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Joint application for the hydrogen core network

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Berlin, July 22, 2024

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1 Introduction and background

The gas transmission system operators share the German government's goal of a rapid and cost-efficient development of the hydrogen infrastructure that enables the market ramp-up and is embedded in the EU internal market.

With its initiatives to amend the Energy Industry Act (EnWG), the German government has laid the essential regulatory, antitrust and network planning foundations required for the development of an expandable hydrogen core network with the target year 2032. The last amendment to the EnWG came into force on May 17, 2024.

With this application, the gas transmission system operators fulfil their statutory duty pursuant to Section 28q (2) EnWG. This official joint application will be put out to consultation again by BNetzA. The application should be approved by BNetzA within two months.Once this has happened the network operators will immediately begin implementing the hydrogen core network.

A Germany-wide hydrogen core network that enables broad access to hydrogen as an energy source and feed stock forms the basis for the development of a liquid hydrogen market and is a prerequisite for Germany to fulfil its desired pioneering role in climate protection. Therefore, it is important to plan the hydrogen core network in a forward-looking and scalable manner. In order to ensure the necessary flexibility to adapt the plans as required, Section 28q (8) EnWG provides for a review of all measures of the hydrogen core network as part of the integrated gas and hydrogen network development plan which were not started before the end of 2025 and put into operation by the end of 2027. In addition, the legal possibility of prolonging investments beyond the target year of 2032 until 2037 has been provided for. This has made it possible for the regular network development planning process to respond to changes in demand. The target year of the core network continues to be 2032. The temporal flexibilisation can be applied to core network projects approved by BNetzA as part of the core network planning process. This enhances the flexibility of efficient network development planning in line with actual demand and at the same time maintains the framework and reliability for core network investments. The flexibilisation not only reduces the amortisation risk for the government and the network operators and their investors, but also dovetails the design of the core network with the ramp-up of the hydrogen economy in Germany and Europe.

Pursuant to Section 28q (2) EnWG, the operators of gas transmission networks have a clear mandate to develop a supra-regional hydrogen core network (onshore and offshore). Other infrastructures that are suitable for safely transporting hydrogen at the transmission level are to be taken into account.

Existing demand at the distribution network level that meets the criteria of the scenario for the hydrogen core network in accordance with Section 28q (4) EnWG are already being taken into account in terms of capacity in the technical planning process for the hydrogen core network. Additional demand not included in the core network will be incorporated in a second step as part of the future regulatory process for integrated network development plan for gas and hydrogen. The coordination office responsible for the integrated network development plan (KO.NEP) submitted the draft scenario framework as the basis for the first integrated network development plan for gas and hydrogen on July 10, 2024.The draft for the actual network development plan for gas and hydrogen will be submitted on May 31, 2025. In addition, the legal and regulatory requirements for the conversion to

hydrogen of network areas and connected customers at the distribution level will need to be created in a timely manner.

With this application, the transmission system operators are submitting their plans for the hydrogen core network, including suitable pipelines from other potential hydrogen network operators who responded to the opportunity given by transmission system operators to comment in July 2023 and during the consultation on the draft application by BNetzA in December 2023/January 2024.

The transmission system operators examined the pipelines reported by these other potential hydrogen network operators on the basis of technical and legal criteria. The reported infrastructure had to contribute to meeting the objectives set out in law and meet the criteria for the hydrogen core network scenario. Where pipeline notifications met the technical and legal requirements for integration into the hydrogen core network and the infrastructure is required to fulfil the transmission task, they were taken into account for the modelling exercise and became part of the hydrogen core network applied for. This was done regardless of the fact that some potential hydrogen network operators have made the use of their pipeline notification subject to various reservations regarding the clarification of the regulatory and financial framework for the hydrogen core network.

In the interest of overall economically optimized planning, the hydrogen core network will consist primarily of repurposed pipelines from the existing natural gas infrastructure as well as new hydrogen pipelines which need to be built. For the natural gas pipelines to be converted, the transmission system operators will demonstrate that, at the time of conversion to hydrogen, they have ensured that the remaining transmission system can meet the capacity requirements on which the supplemented scenario framework for the Gas Network Development Plan 2022-2032 is based. Therefore, the transmission system operators have identified the necessary additional expansion measures for the natural gas network, which must be approved at the same time as the hydrogen core network. The other potential hydrogen network operators have confirmed that the operation of the remaining methane network will be able to continue until 2032 once the pipeline conversions notified by them have been completed.

The rules governing the financing of the hydrogen core network – especially the arrangements surrounding the so-called amortisation account – have to be applied in accordance with the EU Commission’s approval of the German state aid scheme. This approval therefore has a direct impact on the application of the statutory provisions (Section 28r (10), Section 28s (6) EnWG). On 27 June 2024, it was announced in the Federal Law Gazette that the European Commission had granted state aid approval for the application of Section 28r (1) to (9) and Section 28s (1) to (5) EnWG on 21 June 2024 and that the aforementioned provisions have to be applied in accordance with this approval. The gas transmission system operators' application is based on the assumption that the provisions of Sections 28r and 28s EnWG will continue to apply unchanged and in full under the state aid approval.

The gas transmission system operators want to point out that not all regulatory decisions on the hydrogen core network have already been taken at the time this application is submitted. Among other things, BNetzA's decision on the ramp-up fee in the second half of 2024 is still pending, and there are still no rules in place regarding a market model for hydrogen, including the marketing of transmission capacities. In addition, future market

roles such as storage, particularly during the market ramp-up phase, have not yet been clarified.

Key elements of the contractual details governing the provision and financing of the amortization account for the establishment of a hydrogen core network between the parties have been set out in a Memorandum of Understanding (MoU), which the transmission system operators have taken into consideration for their decision to submit the application. The contractual details of the MoU still have to be finalised in a legally binding manner.

The transmission system operators are united and committed to the hydrogen core network concept, and they want to build and operate the hydrogen core network. Due to the many years of expertise in the rapid and professional creation of this infrastructure they are well suited for providing the transmission network of the future. With the core network application, they are presenting their plans for a fully functional network by the year 2032. The application includes all measures of the planned hydrogen core network and seeks to obtain full approval for all of them. Once approved, the hydrogen core network will be launched and gradually implemented.

2 Application for the hydrogen core network

1 The gas transmission system operators apply for the approval of the hydrogen core network in accordance with Section 28q (2) sentence 1 EnWG as follows:

1.1 Approval of the hydrogen core network newbuild measures in Annex 3 with the ID numbers KLN001-01 to KLN068-01, KLN 072-01 to KLN079-01 and KLN081-01 to KLN106-01 as well as KVS000-01, KVS003-01 und KVS007-01 in the "Application ID" column, including all ancillary facilities of the pipelines and compressors required for system operation. The company or companies named in the column "Responsible company or companies" are responsible for the delivery of the relevant project.

1.2 Approval of the hydrogen core network conversion measures as set out in Annex 4 with the ID numbers KLU001-01 to KLU025-1b, KLU027-01, KLU029-01 to KLU057-01b, KLU059-01 to KLU132-01, KLU137-01 and KLU139-01 to KLU143-01 in the column "Application ID", including all ancillary facilities of the pipelines required for system operation. The company or companies named in the column "Responsible company or companies" is/are responsible for the delivery of the relevant project.

As the conversion of the infrastructure to hydrogen requires the implementation of associated natural gas reinforcing measures, the transmission system operators apply for the respective conversion only under the condition that the relevant natural gas reinforcing measures are approved as part of the core network application.

1.3 Approval of the hydrogen core network measures set out in Annex 2 with the ID numbers AND007-01, AND023-01, AND025-01 to AND045-01, AND055-01, AND058-01, AND059-01, AND064-01, AND065-01, AND067-01 to AND071-01, AND073-01b to AND074-01a, AND082-01, AND088-01, AND089-01, AND093-01, AND094-01, AND096-01 to AND100-01, AND102-01, AND106-01 to AND110-01 and AND113-01 to AND119-01 in the column "ID numbers", including all ancillary systems of the pipelines and compressors required for system operation. The company or companies named in the column "Operator/owner/responsible company" is/are responsible for the delivery of the relevant project.

2 In addition, the transmission system operators apply for approval of the natural gas reinforcing measures in Annex 5 with the ID numbers 436-02b, 760-01, 761-01, 767-02, 768-01, 941-01 to 945-01, 947-01 to 952-01, 960-01, 961-01, 964-01, 965-01, 967-01, 968-01, 1001-01 to 1013-01, 1015-01 to 1036-01 and 1038-01 to 1063-01, including all ancillary facilities of the pipelines and compressors required for system operation. The company or companies named in the column "Responsible company" are responsible for the delivery of the relevant project.

Nomination of the companies responsible for the project, if not already included in Annex 3-5, shall be based on Section 15c (3) EnWG in conjunction with Section 28q (7) EnWG for confirmed gas and hydrogen network development plans.

The gas transmission system operators want to point out that the application for the hydrogen core network is submitted in full for all projects of the entire hydrogen core network.

The EnWG provides for a review of all core network measures as part of the integrated gas and hydrogen network development plan, the only exception being measures that are to be started by the end of 2025 and commissioned by the end of 2027 (see Section 28q (8) EnWG). The reviewed measures will be confirmed by BNetzA in the integrated gas and hydrogen network development plan, provided the relevant demand actually exists. Upon confirmation of these projects in future network development plans, project owners tasked with binding effect, unless this has already happened earlier. Regular integrated network development planning for gas and hydrogen will thus play an important role in the delivery of an efficient and resilient hydrogen core network. The subsequent designation of individual project owners as part of the integrated network development planning will have no effect on the probability of these projects actually going ahead.

In the case of joint projects, all transmission system operators involved will agree to make the switch to hydrogen.

In addition, the transmission system operators will continue to develop and provide more details on the approved hydrogen core network measures through appropriate preparatory work. Some preparatory work by the respective transmission system operators for these projects – particularly those expected to be commissioned in 2030 to 2032 – has already begun, for example with regard to spatial planning or possible routes in order to meet as much customer demand as possible in an optimised way. The relevant contact persons for the projects will be published on the FNB Gas e.V. website (https://fnb-gas.de/wasserstoffnetz-wasserstoff-kernnetz/) until the project owners are officially named.

This approach offers all stakeholders a significantly higher degree of certainty regarding the specific requirements of the individual core network measures. In addition, changes in market or regulatory conditions can be better taken into account for investment decisions.

3 Consultation on the draft application for the hydrogen core network by BNetzA

BNetzA launched a consultation on the draft application for approval of the hydrogen core network from November 15, 2023, to January 8, 2024. In the interests of a transparent and efficient process, all stakeholders and the public were given the opportunity to comment on the draft application before the start of the formal procedure. The purpose of the preceding consultation process was to prepare the approval process for the hydrogen core network and to enable timely approval once the application has been submitted.

BNetzA received 181 comments as part of the consultation. Many respondents welcomed the submission of the draft application and supported it. In addition, the comments address the following issues in particular:

- Other entry and exit projects to be considered,
- Development of further regions via additional pipeline sections,
- Commissioning times of pipeline projects,
- Notifications of changes and new pipeline projects from other potential hydrogen network operators,
- Interconnection with distribution networks in integrated network development planning,
- Consideration of bidirectional hydrogen capacities at European cross-border interconnection points, and
- Consideration of the H2-ready gas-fired power plants currently being planned.

BNetzA made the comments available to the transmission system operators in compliance with confidentiality requirements. The transmission system operators reviewed the comments and submitted their assessment to the Federal Network Agency. BNetzA itself also assessed the comments and answered them in detail in an FAQ document .[1]

During the review of the statement by the transmission system operators, particular attention was paid to the additionally reported entry and exit projects as well as changes and new reports of pipeline projects from other potential hydrogen network operators.

The additionally reported entry and exit projects were checked to determine whether they fulfil the requirements set out in section 4.1 to determine the scenario for the hydrogen core network. This was the case for a total of 27 projects. These were listed in Annex 1 under project numbers 763 to 789 in addition to the project notifications already presented in the draft application.

[1] The document is available on the website of the Federal Network Agency at https://www.bundesnetzagentur.de/DE/Fachthemen/ElektrizitaetundGas/Wasserstoff/Kernnetz/start.html.

