



The
Federal Government



NATIONALE
WASSERSTOFF-
STRATEGIE
Schlüsselement
der Energiewende

National Hydrogen Strategy Update

NHS 2023

[bmwk.de](https://www.bmwk.de)

Imprint

Publisher

Federal Ministry for Economic Affairs
and Climate Action (BMWK)
Public Relations
11019 Berlin
www.bmwk.de

Current as at

July 2023

This publication is available for download only.

Design

PRpetuum GmbH, D-80801 Munich

Image credits

iStock/smirkdingo (title page)

Central ordering service for publications of the Federal Government

Email: publikationen@bundesregierung.de

Tel.: +49 30 182722721

Fax: +49 30 18102722721

This report has been published by the Federal Ministry for Economic Affairs and Climate Action as part of its public relations work. It is distributed free of charge and is not intended for sale. It must not be used by political parties or groups for purposes of election campaigning.

Contents

I. Introduction	2
1. Background	2
2. NHS update and target vision 2030	3
II. Fields of action, target visions and measures	5
1. Ensuring availability of sufficient hydrogen	5
a) Expansion of the production of hydrogen and hydrogen derivatives in Germany	6
b) Import of hydrogen and hydrogen derivatives	9
2. Developing an efficient hydrogen infrastructure	14
a) National hydrogen infrastructure	16
b) European Hydrogen Backbone network	17
c) Infrastructure for imports from third countries	17
3. Implementing hydrogen applications	19
a) Industry	19
b) Transport	20
c) Power	23
d) Heat (building sector)	24
4. Creating effective framework conditions	26
a) Planning and approval procedure	26
b) Sustainability standards and certification	27
c) Strengthening research, innovation and training of professionals	29

I. Introduction

1. Background

In June 2020, with the National Hydrogen Strategy (NHS), the Federal Government presented for the first time a strategy for achieving the goals of its hydrogen policy. The NHS laid down a coherent framework for action for the future production, transport and use of hydrogen and its derivatives, including the relevant research, innovations and investments. Phase 1, the start of the market ramp-up, which is described in the NHS, has now been successfully implemented on the basis of the measures planned. The National Hydrogen Council has supported the work carried out by the Federal Government in an advisory capacity. In its Status Report (September 2021) and the Progress Report (May 2022) (<https://www.nationale-wasserstoff-strategie.de>), the Federal Government described in detail what has been achieved to date.

The NHS of 2020 in principle still applies. In the NHS, the Federal Government has committed itself to evaluating and further developing the strategy after a period of three years. In addition, the coalition agreement of 10 December 2021 provides for an ambitious update of the NHS, which has become even more important now in view of the framework conditions on the energy markets, which have fundamentally changed.

The Russian war of aggression against Ukraine, which violates international law, and its effects on the global energy markets have more than clearly documented the problem of excessive dependence on energy imports from individual countries for Germany's security of energy supply. Against this background, the goals of the NHS 2020 to achieve a high level of security of supply through competitive intra-European hydrogen production, in addition to diversifying and securing international

imports, are gaining in significance not only for climate action reasons but also in terms of security policy. For this reason, updating the NHS and the planned import strategy for hydrogen and its derivatives that is based on it, in conjunction with the implementation of the National Security Strategy, the Future Strategy for Research and Innovation and the Foreign Climate Policy Strategy, represent important building blocks for Germany's security and future viability.

The NHS update also sends an important signal in terms of industrial policy: Germany will be strengthened as an industrial and business location and a basis for sustainable jobs will be created. In addition to doubling the national target for the expansion of electrolyser capacity from 5 to at least 10 GW by 2030, the coalition agreement calls for infrastructure expansion to be accelerated and for Germany to become the lead market for hydrogen technologies by 2030.

To achieve the ambitious statutory climate targets, a significant increase in energy efficiency and a major and accelerated expansion of renewable energies are indispensable. All sectors must make a significant contribution for this to happen. The direct use of electricity (e.g. electromobility, heat pumps) is associated with lower conversion losses compared with the use of hydrogen and should be used wherever possible, if this is considered to be the cost-effective option in terms of overall system efficiency and security of supply, apart from it being an economic and environmental perspective. In the course of the transformation, so-called sector coupling, through which renewable electricity will be made increasingly available for buildings, transport and industry, will gain in importance. Green hydrogen¹ and its derivatives will assume a key role in terms of storing and transporting renewable energy. The present

1 Hydrogen produced on the basis of renewable energies.

update of the NHS shows how the required market ramp-up of hydrogen can be further accelerated through specific, toughened measures in order to make a contribution to Germany's transformation to a climate-neutral economy by 2045.

2. NHS update and target vision 2030

The use of hydrogen and its derivatives will play a key role in the decarbonisation process, in particular for the transformation process in the energy sector, the transport sector and industry that is due to be completed by 2030. For this to happen – in view of investment cycles that frequently last many years – the foundations for forward-looking investment decisions need to be laid today and in this legislative period.

The NHS update is intended to establish reliable guard rails for private investments in sustainable, but in particular the economic, ecological and social production, transport and use of hydrogen, its derivatives and hydrogen application technologies. It is imperative that the required integration into the overall German energy system be in line with international human rights, labour and environmental standards (e.g. OECD Guidelines for Multinational Enterprises, UN Guiding Principles on Business and Human Rights) in addition to meeting standards on corporate due diligence.

In the overall context of the UN 2030 Agenda for Sustainable Development, the NHS is also intended to contribute to achieving Goal 7 „Ensure access to affordable, reliable, sustainable and modern energy for all“ in particular and Goal 13 „Take urgent action to combat climate change and its impacts“ on time.

Broken down into short-term measures for the year 2023, medium-term measures for the years 2024/2025 and, in some cases, what are already long-term measures to be implemented by 2030, the NHS update sets out the work programme with which the NHS targets for 2030 shown below are to be successfully implemented:

- **Accelerated market ramp-up of hydrogen:** the market ramp-up of hydrogen, its derivatives and hydrogen application technologies will be significantly accelerated and the level of ambition along the entire value chain massively increased.
- **Ensuring sufficient availability of hydrogen and its derivatives:** the target for domestic electrolyser capacity in 2030 will be increased from 5 GW to at least 10 GW. The remaining demand will be covered by imports. A separate import strategy will be developed.
- **Development of an efficient hydrogen infrastructure:** by 2027/2028, a hydrogen start-up grid with more than 1,800 km of repurposed and newly built hydrogen pipelines will be set up in Germany using IPCEI funding; approx. 4,500 km will be added throughout Europe (European Hydrogen Backbone). With more expansion, all major production, import and storage centres will be connected to the relevant consumers by 2030.
- **Implementation of hydrogen applications in the sectors:** by 2030, hydrogen and its derivatives will be used in applications in industry, heavy-duty commercial vehicles² in particular, and increasingly in aviation and shipping. In the power sector, hydrogen will contribute to the security of energy supply; by using gas power

2 N3 class vehicles offer the greatest leverage in CO₂ reduction.

plants that can be converted to climate-neutral gases (H₂-ready) and system-serving electrolyzers, primarily as variable and system-serving stabilisers or flexible loads. For the use of hydrogen in centralised and decentralised heat supply systems in the future, the relevant framework conditions are currently being further developed in the Renewable Energy Sources Act, in thermal design and in the European gas market package.

- **Germany will become the lead provider of hydrogen technologies by 2030:** German suppliers are increasing their technology leadership and now offer the entire value-added chain of hydrogen technologies from production (e.g. electrolyzers) to a variety of applications (e.g. fuel cell technology).
- **Creation of appropriate framework conditions:** coherent regulatory conditions at national, European and, if possible, international level will support the market ramp-up. They will primarily include efficient planning and approval procedures, uniform standards and certification systems that are adequately equipped, in addition to coordinated administration at all levels.

In order to achieve this target vision, the NHS will be continuously developed in the years ahead and will be adapted to current requirements as needed.

The Federal Government is legally committed to achieving climate neutrality by 2045 and in the meantime to pursuing an ambitious reduction path. To achieve this goal, the supply of safe, sustainable and climate-neutral hydrogen is indispensable, which the Federal Government will ensure with the appropriate framework conditions. The Federal Government's goal is to achieve a reliable supply for Germany of hydrogen which is green and sustainable on a long term basis. Direct financial support for hydrogen production is limited to the production of green hydrogen. In order to ensure a rapid development and ramp-up of the hydrogen market and to meet the expected demand, particularly in the transformation phase, and in this way ensure that the technological transition to hydrogen will come about, other colours of hydrogen will also be used, at least until sufficient green hydrogen is available – primarily low-carbon hydrogen from waste or natural gas in combination with CCS. We also intend to promote the use of green hydrogen and, where necessary in the market ramp-up phase, low-carbon blue³, turquoise⁴ and orange⁵ hydrogen to a limited extent on the application side, taking into account ambitious GHG limits, including emissions in the upstream chain, in addition to maintaining the statutory target of climate neutrality.⁶

