developed a set of measures in its 2023 National Hydrogen Strategy in order to ensure sustainable, secure, diversified and stable imports of hydrogen and hydrogen derivatives. The mix of instruments deployed under the Import Strategy[1] addresses different sections of the value chain (upstream, midstream, downstream) of the international hydrogen market and includes first and foremost practical and reliable policies and additional regulatory incentives and funding instruments. Among other goals, this is intended to establish reliable demand in Germany which can be an important signal for the development of the international market.

4.1 Strengthening of demand

A practical and reliable policy environment is to increase the demand for imports of hydrogen and its derivatives. In addition, customised funding instruments and incentive systems on the demand side close funding gaps in transformation projects in the area of hydrogen and hydrogen derivatives and therefore contribute to their market-readiness. This is particularly true for projects in the industrial sector, in the case of heavy commercial vehicles, the aviation sector and shipping, and for power plants. This creates demand for imports when procurement costs for hydrogen and hydrogen derivatives are not yet competitive. The resulting offtake security makes it easier for international producers of hydrogen and its derivatives to make investment decisions.

4.1.1 Funding instruments for the use of hydrogen and hydrogen derivatives

The **Carbon Contracts for Difference (CCfDs)** funding programme covers the cost difference between a climate-friendly plant and a conventional plant over a course of 15 years and facilitates the transition of production processes in particular for companies that are very energy-intensive and have high emissions of carbon dioxide. The funding support is flexible and is automatically adjusted to future price developments. The transition to climate-neutral technologies also contributes to increasing the demand for hydrogen and its derivatives. CCfDs create markets for the use of hydrogen and hydrogen derivatives and thus boost reliable demand for hydrogen imports in Germany. CCfDs are therefore not only a central climate action instrument but are also of great importance for the security of Germany as a centre for industry.

Another element that will contribute to an increase in demand for hydrogen in Germany is the **Federal Funding for Industry and Climate Action (BIK).** This instrument funds investments to decarbonise industry. The goal of the programme (programme duration is April 2024 until 2030) is to support wide-ranging investments in production facilities equipped with climate-friendly technologies on an industrial scale. These fund the electrification and introduction of CCU/S-technologies and the transition to hydrogen. An investment grant of up to €200 million per company is possible.

1 All measures that are described in or can be derived from the Federal Import Strategy are to be implemented in the context of the Climate and Transformation Fund and the financial and personal resources available in the individual budgetary plans (of the respective ministries).

The **H2Global** funding instrument with its double-sided auction mechanism creates further reliable demand and links and synchronises the international hydrogen supply and the demand for hydrogen in Germany. As an instrument for price determination and market preparation, H2Global reduces the risk of default by bundling several offers and making it easier for small and medium-sized companies in particular to participate as buyers on the hydrogen market.

Fig. 2: Measures and mix of instruments of the Import Strategy

Source: BMWK

The **Power Plant Security Act** and **the capacity mechanism** of the Federal Government create the framework for investments in flexible and climate-friendly power stations in Germany. In the short term, this includes inviting tenders for new power plant capacities for hydrogen-capable gas-fired power plants. The H2-ready gas-fired power plants are to be fully converted to hydrogen 8 years after commissioning. In addition, as part of applied energy research, funding is to be provided for initially 500 MW of capacity in power stations using 100% hydrogen.

The **EU Innovation Fund** is one of the largest EU funding programmes for the commercial demonstration of innovative low-carbon technologies. In addition to promoting hydrogen production through auctions by the European Hydrogen Bank, the Fund also provides funds to subsidise decarbonisation projects in emission-intensive industries and in the mobility sector. The EU Innovation Fund is fed by revenues from the EU emissions trading system. The European Commission is currently expecting a budget of €40 billion for the period from 2020 to 2030 (calculated using a carbon price of €75/tCO_2).

In addition, the EU has expanded the **Important Projects of Common European Interest (IPCEI)** instrument to hydrogen projects. IPCEIs are projects that serve the overarching European interests of the Member States. The IPCEI Hydrogen aims to support the hydrogen ramp-up in Germany and in Europe by promoting it along the entire hydrogen value chain. The IPCEI Hydrogen therefore includes several waves: Hy2Tech, Hy2Use, Hy2Infra, Hy2Move. Important hydrogen projects in the industrial and mobility sectors can also be funded and can stimulate demand, in addition to technology and infrastructure projects. The German projects in the IPCEI Hydrogen are co-financed, with 70% from the Federal Government (the Federal Ministry for Economic Affairs and Climate Action, the Federal Ministry for Digital and Transport) and 30% from the Länder (states) involved. The total funding volume is around €13.5 billion. Depending on the funding gap, the European Commission approves the specific funding amount for the respective hydrogen projects. The Commission has now already approved the four IPCEI waves Hy2Tech, Hy2Use, Hy2Infra and Hy2Move. In addition, some projects originally submitted under the IPCEI regime have now been approved under the regime of the Climate, Energy and Environmental Aid Guidelines (CEEAG).

The use of hydrogen and fuel cells as well as the use of electricity-based fuels are an important element for climate-neutral mobility and complement other alternative forms of propulsion. At national level, the promotion of research and development, the creation of a hydrogen fuelling station network and the procurement of vehicles further encourages the use of hydrogen in the mobility sector. The Federal Ministry for Digital and Transport promotes mobility applications and hydrogen refuelling infrastructure across all modes of transport through the **National Hydrogen and Fuel Cell Technology Innovation Programme** (NIP) as well as the vehicle ramp-up through technology-neutral funding measures, e.g. for light and heavy commercial vehicles with alternative propulsion systems.

To provide better orientation through the existing and emerging funding programmes of the individual ministries in the hydrogen sector, the Federal Government has set up a one-stop shop for funding advice, the **Hydrogen Pilot Office**, at www.nationale-wasserstoffstrategie.de.

4.1.2 Regulatory incentives for German companies for an increased use of hydrogen and hydrogen derivatives

In addition to funding instruments, there are various incentive instruments to support market developments for hydrogen and its derivatives in Germany and in Europe. Within the EU, the focus is primarily on emissions trading and quotas for hydrogen and its derivatives. They provide companies with concrete GHG reduction and usage paths for hydrogen.