The inclusion of the additional requirements reported in the BNetzA consultation in the load cases of the modelling of the hydrogen core network (see section 6.4) is not necessary, as extensive requirements have already been analysed. These connectees can be accessed via the hydrogen core network, as the calculated transport capacity of the hydrogen core network will be allocated to enquiring connectees on a non-discriminatory basis. The marketing regime has not yet been determined at the time of submission of this application. Nevertheless, Section 28n (1) EnWG obliges the operators of hydrogen networks to *"grant third parties connection and access to their hydrogen networks on reasonable and non-discriminatory terms"*. To this end, they are obliged to *"develop common contractual standards [and] offer entry and exit capacities, taking into account the development of the hydrogen market"*. These rules to be developed will ensure that all interested parties are granted non-discriminatory access to the hydrogen core network, irrespective of the consideration in the load cases of the modelling of the hydrogen core network.

In addition, further potential hydrogen network operators reported changes to the pipeline notifications from July 2023, with individual pipelines being deleted, technical parameters changed and new pipelines added. There were also new notifications from other potential hydrogen network operators who registered for the first time as part of the BNetzA consultation. All sufficiently concrete notifications of changes and new pipeline projects were checked for integration into the hydrogen core network as part of further modelling. The result is shown in Annex 2.

There were also changes to the measures taken by the transmission system operators as part of this modelling. These changes were prompted in particular by findings from current feasibility studies and optimization options as part of the final modelling.

As a result of the consultation of the draft application of November 15, 2023, by BNetzA, the hydrogen core network to be applied for by the transmission system operators was slightly changed. These changes are described in Section 7.3 and in Annexes 1 to 5.

Some comments noted that the commissioning dates published in the draft application deviate from the original plans for joint IPCEI projects. If pipelines are commissioned too late, this would also jeopardize generation and consumption projects that are to be connected to these pipelines and are themselves eligible for IPCEI funding. In fact, the funding decisions for the IPCEI pipeline projects had still not been handed over to the companies at the time this application was submitted. This delay of several years to the initial planning means that the pipeline projects and therefore also the commissioning of these projects will be further delayed. For more information on the determination of the commissioning dates, please refer to the explanations in section 7.3.

For all other content and topics of the BNetzA consultation, the transmission system operators refer to BNetzA's FAQ document [BNetzA 2024].

4 Scenario for the hydrogen core network

The following outlines the basic procedure for determining the scenario for the hydrogen core network in 2032 (see section 4.1) and the resulting findings (see section 4.2).

4.1 Basic procedure for determining the scenario for the hydrogen core network

Criteria for defining the scenario for the hydrogen core network

The legal basis for the hydrogen core network scenario is set out in Section 28q of the Energy Industry Act (EnWG). For operationalization, the criteria for defining the scenario for the hydrogen core network were further specified and agreed in joint discussions between BMWK, BNetzA, BKAmt, BMF, FNB Gas and BDEW. The scenario has a controlling function for the hydrogen core network and is the basis for hydrogen core network modelling by the transmission system operators.

The starting point for the hydrogen core network scenario was the result of the Hydrogen Production and Demand – HPD *("Wasserstoff Erzeugung und Bedarf – WEB")* 2021 market survey from the Gas Network Development Plan 2022-2032 [FNB Gas, 2023], which was adjusted using new information. For example, projects that are no longer being pursued, as far as the transmission system operators are aware, were removed. Analyses of the hydrogen strategies of the federal states and feedback on specific projects by the federal states were also incorporated into the scenario.

The next step was for the transmission system operators to review the project notifications to determine the extent to which they meet the following BMWK and BNetzA criteria. The selection of projects for the feed-in and withdrawal of hydrogen based on these criteria is intended to ensure that the hydrogen core network to be determined meets the political targets.

The scenario for the hydrogen core network is based on the following criteria:

- The project is part of an IPCEI or PCI process.
- The project serves to integrate the hydrogen core network into a (prospective) European hydrogen network.
- The project is part of a living lab for the energy transition, which is funded by the BMWK.
- The project serves to decarbonize the following industrial sectors and processes:
    - Iron and steel:
        - Production of crude steel from the primary route
        - Heating and annealing furnaces, steel rolling mills: continuous heating of flat/long steel, dis/continuous heat treatment of flat steel
        - Forming technology: dis/continuous heating of forged components

  - Chemicals:
    - Ammonia synthesis
    - Basic chemical production: ethylene/olefins, methanol
  - Refineries:
    - Desulphurization, hydrocracking, e-kerosene, methanol
  - Glass industry, including glass fibre:
    - Continuous melting of container glass in large systems
    - Continuous melting of flat glass
  - Medium to large production facilities for ceramics and brick products
- The project serves to feed in hydrogen produced by electrolysis plants. The planned entry capacities for hydrogen are scaled down to a flat rate of 50 % per site. Deviating from this, the full planned entry capacity (i.e. 100 %) is used as the basis for the following electrolysers:
  - Electrolysers promoted as IPCEI (approx. 2.5 GW_e)
  - Electrolysers that are being promoted as living labs for the energy transition (approx. 0.2 GW_e)
  - Conveyed offshore electrolysers (approx. 1 GW_e brought onshore via AquaDuctus pipeline)
- The project serves to store hydrogen and has been pre-notified as an IPCEI project or has concrete indications of investment.
- Consideration of CHP locations from the market master data register ("*Marktstammdatenregister*", cf. https://www.marktstammdatenregister.de/MaStR/) with an electrical CHP capacity of more than 100 MW (corresponds to a rated heat input of at least 235 MW_{th}).

Based on these criteria and taking into account a maximum distance of 20 km to the hydrogen core network and a balanced regional distribution, the projects for the hydrogen core network scenario were selected.

An overview of the projects included in the scenario for the hydrogen core network and in the modelling can be found in Annex 1 to the joint application for the hydrogen core network. Annex 1 also contains project notifications that fulfil the requirements for inclusion in the scenario for the hydrogen core network, but whose connection was not economically feasible due to the distance to the hydrogen core network (>20 km) or whose notification was only made during the informal consultation on the draft application for the hydrogen core network.

Demand indications that have not been included in the scenario can be included in the regular planning process for integrated gas and hydrogen network to be then be taken into account for the further development of the hydrogen infrastructure.

Explanation of the criteria for defining the scenario for the hydrogen core network

The criteria agreed between the BMWK, BNetzA, BKAmt, BMF, FNB Gas and BDEW for determining the scenario for the hydrogen core network are explained in more detail below.

IPCEI projects (Important Projects of Common European Interest) and **PCI projects** (Projects of Common Interest) as well as the **integration into a European hydrogen network** form the basis for the consideration of infrastructures in the hydrogen core network.

Important Projects of Common European Interest (IPCEIs) are large-scale hydrogen projects that are to receive state funding as part of a joint European hydrogen project (so-called "hydrogen IPCEIs", co-financing: federal government 70 %, federal state 30 %). The projects were selected as part of an expression of interest procedure, taking special requirements into account. The German projects will be funded together with projects in European partner countries. The various national projects are to be interconnected in such a way that all countries benefit from each other and can develop a European hydrogen economy together. The hydrogen core network takes into account the production, consumption, pipeline and storage projects of the hydrogen IPCEI.

Projects of common interest (PCIs/PMIs) are cross-border infrastructure projects that connect the energy systems of EU Member States (and possibly beyond). The EU Commission awards PCI status for cross-border infrastructure projects every two years. With this status, project developers can apply for further (EU) funding, e.g. from the Connecting Europe Facility (CEF). In addition, PCIs should benefit from improved regulatory conditions, lower administrative costs thanks to optimized environmental assessment procedures as well as accelerated planning and approval processes – especially at national level. By mid-December 2022, project developers (mostly European transmission system operators) had submitted a total of 180 applications for PCI/PMI status. Many of the projects combine several individual projects as an interconnection/corridor. The majority of the projects are geared towards hydrogen supply in Germany, among other things. Divided into three regional groups, in which Germany is represented, the projects and their contribution to the criteria of market integration, security of supply and competition are discussed. With Delegated Regulation (EU) 2024/1041 of November 28, 2023, amending Regulation (EU) 2022/869, the EU Commission has granted PCI status to hydrogen projects [EU Commission, 2024].

The prospective **integration of the hydrogen core network into a European hydrogen network** is in line with the German government's National Hydrogen Strategy (NHS). The aim is to establish stronger and closer cooperation with interested EU member states in the medium term, which will enable a coordinated market ramp-up, set common standards, facilitate coordination and enable coordinated imports. A large proportion of the hydrogen required in Germany will be covered by imports; according to the Federal Government's assessment based on an analysis of current scenarios, around 50 % to 70 % of hydrogen demand will be covered by imports from abroad in the long term.

Living Labs for the energy transition on hydrogen technologies will also be included in the hydrogen core network. These projects, which are funded by the BMWK and others, make it possible to test hydrogen technologies in practical applications under real

conditions and on an industrial scale, which is facilitated by a connection to the hydrogen core network.

In the **industrial sector,** hydrogen-based technologies are a suitable transformation option, especially in those sectors where they replace fossil raw materials such as natural gas, oil or coal in material use. Likewise, the energetic use of hydrogen can also represent the only option for decarbonization in certain areas. For this reason, projects from the project list of the transmission system operators ["Netzentwicklungsplan Gas 2022-2032", FNB Gas, 2023] determined as part of a market survey on hydrogen production and demand (WEB 2021) are included in the modelling of the hydrogen core network. These are then assigned to industrial sectors where, from today's perspective, there is no sensible option for decarbonizing the industrial process as an alternative to hydrogen use. This includes iron and steel, chemicals, refineries, the glass industry, ceramics and brick products.

According to the BMWK's long-term scenarios, **hydrogen storage** in Germany will play a decisive role in the success of the energy transition in the future. Due to the advantageous geological conditions in Germany (salt domes), it also makes sense to implement extensive storage projects for hydrogen with a view to the European dimension. In the future, hydrogen storage facilities will be of central importance for supplying hydrogen to hydrogen-fired power plants and combined heat and power plants, among other things. By connecting storage sites and building a cross-border gas transmission infrastructure, German storage facilities can also facilitate the cross-border trade in hydrogen, which promotes the integration of the European hydrogen market. Investment in the German hydrogen storage infrastructure can improve the overall security of supply for hydrogen within the EU.

The consideration of higher storage capacities was addressed in comments on the scenario. The transmission system operators share the view that higher storage capacities (and a higher working gas volume) would increase the security of supply of the hydrogen core network. The question of the required storage capacity was not systematically examined during the creation of the hydrogen core network. In addition, the transmission system operators do not consider it compatible with the scenario's project-based approach to reduce capacities at cross-border interconnection points, PtG plants or import terminals in order to take higher storage capacities into account. The hydrogen demand must be covered by the sources mentioned and the projects named in Annex 1 themselves originate from specific projects. A reduction in capacities would not only interfere with these specific projects, but would also mean that the opportunities for market-driven procurement would be restricted.

The hydrogen core network should continue to guarantee sufficient connection options for **production regions and electrolysers.** The feed-in capacity of electrolysers to be taken into account should be in line with the National Hydrogen Strategy. In the current version, a target value of at least 10 GW (domestic electrolysis) is specified for the year 2030 and a strong ramp-up is targeted for the following years. In order to implement the targets and assumptions of the National Hydrogen Strategy in practice, the projects identified by the transmission system operators as part of a market survey on hydrogen production and demand in 2021 will be included with adjusted capacity for the modelling of the hydrogen core network. The locations of electrolysers are to be selected in a system-friendly manner in order to ensure compatibility with national hydrogen and electricity network

planning and also to guarantee secure electricity network operation in the future. This is because only electrolysers in close proximity to the renewable energy plants they have built or contracted can draw electricity without bottlenecks at all times of the year. Locations that serve the system thus avoid bottlenecks in the transmission network, additional network expansion and additional CO_2 emissions from redispatch power plants.

The hydrogen core network is also intended to cover large **combined heat and power (CHP)** sites for which continued operation with the subsequent use of hydrogen is likely. The threshold value of 100 megawatts of electrical CHP capacity focuses on locations with a high heat demand, where it is highly likely that CHP will continue to play a role in heat supply in the future. Initial preliminary considerations based on this size criterion have also indicated good spatial coverage by the hydrogen core network. While the size criterion is aimed at the spatial design of the core network, the additional assumption of an average of 2,500 full utilization hours is relevant for the dimensioning of the network and the amount of hydrogen to be provided. An average operating time of 2,500 full load hours per year should be assumed for each megawatt of electrical CHP capacity. In a first step, the modelling is based on the assumption that the majority of existing power plant sites will be converted to hydrogen use at a later date. This is to be expected particularly for locations with high heat demand. A survey of transmission system operators was also used to take into account locations for which there are already sufficiently solid plans at the present time (June 2023) for a later conversion to hydrogen operation.