3 Hydrogen produced from natural gas in combination with CCS.

4 Hydrogen produced by methane pyrolysis.

5 Hydrogen produced on the basis of waste and residual materials.

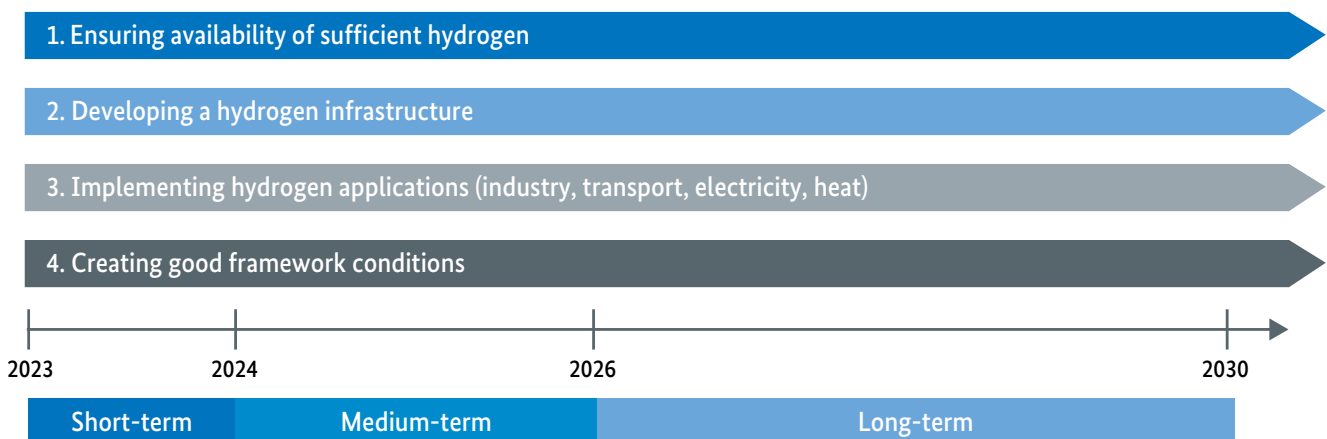
6 This can be done, for example, via the climate protection contracts (so-called Carbon Contracts for Difference – CCfD). This hydrogen must meet an ambitious CO₂ limit value for greenhouse gas emissions, taking into account the life cycle analysis (LCA approach) based on savings geared to the comparative value for fossil fuels (25 grams of CO₂ eq./MJ H₂, analogous to EU taxonomy). In the event that the EU stipulates stricter sustainability requirements in another binding legal act, these will apply.

II. Fields of action, target visions and measures

In Phase 2 of the NHS implementation, the Federal Government will focus on four major areas. In the following section, the required fields of action and the associated goals for the year 2030 are defined and supported with measures. Many fundamental measures have already been initiated in parallel with the preparation of this update or have been planned in the short term for the year 2023. The

Federal Government has already made substantial funds available for the hydrogen ramp-up and will continue to do so in the future. However, all the measures mentioned here are subject to funding and can therefore be implemented only if they can be financed or counter-financed in the respective individual budget or special fund within the scope of the applicable budget and financial planning.

Fields of action of the NHS update



1. Ensuring availability of sufficient hydrogen

Target vision 2030: sufficient hydrogen and hydrogen derivatives will be available to cover the demand in the various application areas cost effectively and to set up the corresponding value-added chains. Part of the demand for hydrogen and its derivatives will be covered by system-serving production using renewable energy sources in Germany. To this end, the domestic electrolyser target will be doubled from 5 GW to at least 10 GW by 2030. In addition, a large part of the demand will be covered by imports from other EU member states and international partner countries. Transport by pipeline will make it possible to import elemental hydrogen, while imports by ship will mainly involve hydrogen derivatives. The import of hydrogen will be based on the „Hydrogen Import Strategy“ (see Chapter 1. b)). In the case of imports from partner countries of German development cooperation, Germany will ensure that maximum synergies are achieved with a local, social-ecological transformation of society and the economy and energy transition, in addition to the Sustainable Development Goals (SDGs).

For the NHS update, a **total hydrogen demand of 95-130 TWh** has been assumed for the year **2030**. This includes the projected demand for hydrogen derivatives such as ammonia, methanol or synthetic fuels and is in line with various energy scenarios, which see a newly emerging hydrogen demand in Germany of between 40–75 TWh for 2030, which is expected to increase sharply after 2030. Added to this is the existing demand for hydrogen in Germany of around 55 TWh, which is currently covered by grey hydrogen. This latter demand may be reduced by 2030 due to production conversions or in the course of transformation. Depending on price and market developments, the total demand for hydrogen and hydrogen derivatives could continue to increase significantly until 2030 and accelerate the market ramp-up. The Federal Government will continuously monitor the development of demand and, if necessary, address it in a forward-looking manner with appropriate measures.

a) Expansion of the production of hydrogen and hydrogen derivatives in Germany

The Federal Government is placing a particular focus on the expansion of domestic electrolyser capacities on an industrial scale: we are doubling the electrolyser target for the production of green hydrogen from 5 GW to at least 10 GW in 2030.

High-volume, sustainable domestic green hydrogen production will provide a secure supply that will cover demand with short transport routes and will create the basis for a functioning domestic market that covers all stages of the value-added chain. Among other things, this will also include the production of high efficiency electrolysers.

The backbone of the domestic production of green hydrogen will be the expansion of electricity gen-

eration using renewable energy sources, where we intend to make substantial progress. To this end, the most comprehensive amendment to the Renewable Energy Sources Act (EEG) since its inception, in addition to extensive amendments to the Wind Energy at Sea Act and other laws, were adopted in 2022 in the Energy Emergency Package, the so-called “Easter Package”. Further measures will be necessary, in particular for planning and approval procedures and with a view to reducing unnecessary bureaucracy. The Federal Government will continue to consistently address these issues.

The expansion of domestic production of green hydrogen will lay the foundation for setting up an efficient electricity and gas system in Germany in the long term. At the same time, it will be important to ensure that the production of hydrogen in Germany does not release additional greenhouse gas emissions or cause negative environmental impacts and additional bottlenecks. This requires that the majority of the electrolysers in place by 2030 must be located and operated based on a system-serving approach. A more detailed definition of requirements for system serviceability is currently being drawn up in more detail – taking into consideration the principles and requirements of EU law developed to date and in consultation with the ministries – and taking into account, among other things, the economic efficiency of hydrogen production and questions as to whether there will be sufficient quantities available for the consumers. With an intelligent dovetailing of electrolysis with the electricity system and the transport and storage infrastructure for hydrogen (“system-serving electrolysis”), we will gain a key flexibility option for the energy transition and limit the need for electricity grid expansion. An appropriately timed correlation between the generation of renewable energy and electricity consumption, in addition to locating electrolysis sites close to the generation

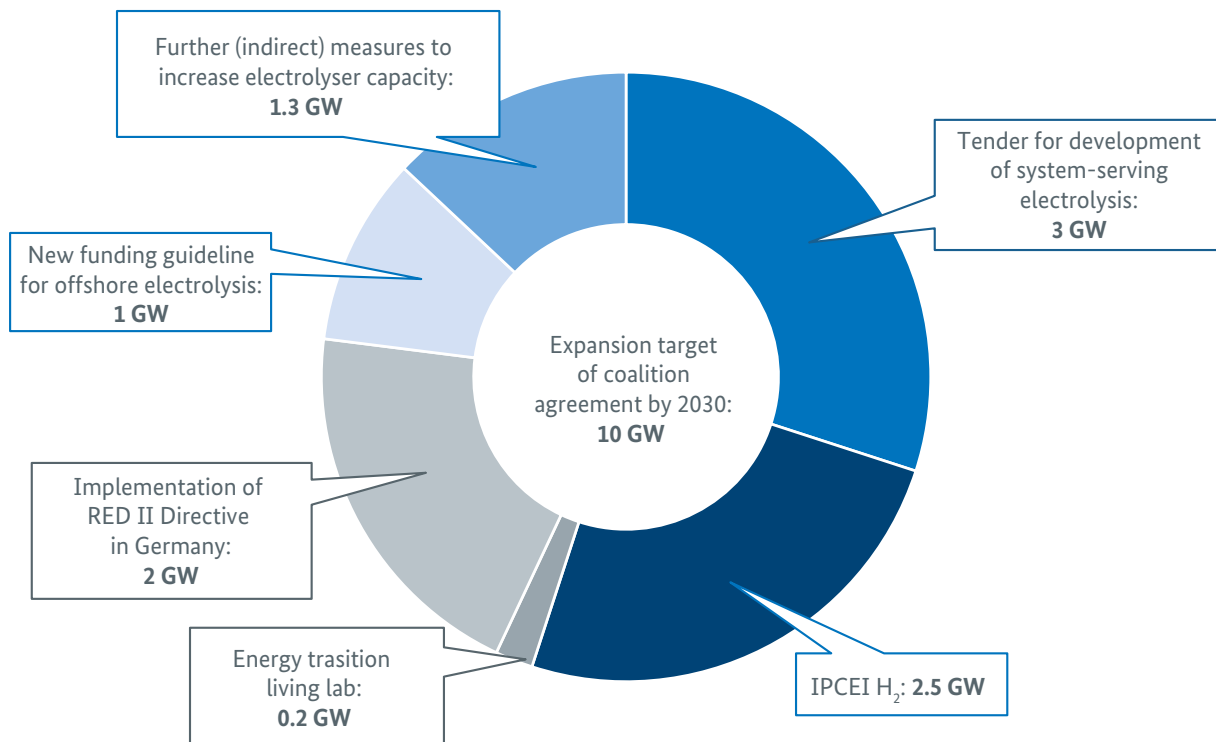
facilities, will provide an effective integration of renewable energy sources and support the power system (cf. Chapter 3. Implementing hydrogen applications – Power). This will also make the decentralised production and storage of hydrogen easier. System studies such as long-term scenarios show that the system-serving sites in northern Germany are located near the coast and that a system-serving operation requires a flexible deployment of electrolysis primarily at times of low residual load and moderately low full-load hours. During the initial period in particular, when no large-scale hydrogen grid is available, however, exceptions to this will be needed for the first demonstration and pilot projects in industry and the mobility sector, for example. With regard to the

environmental impacts, it will also be important to assess and minimise the effects on the water balance and the aquatic ecology, in addition to preventing competitive situations arising with other water uses.