The **EU Emissions Trading System** (ETS I) is a key EU lever for climate action. The emissions recorded in ETS I are to be cut by 62% by 2030 compared to 2005 levels. With the latest amendment to ETS I, the EU has expanded the scope of emissions trading from power plants, energy-intensive industries and intra-European air traffic to European and, partly, international maritime transport. ETS I now applies to all sectors that the Federal Government considers (according to its 2023 National Hydrogen Strategy) to be among the key hydrogen users. The legally defined long-term reduction path in ETS I leads to **rising CO_2 prices** due to the continuously decreasing supply of emission allowances, thus creating incentives for the use of hydrogen, amongst other things. ETS II will create a complementary emissions trading system for the heating and transport sectors, which will have a similar effect from 2027.

Hydrogen is also subject to the European **Carbon Border Adjustment Mechanism (CBAM):** from 2026, allowances for the emissions generated during production must be purchased and submitted for imported hydrogen (and for the hydrogen derivative ammonia). This will not only protect the European hydrogen industry from carbon leakage: in the future, hydrogen produced with fossil fuels will also become relatively more expensive compared to low-emission hydrogen.

The EU regulatory basis for the introduction of usage quotas is formed by the EU Renewable Energy Directive (RED), the ReFuelEU Aviation and FuelEU Maritime regulations. They are the central EU regulatory levers for stimulating the demand for hydrogen and hydrogen derivatives and for scaling it in the Member States.

The second amendment to the **EU Renewable Energy Directive (RED III)** from 2023 sets **targets in industry and quotas in the transport sector for the use of renewable fuels of non-biogenic origin (RFNBOs)**. RFNBOs are liquid or gaseous fuels based on electrolytically produced, renewable hydrogen. In the transport sector, the use of RFNBOs and advanced biofuels is to increase to a share of 5.5% by 2030. However, at least 1% must be met by RFNBOs. These requirements will be implemented nationally by mid-2025. RFNBOs can already be counted towards the GHG quota. Further to this, RED III sets binding targets for the industrial use of RBNBOs for all Member States (not for companies). EU Member States must ensure that the share of RFNBOs in the industrial sector increases to 42% by 2030 and to 60% by 2035 of the hydrogen used in industry for energy and materials.

ReFuelEU Aviation requires aviation fuel suppliers to add increasing amounts of sustainable aviation fuels (SAFs) to kerosene. A minimum blend of 2% will be added as of 2025. This will gradually increase and is to reach 70% in 2050. The regulation also specifies a minimum share of synthetic fuels, which includes RFNBOs but also low-carbon hydrogen derivatives. From 2030, 1.2% of the fuels used must be synthetically produced. By 2050, the share is to rise to 35%.

The **FuelEU Maritime** Regulation defines similar targets for **shipping**. It sets out uniform rules for reducing the greenhouse gas intensity of ships. This takes into account all voyages of ships larger than 5,000 gross registered tonnes to and from the EU, all intra-EU voyages and the energy consumption in ports. The targets for reducing greenhouse gas intensity increase from 2% in 2025 to 80% in 2050. RFNBOs are factored in with a multiplier of 2 until 2033. If the share of RFNBOs is less than 1% by 2031, a sub-quota for RFNBOs of 2% will automatically apply from 2034. The Federal Government is committed at EU level to adapting the FuelEU Maritime reduction targets to the more ambitious strategy of the International Maritime Organisation (IMO). The IMO has set itself the goal of covering at least 5%, if possible 10%, of energy consumption in international shipping with climate-neutral technologies and fuels by 2030 and of achieving climate neutrality in international shipping by 2050.

The greenhouse gas reduction quota (GHG quota) in transport set out in **section 37a of the Federal Immission Control Act** obliges fuel distributors to gradually increase the proportion of renewable fuels. On the one hand, special incentives for the use of renewable hydrogen and its derivatives have been implemented (multiple counting). On the other hand, there is a mandatory quota for hydrogen-based synthetic aviation fuels of 2% by 2030. With the current amendment of the Federal Immission Control Act, the **RFNBO quotas** in the transport sector defined in RED III will be **incorporated into national law** in 2024.

In addition to instruments that address the purchase of hydrogen and its derivatives and their further processing, the focus is now also on customer purchases. The **concept** of **"Lead markets for climate-friendly raw materials"** presented by the Federal Ministry for Economic Affairs and Climate Action in May 2024 aims to strengthen demand for climate-friendly raw materials such as steel, cement and the chemical raw materials ammonia and ethylene. Transparent and reliable definitions of these raw materials are a central part of this concept. The definitions can be used to create labelling systems that will strengthen demand for green basic materials and help with the development of lead markets.