The **regional balance** of the hydrogen core network is an important concern for the German government. The hydrogen core network includes projects of a supra-regional nature to create a Germany-wide hydrogen network. The route of the hydrogen core network therefore includes both north-south and west-east corridors in order to connect central hydrogen locations throughout Germany.

The results of the scenario for the hydrogen core network are presented below.

4.2 Results of the scenario for the hydrogen core network

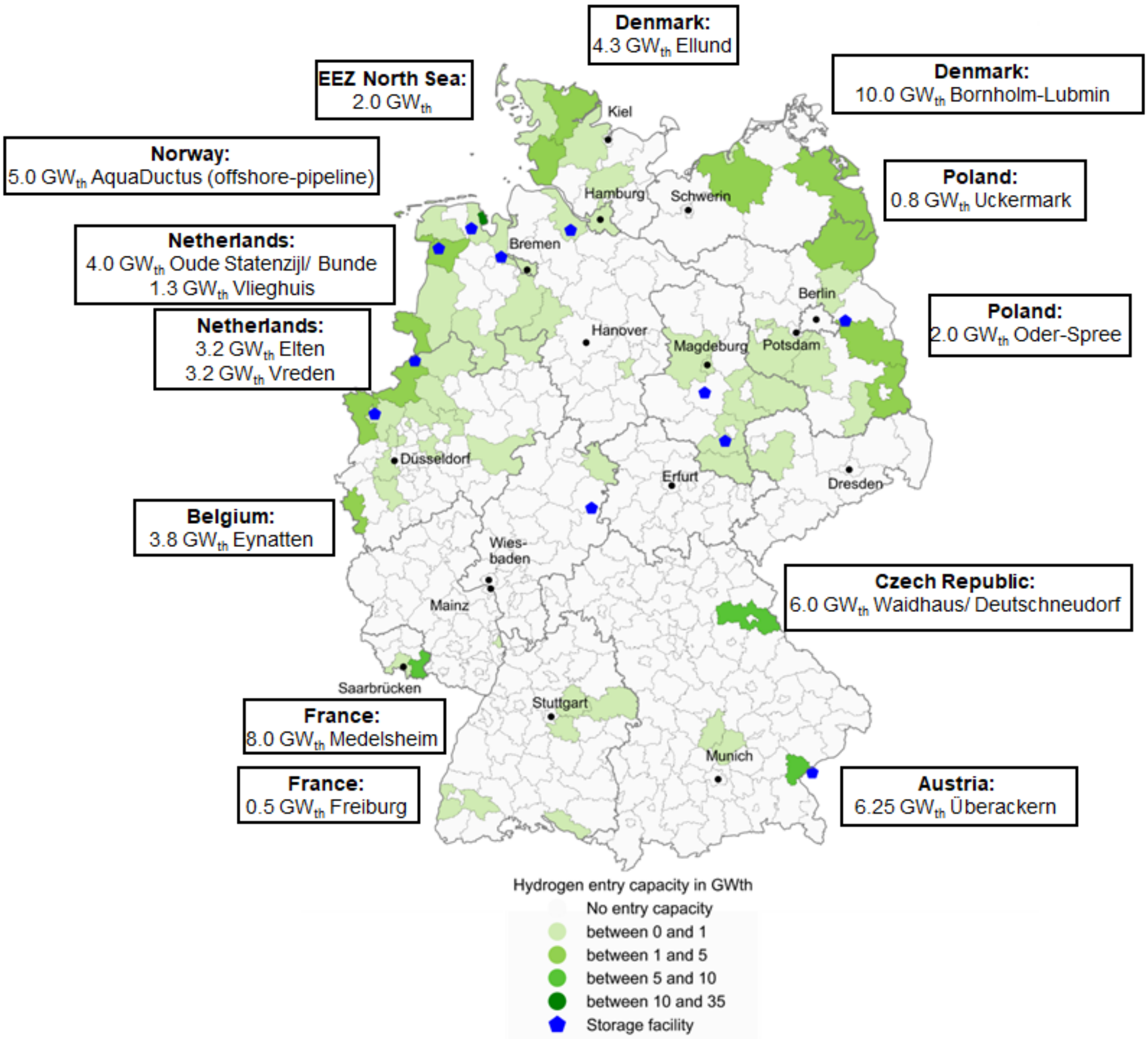
A total of 293 hydrogen projects have been considered in the scenario for the hydrogen core network. Table 1 below shows the calculated entry capacities for hydrogen in total and Figure 1 shows them for every region at district level. Other entries include, in particular, imports via marine terminals where hydrogen is landed in another form, such as LOHC or ammonia, and then fed in as hydrogen.

Table 1: Entry capacities considered for the hydrogen core network, data for 2032 based on gross calorific value

	Unit	Cross-border IP	Electrolysis	Storage	Other entries	Total
Entry capacity	GW_{th}	58	15	8	19	101

Source: Transmission system operators

Figure 1: Entry capacities for hydrogen at district level and at cross-border interconnection points (IPs), figures in GW_{th} for 2032 based on gross calorific value



Source: Transmission system operators, Geo-Basis-DE/BKG(2023) (basic map)

Further information on the entry capacities at the cross-border IPs can be found in Appendix 1.

Table 2 shows the hydrogen exit capacities and volumes for the year 2032 in total, while in Figure 2 they are shown for every region at district level. The calculated total capacity is taken into account for modelling of the hydrogen core network.

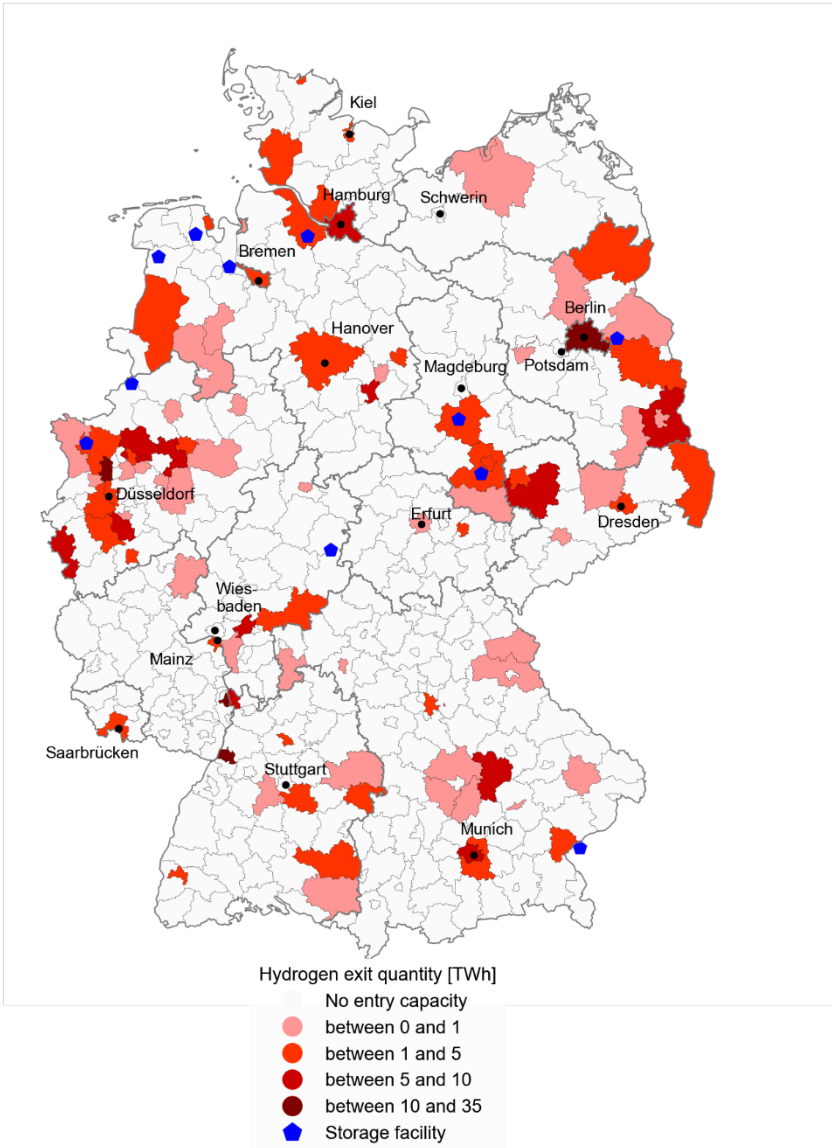
Table 2: Hydrogen exit capacities and volumes considered for the hydrogen core network, data for 2032 based on gross calorific value

	Exit capacity* [GW_{th}]	**Exit quantity* [TWh_{th}], gross calorific value**
Total	**87**	**278**
- of which IPCEI, PCI and living lab projects	10.6	49
- of which projects for integration into a European hydrogen network	0.3	0
- of which iron and steel	7.7	50
- of which chemicals	5.2	32
- of which refineries	4.2	30
- of which glass industry, incl. glass fibre	0.3	1
- of which medium to large production facilities for ceramics and brick products	0.2	1
- of which CHP power plants	62.0	157
- of which storage facilities	7.6	11

* Double counting is possible, i.e. a project can be assigned to several criteria.

Source: Transmission system operators

Figure 2: Hydrogen exit volumes at district level in the scenario considered for the hydrogen core network, data for 2032 in TWh as gross calorific value



Source: Transmission system operators, Geo-Basis-DE/BKG(2023) (basic map)

5 Pipeline notifications from potential hydrogen network operators

Operators of distribution networks, hydrogen network operators and operators of other pipeline infrastructures had various options for contributing pipeline notifications to the hydrogen core network process:

1. Pipeline notifications based on the planning status published by the transmission system operators in July 2023

2. Pipeline notifications as part of the BNetzA consultation on the draft application from November 2023 to the beginning of January 2024.

With the publication of the first planning status for a supra-regional hydrogen core network on July 12, 2023, operators of distribution networks, hydrogen network operators and operators of other pipeline infrastructures were also given the opportunity to comment and report further hydrogen infrastructures for the hydrogen core network in accordance with Section 28q (5) EnWG. The e-mail address info@fnb-gas.de and a special form for pipeline notifications accessible via the FNB Gas website, were available for providing feedback to FNB Gas. The pipeline notifications received from other potential hydrogen network operators during this first phase were considered in the draft application for the hydrogen core network.

From November 15, 2023, BNetzA consulted the transmission system operators' draft application for the hydrogen core network in order to speed up the review and approval process. Comments on the draft application for the hydrogen core network could be submitted until January 8, 2024. In this context, pipeline notifications from potential hydrogen network operators were updated or new notifications were submitted.

All pipeline notifications submitted in the two phases will be considered by the transmission system operators in the application for the hydrogen core network, although some pipeline notifications were withdrawn by the respective potential hydrogen network operator.

The transmission system operators received a total of 123 pipeline reports from potential hydrogen network operators. The reported pipelines are technically very heterogeneous. The nominal diameter is between DN 40 and DN 1000, the lengths vary from 0.2 km to 92 km, and the maximum permissible operating pressure MOP is between 8 barg and 100 barg. The total length of the reported infrastructures is just under 1,700 km. Of these, around 40 km are already in use today (hydrogen), around 530 km constitute new construction and around 1,120 km conversions.

In March 2024, the transmission system operators wrote to the other potential hydrogen network operators that were part of the hydrogen core network in the draft application of November 15, 2023, and new registrants as part of the BNetzA consultation and asked for further information. This information has been included in Annex 2. The transmission system operators have checked whether pipelines reported by other potential hydrogen network operators fulfil the technical requirements for integration into the hydrogen core network and whether this infrastructure can be used for the transport requirements. The other potential hydrogen network operators who submitted pipeline notifications for the

hydrogen core network were informed by the transmission system operators as to whether or not their pipeline notifications were considered in the draft hydrogen core network. The results are summarized in section 7.4.

In section 7.4 the transmission system operators categorize the pipeline notifications of other potential hydrogen network operators as follows:

- Pipeline notifications considered in the hydrogen core network,
- Pipeline notifications not included in the hydrogen core network,
- Withdrawn pipeline notifications therefore not included in the hydrogen core network.

In Annex 2, the transmission system operators justify the categorization made for each pipeline notification.