The present update of the NHS is intended to create the conditions for developing an appropriate mix of instruments to achieve the newly set target of at least 10 GW of domestic electrolyser capacity by 2030 for the production of green hydrogen, while at the same time ensuring competitive prices.

In addition to research and innovation, the mix of instruments will also include the direct funding of electrolyzers, both those located onshore and those

Mix of instruments



Source: BMWK

combined with offshore wind energy. Moreover, the implementation of the European regulatory framework and demand-side measures will provide an incentive for investments in hydrogen production and remove obstacles in the planning and approval of electrolyzers, without substantially lowering existing standards. Furthermore, the Federal Government will support decentralised hydrogen production at the municipal level to ensure the fastest and broadest possible availability of hydrogen.

Short-term measures (2023)

- The funding budget for the first hydrogen projects within the framework of the IPCEI Hydrogen has already been increased in the 2023 budget, primarily so as not to jeopardise the completion of the projects as a result of the enormous increase in prices. Within the framework of the IPCEI Hydrogen, approval under state aid rules to issue funding decisions for electrolysis projects with a total installed capacity of approx. 2.5 GW is to be granted in 2023.
- Through the adoption of the regulation pursuant to Section 96 (9) of the Wind Energy at Sea Act, 500 MW of installed electrolyser capacity for the production of system-serving green hydrogen will be put out to tender annually from 2023 to 2028.
- The continuing implementation of the amended European Renewable Energy Directive (RED II) at national level in Germany will create incentives for investments in electrolyzers amounting to at least 2 GW for applications in the transport sector (in particular for the replacement of grey hydrogen with green hydrogen in refineries, direct use in various fuel cell vehicles and also in cases where e-fuels are used).
- As part of the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP), approval has been granted for decentralised projects with an electrolysis capacity of 60 MW to supply hydrogen filling stations. In 2023, additional capacities of around 40 MW are planned with the launch of an additional funding call. This will result in 0.1 GW of electrolyser capacity in the medium term from the NIP. Beyond 2023, the funding of electrolyzers for domestic hydrogen production for use as an alternative fuel for transport will be continued by the BMDV's overall concept for renewable fuels.

Medium-term measures (2024/2025)

- Revision of the funding programmes towards an even more closely interlinked funding strategy with as little red tape as possible for the expansion of the domestic production of green hydrogen in Germany for the second half of the 2020s based on the experience gained from funding programmes that have already been implemented.
- Further development of the national H2Giga electrolysis initiative that focuses on the series production of electrolyser technologies and research projects to develop new concepts in order to fill the innovation pipeline with new ideas and, on the other hand, to enable concepts designed to increase the efficiency level of electrolyzers for efficient hydrogen production, for example, to penetrate the market (see also Chapter 4. c).

b) Import of hydrogen and hydrogen derivatives

Since the potential of domestic hydrogen production is limited, the majority of the demand will have to be covered in the long term by imports of hydrogen and its derivatives. According to the Federal Government's assessment based on an analysis of the current scenarios, around 50 to 70 percent (45 to 90 TWh) of the 95 to 130 TWh demand forecast for 2030, will be covered by imports from abroad (in the form of hydrogen and hydrogen derivatives). The share of imports to cover the hydrogen demand will continue to increase in the years beyond 2030. Moreover, a domestic supply to meet demand would make neither economic sense nor would it serve the energy transition-related transformation processes as a whole. For this reason, in addition to the focus on the domestic production of hydrogen, the NHS is supplemented by an **import strategy for hydrogen and hydrogen derivatives** (hereinafter referred to as import strategy) and thus by an important foreign policy dimension and economic and development policy dimension, that will contribute to the global energy transition.

The import of hydrogen and derivatives in particular is planned to be largely ship-based, at least until 2030, while the transport of ammonia, for example, which produces less N₂O as a greenhouse gas and NO_x in general as a regional air pollutant and precursor substance for tropospheric ozone, will be carried out in the near term. Imports of green methane, synthetic methanol, LOHC (Liquid Organic Hydrogen Carrier) and liquid hydrogen can play a role in the medium to long term. Beyond 2030, the pipeline-based import of green hydrogen from Europe and possibly neighbouring regions is to be increasingly expanded, but without abandoning the principle of minimising risk through diversification.

The technological conversion from fossil energy sources such as coal and natural gas to hydrogen on the application side can take place before sufficient green hydrogen is available. The avoidance of negative lock-in effects will be ensured as comprehensively as possible, through the design of funding programmes that give priority to green hydrogen, for example, and by means of the Carbon Management Strategy planned for 2023 (for more details, see Chapter 4. b).

Short-term measures (2023)

- The import strategy will be a key instrument: the Federal Government will be publishing an import strategy in 2023 (see box below) with a focus on sustainable production and transport options aligned with the goals of the 2030 Agenda and the required import infrastructure, both for transport by ship and by pipeline, e.g. for hydrogen from Norway.
- Within the framework of the IPCEI Hydrogen, numerous projects have been selected that already support the distribution of hydrogen within the EU, including projects to carry out research on LOHC storage and transport technology, which are intended to complement the activities that already exist as part of the TransHyDE hydrogen flagship project and the Helmholtz Cluster H2. Using this technology for liquid organic carriers for hydrogen, the intention is that long-distance transport by ship in particular will be able to take place cost effectively and safely, which will also be necessary for imports from outside the EU. Further projects for the import of hydrogen from neighbouring European countries are also to be initiated in the short term.

- Existing and, if necessary, new funding instruments for imports will be examined and further developed: in the short and medium term, government support will most likely be necessary to close the cost gap. The aim, therefore, is that existing funding instruments (H2Global, funding guideline for international hydrogen projects, PtX platform with PtX development fund H2Upp) be continued and developed further. Regional forms of cooperation are to be developed within H2Global and new funding instruments will be developed as they are needed.
 - The market ramp-up is to be supported by accompanying measures in international forums such as the IEA, IRENA, CEM/MI, IPHE and G7/20. Good governance standards for the hydrogen market ramp-up are to be defined at G7 or G20 level. These should include, among other things, guidelines for minimising environmental impacts, the funding of local social-ecological transformations of society and the economy and energy transitions, recommendations regarding any possible impact they may have on the respective national energy transition, labour market standards, protection of human rights, approaches designed to improve the economic quality of the value-added stages in developing and emerging countries in the sense of a green industrialisation process or “best practice” examples for increasing the acceptance of projects. Regional cooperation, especially in finding transport solutions for hydrogen and derivatives, should also be supported. Furthermore, dialogue with the current exporters of fossil fuels on the opportunities and challenges of a global hydrogen market is to be intensified.
- ### Medium-term measures (2024/25)
- At EU level, the existing cooperation with the EU Commission and the Member States is to be deepened in order to exploit the full European potential for hydrogen production in suitable regions such as Southern Europe and the North Sea, Baltic Sea, Mediterranean and Black Sea regions.
 - European cooperation on non-European imports will be intensified, as Europe will continue to depend on hydrogen imports, including from non-European regions. In order to procure the required quantities in the face of global competition and to bring down costs, cooperation between European member states is aimed at. In this process, the development of European instruments to promote the hydrogen market ramp-up (e.g. the European Hydrogen Bank, a joint purchasing platform or European CCfDs) is being sought as a supporting instrument.
 - Existing bilateral hydrogen, energy and climate partnerships will be used as a policy framework to set up cross-border hydrogen value-added chains, and the Green Hydrogen Strategic Research and Innovation Agenda will be used to drive research collaboration in this field in Europe and beyond, including the launch of port alliances to link up import and export ports.
 - In order to secure the required imports, the aim is to further deepen and consolidate the discussion on hydrogen within the climate and energy partnerships or within the scope of the strategic hydrogen partnerships, and to establish new hydrogen partnerships. The partnerships are to be used to exploit the available export potential,

particularly that of green hydrogen, by means of instruments that make sense (e.g. funding instruments, political support). Boosting mutual investments in H₂ infrastructure and joint R&D activities are also to be discussed on a partnership basis, as in the Clean Hydrogen Partnership. The aim is to conduct these discussions on an equal footing and in this way take into account the collaboration interests of the partners without giving up one's own core interests.