4.2 Creating a sustainable import infrastructure

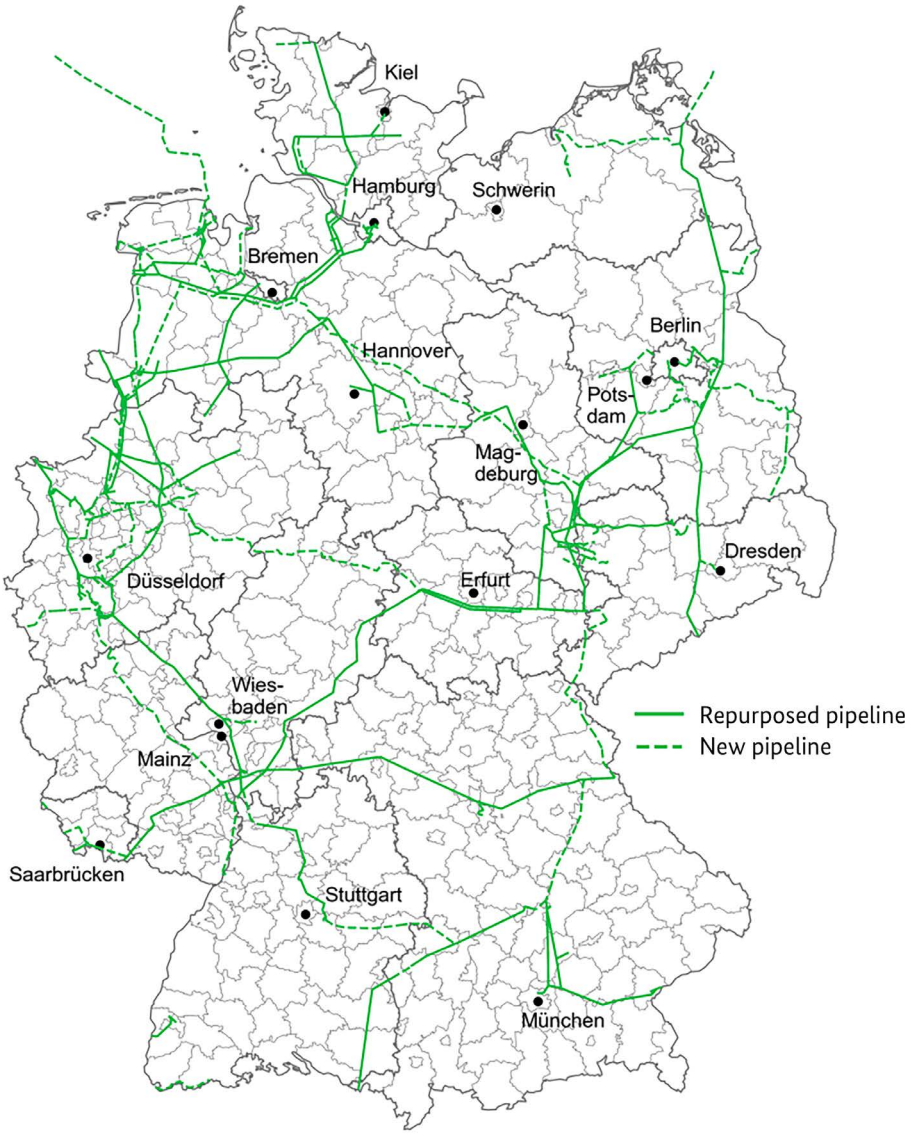
For Germany's import needs to be met, it is necessary to organise a linking of production and demand clusters and a cross-border transport of hydrogen and its derivatives. It is therefore important to quickly establish and expand a diversified import infrastructure and to do so in a forward-looking manner. To this end, the Federal Government is focusing simultaneously on the construction both of pipeline-based import infrastructure and of import terminals.

4.2.1 Establishing and accelerating a pipeline-based import infrastructure in Germany

In Germany, the Federal Government is advocating the construction of a meshed, pipeline-based hydrogen network in order to be able to transport and distribute imported hydrogen across the region.

The hydrogen transport network will be built in two stages. In a first stage, a **hydrogen core network** is to be gradually built up by the target year 2032. It serves as a basic skeleton network for connecting key hydrogen locations across Germany (electrolysers, import terminals and pipelines, industrial centres, power plants and combined heat and power plants, underground storage facilities). On 22 July 2024, the gas transmission system operators as future hydrogen network operators submitted a joint application for a core network to the Federal Network Agency (BNetzA) that will be around 9,700 km long and is to be built between

Fig. 3: Hydrogen core network (as of July 2024)



Source: FNB Gas e.V.

2025 and 2032. It is to consist of roughly 60% repurposed natural gas pipelines and 40% newly built hydrogen pipelines. According to the current planning status, 15 interconnectors will be an essential part of the German core network. In addition, the core network planning also considers the feed-in capacity from import terminals and thus indirectly also imports of hydrogen derivatives.

In a second stage, the hydrogen core network is to be developed further as required, as part of the integrated network development planning for gas and hydrogen, to create an increasingly meshed transport system. The legal basis for this was created with the Second Act Amending the Energy Industry Act, which came into force on 17 May 2024.

The financing model that will be enshrined in German law provides that the **hydrogen core network** will in principle be **financed** entirely through grid fees, i.e. by the private sector. The Federal Government's financing concept, developed jointly with the gas transmission system operators, provides for capping grid fees in an initial phase in which not enough users are yet connected to the grid. This is intended to avoid high grid fees that have a prohibitive effect on the market ramp-up. The interim financing is provided via a so-called **amortisation account**, which will be balanced out over time as more and more users are connected to the grid and share the costs. To find out how the amortisation account works, please consult the FAQs on the hydrogen core network prepared by the Federal Ministry for Economic Affairs and Climate Action.

For a successful market ramp-up, it is essential to quickly establish and expand the infrastructure for the production, storage and import of hydrogen. The Federal Government has created the legal framework for this, by introducing the **Hydrogen Acceleration Act.** It **accelerates, simplifies and digitises the relevant planning, approval and award procedures** and reduces regulatory requirements. Further to this, the development of a **digitalisation platform** for application and approval procedures for the hydrogen infrastructure is planned. To implement the individual projects, a large number of specialised authorities and offices at federal, Länder and municipal levels must be involved. Depending on the type of project, procedures for public consultations may be required as well. Digitisation and artificial intelligence-based decision-making are to significantly minimise the human resources usually required for application and approval procedures.

The expected demand for storage volume and storage capacity is currently being analysed, as well as possible strategies to transform natural gas storage facilities to hydrogen storage facilities and the economic challenges associated with the conversion and construction of new storage facilities. A **hydrogen storage strategy** will be presented by the Federal Ministry for Economic Affairs and Climate Action by the end of 2024.

4.2.2 Connections through trans-European hydrogen networks and import corridors

The Federal Government also aims at integrating the German hydrogen core network in Europe as early as possible. It is to be closely connected to the emerging hydrogen networks of EU Member States and neighbouring countries via interconnectors and trans-European hydrogen import corridors. Infrastructure projects in the IPCEI Hydrogen are the first stage of building a **trans-European hydrogen network.** The **Hy2Infra wave of the IPCEI Hydrogen**, which includes ten

German hydrogen pipeline projects with a total of around 2,100 km, was approved by the European Commission in February 2024 and is now to be promptly implemented via national decisions. In addition, the **EU Gas and Hydrogen Internal Market Package**, which was adopted by the European Council in May 2024 and will soon come into force, sets out the legal framework for the construction and financing of dedicated, pipeline-based hydrogen networks.

The question of how the necessary Europe-wide infrastructure investments can be stimulated quickly remains highly relevant. The Federal Government is proactively involved in **the development of a European financing concept** for hydrogen infrastructure and is pursuing this as a strategic, joint European project. In the infrastructure sector, the Federal Government plans to further develop the following topics in particular with European partner countries:

- **Co-financing of Projects of Common Interest (PCIs)**: The Connecting Europe Facility (CEF) as the central EU instrument for financing PCI projects should be significantly increased. If this is not possible, alternative options will be looked into at European Union level, e.g. a European Hydrogen Infrastructure Fund. PCI projects are designed to close existing gaps in the infrastructure of the European energy grid and are characterised by economic, social and ecological benefits for at least two EU Member States.