In addition, some potential hydrogen network operators have made their pipeline applications subject to clarification of the regulatory and financial framework conditions for the hydrogen core network. Therefore, the transmission system operators cannot make a binding statement in the application for the hydrogen core network as to whether the pipelines of the other potential hydrogen network operators will be available for the hydrogen core network. As part of the review of this application pursuant to Section 28q (6) sentence 4 EnWG, BNetzA will ask the other potential hydrogen network operators "*to declare whether they agree to the inclusion of their infrastructure facilities in the hydrogen core network.*"

6 Modelling of the hydrogen core network 2032

The following section describes the basic parameters for the modelling. Firstly, the basic planning principles are presented (see section 6.1). This is followed by a description of the transport infrastructures (see section 6.2), which form the basis for modelling the hydrogen core network. The basic modelling procedure is then described (see section 6.3). Finally, the load cases for modelling the hydrogen core network are presented (see section 6.4).

6.1 Basic planning principles and assessment of alternatives

Basic planning principles

The basic planning principles according to which the transmission system operators have determined the hydrogen core network are specified in Section 28q (1) sentence 2 of the amended EnWG:

*"The aim is to establish a **Germany-wide, efficient, rapidly realisable, expandable and climate-friendly hydrogen core network** that contains all effective measures to connect the future key hydrogen production sites and potential import points with the future key hydrogen consumption points and hydrogen storage facilities."*

In particular, the specific description of maxims clearly shows that the principles of "Germany-wide", "efficient", "quickly realisable", "expandable" and "climate-friendly" must be followed in hydrogen core network planning.

The hydrogen core network lays the foundation for the decarbonization of the economy and industry as well as other potential sectors and thus makes a key contribution to a climate-friendly energy supply in Germany.

In this context, efficiency means, among other things, that the plans for a hydrogen core network must be set out in such a way that interventions in the environment and nature are kept to a minimum. The hydrogen core network in its target state must also be highly effective in terms of cost in order to meet future requirements, and initial implementations must be possible in a timely manner.

Efficiency also means cost efficiency. Conversion of existing pipeline infrastructure is always preferable for cost reasons. This is simply because converting pipeline infrastructures only requires around one fifth of the investment needed for construction of new hydrogen pipelines. In addition, converting pipeline infrastructure can be done much faster than new construction. However, new construction is generally necessary if there are a few conversion options or none at all because there is no infrastructure in place, or if the infrastructure to be converted is too small.

In the course of analysing cost efficiency, an examination was carried out to determine whether the connection of hydrogen entry and exit projects that are not used for combined heat and power generation makes economic sense. One of the decisive factors here is the distance to the transport pipelines of the core network. At a distance of more than 20 km, the connection was categorized as not economically feasible and not taken into account. The result of this assessment is noted in Annex 1 with a corresponding comment on the project. A strategic expansion is therefore efficient and sensible, based on

adequate dimensioning and focusing on the robustness and resilience of the network with regard to its future requirements through efficient, demand-oriented scalability. Scalability can be realized through planning that allows a subsequent increase in transmission capacity, which is achieved with an increase in the effective pipeline pressure through additional installation of compressors along the pipeline route.

In deriving the principles for network planning, it should also be noted that transport capacity competes with the flexibility required for operational processing (depending on the network access regime).

The main factors influencing the potential (transmission and flexibility) of the network are:

- Network geometry (volume): larger nominal diameters are advantageous here.
- Pressure conditions: a high-pressure design is advantageous (operation far from the design pressure).
- Pressure load change: high pressure and larger diameters are advantageous.

It is important to bear in mind that dimensioning and spatial development are sometimes contradictory aspects. Reducing the dimensions of a new hydrogen pipeline by one or two diameter classes can justify 30 % to 50 % of the length of an additional new pipeline. This is cost-neutral, as very large diameter classes are very expensive. New pipelines can open up additional regions, strengthen the cross-connection of the infrastructure and increase the security of supply.

A reduction in the diameter classes also has further positive effects in terms of cost efficiency and rapid feasibility.

From a diameter greater than DN 1200, pipeline construction requires sophisticated technical solutions as the nominal diameter increases, such as the use of larger construction machinery and the handling of greater tonnages. These, in addition to technical aspects, limit the range of suppliers and availability. Large diameters also have an impact on civil engineering, including dewatering; each water crossing is therefore enormously complex and could result in a much greater impact on the protected assets (nature and soil conservation).

To summarize, for dimensioning, it is important to ensure that the sometimes conflicting objectives are examined in terms of their advantages and disadvantages with regard to their implementation and operation. For example, large diameters offer advantages in terms of network geometry (pipe volume, transport capacity), but there are also disadvantages on the cost and execution side (approval and deadline risk).

Ultimately, experience shows that dependence on individual gas importers is relevant to security of supply. It is therefore important to ensure the transportability of hydrogen at any time and over long distances from the outset. In order to reduce dependencies, the network needs several high-capacity import points as part of a European network as well as hydrogen storage capacities. Security of supply can be ensured through the robustness and resilience of the hydrogen core network, which can be achieved through diversification – several reliable sources should be developed and a good degree of cross-connection aimed for in the hydrogen core network. The transmission system operators assume that this is achieved, among other things, by the logic of freely allocable

capacities (FACs) for the entry/exit capacities applied in the load cases and the design with the appropriate diameters and pressure levels.

Assessment of alternatives

Against the background of the legal requirement pursuant to Section 28q (2) sentence 2 EnWG, the transmission system operators have examined the results of the hydrogen core network for possible alternatives that are more cost-efficient.

The aim of the assessment of alternatives is to demonstrate specifically that the pipelines to be converted and newly constructed, as identified and proposed in the draft application for the hydrogen core network, and their ancillary facilities represent the most cost- and time-efficient solutions in the long term.

For conversion pipelines, the assessment of alternatives is based on a comparison between the investment required for conversion and that for possible new construction of a hydrogen pipeline. In addition to the original costs of an individual pipeline conversion, the cost of the corresponding project to reinforce the natural gas infrastructure is also included in the cost comparison. Where a natural gas reinforcing measure is assigned to several conversion projects, the costs of these natural gas reinforcing measures are allocated proportionately. Examining the extent to which natural gas reinforcing measures allow a natural gas pipeline to be converted to hydrogen also means following the concept of efficiency. If fewer measures are required for natural gas than for hydrogen, these will be given priority in the planning in order to follow the principle of cost efficiency and faster realization.

Examining the options for new pipelines includes checking whether the conversion of existing gas transmission system infrastructure or natural gas pipelines reported by other potential hydrogen network operators should be given preference over a newbuild project. This consideration also includes examining whether a new pipeline is fundamentally necessary due to the lack of conversion pipelines. The review is based on the following criteria:

1. A pipeline which could potentially be converted is still required in the methane network and cannot be compensated for by comparatively inexpensive measures.
2. The pipeline which could potentially be converted is too small.
3. A new pipeline has to be built as there is no pipeline that can be converted.
4. The new pipeline serves to develop new production or demand areas in the sense of a regional balance.
5. There is no need for other new pipeline routes.
6. A new pipeline is not economically viable compared to a compressor.
7. Compression or higher upstream pressure by foreign TSO.

Criteria 6 and 7 relate to the construction of new compressor stations.

When deriving the principles for network planning, planners should also note that transmission capacity competes with the flexibility required for operational processing (depending on the network access regime).

The results of the assessment of alternatives for the converted and newly built pipelines are presented in Appendix 2 and Annexes 3 and 4.

6.2 Transmission infrastructures as a basis for modelling

The following transport infrastructures in particular were used as the basis for modelling the hydrogen core network:

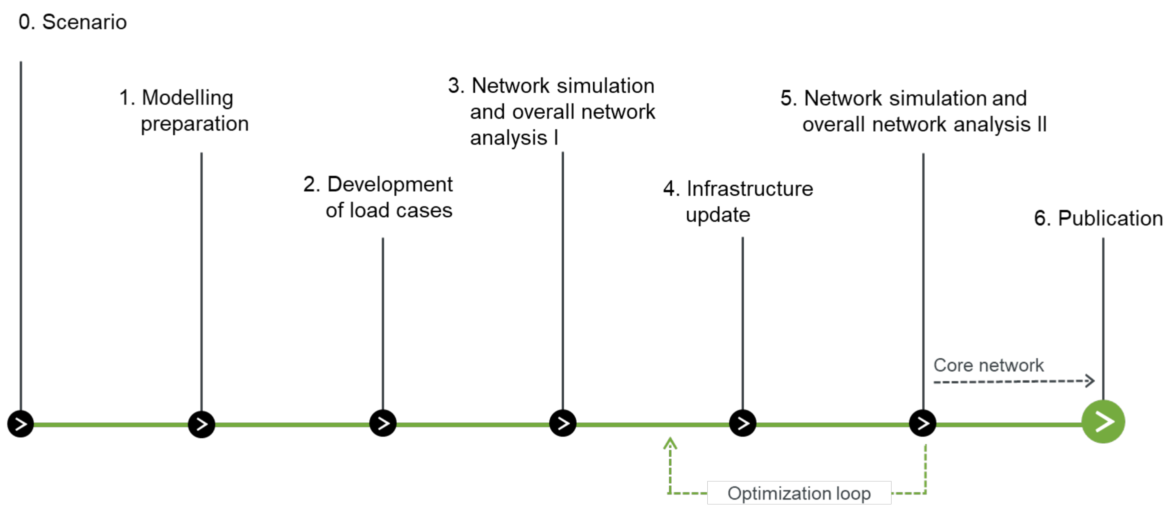
- The hydrogen network of the Gas Network Development Plan 2022-2032
- Pipeline infrastructures from IPCEI, PCI and living lab projects
- Pipeline notifications from other potential hydrogen network operators (see section 5).

As part of the modelling, various load cases are used to check which pipelines are required for an efficient, functioning hydrogen network and whether additional pipelines may be required. In addition, the necessary compressor stations are determined as part of the modelling.

6.3 Basic procedure

The entire modelling process flow is shown schematically in Figure 3.

Figure 3 Process steps for hydrogen network planning



Source: Transmission system operators

Description of the individual process steps

0. Scenario

- The modelling is based on the coordinated scenario for the hydrogen core network. The basic procedure and the results are described in section 4.

1. Modelling preparation

- In accordance with 6.2, the transmission system operators implement the transmission infrastructures in a simulation tool based on fluid mechanics methods with the aim of creating a uniform modelling basis.
- Entry and exit capacities to be considered are assigned to suitable network connection points of the transmission infrastructures.
- Assumptions are defined for the modelling (e.g. feed-in temperatures and transfer pressures).

2. Development of load cases for a functional and reliable hydrogen core network

- The transmission system operators develop different flow situations based on defined load cases in order to carry out load tests on the infrastructure.
- The conditions for the utilization of the entry and exit points are defined in a load case.

3. Network simulation and overall network analysis I

- The transmission system operators carry out a network simulation and check whether the infrastructure taken into account to date is sufficient and adequate to meet transmission requirements.
- The test is carried out based on the defined load cases.

4. Infrastructure update

- If the planned infrastructure cannot meet the transmission requirements, the transmission system operators include additional pipelines and compressors to eliminate bottlenecks. Infrastructure elements that were not required in the previous network simulation can also be removed again (optimization).
- Existing pipelines as well as newbuild pipelines, pressure regulating systems, valves or compressors can be part of the modelling.

5. Network simulation and overall network analysis II

- The transmission system operators carry out a network simulation based on the revised infrastructure and check whether it is sufficient and adequate to meet the transmission requirements.
- The transmission system operators carry out an optimization of the alternative solutions, applying further assumptions if necessary.
- If the infrastructure is sufficient to cover the transmission requirements and no more scope for optimization is identified, the modelling process ends.

6. Publication

- The results of the hydrogen core network will be published as part of BNetzA's consultation process.

6.4 Definition and results of the load cases

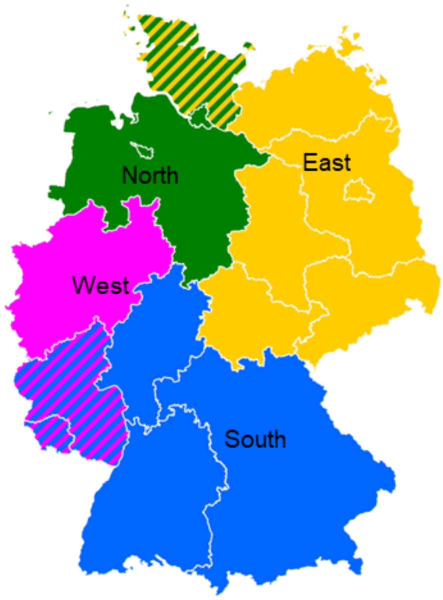
Load cases

To design the hydrogen core network, it is necessary to consider different load cases to ensure resilience under significantly different load situations and free allocability of the specified capacities.