- International lighthouse projects are supported and implemented within the scope of the climate, energy and hydrogen partnerships. One of the aims is to carry out large-scale and economically feasible projects for the production and local (partial) use of green hydrogen in countries with a high potential for renewable energy sources and an existing industrial infrastructure, and to use the products for building sustainable local economic structures and for importing into the EU and Germany.
- Various countries worldwide have already positioned themselves as future exporters of hydrogen (derivatives). Due in some cases to their high resource potential, many developing and emerging countries in particular are able to contribute to the diversification or decarbonisation of their economies and those of their partner countries in the medium to long term through hydrogen production, use and trade. These efforts are to be supported and encouraged by foreign policy dialogue and the corresponding development policy instruments in collaboration with the private sector in order to facilitate the investment of significant private funds in the partner countries and their entry into the emerging hydrogen market and to support sustainable development based on the principle of a just transition in the partner countries. We will continue to provide political backing and support for these processes within the scope of our hydrogen, energy and climate partnerships.
- A common market with uniform standards for green hydrogen and for low-carbon hydrogen will be supported, e.g. the G7 "Climate Club" initiated under the German G7 presidency. This can prevent a fragmentation of markets or form the basis for a swift international market ramp-up.

Hydrogen import strategy

In order to secure the import demand for sustainable hydrogen and hydrogen derivatives in the long term, a „Hydrogen import strategy“ is to be adopted within the scope of the following guard rails. The Federal Government's intention is to create a sound basis for the import of hydrogen from future exporting countries and for domestic consumers.



The aim will be to open up broadly diversified import channels and avoid new dependencies. For this reason, the import strategy will send a signal to European and international partner countries indicating that the Federal Government intends to forge partnerships worldwide, establish reliable, sustainable supply chains to Germany in addition to sustainable standards, and be available as a technology partner. The import strategy will provide the framework for action to secure the quantities of hydrogen required in total and in the long term. It is an integral part of the NHS.

The import strategy will focus on both European and non-European partnerships and imports. In order to set up hydrogen imports on a global scale, transport by ship will be considered in addition to pipeline imports. Various sustainable transport routes will be taken into account, including the creation of green corridors and the increasing use of green fuels for ship imports. This involves forward-looking planning that also takes into account the lead times for the procurement of ships, for example.

Pipeline imports of hydrogen produced in wind and sun-rich European regions or in regions close to Europe potentially offer advantages – provided there is a corresponding, competitive supply. The expansion of the European Hydrogen Backbone will not only strengthen the common European energy market and ensure a high level of European security of supply, but will also avoid dependence on individual energy-exporting countries. In this context, the Federal Government advocates a jointly coordinated, European hydrogen ramp-up at EU level and within the scope of bilateral partnerships. In addition to an EU-wide hydrogen network, one of the aims is to make the entire European hydrogen production potential available. In particular, the production of green hydrogen will be rigorously pursued in EU member states that have sufficient potential for renewable energy sources available for the European hydrogen market. The focus must be on unbureaucratic regulations, which should provide flexibility, especially in the ramp-up phase.

Additionally, the aim is for international imports from a diversified portfolio of exporting countries that meet minimum standards and, if possible, are subject to a common or recognised certification system for hydrogen. The import strategy is also to take into account sustainability criteria as specified in the 2030 Agenda (SDGs) and local value added, in addition to the issues related to the transport of hydrogen and hydrogen derivatives. In the case of partner countries of German development cooperation, the aim is to achieve maximum synergies based on the goals of the 2030 Agenda, in particular moving ahead with local energy transitions based on the principle of a social-ecological transformation of society and the economy and the Sustainable Development Goal (SDG) 7.

The purpose of the H2Global initiative, the first international trading platform for green hydrogen and its derivatives, which was launched at the beginning of the legislature, is to promote non-European imports of green hydrogen and to support the global market ramp-up. In H2Global, prices and quantities for trading in green hydrogen derivatives are to be determined transparently for the first time.



The double-auction mechanism⁷ guarantees that public funds are used efficiently. Companies from all non-European countries can participate in the tenders. The current sustainability criteria are to be evaluated over the course of the programme and adjusted if necessary. In addition, a Europeanisation process for H2Global is being worked on. Hydrogen partnership agreements have also been concluded with seven non-European countries.

In addition to compliance with environmental standards, such as the avoidance of water scarcity and pollution, among other things, diversification of the suppliers and producers of hydrogen beyond the current energy-exporting countries will be essential. This diversification must take into account the geopolitical impacts, but also such things as local land rights. The interest of current fossil fuel exporters in contributing to or participating in the global energy transition in the hydrogen sector will also be taken into account.

At the same time, new export partners should be supported in their efforts to build a value-added chain for hydrogen. The development of a hydrogen export economy will also provide opportunities for economic development and incentives for many energy-exporting countries to decarbonise their own industry and energy systems. The large-scale expansion of international hydrogen projects should significantly reduce the currently high prices for hydrogen and make hydrogen globally attractive more quickly compared with fossil fuels. The international hydrogen market ramp-up will also provide excellent opportunities for the German export industry. German companies are market leaders in technologies that are needed for the production, transport, use and reconversion of hydrogen.

However, the increasing demand for hydrogen must not be allowed to impede or prevent local value added or climate action and environmental protection in developing and emerging countries, or allow human rights to be violated during production and transport. Hydrogen projects are not to hinder but must support the local energy transition, the expansion of renewable energies to improve the local energy supply and social-ecological and transformations of the local economy. Furthermore, it is vital that these projects are in compliance with international human rights standards, labour and environmental standards and standards relating to corporate due diligence (e.g. OECD Guidelines for Multinational Enterprises, UN Guiding Principles on Business and Human Rights and the 2030 Agenda).

⁷ The mechanism of H2Global consists of two separate auctions. The first step determines which exporter is offering the lowest price for deliveries of green hydrogen. In a second step, the purchased quantity is auctioned among the interested buyers. The companies with the highest bid are awarded the deliveries. The difference between the higher purchase price and the lower sales price is compensated for by a payment to HINT.CO GmbH. The cost difference will decrease in the medium term. The required compensation for the cost difference is thus reduced and becomes obsolete in the long term.

2. Developing an efficient hydrogen infrastructure

Target vision 2030: An initial hydrogen network of more than 1,800 km of repurposed and newly built hydrogen pipelines in Germany and around 4,500 km throughout Europe is being funded via the EU's IPCEI hydrogen funding programme and is expected to be completed by 2027/2028. By 2032, the available transport infrastructure is to be expanded to link up all the major production, import and storage centres with the relevant consumers.

The German hydrogen network will be connected to neighbouring EU countries as early as 2030 via an initial European hydrogen network (European Hydrogen Backbone). High-capacity pipelines are to be put into operation primarily for the import of substantial quantities of hydrogen from Norway, but also from other European countries. In order to meet the demand for hydrogen at an early stage with hydrogen or hydrogen derivatives produced outside the EU, an appropriate number of import terminals will be built on German coasts for hydrogen transport by ship by 2030. Hydrogen storage facilities will also be connected to the network and, if required, a national hydrogen reserve is to be made available to meet demand, in order to become less dependent on production or import failures.

The supply of hydrogen for a refuelling infrastructure for road vehicles constructed to meet the demand will be secured (see section on transport).

The network is designed to ensure that, as far as possible, regional differences are not exacerbated.

For the market ramp-up – in addition to the availability of hydrogen – a forward-looking and rapid development of a hydrogen terminal, network, refuelling and storage infrastructure is imperative. At its core, this will primarily include a national hydrogen network that is capable of connecting future consumers in Germany with the production and import locations, with ports being of particular importance as hubs for providing energy security. In areas where pipeline supply is not possible, sea, rail and road transport options should be examined, to the extent this makes economic sense. The interests of German medium-sized enterprises as the backbone of the German economy should also be taken into account, in order to create the conditions for a transformation to future-proof, sustainable production.

For a cost-effective and rapid development of the hydrogen network, it is logical that existing natural gas transport pipelines in particular be repurposed to transport hydrogen in order to avoid fossil lock-ins. The Energy Industry Act already provides an initial legal framework with various forms of relief for the repurposing of pipelines. The comprehensive European regulatory framework (hydrogen and decarbonised gas market package) will be swiftly implemented nationally on completion of the EU legislative procedure (expected by the end of 2023). As a basic principle, in the context of Germany's ongoing transformation towards a decarbonised economy, natural gas pipelines will become increasingly available and subsequently repurposed. At the same time, the future hydrogen network will not be identical in terms of its scope to the previous natural gas network. It will be possible to use hydrogen

hubs to secure supply throughout the country – in the transport sector, for example, or for medium-sized enterprises located at a distance from the large industrial centres.

Whatever the case, closely coordinated, cross-sectoral planning between electricity, gas, hydrogen, transport and heat grids will be necessary in order to jointly reconcile the climate, energy and environmental objectives. This will be done using the in-depth expertise of relevant research initiatives.

In order to map out a coordinated and system-serving structure of a hydrogen core network, in addition to determining its financial viability, appropriate framework conditions that address the obstacles to the development of the hydrogen network must be in place:

1. Consistent planning and coordination of the network.
2. Incentives for the willingness to invest in the repurposing of existing pipelines and the construction of new pipelines (among other things, uncertainties in the ramp-up of the new infrastructure must be addressed: risks of fluctuations in terms of deadlines and quantities, anchor customers, imports, etc.).
3. Parallel operation of gas and hydrogen networks.

A **concept for hydrogen storage** is also being developed at the same time that will integrate the successive conversion of existing gas storage facilities and the construction of new hydrogen storage facilities as necessary. In a power system that is increasingly geared towards volatile renewable energy sources, these are precisely the storage facilities that will provide the intermediate storage of renewable

energy sources and thus, when connected to the hydrogen transport network, cover any delays between generation and consumption. With the largest existing gas storage potential in Europe, Germany can also play a central role in the European hydrogen network.