- **Risk hedging:** The amortisation account for the German hydrogen core network serves to secure private investments in the hydrogen infrastructure. The Federal Government is exchanging experiences with European partners to examine whether the instrument can be adopted in other EU Member States.

- **State guarantees for supply or offtake contracts:** Due to the uncertain market situation, long-term supply and offtake contracts between network operators, traders and customers in the hydrogen sector are currently not possible. The Federal Government plans to use the full range of instruments to promote foreign trade and investment.

- **Network charges:** Network charges are a decisive parameter for the business model and for the investment ratings of hydrogen pipelines. The Federal Government is entering into early coordination with the EU Member States on harmonised network charges.

Apart from a trans-European grid, the Federal Government is also pursuing the goal of promoting and bundling import and infrastructure projects along specific hydrogen import corridors. At present, at least **four pipeline-bound import corridors** are emerging: the North Sea Region, the Baltic Sea Region, South-West Europe and South Europe. Cross-border EU infrastructure projects, **PCIs or Projects of Mutual Interest (PMIs)** are a starting point for these corridors. PCIs/PMIs are infrastructure projects that connect energy systems of EU Member States and potentially of neighbouring regions. Projects with a PCI status are treated as priority projects by the European Commission and the EU Member States. The PCIs/PMIs receive access to funds of the Connecting Europe Facility (CEF) and to faster approval procedures.

Cooperation projects between the relevant neighbouring countries are being established and deepened along these corridors. The different focus areas for cooperation are described below as an example:

The Federal Government wants to create an integrated general system in the **North Sea Region**. The enormous generation potential for renewable electricity (especially for offshore wind) and hydrogen is to be used and made available in a closely meshed network. To this end, the Federal Government is working with its partners to adapt the regulatory framework for investments in offshore wind power capacities and to create uniform approval processes. The Federal Ministry for Economic Affairs and Climate Action plans to present an offshore cooperation strategy for renewable electricity and green hydrogen at the 2025 North Sea Summit in Hamburg. Furthermore, it is pursuing several concrete hydrogen infrastructure projects:

- A first cross-border pipeline is to be built between Germany and **Denmark**. Preparations are being made to create the framework for a final investment decision (FID) in 2025 and to plan for operations to begin at the end of 2028. The Federal Government believes that rapid implementation will provide an important impetus for other cross-border hydrogen projects.

- A joint feasibility study on a hydrogen pipeline between Germany and **Norway** has already been carried out. Preparatory work is currently being undertaken to create the framework for a final investment decision (FID). This is being done by a task force of officials from the ministries of both countries. The pipeline is expected to facilitate hydrogen imports from Norway as early as 2030.

- As part of the energy partnership with the **United Kingdom**, talks are being held on the possible construction of a hydrogen pipeline between Germany and the United Kingdom (e.g. Scotland).

Fig. 4: Schematic depiction of European import corridors (as currently envisaged; dotted line indicates prospective expansion)

Source: BMWK

- As part of their respective national hydrogen network development, both the **Netherlands** and **Belgium** are primarily targeting ship-based imports and a close connection to the German core network. According to the current draft application from November 2023, the hydrogen core network plans for four German-Dutch interconnectors and one German-Belgian interconnector by 2032.

The **Baltic Sea Region** is another important element for Germany's hydrogen supply due to its high potential for onshore and offshore wind power and its good hydrogen storage potential.

The Federal Government is therefore also committed to developing an integrated renewable energy system in the region, which also includes the planned Offshore Cooperation Strategy. Two pipeline projects involving all EU Baltic Sea countries are currently being developed. An offshore pipeline through the Baltic Sea ("**Baltic Hydrogen Collector**") and an onshore pipeline through the Baltic States and through Poland ("**Nordic Baltic Hydrogen Corridor**") are to create connections between Finland and Germany.

The Iberian Peninsula is characterised by high potential for solar and wind energy. The **South-West corridor** is planned to connect Spain, Portugal and possibly Morocco with Germany via France. The **"H2Med"** pipeline project and its connection to Germany **"Hy-FEN"** are intended to exploit the potential for hydrogen imports. To accelerate expansion, the Federal Government is also deepening the dialogue with the neighbouring countries regarding the regulatory framework conditions and is also committed to joint projects, e.g. in the area of electrolyser production.

The **Southern Corridor** is intended to create a direct pipeline connection between Algeria, Tunisia, Italy, Austria and, in the future, Switzerland to Germany, consisting largely of converted natural gas pipelines. The European part of the corridor ("**SoutH2**") has been granted PCI status. The implementation of the corridor requires a timely and ambitious ramp-up of hydrogen production in Tunisia and Algeria. In order to advance the development of the corridor, Germany, Italy and Austria are cooperating with each other within the framework of a trilateral working group and are coordinating closely with the European Commission, Tunisia and Algeria. Switzerland has observer status.

4.2.3 Establishing a terminal infrastructure and green ship corridors

In order to enable the import of hydrogen derivatives by ship, import terminals must be built and German ports must be converted so that they are capable of handling large quantities of derivatives. In particular, available heavy-duty areas and quay walls in the seaports must be expanded or upgraded.

The onshore LNG terminals that are currently being planned are designed in accordance with the **LNG Acceleration Act** in such a way that they can bring hydrogen derivatives on shore when they are no longer used to land LNG. This is intended to prepare a cost-efficient transformation from the gas to the future hydrogen infrastructure and to improve the profitability of investments in hydrogen infrastructure. Additional large capacities of ammonia imports are therefore only expected to arise from the early 2040s (the maximum duration of LNG use is specified in the LNG Acceleration Act). In addition to the onshore ammonia terminals, Germany is also considering the possibility of stationing mobile **ship-based import terminals** (Floating Storage and Regasification Units (FSRUs)) to be used for the regasification of ammonia in German seaports. Competitive costs and the technological development status of the FSRUs are key influencing factors.