The basis for deriving the load cases is the scenario for the hydrogen core network developed for this purpose under the leadership of the BMWK and BNetzA and agreed with the transmission system operators based on the assumptions for entry and exit capacities described in section 4.

The main feature of the various load cases is the testing and design of the network for different regional distributions of entry and exit loads. For this purpose, Germany is divided into different regions (North, West, East, South), which are then tested diametrically with their spatially assigned entry and exit loads. This means, for example, that if all entries in the North are tested in terms of transmission capacity or free allocability, then this results in a diametrical effect in the South which then has to cope with high exit loads.

Figure 4 Regions of the load cases considered on the entry side*



* Shaded areas are contained in two regions: Rhineland-Palatinate/Saarland in West/South, Schleswig-Holstein in North/East.

Source: Transmission system operators

In addition, structurally different load cases are defined to reflect the load and distribution across Germany. A distinction is made between autumn, winter and no-wind/no-sun load cases, which essentially differ in terms of the level of load and, especially in winter, the temperature-dependent CHP output. As the hydrogen network sees a much lower load in summer due to lower consumption, it is not necessary to consider a separate summer load case for network design purposes.

The currently assumed load situations would still be appropriate and relevant to the design even if additional storage capacity were to be used. The idea of reducing network expansion through additional storage capacity would not be compatible with the premise of fixed, freely allocable capacities and the specified scenario for the hydrogen core network. Additional load cases for the use of storage could even lead to additional expansion if the storage capacities were not recognized as useful for the network from the outset. The usefulness of storage utilization for the network is in turn dependent on the assumed market model.

The transmission system operators have identified a total of six so-called "restrictive" load cases for the network design, which are described below:

No wind, no sun conditions

In this scenario, wind and solar plants generate little electricity over a limited period of time due to weather conditions, which is why electrolysers do not produce or feed in any hydrogen during this time. In this case, electricity consumption is covered by dispatchable capacities, in particular CHP plants. Only non-volatile entries were used to cover the balance. This situation requires a network-stabilizing withdrawal of hydrogen from storage. At the same time, it is assumed that all available hydrogen CHP plants are used in order to provide both heat and electricity for the transmission network.

- Entry capacity:
  - Volatile entry projects 0 %, non-volatile entry projects including cross-border IPs 100 %,
  - Storage 100 %.
- Exit capacity:
  - CHP 100 %, industry 100 %, storage 0 %.

Winter load case

In the winter and autumn load cases, the transmission system operators test whether the regionally bundled entry capacities assumed in the scenario can be managed simultaneously.

Due to the high entry capacities in the north, a winter load case is only tested for maximized northern entries. For this purpose, rather low off-takes in the north are compared with high off-takes in the south with simultaneously low entry capacities in the south in order to test a maximum restrictive transmission case in winter. Withdrawal from storage is not used in this load case so as not to add to the network load which is already high because of the entries in the north. Instead, "integrated storage usage" is assumed, where there is either injection into storage or the storage facilities are not used. The latter is less useful for network operation in this situation and is therefore assumed.

The CHP off-takes are taken into account depending on the regional design temperature. For this purpose, a temperature analysis was carried out across the whole of Germany.

In the first step, the average daily air temperatures at a height of two metres were determined using data from the Climate Data Centre of the German Weather Service at 21 representative measuring points selected in the vicinity of the largest reported CHP plants over an observation period of approx. ten years (January 1, 2013, to June 11, 2023). The temperature data was consolidated in five regions (Bavaria/Baden-Württemberg, NRW/Rhineland-Palatinate/Saarland/Hesse, Schleswig-Holstein/Bremen/Lower Saxony Hamburg, Mecklenburg-Western Pomerania/Berlin/Brandenburg, Saxony/Saxony-Anhalt/Thuringia) to consider different temperature ranges occurring simultaneously in Germany. It was assumed that the maximum CHP offtake in the diametrically opposed southernmost federal states of Bavaria and Baden-Württemberg occurs at the lowest mean daily temperature (TM_{min}) measured during the period under consideration (reference value) and this was compared with the highest mean daily temperatures (TM_{max}) measured on the same day in the other regions.

The following temperatures were determined for February 10, 2021, the day with the lowest daily mean temperature (TM_{min}) in Bavaria and Baden-Württemberg during the period under consideration:

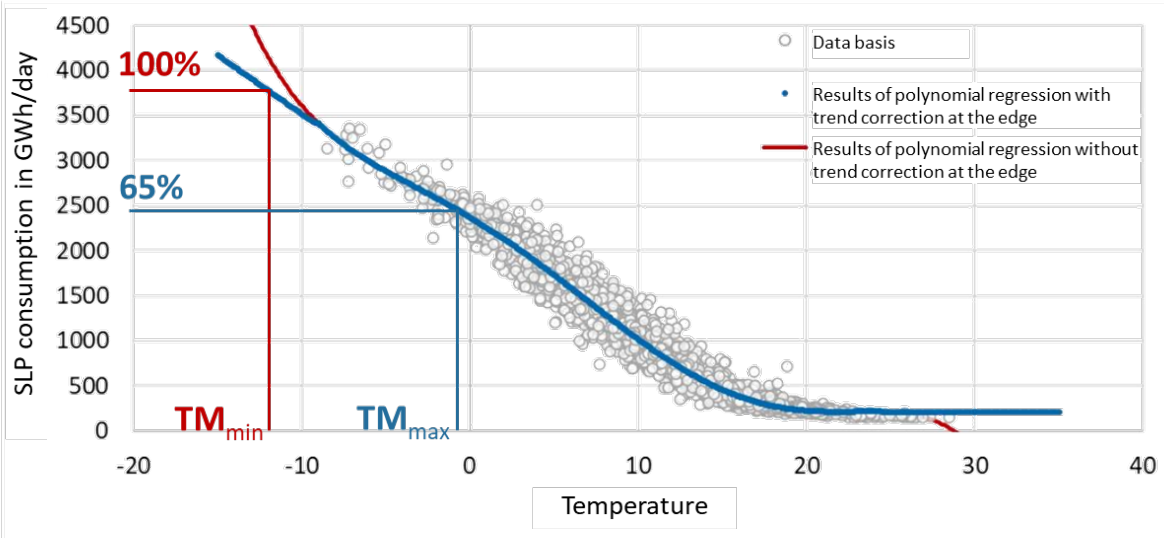
Table 3 Lowest and highest daily mean temperatures on February 10, 2021, by region

	Unit	Region BY/BW	Region MV/BB/BE	Region TH/ST/SN	Region SH/HH/NI/HB	Region NW/HE/SL/RP
TM_{min}	°C	-11.4				
TM_{max}	°C		-1.4	-2.7	-2.7	-5.5

Source: [German Weather Service, 2023]

In the second step, the temperature data obtained was used in a polynomial regression of the BDEW, which estimates the SLP gas consumption depending on the weighted average daily temperature. The standard load profile (SLP) was used because it provides a good representation of the heating load behaviour, which can also be assumed as a first approximation for the heat-led use of CHP plants.

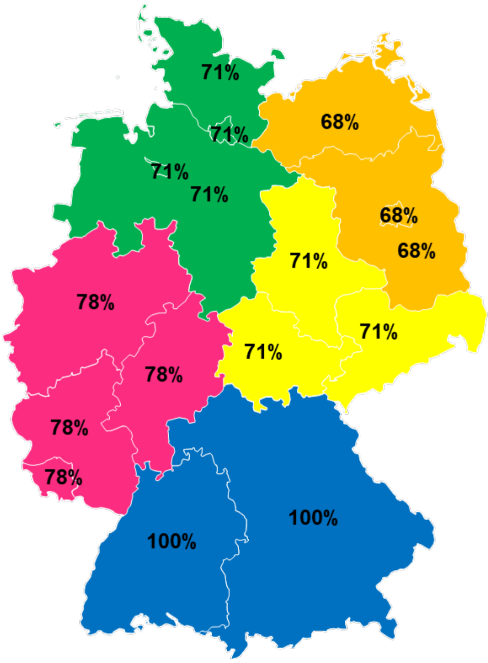
Figure 5: Determination of scaling factors for the CHP exit capacities using a polynomial regression



Source: Transmission system operators, adapted from [BDEW, 2022]

The exemplary determination of a scaling factor is shown in *Figure 5*. The values derived for the winter load case are shown in *Figure 6*.

Figure 6: Temperature-dependent CHP exit capacity for the winter load case



Source: Transmission system operators

The result of the analysis showed a range of 68 % to 78 % of the maximum temperature-dependent reductions of the other federal states in the case that the southern federal states are close to the design temperature (at maximum reduction). Depending on the federal state, this 68 % to 78 % is used as relief potential through CHP.

- Entry capacity:
  - Entry projects including border crossing 100 % in the North region, storage 0 %,
  - Other entries to cover the balance, with priority given to those located as far north as possible.
- Exit capacity:
  - 100 % of the possible exit capacity in the southern region, injection is not used,
  - 20 % remaining federal states, CHP between 68 % and 78 % depending on the federal state, storage 0 %.

Autumn load cases

In the four autumn load cases, the maximum entry capacities (without storage) are applied for each region based on the four regions formed – North, West, East and South. There is also examination of whether a Germany-wide demand of 20 % can be covered. 20 % roughly corresponds to the base load of industrial customers in today's natural gas network. If there is a surplus of entry capacity, the most distant exits are also increased until balancing is achieved.

- Entry capacity:
  - For entry projects 100 % in the respective region, 0 % in the other regions,
  - Storage facilities 0 %.
- Exit capacity:
  - At least 20 % for industry, CHP and storage.

Due to similar temperatures in autumn and spring, spring load cases do not have to be considered separately.

7 Hydrogen core network 2032

The next section presents the results of the modelling exercise. Based on the priority given to the conversion of pipelines (see section 7.1) and the procedure with connecting pipelines (see section 7.2), the results for the hydrogen core network (see section 7.3) are shown. Section 7.4 provides an overview of the included and excluded pipelines of other potential hydrogen network operators for this hydrogen core network. The changes to the hydrogen core network compared to the draft of November 15, 2023, can be found in section 7.5.

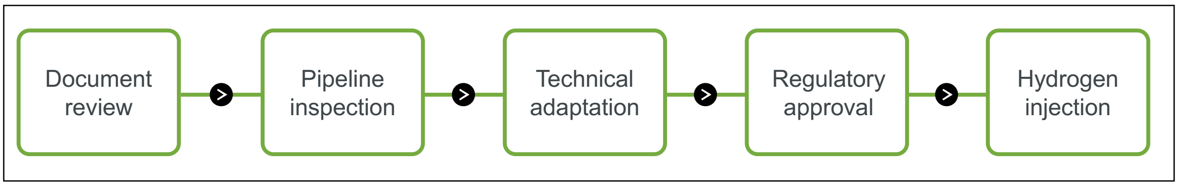
7.1 Priority and conversion process

According to Section 28q (2) sentence 4 EnWG, the possibility of converting existing pipeline infrastructures must be prioritized. After all, the conversion of an existing pipeline infrastructure, if it is sufficient for the requirements of the hydrogen core network, will generally be the most cost- and time-efficient solution in the long term. This is generally also the case if additional expansion measures of the existing natural gas network are required to a minor extent for the conversion. Furthermore, the impact on the environment is significantly lower.

When a pipeline is converted from natural gas to hydrogen, its use for a different medium means that it undergoes a significant change in this process within the meaning of the Ordinance on High-Pressure Gas Pipelines (*Gashochdruckleitungsverordnung*).

The conversion is planned by the pipeline operator in cooperation with an expert in accordance with the Ordinance on High-Pressure Gas Pipelines. The network operator and the expert draw up a catalogue of measures for each individual pipeline (individual assessment). This catalogue is dealt with by the network operator under the supervision of the expert. The conversion is carried out according to the following technical scheme:

Figure 7: Process of pipeline conversion from methane to hydrogen



Source: Transmission system operators

In addition to various laboratory analyses (random checks of circumference seams and material samples), the pipeline is inspected using an inspection device known as a pig. The pig is inserted into the pipe through a sluice and fills the entire pipe cross-section. It is then pushed through the pipeline by the gas flow and records measurement data on the condition of the pipeline. The route in which the pipeline is located only needs to be dug up at certain points for this inspection. The collected data is then analysed using special software.