Appropriate and reliable framework conditions are therefore needed not only at national but also at European level. The development of a European hydrogen network is in the interest of the whole of Europe and is being pursued by the Federal Government with high priority in order to achieve the EU climate action goals and to diversify the energy supply in the EU. The starting point of the **European Hydrogen Backbone** will be formed by transnational pipeline projects within the framework of the IPCEI Hydrogen. These must be supported quickly by additional cross-border network expansion, especially to ensure EU-wide distribution of the hydrogen import quantities needed.

The expansion of the hydrogen refuelling infrastructure with large-volume capacities primarily to cover **heavy goods transport** will be stepped up by industry and will be continued as demand increases in order to achieve the climate targets and the planned vehicle ramp-up. The Federal Government supports this expansion and is examining further funding models for this purpose.

To make CO₂-neutral **aviation** possible for short- and medium-haul routes, in addition to climate-neutral **shipping**, support for the development of an initial refuelling infrastructure for liquid hydrogen or hydrogen derivatives will be examined, depending on the progress made in the availability of the appropriate aircraft and ships.

a) National hydrogen infrastructure

As part of the network planning coordinated between electricity, gas and hydrogen, the national hydrogen network will be developed beyond the IPCEI hydrogen network to meet the foreseeable demand for hydrogen. Due to the initially low number of users connected to the hydrogen core network, complete user financing via network charges would lead to high charges in the ramp-up phase. However, grid charges should not be prohibitively high, especially in the start-up phase, and should be as uniform as possible. Appropriate solutions, such as deferred payment of charges, are being examined. In addition to structural considerations, the requirements of the transport sector will also be taken into account in network planning.

At the present time, large-scale storage of hydrogen and hydrogen derivatives is not yet feasible, but is not necessary, since there is insufficient storage capacity available and the costs are still very high. However, this will become more important, especially from the second half of the 2020s onwards as the quantities produced and required increase. In view of the long-term investment cycles, it is important to set the right course now and to examine demand and ramp-up at an early stage.

Short-term measures (2023)

- Energy industry law is to be amended this year to create the legal basis for a first hydrogen core network. Two steps are planned:
 - Step 1: Submission of an initial hydrogen core network by the gas transmission system operators, which is to be confirmed by the Federal Network Agency and imple-

mented by 2032, and is to connect the relevant regions in Germany on the supply and application side.

- Step 2: In a subsequent amendment to the Energy Industry Act, the legal basis for expanding the periodic gas network development plan into an integrated gas and hydrogen network development plan will be created.
- As part of the TransHyDE hydrogen flagship project, the basis for sound planning and the technological prerequisites for the efficient transport of hydrogen is being created to support the integrated and technology-neutral development of the energy grids within the scope of the set goals.
- Potential and system analyses, in addition to transformation roadmaps, will be specifically funded in order to accompany the development of the hydrogen economy with sound scientific findings and to further develop the energy system in a resilient and reliable manner.

Medium-term measures (from 2024/2025)

- The first gas and hydrogen network development plan is to be developed on the basis of the aforementioned legal bases.
- This will also include taking into account the interactions with electricity, transport and heat during the planning stage as part of the future System Development Strategy, which will support the development of framework conditions for the further expansion of the hydrogen network across sectors.

b) European Hydrogen Backbone network

Looking ahead, the emerging networks of the EU member states are to be connected via a European hydrogen core network (European Hydrogen Backbone). The first stage of development in this endeavour will be a total of 4,500 kilometres of pipelines across Europe to be completed as IPCEI Hydrogen infrastructure projects (1,500 km of new pipelines and 3,000 km of repurposed natural gas pipelines), including cross-border connections.

This nucleus for a European network is to be expanded rapidly in conjunction with the participating member states so that EU-wide distribution of hydrogen produced within Europe or also imported to the main centres of application is secured. The Federal Government's focus is on creating connections to our neighbouring countries in order to set up a well-developed network in Central Europe with connections to both the potential production centres in Scandinavia, Southern and Eastern Europe and the strategically located import hubs in Western Europe.

Short-term measures (2023)

- At EU level, the Federal Government is advocating the prompt creation of unambiguous framework conditions for the further development of the European hydrogen infrastructure, even beyond the IPCEI projects. The framework conditions in the hydrogen and decarbonised gas market package should be in place before the end of the year to ensure that a European hydrogen backbone network is completed by 2030.
- In several bilateral dialogue formats with the EU Commission and interested partner countries, the rapid implementation of cross-border pipe-

line projects is to be negotiated very soon. The Federal Government strongly supports the construction of new hydrogen pipelines or the repurposing of natural gas pipelines within the EU that are no longer needed, e.g. as part of the selection process for Projects of Common Interest (PCI) by the EU Commission or by bilateral agreements based on feasibility studies.

- In addition to those to the North Sea and Baltic Sea regions, pipelines to North Africa are also currently being considered as priority corridors, either via France, Spain and Portugal (H2Med) or via Austria and Italy (Southern Corridor). Discussions are being held with all participating states to move ahead with the creation of joint generation and distribution clusters in both maritime areas.

Medium-term measures (from 2024/25)

- For the medium-term expansion of a European hydrogen core network, discussions on cooperation projects and the development of cross-border infrastructures will take place with EU member states and other partner countries before the expansion of the European Network of Network Operators for Hydrogen begins. Discussions with Norway and Denmark are already more advanced, but talks have also been held with Finland and Sweden, in addition to Austria, Italy and France. Possible options include setting up hubs for the use of offshore wind energy, for example, offshore electrolysis and the conclusion of long-term import agreements.

c) Infrastructure for imports from third countries

The aim is to set up an import infrastructure in Germany and Europe quickly in order to be able to meet the foreseeable hydrogen demand at an early stage

with sustainable hydrogen and hydrogen derivatives produced outside the EU.

To this end, the accelerated construction of import terminals on the German coasts that can be converted to hydrogen or hydrogen derivatives is to be promoted and safe, sustainable shipping routes for imports established, in addition to focusing on the expansion of the hydrogen transport infrastructure in ports. The LNG infrastructures currently being built are an important starting point. They should be built to ensure that they are “H₂-ready”, i.e. that they can be converted at low cost, i.e. that they are also suitable for the unloading of hydrogen derivatives, such as ammonia and methanol, or transport media, such as LOHC. There will also be additional safe domestic transport routes available for hydrogen derivatives such as ammonia or methanol. During production and transport, human rights and environmental due diligence obligations must be implemented in supply chains. With regard to the required transport infrastructure, environmental risks relating to biodiversity, for example, must be evaluated and avoided.

Whenever necessary, pipeline projects are to be implemented with selected countries outside the European Economic Area, as they can provide cheaper and more secure supplies in the long term.

Short-term measures (2023)

- A Hydrogen Acceleration Act is being drafted. To this end, measures to accelerate the expansion of hydrogen import terminals, among other things, are being examined.
- In order to develop the required import infrastructure and in view of the high demand for

imports, outstanding questions are being clarified in ongoing cooperation activities with international partners.

- With a view to transport by ship, it must be possible to convert any new LNG terminals to be constructed for hydrogen or its derivatives.
- Development plans for refuelling infrastructures in the ports are already advancing at a fast pace due to Germany’s obligation under European law. As part of the development of a “National Port Strategy”, strategic measures for the further development of ports as sustainable hubs of the energy transition are to be developed in coordination with the federal states to ensure that the infrastructural requirements for hydrogen imports are met in the ports.

Medium and long-term measures (2024/2030)

- As part of the Hydrogen and decarbonised gas market package, the foundations for the EU-wide planning of hydrogen networks will be established.
- In coordination with planned hydrogen projects, a European Hydrogen Backbone must also take into account strategic hydrogen pipelines to countries bordering the Union, such as Norway, the United Kingdom, Ukraine, Morocco, Tunisia and Algeria, for example. On the basis of bilateral agreements, a feasibility study is currently being carried out on total hydrogen deliveries from Norway.
- Further terminals for hydrogen or its derivatives only are to be built.

3. Implementing hydrogen applications

Target vision 2030: based on what we know today, the area of application for hydrogen and its derivatives by 2030 will be primarily in the industrial sector, e.g. in the chemical and steel industries, as well as in transport for use in fuel cells or as a renewable fuel. In the heat sector, no broad application is seen by 2030, although the repurposing of gas distribution networks for hydrogen and the use of decentralised H₂ boilers are also to be made legally and technically possible.

In the power sector, electrolyzers on the consumption side will be used primarily as variable system-serving stabilisers or flexible loads. On the other hand, hydrogen can be converted back into electricity on the generation side in times of high electricity demand and low power generation using renewable energy sources, if required. Sufficient quantities of hydrogen will also be required by 2030 for testing purposes and for the market ramp-up of hydrogen power plants based on hydrogen turbines, fuel cells and combustion engines, which will have to begin in the next few years. In addition, any new gas-fired power plants to be built in are also to be designed as „convertible to hydrogen or its derivatives“ (H₂-ready).