The **National Port Strategy** defines the need for action in order to expand and convert the port infrastructure and thus create sufficient and sustainable import capacities for hydrogen derivatives. One point is that the legal framework for the approval of plants is to be uniformly adapted. In addition, the EU regulation on the **development of infrastructure for alternative fuels** (AFIR) sets out clear requirements for the upgrading of

maritime and river ports (e.g. for the provision of shoreside power infrastructure and the provision of LNG refuelling points). In addition, the Member States are to include plans for infrastructure development, especially for electricity, hydrogen and ammonia in the ports, in their national strategic frameworks.

The Federal Government is currently developing a **National Action Plan for Climate-Friendly Shipping** (NAPS) under the lead responsibility of the Federal Ministry for Digital and Transport and the Federal Ministry for Economic Affairs and Climate Action and with the involvement of numerous other stakeholders. This also covers the issue of alternative fuels supply, in addition to maritime industrial policy and topics of alternative propulsion and energy systems and the modernisation of fleets. In this context, hydrogen and hydrogen derivatives and their availability in German ports are of particular importance. Further to this, in line with the Clydebank Declaration[2], the NAPS also promotes the establishment of green shipping corridors. Green shipping corridors are so-called living labs and can represent an important step in activating industry pioneers along the entire value chain and thus in accelerating the decarbonisation of the shipping industry and in achieving climate goals. The action plan is to be completed in spring 2025 and implemented from mid-2025.

4.3 Product requirements and certification procedures

A reliable and sustainable international market ramp-up for hydrogen and its derivatives requires sustainability standards that are as uniform, ambitious and workable as possible, and also transparency regarding the properties of the hydrogen products traded. To this end, the Federal Government is working to establish common or internationally recognised certifications with minimum standards for hydrogen imports, as well as a diversified portfolio of export countries. The hydrogen strategy developed by the Federal Government and the EU focuses on promoting a green or renewable hydrogen market and on setting the respective regulatory course. In addition, technical standards (especially hydrogen purity and safety criteria) play an important role in ensuring the interoperability of hydrogen technologies, infrastructures and markets.

In the holistic sense of the SDGs, and as part of the development cooperation projects, in addition to the renewable properties of hydrogen, it is also very important to comply with other product requirements (in particular with sustainable water supply and land use, as well as social standards), so that the hydrogen market ramp-up can contribute not only to climate action but also to sustainable development and local value creation in partner countries. It is therefore necessary to consider the sustainability of the value chain and thus of the supply chain for hydrogen and its derivatives as a whole. Germany is of the opinion that it would be important to avoid significant additional emissions. Where funding is awarded to projects, the GHG limit must therefore be observed when producing hydrogen and its derivatives. In addition, local hydrogen usage options should be taken into account and it should be possible to ensure local value creation and participation that contribute directly to the national energy transition. Considering the importance of local water supplies and

2 At the UN Climate Change Conference COP26 in Glasgow, more than 20 countries signed the “Clydebank Declaration”, which is to promote the zero-emission target in shipping in the coming years. The declaration envisages the establishment of green shipping corridors with emission-free maritime routes between two (or more) ports. At least six of these zero-emission corridors are to be established by the middle of the decade, with more to follow by 2030.

with a view to the public acceptance of hydrogen projects, hydrogen production must not lead to local water shortages. Competing land use options should also be weighed up when providing renewable energy. For partnerships outside of German development cooperation, procedures described in 4.3.1 remain valid with regards to sustainability standards and transparency.

4.3.1 Product requirements and regulatory anchoring

Climate-related product requirements in Germany are rooted in European legislation, (particularly the RED III and the Internal Gas and Hydrogen Market Directive, including its delegated acts). The EU has defined a uniform **maximum GHG limit value of 3.4 kg CO_2-eq/kg H_2** for renewable and low-carbon hydrogen. Furthermore, the production of **RFNBOs** must meet specific requirements[3]. These requirements include **electricity sourcing criteria** (additionality of renewable energy plants and their geographical and temporal correlation with the production of hydrogen). Furthermore, requirements are defined for the carbon source used for the production of carbon-based hydrogen derivatives. Evidence must be provided that the hydrogen produced is renewable if it is to be deemed to meet the requirements imposed by the Federal Immission Control Act. The 37th Federal Immission Control Ordinance has transposed these requirements into national law.

The **accounting rules for low-carbon hydrogen** and its derivatives are currently being drafted by the European Commission as part of a delegated Act on the Internal Gas and Hydrogen Market Directive.

The requirements mentioned above must be transposed into national law. They apply across all sectors and to **both domestic production and hydrogen imports** from within the EU or from third countries.

Standards recognised by international banks and UN institutions are taken as a basis for efforts to improve and verify the sustainability of products and supply chains. It is essential that projects in developing and emerging countries comply with international human rights, labour and environmental standards and standards on corporate due diligence. As the existing standards are developed further, it is to be taken care that these standards are conducive to creating investment and planning security and establishing a sustainable, secure hydrogen trade. It also needs to be ensured that these can be implemented in an unbureaucratic and pragmatic manner and allow for the planned imports to Germany to be achieved. In introducing the **Supply Chain Due Diligence Act**, the Federal Government has furthermore created a national framework to improve the sustainability of the supply chain for various products. The fact that comprehensive sustainability standards have been established in the international **H2Global** funding programme at an early stage has also set benchmarks which help to promote sustainable hydrogen projects in partner countries.

4.3.2 Certification processes at European and national level

The product requirements are certified on the basis of reliable and, insofar as possible, uniform systems in order to be able to document the requirements linked to sustainability criteria in a global hydrogen market. They also create legal

3 These requirements are specified in delegated Acts to the RED (DA 2023/1184 and DA 2023/1185).

certainty for German hydrogen customers. Once again, the European legal framework applies in Germany. The RED III and the Internal Gas and Hydrogen Market Directive contain requirements for certifiers regarding the accounting methods and certification governance to be complied with. These stipulate a system of mass balancing by independent testing organisations as an eligibility requirement for crediting within the scope of funding and quota instruments. Certifiers can have their specific, voluntary certification processes recognised by the Commission as being compatible with the relevant EU rules. An EU-wide comparison of certified hydrogen quantities is carried out based on the Union database. The cross-sector certification requirements are currently being implemented at national level and incorporated into the national regulations. An electronic register will be established, which will be linked up to the Union database. The Federal Environment Agency is responsible for implementation.

4.3.3 International certification and standards

The European certification requirements have been designed for international application. The EU is thus playing a pioneering role and has set the course for the international tradability of hydrogen certified as renewable.