Based on the findings of the pigging and the documentation review, the gas pipeline will be adapted in accordance with Section 113c EnWG in conjunction with the applicable technical regulations for hydrogen. For the actual implementation of the measures for this

purpose, compressors, for example, are used to empty the pipelines and minimize methane emissions. The pipeline is then filled with hydrogen in order to switch to a regular transport regime.

7.2 Dealing with connecting pipelines

According to Section 28q (1) sentence 2 EnWG, the aim of the hydrogen core network is *"to establish a Germany-wide, efficient, rapidly realisable, expandable and climate-friendly hydrogen core network that contains all effective measures to connect the future key hydrogen production sites and potential import points with the future key hydrogen consumption points and hydrogen storage facilities".*

So-called connecting pipelines are not part of the hydrogen core network. For this delimitation, the transmission system operators have developed criteria to define connecting pipelines, and this forms the basis for classification of connecting pipelines.

The transmission system operators point out that these criteria for defining connecting pipelines only apply to the hydrogen core network. For the further integrated network development planning (gas and hydrogen), the transmission system operators assume that the basic criteria for network connection processes will then be applied, similarly to those already used for gas.

The transmission system operators have developed five criteria for the definition of connecting pipelines based on various parameters. Inclusion in the hydrogen core network is checked on the basis of the following criteria and test questions:

1. Has an IPCEI application been submitted for the pipeline?
2. Is the pipeline a repurposed pipeline?
3. Does the pipeline have a diameter greater than DN 300 (transmission system type)?
4. Is the pipeline integrated into the overall network (development of a larger region)?
5. Is more than one customer connected to the pipeline?

All pipelines in the hydrogen core network for which an IPCEI application was submitted were included in Annexes 2 to 4. If no IPCEI application was submitted for the pipelines, the assessment was based on the other criteria (assessment questions 2 to 5). Where all test questions 2 to 5 are answered with "no", such a measure is defined as a connecting pipeline. If one of the test questions 2 to 5 is answered with "yes", it is not a connecting pipeline.

For pipelines of other potential hydrogen network operators, the transmission system operators requested confirmation that the reported pipelines were not connecting pipelines. On the basis of this feedback, connecting pipelines were not included in the hydrogen core network.

7.3 Results of the hydrogen core network

Based on the scenario described in section 4 and the transmission infrastructures for the modelling (see section 6.2), the transmission system operators carried out network simulations for the hydrogen core network.

The presentation of results for the hydrogen core network includes the pipeline infrastructure (conversion and newbuild pipelines, including the costs for ancillary facilities, in particular gas pressure regulating and metering systems) and compressor stations. Customer facilities for compression and metering at domestic feed-in points (e.g. for electrolysers) and connecting pipelines are not included (see section 7.2).

The hydrogen modelling leads to the following overall results for the hydrogen core network:

Table 4: Results of the modelling exercise for the hydrogen core network

	By end of 2032
Technical parameters for the hydrogen core network	
Compressor stations [MW]	291
Pipelines [km]	9,666
- TSO pipelines to be converted	5,047
- TSO pipelines to be built	3,561
- TSO offshore pipelines	256
- pipelines of other potential hydrogen network operators to be converted	462
- pipelines of other potential hydrogen network operators to be built	340
- For information: Czech German Hydrogen Interconnector (CGHI)* [km]	168
Investment in hydrogen core network [EUR bn]	
Compressor stations	1.7
Pipelines (incl. costs for ancillary facilities, e.g. GPRM systems)	18.0
- TSO pipelines to be converted	3.2
- TSO pipelines to be built	12.3
- TSO offshore pipelines	1.7
- pipelines of other potential hydrogen network operators to be converted	0.2
- pipelines of other potential hydrogen network operators to be built	0.6
Total investment	**19.7**

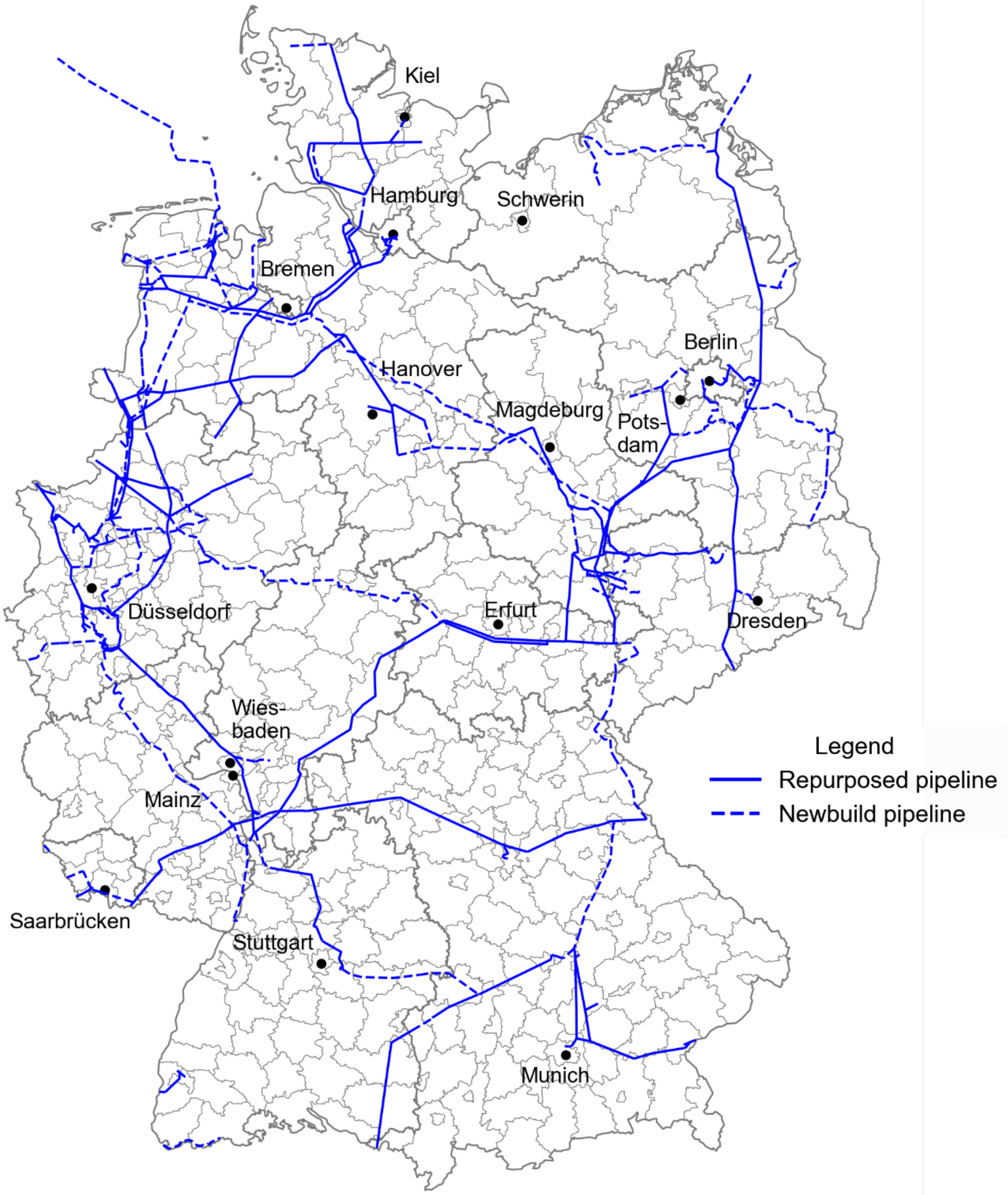
* CGHI was included in the modelling but does not form part of the hydrogen core network.

Source: Transmission system operators

Figure 8 below shows the draft of the hydrogen core network and the scope of the pipeline infrastructure with a total length of around 9,666 km. This includes the pipelines of other potential hydrogen network operators (see section 7.4). The following Figure 9 shows the location of the hydrogen core network in relation to the previously determined hydrogen entry and exit demand.

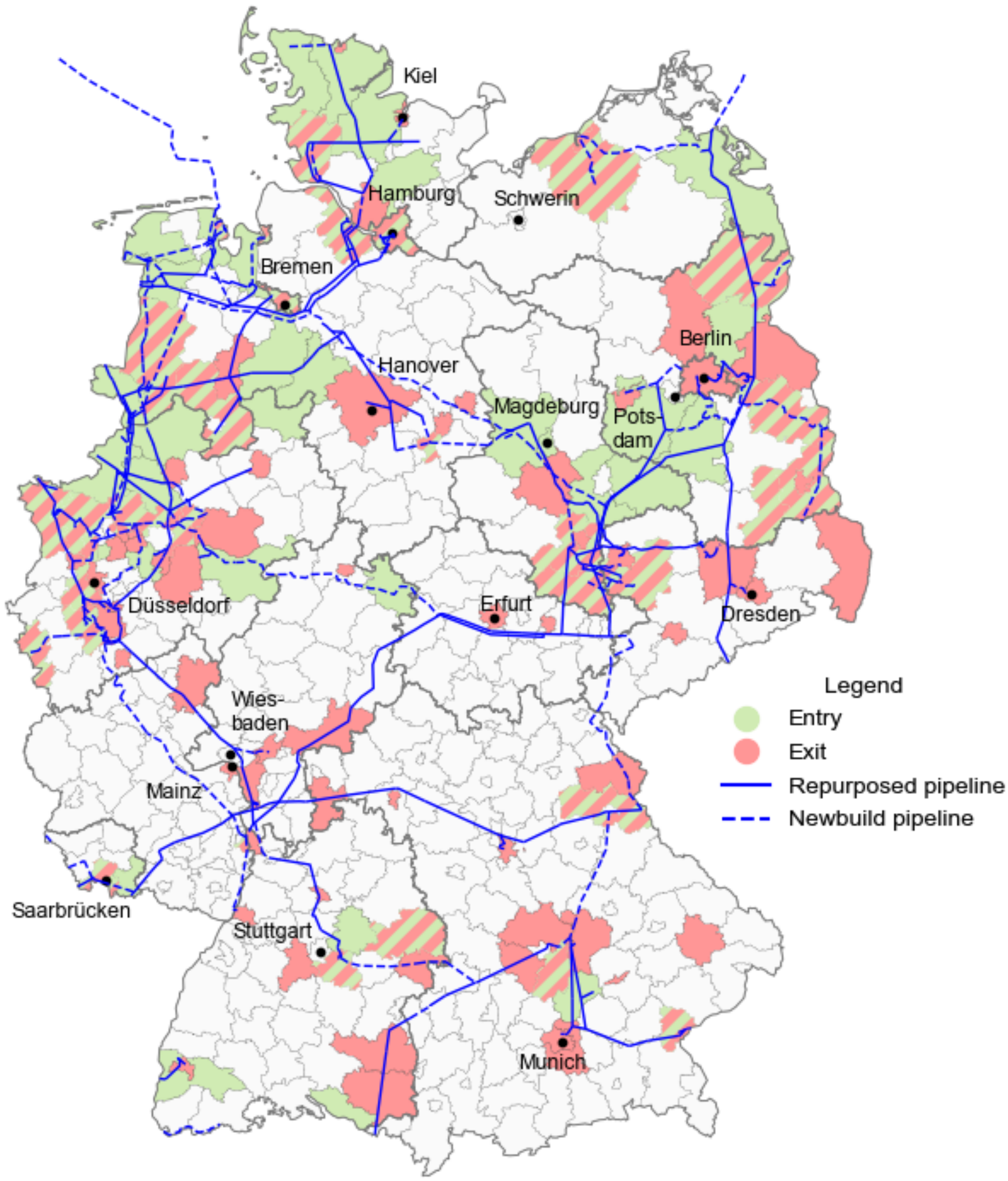
Annex 6 contains a detailed map of the hydrogen core network with an assignment of the ID numbers from annexes 2, 3 and 4.

Figure 8: Result of the modelling of the hydrogen core network (incl. pipelines of other potential hydrogen network operators)



Source: Transmission system operators, Geo-Basis-DE/BKG(2023) (basic map)

Figure 9: Result of the modelling of the hydrogen core network, with entry and exit areas



Source: Transmission system operators, Geo-Basis-DE/BKG(2023) (basic map)

A detailed overview of all network expansion measures for the hydrogen core network can be found in Annexes 2 to 5. It is not yet possible to provide a detailed description of ancillary facilities, in particular gas pressure regulating and metering systems, as the principles for network access, operation and control of the network have not yet been finalized.