In principle, there are many different applications possible for hydrogen and its derivatives. Whether more hydrogen is used or not will depend primarily on whether it is available in sufficient quantities or not and on its attractiveness in terms of price compared with alternative options. As long and insofar as hydrogen is a scarce and expensive commodity and energy carrier, the focus is likely to be on applications for which direct electrification is not economically viable, for example, or for which no alternative technical solutions exist to achieve climate neutrality.

From the Federal Government's point of view, the use of hydrogen in the individual areas of application should not be restricted. From an economic and industrial perspective, however, it must be considered that with increasing demand, the price of hydrogen may rise, particularly for consumers who have no alternatives to hydrogen or hydrogen derivatives. For this reason, therefore, there are appropriate mandates for action and development

in these sectors in particular. State funding should focus on areas in which the use of hydrogen is absolutely necessary or where there is no alternative.

We have also taken into account the special interests of medium-sized enterprises outside the large industrial centres.

a) Industry

In the industrial sector, hydrogen-based technologies are an appropriate transformation option, especially in those sectors where they replace fossil raw materials such as natural gas, oil or coal in the way they are used. By the same token, it is possible that the energetic use of hydrogen is the only decarbonisation option in certain sectors.

In the field of process heat supply, hydrogen competes in the low and medium temperature range with direct electrical solutions such as large heat

pumps, electrode boilers or e-crackers. In the case of high-temperature applications, however, where electrification is not or not yet technically or economically feasible, hydrogen is the only decarbonisation option to date. This applies in particular to primary steel production and areas of the chemical industry. Moreover, hydrogen also contributes to avoiding process emissions in such cases that would otherwise be difficult to avoid. The Federal Government will be focusing on this area in the market ramp-up phase. BMWK's long-term scenarios predict a demand for hydrogen of between 290 and 440 TWh for industry in 2045.⁸ This wide range results, among other things, from different possible development paths for industry in Germany, especially in the basic chemicals industry.

In order to push ahead with the hydrogen ramp-up and boost the transformation-related investments necessary for the conversion to climate-neutral production processes in industry, and in particular to encourage the necessary springboard innovations, financial support will be required, at least in the short to medium term. This will ensure that the transformation takes place at an early stage. This is vital with regard to both the climate goals and the competitiveness of Germany as an industrial and business location. In addition to financial support, further preconditions for the successful marketing of low carbon and carbon-neutral products from industry are to be established (primarily green lead markets). Stimulating demand for green products will help to reduce the need for state support in the medium to long term.

Short-term measures (2023)

- Various key support measures for the industrial sector and their close coordination and dovetailing have already been introduced or will be introduced in the short term:
 - climate protection contracts for industry: support for additional costs incurred by companies in emission-intensive sectors due to the construction of more climate-friendly facilities (CapEx) and operation (OpEx) compared with conventional facilities;
 - funding within the framework of the IPCEI Hydrogen;
 - Decarbonisation of Industry funding programme.

Close dovetailing of the funding systems is provided.

In addition to financial support, the conditions for the profitable marketing of climate-friendly products must be created. For this purpose,

- a concept on "green lead markets" will be presented that includes definitions of the basic terms and the instruments for creating demand for climate-friendly basic materials, starting with steel and cement. Possible levers for this are labelling, product standards as well as criteria and quotas in public procurement.

b) Transport

In the transport sector, electrification with batteries and fuel cells as well as the use of electricity-based renewable fuels are, in addition to traffic

⁸ Other studies (e.g. by the National Hydrogen Council) arrive at different forecasts.

reduction and modal shift, the key levers for achieving climate targets. Hydrogen and its derivatives are an important building block for sustainable climate-friendly mobility and complement alternative drive systems. This means that the transport sector can also contribute as a driver to the upscaling of a hydrogen economy.

As part of the national implementation of the RED II in September 2021, an obligation to place electricity-based PtL (Power-to-Liquid) aviation fuels on the market was agreed on for aviation. In accordance with the Federal Government's joint paper on climate-neutral aviation of June 2022⁹, the development of fuel cell-based powertrains and auxiliary power units for hydrogen-based aviation will also be focused on. In order to make climate-neutral aviation possible for short and medium-haul flights, support for the development of an initial refuelling infrastructure for liquid hydrogen will be examined, depending on the progress made in the availability of the appropriate aircraft.

Sufficient quantities will be needed for hydrogen and its derivatives to make their contribution to achieving climate protection goals in transport. Accelerating the production and use of hydrogen and electricity-based fuels (e-fuels) will be particularly necessary in the field of aviation and shipping, and for special applications such as those found in the military sector. This will require further research activities and the development of appropriate measures (e.g. regulation and standardisation) (see Chapter 4. c)).

In addition, planning and thus investment security will be necessary. The Federal Government is also

supporting the expansion of the hydrogen refuelling infrastructure defined in the EU Alternative Fuels Infrastructure Regulation (AFIR) through funding programmes in the implementation phase and is also examining new funding models.

A master plan for hydrogen and fuel cell technology in transport will be developed to drive forward the upscaling of hydrogen and fuels produced from it, fuel cell vehicles and fuel cell components and systems and the necessary infrastructures in a targeted manner. By taking into account and combining the existing processes and strategies, funding programmes and regulatory measures, the master plan will define specific action steps that will be backed by a time schedule and will address the possible contribution to achieving the national climate targets by 2045.

Short-term measures (2023)

- In the EU negotiations on the revision of the RED II, the Federal Government advocated, among other things, sub-quotas for renewable fuels of non-biogenic origin (i.e. hydrogen and e-fuels). This quota is being ambitiously implemented nationally. Similarly, the Federal Government has successfully supported a mandatory PtL paraffin quota at EU level in the ReFuelEU Aviation initiative negotiations, as well as a so-called "sunrise clause" and sub-quota for renewable fuels of non-biogenic origin (RFNBOs) in the ReFuelEU Maritime initiative.
- Active support and participation in the international development and harmonisation of

⁹ Climate Neutral Aviation, Joint Paper of the Federal Government of 21.06.2022, https://www.bmwk.de/Redaktion/DE/Downloads/J-L/220621-Klimaneutrale-Luftfahrt-Juni-22-Vfin-Anlage-BR.pdf?__blob=publicationFile&v=1.

standards for transport applications for the storage, transport and use of hydrogen and its derivatives as well as fuel cell systems.

- The amending directive on the revision of the Eurovignette Directive will be implemented shortly. In accordance with the Eurovignette Directive, road tolls for HGVs vary based on CO₂ emissions and pollutant emissions, among other things, in order to promote incentives for the use of more environmentally friendly vehicles – including hydrogen-powered vehicles.
- Implementing short-term measures to ensure the proactive development of an initial hydrogen refuelling infrastructure network by 2025.
- IPCEI projects in the transport sector, covering the entire value chain, will be supported and funded in the best possible way, if necessary on an alternative legal basis: from the development and production of fuel cell systems and components to the development and production of vehicles and the initiation of a trans-European interconnected core network for the refuelling infrastructure.
- The continuation of the “HyLand – Hydrogen Regions in Germany” competition is planned, and further development is being examined.
- In 2023, notification will be given of a cross-modal funding measure for investments in facilities for the production of electricity-based fuels in Germany in order to provide the necessary proof of technology on an industrial scale and in this way offer German companies development potential, e.g. for the export of these facilities and production technologies.
- The funding of research and development in the field of aircraft propulsion technologies based on hydrogen and fuel cell technology will be continued, e.g. within the framework of the National Hydrogen and Fuel Cell Technology Innovation Programme and the Aviation Research Programme. The planned Hydrogen Innovation and Technology Centre (ITZ) is to offer testing infrastructures for hydrogen and fuel cell applications in aviation at its North location (Hamburg, Bremen, Stade).
- For the end of 2023, here are plans to launch a national module under the H2Global mechanism to promote industrial PtL paraffin production.
- A decentralised “Hydrogen Innovation and Technology Centre” has been set up for the purpose of creating a testing and development environment across all modes of transport, which has been lacking in Germany to date, and which will contribute to the development of framework conditions that are particularly relevant for industry, such as norms and standards.
- The development of port infrastructure for the refuelling of ships with hydrogen and its derivatives will be examined in the development of a “National Port Strategy”. Development plans for refuelling infrastructures in the ports are already being driven forward rapidly as a result of to Germany’s obligation under European law.

Medium-term measures (2024/2025)

- Examination, updating and further development of existing funding programmes in the field of hydrogen and fuel cell technology, including refuelling infrastructure, the produc-

tion of renewable fuels as well as the use of hydrogen and its derivatives, especially in transport applications that rely on liquid or gaseous renewable electricity-based fuels for decarbonisation even in the long term, including the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP), the Overall Promotion Concept for Renewable Fuels and IPCEI Hy2Move.

- Development of an overall strategy for the hydrogen transformation of shipping within the framework of a “National Action Plan for Climate-Friendly Shipping” including a technology-neutral funding framework for demonstration projects for alternative propulsion systems and fuels based on hydrogen technologies.

Long-term measures (2027/2030)

- Once the AFIR enters into force, the Federal Government will take further measures, if necessary, to ensure a needs-based network of hydrogen refuelling stations, especially for commercial vehicles, in line with the market ramp-up by 2030.

c) Power

In an increasingly climate-neutral power system, grid-connected hydrogen will become an important energy carrier, as it makes the long-term storage and transport of energy from renewable sources possible. This also includes hydrogen derivatives such as synthetic methane, ammonia, methanol, paraffin and other synthetic fuels.