In order to avoid market fragmentation and the creation of trade barriers, the next step for the Federal Government is to establish interoperability between various national and regional certification systems. It is to be welcomed that the declaration of intent adopted at COP28 on the mutual recognition of certification systems for renewable and low-carbon hydrogen has received broad support. The Federal Government is actively involved at international level (e.g. in the G7/G20, IPHE, IEA H2 Technology Collaboration Programme) in the political and technical discussions relating to implementation and supports the development of international ISO standards.

The Federal Government evaluates compliance with sustainability criteria in supply chains as well as in national funding programmes (e.g. H2Global, guarantee instruments). It does this not least as part of its regular monitoring of the implementation of the National Hydrogen Strategy and adjusts them where necessary. For this purpose, the Federal Government is developing a catalogue of indicators, which it will also adapt on an ongoing basis. Any insights gained from this and from dialogue with various stakeholders, including those in potential export countries, are also fed into political and technical discussions at international level (e.g. EU, G7/G20, Climate Club). The aim is to establish internationally ambitious, workable and, as far as possible, uniform sustainability standards and certification systems at an early stage.

The Federal Government equally advocates compliance with and the (further) development and harmonisation of technical standards for hydrogen technologies, infrastructure and transport in the EU (e.g. Pentalateral Forum) and in international forums (e.g. in IPHE). In particular, the Federal Government is advocating for an agreement on hydrogen purity levels and safety requirements.

4.4 Increasing the international supply of hydrogen and its derivatives

The aim of the measures described above is to promote hydrogen offtake, develop a hydrogen infrastructure and establish uniform, workable product and certification. These measures are key instruments of the Import Strategy to support the international hydrogen ramp-up and the availability of sufficient and cost-effective hydrogen and hydro-

gen derivatives. In addition, the supply side can be supported where a FID is not made due to particular risks in the hydrogen market. To date, only a small number of hydrogen production and export projects worldwide have achieved FID status. To make projects bankable and competitive, the Federal Government is using its existing set of financing and guarantee instruments in an efficient and targeted manner.

4.4.1 Financial support instruments for the production of hydrogen and its derivatives

In particular, the Federal Government supports the goal of speeding up investments in the production of green/renewable hydrogen, closing existing financing gaps and overcoming investment risks. To this end, several national and European funding programmes have been implemented to support hydrogen projects in the EU and third countries.

The Federal Government is actively involved in the further development of the **European Hydrogen Bank (EHB)** as a key instrument for promoting the production of hydrogen in the EU. The EHB's first EU-wide pilot auction was launched in November 2023, in which over 130 bids were submitted, seven of which were awarded funding in early May 2024. In addition, the European Commission is working on setting up the international leg of the EHB, which will enable the joint promotion and purchase of hydrogen from third countries. The Federal Government strongly supports close coordination with the European Commission and cooperation with H2Global.

H2Global remains the Federal Government's central instrument for facilitating the purchase of hydrogen and its derivatives from outside Europe. What sets H2Global apart from other funding programmes is its **double-sided auction mechanism**. On the production side, international auctions are held for the purchase of hydrogen and hydrogen derivatives. The cheapest bid is awarded the contract; on this basis, the producer concludes a long-term supply contract with Hint.co GmbH, a company supported by the Federal Government. On the demand side, the quantities of hydrogen that have been delivered to EU countries in this way are to be auctioned on to the highest bidder. The difference between the supply and demand price is offset by the H2Global subsidy mechanism. H2Global is thus a programme that not only compensates for regional differences between hydrogen prices and closes existing financing gaps for hydrogen projects, but that also allows for supply and demand to be synchronised and simplifies hydrogen pricing. It thus **makes a significant contribution to developing an international market for hydrogen**. Following the opening of the first bidding window in 2022, a second funding window totalling €3.5 billion is currently being prepared.

The Federal Government is open to the **participation of other countries in H2Global** and is already working on this with countries including the Netherlands and Canada. In order to achieve the EU's goal of 10 million tonnes of hydrogen imports in 2030, the Federal Government is actively seeking to gain further partners to join H2Global.

In December 2023, the Federal Government topped up the **Green Hydrogen Fund** set up at the **European Investment Bank (EIB)** in 2021. The fund promotes investments and consulting services along the entire hydrogen value chain, from the production of green hydrogen and its derivatives, to their transport, storage and application. In doing so, it is providing an important boost for the global hydrogen economy. The Federal Government's aim is to mobilise much more addi-

tional funds over the next few years, for example by involving other donor countries, development banks and private financial institutions.

The **funding guideline for international hydrogen projects** set up by the Federal Government is a programme to support international hydrogen pilot projects outside the EU and EFTA. The aim of the projects is to test the interaction between different technologies at a specific location and to promote the industrial scaling of proven technologies that hitherto have been tested on a small scale.

The **PtX development fund** established in 2022 (worth €270 million) will be used to launch large-scale hydrogen projects in partner countries. The aim is to create local value chains and a favourable economic policy environment for the development of local green hydrogen economies. A public anchor investment is to be used to leverage additional private capital. An initial call for expressions of interest for projects in pilot countries was launched in December 2023.

Public funds alone will not be sufficient to finance the necessary investments in the hydrogen sector. In addition to the German government's funding instruments, hydrogen production projects are also dependent on **funding from multilateral development banks** and the private sector. The Federal Government is consistently urging development banks to also support hydrogen projects. **Cooperation between the public and private sectors** should furthermore be used to leverage investments from the private sector (e.g. blended finance vehicles).

Private sector mobilisation goes beyond the mere mobilisation of private capital. Emerging and developing countries offer very good opportunities for producing hydrogen. However, they need a stable policy environment to be attractive places for investment. The Federal Government is supporting capacity building for German and local stakeholders so as to enable them to network and make informed investment decisions.

4.4.2 Guarantee instruments to promote foreign trade and investment

The Federal Government's proven instruments to promote foreign trade and investment serve to support German companies in the area of technology exports and risk hedging to help them implement projects for the production of hydrogen and its derivatives in third countries. The mix of instruments includes the provision of **export credit guarantees**.