The transmission system operators have provided commissioning data for the measures identified in Annexes 3 to 5. For this purpose, the speed of realization of the measures was generally based on the experience of the transmission network operators from the natural gas expansion measures implemented in the past. The realization speed must always be determined on a measure-specific basis; various parameters play a role here, such as the type and scope of the measure, existing preparatory work, availability of resources, necessary special constructions or investment cycles. The hydrogen core network was determined for the year 2032; earlier commissioning dates are partly based on existing agreements with future hydrogen connection customers. The transmission network operators point out that implementation of the measures for the hydrogen core network must begin quickly.

Figure 9 clearly shows that the hydrogen core network does not directly access all districts. Districts with hydrogen requirements for CHP plants that are not located on the hydrogen core network were nevertheless taken into account in the hydrogen modelling in terms of capacity. These districts can be connected to the hydrogen core network as part of further future hydrogen network development. The following paragraphs look at individual districts as examples.

The hydrogen demand of the city of Chemnitz is based on an existing CHP plant. This demand was assumed to arise at the closest possible point in the hydrogen core network. The development of this service area can be examined as part of the integrated network development planning for gas and hydrogen (Section 15a EnWG) as soon as concrete plans regarding the conversion of the CHP plant are available.

The hydrogen demand in the district of Deggendorf (administrative district of Lower Bavaria) is due to the CHP plant of an industrial company. This is not a local/district heating supply, but the heat generated is used in the company's production process. This district cannot be connected to the hydrogen core network via existing pipelines of the transmission system operators or via pipeline systems reported by other potential hydrogen network operators. The creation of a connection concept for the district of Deggendorf and the hydrogen development of the Lower Bavaria region is planned and can be included in the integrated network development planning for gas and hydrogen (Section 15a EnWG).

The cost calculation, both for the pipelines of other potential hydrogen network operators and for the pipelines of the transmission system operators, was based on the guideline cost rates for the transmission infrastructure assumed in the Gas Network Development Plan 2022-2032. They were expanded to include suitable factors to take into account the basic additional or reduced costs for hydrogen-compatible components as well as current findings. The transmission system operators refrain from publishing the indicative cost rates in this document due to possible market effects. For the above-mentioned reasons, a flat-rate approach based on the experience of the transmission system operators in terms of pipeline kilometres is used for the costs of gas pressure regulating and metering systems.

The results of the hydrogen core network presented above represent the most efficient solution to the mandate given to the transmission system operators in the Energy Industry Act to develop a supra-regional hydrogen core network. This is particularly evident when one takes into account the entry and exit points to be included by the BMWK, their

capacity, the defined load cases and the far-reaching consideration of the cost-efficient conversion of existing infrastructure (see section 7.1).

This means that the majority of project notifications can be connected to the hydrogen core network with only small distances to the pipeline infrastructure. The majority of the connection users can be connected to converted existing networks.

On the one hand, new pipelines are used to connect large new import points or, on the other hand, for supra-regional or European networks, which also enable the import corridors to be connected via the hydrogen core network. The high-capacity import points are a fundamental component of Germany's future hydrogen supply strategy and, according to the Federal Government's assessment, will cover around 50 % to 70 % of hydrogen demand in the long term, based on an evaluation of current scenarios. Consequently, a high-capacity pipeline infrastructure will also have to be built in this case. Further high-capacity pipeline infrastructure will be required to cope with load scenarios due to defined load cases. The transmission system operators are faced in particular with the task of linking the consumption and feed-in centres in eastern and western Germany as well as in northern and southern Germany. These connections must be strengthened in the event of a very one-sided network load.

A reduction in the number of kilometres of pipeline to be converted from existing infrastructure would therefore reduce the number of notified projects that can be connected. Not building new minor connections between the existing networks would impair the efficiency of the hydrogen core network. Less or less powerful pipeline infrastructure for connecting the consumption and feed-in centres would not meet the requirement of a resilient design of the hydrogen core network.

7.4 Consideration of the pipelines of other potential hydrogen network operators

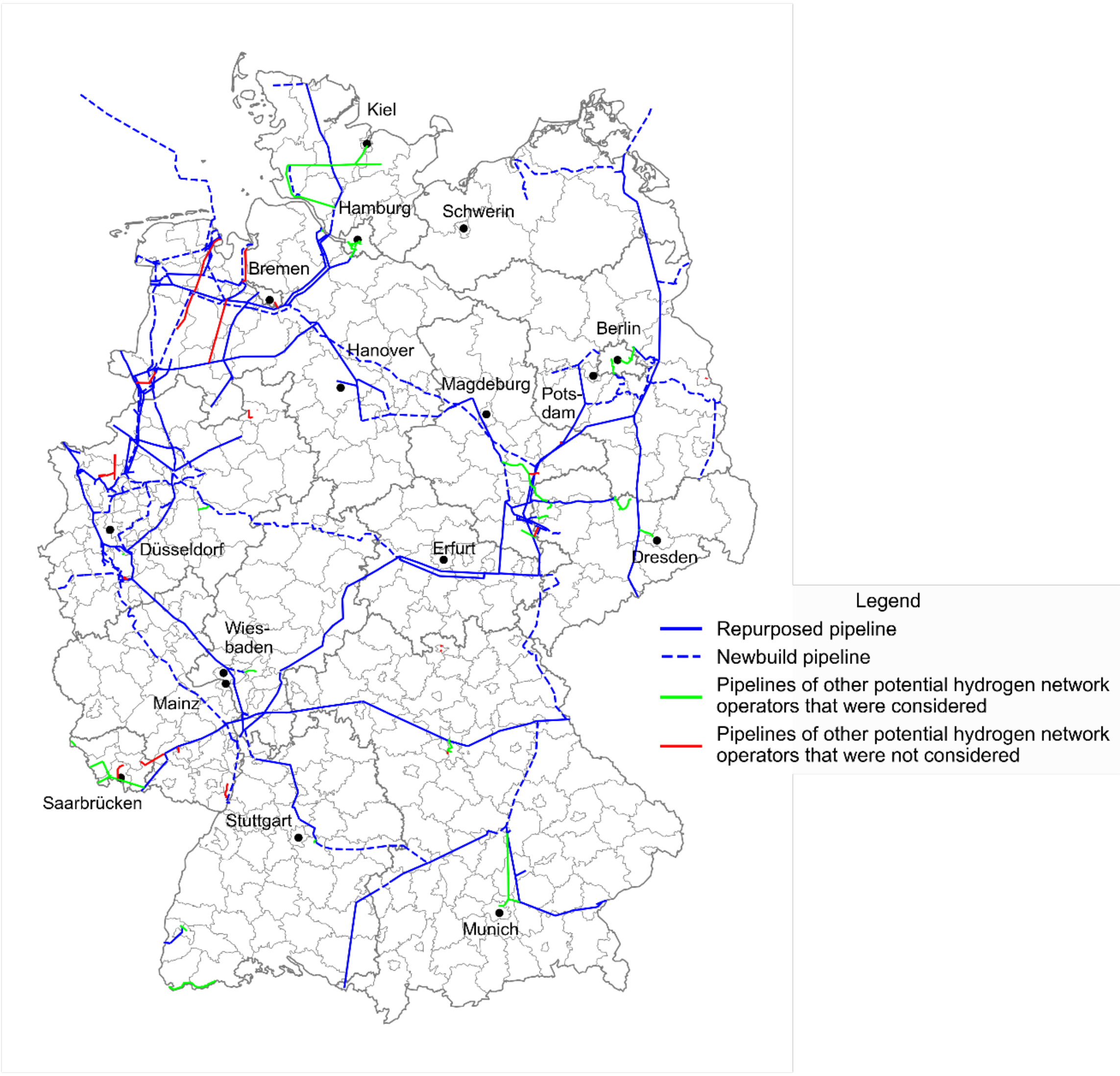
Section 5 described the process of pipeline notifications received from other potential hydrogen network operators. A total of 123 pipeline notifications were submitted by other potential hydrogen network operators. Of these, 34 pipeline notifications were withdrawn.

As a result of the modelling, the transmission system operators propose including 61 pipeline reports from other potential hydrogen network operators with a length of around 800 km in the hydrogen core network (see Annex 2).

Annex 2 to the application for the hydrogen core network lists the pipeline notifications of the other potential hydrogen network operators and provides specific reasons for the consideration or non-consideration of individual pipeline notifications. This also basically fulfils the requirements for the assessment of alternatives pursuant to Section 28q (2) EnWG.

Figure 10 below shows which pipeline notifications from other potential hydrogen network operators were taken into account in the hydrogen core network and which were not. Withdrawn pipeline notifications are not shown in Figure 10.

Figure 10 Consideration of pipelines of other potential hydrogen network operators in the hydrogen core network



Source: Transmission system operators, Geo-Basis-DE/BKG(2023) (basic map)

The decision to include pipelines of other potential hydrogen network operators in the hydrogen core network is ultimately made by BNetzA.

7.5 Changes in the hydrogen core network compared to the draft application of November 15, 2023

Following the publication of the draft application on November 15, 2023, the transmission system operators further examined the hydrogen core network for optimizations. This can reduce investments and the burden on future hydrogen network users. ***The core network will continue to transport hydrogen without any restrictions.*** The changes are described below.

Measure 362-Oude-Bunde (KLU028-01)

Conversion pipeline 362-Oude-Bunde (KLU028-01) is being withdrawn from the hydrogen core network, as parallel pipeline infrastructures are included in the network. This measure is therefore not necessary.

Measure 305A-Wilhelmshaven-Jemgum (KLU026-01)

Conversion pipeline 305A-Wilhelmshaven-Jemgum (KLU026-01) from Wilhelmshaven to Sande is being withdrawn from the hydrogen core network. The costs for the conversion of this pipeline section are not in proportion to the benefits of the pipeline for hydrogen. Further investigations have shown that the construction of a large number of natural gas reinforcing measures would be necessary for the conversion of this pipeline.

Measure 170-Rehden-Reiningen (KLU058-01)

Conversion pipeline 170-Rehden-Reiningen (KLU058-01) is being withdrawn from the hydrogen core network, as the hydrogen core network contains pipeline infrastructure that can perform the same transport task. There is therefore no need for this measure. The related natural gas reinforcing measure 1037-01 is therefore also cancelled.

Measure 433-Coswig-Dresden (KLN080-01)

It is still planned to use pipeline 433-Coswig-Dresden (KLN080-01) to connect Dresden to the hydrogen core network. In coordination with SachsenNetze HS.HD, ONTRAS has so far acted as the project owner. Following intensive discussions between ONTRAS and SachsenNetze HS.HD, SachsenNetze HS.HD have now expressed their interest in taking over as project owner for pipeline 433-Coswig-Dresden (KLN080-01) The pipeline will therefore be included in Annex 2, and the application ID of the pipeline will be changed to AND068-01. The pipeline designation 433-Coswig-Dresden and all other parameters remain the same. This pipeline section is therefore no longer included in Annex 3.

Connecting Rostock to the hydrogen core network

The connection of Rostock to a hydrogen network was originally planned as part of the IPCEI project Doing Hydrogen and the Rostock-Glasewitz-Ketzin pipeline connection. During the further development of the project, it became clear that the initially planned conversion of natural gas pipelines was not suitable for the indicated transport volume. At the same time, the FLOW project was developed, which enables an efficient connection from Mecklenburg-Western Pomerania to the south based on the conversion of existing natural gas pipelines. Thanks to the Rostock-Wrangelsburg cross-connection and transport via the FLOW project, Rostock can be effectively connected to the hydrogen

core network even without the pipeline from the Doing Hydrogen project. The core network will continue to transport hydrogen without any restrictions. As a result, the three pipeline sections 236-Glasewitz-Pritzwalk (KLN069-01), 264-Pritzwalk-Ketzin (KLN070-01) and 265-Ketzin-Buchholz (KLN071-01) in the hydrogen core network are no longer required compared to the draft application of November 15, 2023. A comparison of the alternative pipeline sections Glasewitz-Ketzin-Buchholz and Rostock-Wrangelsburg has shown that the sole connection of Rostock to the hydrogen core network via the Rostock-Wrangelsburg pipeline can minimize the overall economic costs.