Hydrogen power plants can take on both a short-term and a seasonal balancing function in times of high electricity demand and low supply of electricity from renewable energies, insofar as this cannot be provided by other more efficient flexibility options or storage. Based on the BMWK’s long-term scenarios, the annual hydrogen demand in the conversion sector (electricity and heat grids) will increase from currently 0 TWh to up to around 80-100 TWh in 2045.¹⁰ With the phase-out of coal-fired power generation and the subsequent power generation’s general transition away from fossil fuels, the power supply in Germany will become climate-neutral (cf. targets in Section 1a of the Renewable Energy Sources Act. As a result, when new investments are made in gas-fired power plants, it is essential that the power plants can be converted to hydrogen or its derivatives (so-called “H2-readiness”). In 2022, the Combined Heat and Power Act stipulated that new CHP plants with an electrical output of at least 10 MW that are approved from July 2023 onwards must provide evidence that they can be converted to operate with hydrogen at a later date at low additional cost. There is also an almost identical requirement in the Renewable Energy Sources Act for biomethane plants that will be funded from 2023.

In addition, the Renewable Energy Sources Act (Sections 88e and f) provides for funding options for the testing and rapid market ramp-up of hydrogen and its derivatives in power generation (so-called “hydrogen sprinter power plants” and local “RE-hydrogen hybrid power plants”).

The demand for hydrogen from the power sector will place increased demands on the hydrogen

10 Other studies (e.g. by the National Hydrogen Council) arrive at different forecasts.

infrastructure, especially with regard to storage volumes, which must be taken into account when the hydrogen infrastructure is expanded. In addition, it is essential that the expansion of electrolyser capacity is largely system-compatible in terms of location and mode of operation by 2030.

Short-term measures (2023)

- Within the scope of the system development strategy and the “Platform for a climate-neutral electricity system”, the requirements for “system-serving electrolysis” are being examined, in particular at electrolyser locations that serve the overall system and regarding their mode of operation, with special weighting being given to the economic efficiency of their operation, particularly in the ramp-up phase.
- The tenders planned in accordance with Section 28e of the Renewable Energy Sources Act 2023 for so-called “hydrogen sprinter” power plants for the conversion of pure hydrogen or ammonia to electricity will stimulate the testing and a rapid market ramp-up of these power plants, which contribute to balancing volatile renewable power generation. For this purpose, the first step will be to implement the power to issue statutory instruments in accordance with Section 88f of the Renewable Energy Sources Act 2023. With the tenders in the years 2023 to 2026, the construction of 4.4 GW of hydrogen and ammonia power plants is already being funded.
- The tenders planned in accordance with Section 28d of the Renewable Energy Sources Act for local “RE-hydrogen hybrid power plants” will stimulate the testing and rapid market ramp-up of innovative concepts with hydro-

gen-based electricity storage that contribute to balancing volatile renewable power generation. In contrast to the “hydrogen sprinter” power plants, hydrogen is produced on site in this case, so that the entire process chain is addressed from production and storage to reconversion into electricity. For this purpose, the first step will be to implement the power to issue statutory instruments in accordance with Section 88e of the Renewable Energy Sources Act 2023. The construction of a further 4.4 GW of hydrogen hybrid power plants as part of hydrogen-based electricity storage is already being funded with the tenders for the years 2023 to 2028.

Medium-term measures (2024/25)

- In the medium term, an examination will be made to determine whether and to what extent refinancing of controllable, climate-neutral capacities, and hence hydrogen power plants, will be necessary in the future. The foundation for this will be laid primarily by discussions on the design of the future electricity market through the platform for Climate Neutral Electricity Market Design.

d) Heat (building sector)

General speaking, the use of hydrogen in decentralised heat generation systems, according to current knowledge, will tend to play a subordinate role. With regard to the competition for use between the industrial, transport and building sectors, it can be assumed that the demand for hydrogen in the industrial and transport sectors will probably remain constant, even with relatively high or rising prices, while alternatives/substitutes will exist in many buildings and residential areas.

As far as we know today, direct hydrogen use in space heating will only be seen beyond 2030, except in pilot projects. The use of hydrogen boilers or hydrogen CHP systems, however, can be a necessary technology option in buildings that are not connected to a heating network and in which heat pumps cannot be operated efficiently, if there happen to be large consumers of hydrogen in the local area and a sufficient hydrogen supply is available at low prices. In such cases, which will presumably be relatively isolated cases, the use of hybrid heating systems, in which hydrogen covers the peak loads, can contribute to reducing the load on the power system and increasing the flexibility of the overall system. Whether the conversion of natural gas distribution grids to hydrogen and their operation for this level of demand is economically viable will have to be examined. Decisions on such transformation pathways should take into account local circumstances, upstream infrastructures (i.e. above all proximity to the National Hydrogen Backbone) and the expected efficiency of the heat supply, including the distribution grid conversion, based on scientifically sound criteria that have still to be determined. Municipal heat planning, which is to be introduced nationwide as a central planning instrument, is to be used for this purpose. For the provision of space heating, individual cases are to be examined as to whether hydrogen derivatives in combination with biomethane can represent a decarbonisation option for selected gas grids.

The conditions for recognising these various applications as compliance options for the planned obligation to use renewable energies (65% rule) will be enshrined in the amendment to the Building Energy Act.

In large heat grids connected to the national hydrogen transport network, power-controlled hydrogen-powered CHP plants can contribute to the heat supply when connected to heat storage systems. By feeding waste heat from electrolysis, for example, into heat grids, hydrogen processes can indirectly serve the heat supply. Whether the use of hydrogen in small heat grids without a connection to a hydrogen grid, i.e. with local hydrogen production, represents an economically viable alternative will have to be examined for each specific application on the basis of criteria that are as uniform as possible and are state of the art. Further application possibilities in the heat sector are to be tested in the event that sufficiently inexpensive hydrogen will become available beyond 2030.

Short-term measures (2023)

- The potential for the utilisation of waste heat from electrolyzers is to be taken into account in the siting of electrolyzers, along with other variables such as the availability of RE electricity and power grid bottlenecks.
- In the guideline on the Heat Planning Act, which is being developed by the Federal Government in consultation with stakeholders, criteria and implementation aids will be developed to examine the use of hydrogen in decentralised heat generation in the future.

4. Creating effective framework conditions

Target vision 2030: at national, European and, preferably, international level, coherent legal conditions for the sustainable production, transport, storage and import, supply and use of hydrogen and its derivatives will be designed to support the market ramp-up. Uniform standards and certification systems for hydrogen and derivatives will be in place for domestic production and largely coherent systems for their import and supply.

The market ramp-up for hydrogen will be supported and actively shaped by the state, and any collaboration will be funded at all levels of the value-added chain. Dialogue with industry, with the aim of achieving a sustainable and at the same time efficient market ramp-up will be of particular importance.

The development of production capacities, in addition to storage, refuelling and transport infrastructure will be subject to efficient planning and approval procedures, while at the same time protecting the resources involved. Capacities in the ministries, regulatory authorities and administration relevant for the hydrogen sector will be expanded quickly and to meet the demand. Procedures, measures and requirements will be coordinated as far as possible at all levels (municipalities, federal state, Federal Government, EU).

German technology developers will be lead suppliers and hydrogen technologies “Made in Germany” will be in demand on an international scale. CO₂ pricing as a lead instrument, including effective carbon leakage protection, will be continuously developed to improve investment security and incentives.

In addition, we intend to further deepen the exchange of views and cooperation in the hydrogen sector with the other EU member states on the basis of common goals. Because only together will we succeed in ramping up the hydrogen market.

In addition to the priority measures in the fields of generation, terminal, grid, refuelling and storage infrastructures as well as hydrogen applications, the hydrogen market ramp-up requires effective, coherent and transparent framework conditions that will optimally complement the direct funding instruments. Supportive framework conditions will apply not only to individual stages of the value-added chain, such as the evaluation and, if necessary, simplification of **planning and approval procedures** for electrolyzers and for the construction of transport, storage, refuelling and import infrastructure, but will also have an overarching effect, for example in the areas of **research, innovation and education**.

a) Planning and approval procedure

In particular for the construction of the hydrogen production, transport, refuelling and import infrastructure, which is now required immediately, legal requirements for simplification and acceleration are being examined and regulatory barriers dismantled. It is also important to improve the effectiveness of the administration in the field of hydrogen, among other things by expanding resources and competences to meet the increasing demands in the hydrogen sector.

Short-term measures (2023)

- To accelerate the ramp-up of the production of hydrogen and its derivatives as well as the associated infrastructure, the Federal Government will propose a Hydrogen Acceleration Act (see Chapter 2. c)). Among other things, this is intended to bring about an appropriate adjustment and simplification of the regulatory and legislative framework.
- With the aim of achieving a shorter licensing process to expand the decentralised production of hydrogen and its derivatives, an amendment to the Fourth Ordinance for the Implementation of the Federal Emission Control Act (Ordinance on Installations Requiring a Permit – 4th BImSchV) is being examined following a change in the basis of European law.
- Approval procedures for the construction of hydrogen refuelling stations will be simplified and digitalised. Procedures for testing all types of hydrogen refuelling stations will be developed to comply with the Measurement and Calibration Act.
- The need to increase the size of the skilled workforce also exists for the ramp-up of the hydrogen economy. The resources of the administration in the hydrogen sector, including the Federal Network Agency, must also be expanded to meet the demand.

b) Sustainability standards and certification

The sustainable market ramp-up of hydrogen urgently requires **ambitious and, if possible, uniform sustainability standards and certification systems** for hydrogen and its derivatives, both for

domestic production, but primarily for imports. An international agreement on the mutual recognition of standards and certificates will be vigorously pursued. The generation of digital certification solutions that are both robust and innovative is essential. In addition, harmonisation of standards for the production, transport and distribution of hydrogen and its derivatives at European level and with non-European import regions is aimed at.