In November 2023, the Federal Government presented a **climate strategy for its guarantee instruments of foreign trade and investment promotion (climate policy sector guidelines)**. The strategy provides for preferential cover conditions for climate-friendly projects, including renewable and low-carbon hydrogen. It stipulates that applications for risk cover for a minimum contract value of €15 million and payment terms of two years are subject to a climate check. Applications are allocated to climate categories (green, white or red) on the basis of sector guidelines, including guidelines for the energy sector. German companies and banks allocated to the green category receive special favourable conditions, such as higher cover ratios and permission for a higher foreign share of the projects.

The climate strategy has also extended the scope of guarantees for **untied loans**. In contrast to conventional commodity imports, a climate guarantee for an untied financial loan has been established to serve as a funding instrument for renewable

hydrogen, which will contribute to ensuring a stable supply of hydrogen.

Another proven instrument in this regard is **investment guarantees**. They serve to hedge investments against political risks such as war or expropriation in target countries with difficult and risky markets. According to the climate strategy, the guarantee period for climate-friendly projects is generally extended by five to 20 years. Furthermore, significant rebates on annual fees can be granted as well as a reduced deductible for companies.

In addition, the Federal Government seeks to ensure that its foreign trade and investment promotion instruments are as coherent as possible with internationally relevant instruments for the promotion of hydrogen (e.g. through close exchange with export credit agencies of other countries or multilateral and bilateral development banks).

4.5 International cooperation

The Federal Government is working with a large number of partner countries, regions and international organisations to build up the necessary international hydrogen production. As it does so, the Federal Government is planning to diversify the sources of supply as widely as possible, not least in view of security aspects (cf. National Security Strategy). In addition to established partnerships with exporters of fossil fuels, new partnerships are to be developed as international value chains for hydrogen are established. Supplier relationships and infrastructure with exporters of fossil fuels can, together with favourable geographical and climatic conditions, improve the economic viability of hydrogen projects and transition the supplier relationships and value chains to hydrogen and its derivatives.

Here, the formation of a hydrogen economy offers the countries producing hydrogen and its derivatives opportunities for economic development, especially via the initiation of local value creation, whilst also creating incentives for them to decarbonise their own industry and energy systems. Here, support is to be given in particular to emerging and developing countries so that they can benefit from these opportunities and the new market.

4.5.1 Cooperation and dialogue with partner countries in the EU/EFTA

The European hydrogen strategy and the European Commission's REPowerEU plan define the goal of producing 10 million tonnes of hydrogen within the EU by 2030. The Federal Government regards the EU and EFTA Member States as important hydrogen trading partners. The main focus of the hydrogen cooperation in Europe is on countries and regions offering favourable conditions for production, such as high wind and solar potential. This is particularly the case in the North Sea, Baltic Sea, Mediterranean and Black Sea areas. Against this background, the Federal Government is engaged in a large number of bilateral and multilateral European dialogue and cooperation formats (e.g. EU Hydrogen Energy Network, Pentalateral Forum – cooperation between the BeNeLux countries, France, Germany, Austria and Switzerland). The Federal Government uses these dialogue spaces to discuss regulatory and market-related aspects of the hydrogen market ramp-up with partner countries. This also includes an enhanced dialogue on trade-related and geopolitical effects.

4.5.2 Bilateral cooperation with non-European partner countries

The **Climate and Energy Partnerships** and the **Hydrogen Partnerships** are a core instrument of the Federal Government's bilateral cooperation on

hydrogen (cf. Fig. 4). They provide a political framework for dialogue and cooperation with partner countries to promote the local energy transition and to build up sustainable hydrogen production and export capacities. Here, the specific substance of the partnerships is oriented to the individual contexts of the partner countries (e.g. dialogue on possibilities to use H2 in the partner country, export potential and ambitions of the partner countries, identification of obstacles and potential solutions to the establishment of cross-border import routes, development of international standards, discussion of good practice, joint implementation of flagship projects). The Federal Government is aiming to deepen the bilateral cooperation on hydrogen and to put it on a permanent footing in order to lend even broader support to the international market ramp-up and to diversify import routes. In most cases as a result of the constructive and close cooperation in the context of the Climate and Energy Partnerships, the Federal Government has already concluded dedicated agreements on intensive cooperation in the field of hydrogen with a number of countries, e.g. Canada and Australia. Going forward, the existing hydrogen research partnerships are to be integrated into the Climate and Energy Partnerships and Hydrogen Partnerships.

Bilateral hydrogen alliances can help emerging and developing countries in particular to develop their economies and to boost local value creation. This can make the local economies of countries of the Global South more resilient to crises, and can create forward-looking jobs. Green hydrogen and possibilities to use it locally in emerging and developing countries are focused on in bilateral **Climate and Development Partnerships**. The focus here, in line with development policy principles, is on strengthening local stakeholders in order to contribute to the decarbonisation of the local economy. The aim is also to contribute to a diversification of non-European suppliers of hydrogen and derivatives, to strengthen the political dialogue, and to provide information about the value added by German products. These partnerships are open to further bilateral and multilateral donors.

Further to this, the **Just Energy Transition Partnerships (JETPs)** offer scope for bilateral cooperation on green hydrogen with emerging and developing countries. The specific aim of the JETPs is to support a socially just energy transition in the partner countries. This means that maximum synergies with the goals of Agenda 2030 (especially SDG7 – Affordable and Clean Energy) are being aimed at in the cooperation on the ramp-up of the hydrogen market and of exports. Here, the various activities are oriented to the needs of the local economy, in order to attain a socially compatible move away from fossil fuel. The focus is placed on the building of local expertise and capacities via training programmes, local and international networking. German firms benefit from simplified access to local stakeholders.

Hydrogen research partnerships also play an important role, as they bring together scientists, business people and policy-makers at an early stage, and can thus form a nucleus for subsequent import relationships. Early research partnerships with promising hydrogen export countries also strengthen Germany as an exporter of hydrogen technology. In this way, research policy bolsters Germany's industrial and energy policy. Initial training and masters programmes in the context of the research partnerships train academic and non-academic staff to build up a local hydrogen economy.