Sustainability standards and certification systems that are as uniform as possible will help to ensure that product qualities are comparable and verifiable, and that agreed minimum standards for the respective forms of hydrogen production are established and adhered to. In addition, the introduction of certification systems will guarantee that hydrogen use is supported by a massive expansion of renewable energy sources, power system based generation and the displacement of fossil fuel-fired generation, thus ensuring the contribution to climate action of the hydrogen used and the climate-neutral transformation of the energy system. Certification systems will also enable the corresponding product features of internationally traded hydrogen quantities to be clearly allocated to specific consumption quantities in Germany or other countries.

Against this background, it is important that sustainability criteria and certification systems are established and mutually recognised internationally in as many countries as possible. This applies in particular to those countries with which Germany maintains a hydrogen partnership.

Short-term measures (2023)

- Development of unambiguous specifications for taking hydrogen into account in the demand sectors for funding by means of climate protec-

tion contracts (Carbon Contracts for Difference – CCfDs), for example, or via quotas, as in the transport and industry sectors.

- It will be necessary to determine which carbon sources can be classified as sustainable in order for them to be used for hydrogen derivatives (broken down into short/medium and long term). This will be done in parallel with the transformation strategy for industry.
- The Federal Government will play an active role at national, European and international level in the development of certification systems and guarantees of origin, taking into account strict environmental and sustainability criteria, such as the avoidance of water scarcity and competition for use, pollution and competition for land, in addition to the protection of human rights in supply chains. In particular, in order to be able to verify requirements for the direct or indirect funding of the production or use of hydrogen and derivatives, standards must be defined and systems established in the short term. Any lack of basic knowledge will be addressed by carrying out research.
- Implementation of EU requirements (delegated acts in accordance with Articles 27 and 28 of the RED II / RED II revision, requirements for guarantees of origin) into national law is being carried out rapidly. This will create important planning and investment security for companies in the hydrogen economy.
 - The delegated acts (DA) in accordance with to Article 27 and 28 of the RED II / II Revision (EU Renewable Energy Directive) will be the basis for uniform criteria for the production of green hydrogen throughout Europe. For the funding of the market ramp-up, the Federal Government advocates the rapid establishment of reliable and unbureaucratic European criteria for green hydrogen based on the delegated acts. It is important that legal certainty exists as soon as possible in order to encourage investments.
 - Regulations specifying the details of the Register of Guarantees of Origin Act will be adopted in the near future.
- While criteria for the production of green hydrogen are defined by EU specifications, the specifications for blue hydrogen in particular are lacking. Criteria for handling the CO₂ captured during the production of blue hydrogen need, in particular, need to be defined. To this end, the Federal Government will
 - advocate uniform, workable and ambitious criteria with a threshold for GHG emissions for blue hydrogen and
 - establish a dialogue on transport and reliable, long-term CO₂ storage in the EU.
- A carbon management strategy designed to identify possible areas of application for CCU and CCS and address legal and economic framework conditions for CCUS in Germany, such as possibilities for the cross-border transport of CO₂ from Germany is currently being developed the Federal Ministry of Economic Affairs and Climate Action, which has overall responsibility.

Medium-term measures (2024/25)

- The development of an internationally recognised and robust methodology for the reliable calculation of carbon footprints in the production, transport and use of hydrogen and its derivatives, while ensuring the safe handling of

chemicals, which will provide the basis for the application of standards and certification systems. It will subsequently form the basis for trade and how specific hydrogen quantities will be charged. In the development of the methods to be applied, the Federal Government will actively participate in the relevant committees to argue in favour of strict standards that comply with the goals of the Paris Agreement and standards.

- Sustainability criteria for biodiversity, water and land use, in addition to the protection of human rights in supply chains are to be evaluated and taken into consideration. Existing sustainability criteria (e.g. as in the case of H2Global) are to be evaluated in the course of the market ramp-up and adapted if necessary.
- In the medium term, the Federal Government aims to build stronger and closer collaborative relationships with interested EU member states to ensure a coordinated market ramp-up, set ambitious common standards, facilitate coordination and ensure coordinated imports.

c) Strengthening research, innovation and training of professionals

Strengthening research, innovation and further education is central to the establishment and further development of the national, European and global hydrogen economy. Research, energy, climate, industrial, transport and environmental policies must therefore be closely coordinated and interlinked in order to progress more effectively and in a more targeted manner from basic research to application-oriented research and market maturity and on to practical implementation. The particular aspects and objectives of German development policy must also be taken into account.

The current research initiatives on hydrogen production, storage, transport and use in industrial applications and infrastructure (incl. repurposing for hydrogen and its derivatives), such as applied energy research and the living labs of the energy transition, are to be continued, consolidated and further developed in a targeted manner. These will include the following hydrogen flagship projects: H2Giga (hydrogen production), H2Mare (off-shore hydrogen) and TransHyDe (hydrogen transport and infrastructure, incl. H2 readiness), in addition to the funding of research and development in the transport sector within the framework of the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP), the “HyLand – Hydrogen Regions in Germany” programme, the Hydrogen Innovation and Technology Centre (ITZ) and the PtL development platform.

With a view to installing domestic electrolyser capacity, it will be necessary to provide long-term and sustainable support for research and industry in Germany and to speed up the transfer from research to production capacities to ensure that German technology developers remain lead suppliers and hydrogen technologies “Made in Germany” continue to be in demand internationally. To this end, basic and applied research in particular will be strengthened. The focus on completing the industrial implementation phase as quickly as possible will remain consistent. This also applies to demonstration and pilot projects in the field of decentralised energy supply with hydrogen and fuel cell technologies.

The demand-oriented training and further education of skilled workers in the field of hydrogen is elementary for the development of Germany as a domestic market and for technology development.

Short and medium-term measures (2023/2025)

- The innovative resources of all the relevant actors will be bundled in a hydrogen technology and innovation roadmap, which will be developed using the results of the H2Kompass project and strategic measures will be derived from it. It will take into account findings from ongoing measures (e.g. hydrogen lead projects, energy transition living labs and the Trans4Real project, the Hydrogen Technology Offensive, hydrogen potential atlases, such as the Hydrogen Atlas Germany) and the recommendations of the Hydrogen Research Network and the National Hydrogen Council.
- The Federal Government's energy research programme will be continued and new, mission-oriented funding formats will be developed to prepare hydrogen innovations in a focused and impact-oriented manner and launch them on the market more quickly. Structures for pre-competitive cooperation between companies and research institutions will also be established to ensure that the transfer of practical experience is accelerated.
- International cooperation in technology research and development will be targeted, also to further support the efforts of German companies to position themselves internationally as market leaders in hydrogen technologies. This will also include moving ahead with new innovative hydrogen production pathways globally with partner countries in maritime zones.
- Research into the global potential of naturally occurring (so-called "white") hydrogen is under consideration.
- Funding for the further development and upscaling of the required technologies in the infrastructure sector will be targeted in the short term. In order to safeguard hydrogen and hydrogen derivative imports, technologies, including safety aspects and environmental hazards, are to be researched and brought to market maturity, including, for example, hydrogen carrier ships, regasification plants and ammonia crackers. (Basic) research on energy materials will be supported to enable critical materials to be significantly reduced or replaced.
- Fundamental and application-oriented research fields will be funded in cooperation with industry. In addition to research into completely new technologies, this will also include the upscaling of hydrogen technologies in particular. At the same time, improvements in efficiency levels along the entire value-added chain will be accelerated.
- On the research side, the development of guarantees of origin and certification will be supported, and digitalisation will also be a key factor. The aim is to create a system that is as uncomplicated and as unbureaucratic as possible, while at the same time setting stringent incentives for the lowest possible overall carbon footprint and the highest possible sustainability. Sustainability criteria for the production and import of hydrogen can also be included.
- A package of measures to increase the attractiveness of hydrogen-related professions, including an overarching initiative for STEM professionals, will be developed. In addition to long-term measures, this will also include short-term (retraining and further training offers) and medium-term measures (funding of university

studies, immigration of skilled workers). In particular, support will be given to young hydrogen professionals from universities and an international exchange of young professionals will be offered. Capacity building in the field of energy and green hydrogen will be supported, among other things through a master's degree programme with the 15 ECOWAS states in Africa, which is the only one of its kind worldwide.

- New strategic international R&D cooperations (e.g. USA, Taiwan) will be launched and existing partnerships (e.g. Western and Southern Africa, Australia, Canada) will be consolidated. Dialogue platforms with experts from industry, science and politics in the partner countries will be set up or strengthened.
- Research and innovation cooperations with producer and transit countries in the EU will be strengthened in a targeted manner. Joint partnerships with other regions around the world will be considered right from the start (e.g. by using EU initiatives such as Global Gateway).