Further to this, the **International Climate Initiative (IKI)** provides funding for a number of hydrogen projects in developing and emerging

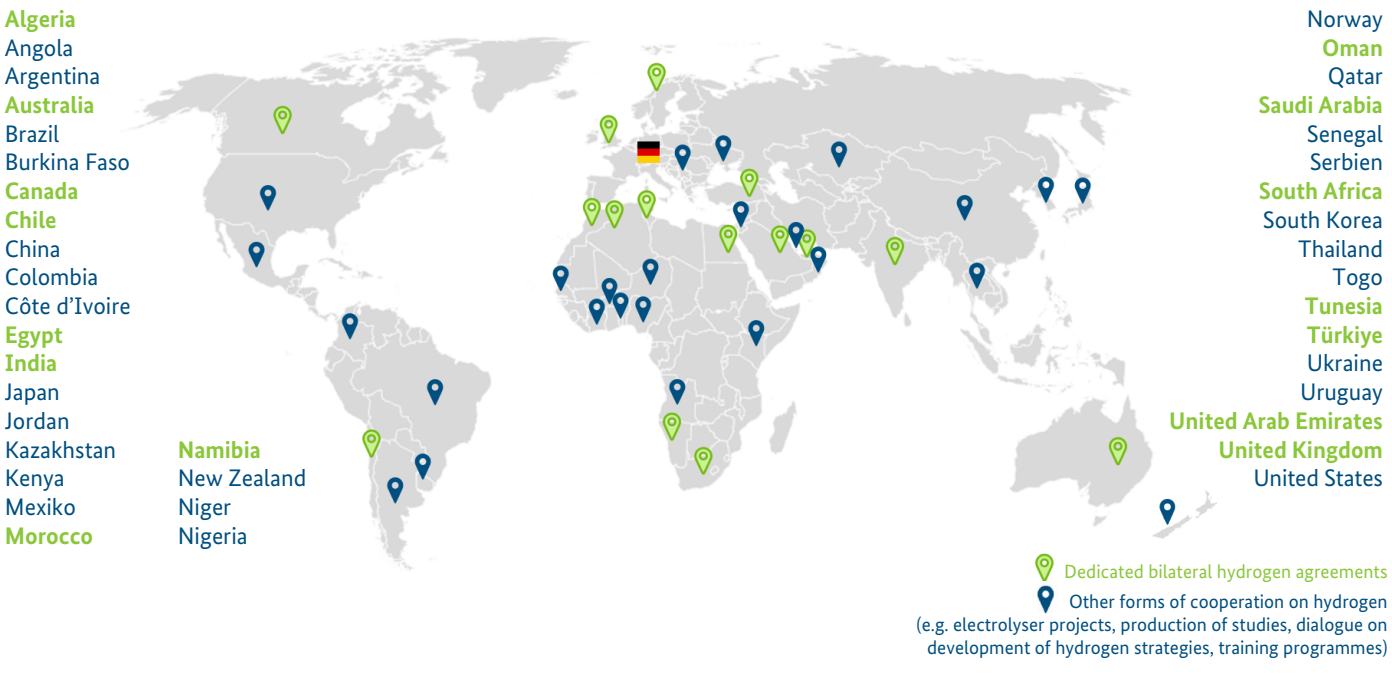
economies. The IKI contains a broad international project portfolio, with a volume of €50 million to promote the establishment of climate-neutral value chains. The IKI helps emerging and developing economies to benefit from and participate in the international market ramp-up at an early stage. The focus is placed on the building of local expertise and capacities (e.g. basic and advanced training courses, skills development programmes, promotion of networking), also for the local energy transition and decarbonisation. Further to this, hydrogen is part of the IKI-funded UNIDO Partnership for Net Zero Industry.

H2-Diplo is another component in the IKI hydrogen portfolio. In the course of this programme, Hydrogen Diplomacy Offices have been set up in several places, particularly in key countries for the export or transit of fossil fuel. They intensify the political dialogue and offer advice on how green hydrogen can be used to decarbonise and diversify the respective economies, and made available for international trade.

In addition to this, support is provided by German and European companies in the field of green hydrogen by the Green Hydrogen Business Alliance of the Federal Ministry for Economic Cooperation and Development. The companies are positioned along the value chain, and the aim is to involve them in projects of the Economic Cooperation Ministry to support the market ramp-up in partner countries. The network currently comprises some 150 German and EU stakeholders from business and science.

The international cooperation at federal level is rounded off by cooperation at subnational level, with close involvement of the Länder and municipalities. One example of such cooperation is port alliances, which aim to network import and export ports.

Fig. 4: Bilateral cooperation on hydrogen by the Federal Government in non-EU countries



Source: BMWK

4.5.3 Cooperation in multilateral forums

In addition to the bilateral cooperation formats, the Federal Government supports the ramp-up of rules-based international markets for hydrogen and its derivatives via its involvement in multilateral forums (e.g. Clean Energy Ministerial (CEM), Mission Innovation (MI), IPHE, International Hydrogen Trade Forum (IHTF), Climate Club and G7/20).

The Federal Government is working in the international arena (e.g. G7/G20, COPs) in particular to promote the further development and mutual recognition of standards and certification systems. The work on standards covers both technical and sustainability standards. Further to this, the multilateral bodies are used for a dialogue on good practice, equal opportunities, obstacles to and possible solutions for the international market ramp-up and establishment of international import corridors, trade rules and barriers.

International organisations like the IEA, IRENA, UNIDO and ISO also provide important knowledge products and platforms for the hydrogen rollout, and are therefore important partners for the Federal Government in the field of international cooperation.

4.6 Support for the market ramp-up of hydrogen from research and development

There are still a large number of challenges to be overcome, open questions to be clarified, and new solutions to be developed for the ramp-up of the international hydrogen market. For example, technology readiness levels of the necessary technologies must be raised further, costs cut and new solutions developed to minimise security risks and hydrogen leakages along the import routes. The Federal Government is therefore providing support for the market ramp-up via targeted research and development programmes in the context of its hydrogen research promotion. Here, the following research instruments in particular are being deployed:

- feasibility studies analyse existing regulatory, technical and economic obstacles along the entire value chain;
- application-oriented research projects adapt existing or emergent technologies to differing local circumstances, e.g. research projects into heat- and sand-resistant processes or specialised transport methods;
- basic research projects progress technologies which might be deployed in the medium to long term but which offer enormous added value for international supply chains, e.g. seawater electrolysis technologies;
- demonstration projects test bilateral supply chains on a pre-industrial scale.

The Federal Government's various research and development activities are fleshed out in the NHS 2023. Further to this, the Federal Government is planning to draw up an interministerial **Hydrogen Technology and Innovation Roadmap** in the context of the NHS 2023.