Further changes

Further minor changes compared to the draft application dated November 15, 2023, are described in Annexes 3 to 5 of the application.

There have already been changes to the published planning status of July 12, 2023, which were described previously in the draft application. This description is now included in Appendix 2 of this document.

8 Identification of measures in the natural gas network to realize the hydrogen core network

In the interests of overall economically optimized planning, the 2032 hydrogen core network will be developed predominantly from converted pipeline systems of the existing natural gas infrastructure and from new hydrogen pipelines to be constructed. The transmission system operators thus meet the requirements of Section 28q (2) sentence 3 EnWG, according to which the possibility of converting existing pipeline infrastructure must be examined and presented as a matter of priority.

Accordingly, the transmission system operators have determined which pipelines in the 2032 hydrogen core network can be obtained through conversion of natural gas infrastructure. Here, there must be certainty at the time the infrastructure is converted to hydrogen that the remaining natural gas transmission network can meet the capacity requirements on which the scenario framework for the Gas Network Development Plan 2022-2032 is based.

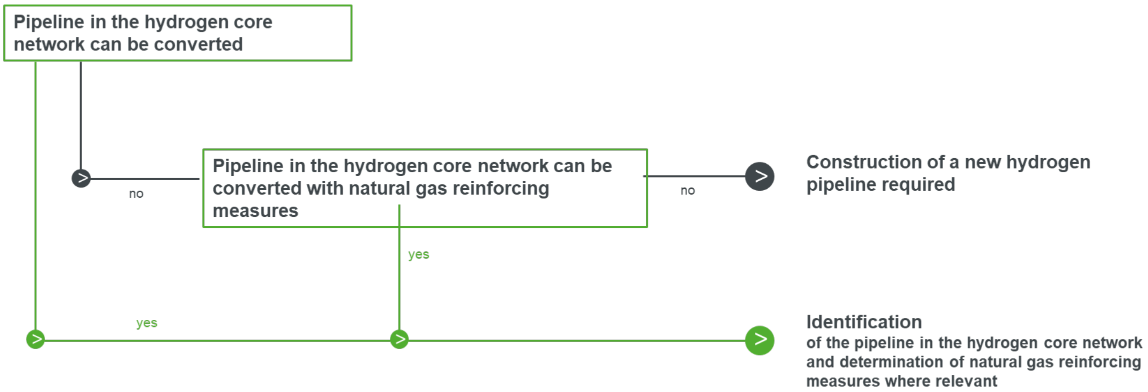
With regard to the additional measures required in the transmission system, the transmission system operators also point out that the measures to reinforce the natural gas infrastructure must be approved together with the measures for the hydrogen core network.

8.1 Procedure

Based on the LNGplus security of supply variant C of the Gas Network Development Plan 2022-2032 and the identified hydrogen core network, the transmission system operators examined which natural gas infrastructure could be converted for hydrogen use in the hydrogen core network by 2032. A key prerequisite for classifying the convertibility of a natural gas infrastructure to hydrogen was that the capacity requirements identified in the LNGplus security of supply variant C can be covered by the remaining transmission network.

The procedure for identifying natural gas infrastructure for use in the 2032 hydrogen core network is shown schematically in Figure 11.

Figure 11: Procedure for determining pipelines for use in the 2032 hydrogen core network



Source: Transmission system operators

The transmission system operators used the infrastructure that was identified as necessary for use in the hydrogen core network to test its convertibility. For this natural gas infrastructure, they examined whether it could be converted to hydrogen use by the end of 2032. If a natural gas infrastructure cannot be converted, a further examination is carried out to determine whether it could be converted by taking measures in the transmission network (so-called "natural gas reinforcing measures"). If the system can be converted in a cost-efficient way by taking reinforcing measures on the natural gas side, the infrastructure also qualifies as convertible and the corresponding natural gas reinforcing measures are assigned to it. This may involve, for example, short new pipelines, partial parallelization of existing systems, the transfer of consumers and consumption areas to other pipeline systems, and the addition of compression capacity or gas pressure control and metering systems.

The possibility of converting existing pipeline infrastructures examined by the transmission system operators in accordance with Section 28q (2) sentence 4 EnWG is regarded as a sub-case of the examination of alternatives to determine the most cost- and time-efficient solution in the long term. The conversion of existing natural gas infrastructures is therefore the result of a network optimization process that is regularly associated with further measures in the remaining transmission network.

As part of this conversion review, the transmission system operators must prove in accordance with Section 28q (2) sentence 6 EnWG *"that the natural gas infrastructure can be separated from the transmission system and that the remaining transmission system can meet the expected remaining natural gas demand at the time of conversion."* The proof can only be provided taking into account the measures required in connection with this, as the remaining natural gas requirements cannot be met otherwise. BNetzA will only approve the application for the hydrogen core network in accordance with Section 28q (8) EnWG if the requirements, in particular those set out in (2), are met; BNetzA must therefore check whether the proof of the conversion capability and the associated mandatory measures to increase the use of natural gas have been provided.

As these measures are inextricably linked to the conversion of an existing pipeline infrastructure to hydrogen, the natural gas reinforcing measures must be approved as part of the application for the hydrogen core network. The transmission system operators are obliged to convert with approval in accordance with Section 28q (7) EnWG. They can only

comply with this obligation if they are also authorized to implement the natural gas reinforcing measures from this point in time, and the obligation of the transmission system operators to implement the natural gas reinforcing measures ensures the supply in the remaining natural gas system (the approval of the natural gas reinforcing measures thus serves to ensure that the pipeline conversion can be approved).

The transmission system operators therefore apply for approval of the conversion of the infrastructure to hydrogen, which is only possible with the implementation of the associated natural gas reinforcing measures, on the express condition that these natural gas reinforcing measures are approved.

8.2 Results

The following table shows the extent to which gas supply infrastructure could be converted to hydrogen use by 2032 and would therefore be available for the hydrogen core network. It also shows the extent to which natural gas reinforcing measures are required for this.

Table 5: Gas supply infrastructure for use in the 2032 hydrogen core network

	By end of 2032
Conversion of pipelines from methane to hydrogen [km]	
Pipelines that can be converted to hydrogen by 2032	**5,047**
- of which convertible without natural gas reinforcing measures	1,703
- of which convertible with natural gas reinforcing measures	3,345
Natural gas reinforcing measures – technical parameters	
- Compressor stations [MW]	97
- Newbuild pipelines [km]	558
Natural gas reinforcing measures – investment	
Natural gas reinforcing measures [EUR bn]	**1.9**
- Compressor stations	0.5
- Pipelines	0.9
- Other measures (incl. conversions, GPRM stations, valve stations)	0.5

Source: Transmission system operators

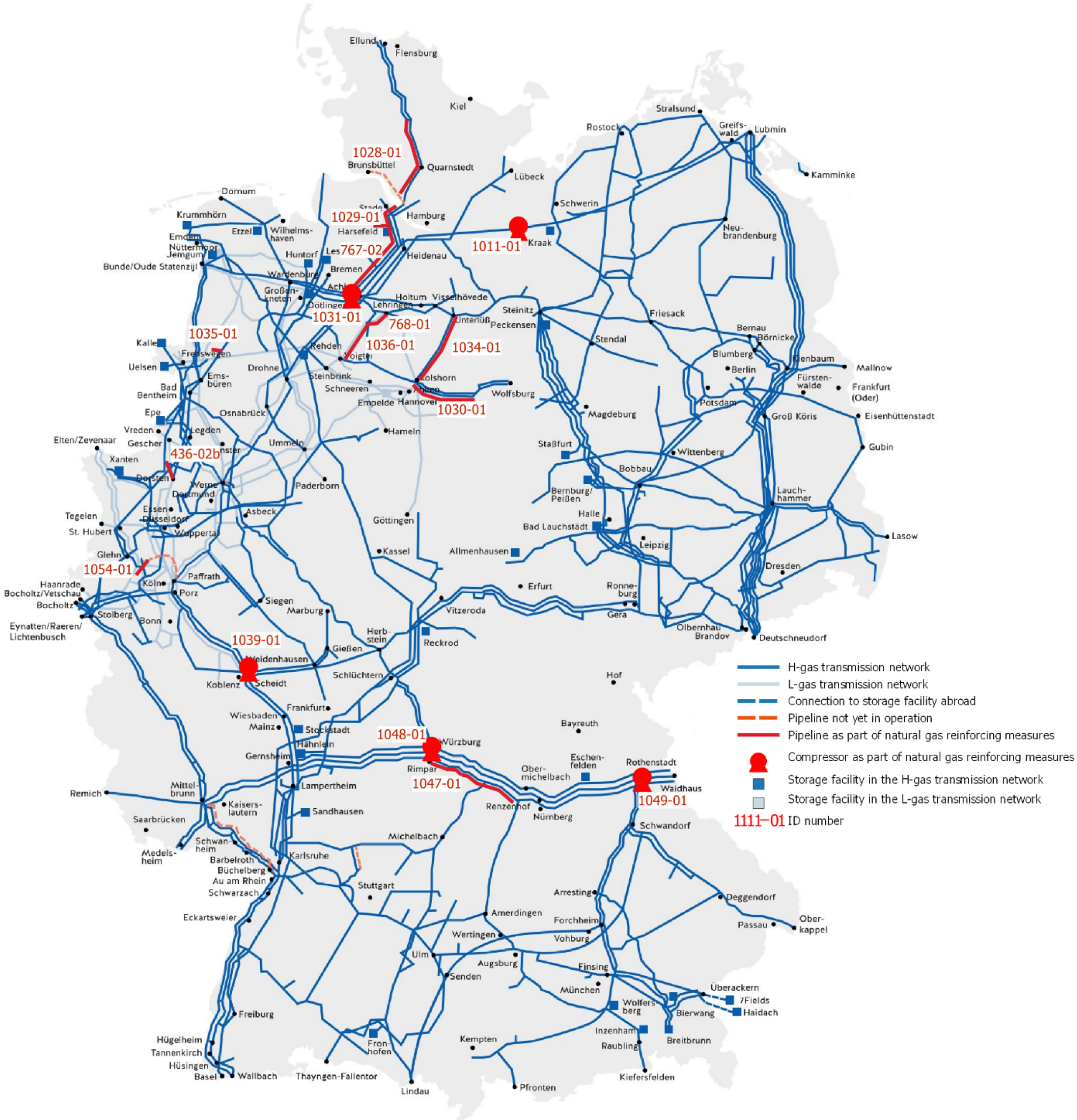
Annex 4 outlines the gas supply infrastructures that could be converted to hydrogen, along with allocation of the natural gas reinforcing measures from Annex 5 that are required for the respective conversions to hydrogen. The natural gas reinforcing measures are also shown in this annex.

It is possible that by the end of 2032, gas supply pipelines with a total length of 5,047 km could be converted, whereby 1,703 km can be converted without natural gas reinforcing measures and 3,345 km with such measures. This means that around a third of the identified pipeline network can be converted without natural gas reinforcing measures. The costs for the natural gas reinforcing measures amount to around 1.9 billion euros, which means that the 3,345 km mentioned above can be converted cost-effectively.

Otherwise, significantly higher investments in the lower double-digit billion-euro range would be required for corresponding new construction of hydrogen pipelines.

The following figure shows the locations of the identified natural gas reinforcing measures. For reasons of clarity, larger pipelines and compressor stations are shown on the map.

Figure 12: Natural gas reinforcing measures for the implementation of the hydrogen core network 2032



Source: Transmission system operators

Classification of the results

The determination of measures in the natural gas network to implement the hydrogen core network for the year 2032 is based on the LNGplus C modelling variant from the Gas Network Development Plan 2022-2032. The transmission system operators did not have a reliable basis for a possible adjustment of the 2022 scenario framework, as provided for in Section 28q (2) EnWG.

However, against the backdrop of the current discussions on municipal heating plans as a central component of energy and climate policy, there are uncertainties regarding future capacity development. The transmission system operators will continue to monitor the development of the capacity requirements of the distribution system operators, in particular how these are embedded in municipal heating planning. The power plant strategy, for which initial key points are already available, will also provide new impetus for the development of capacity requirements. The transmission system operators will therefore monitor the further development of CHP and power plant requirements, also in conjunction with the Electricity Network Development Plan.

The significant declines in output and volumes expected for the achievement of climate protection targets in terms of methane procurement with simultaneous changes in gas imports and storage use also lead to uncertainties. This may mean that in future, adjustments must be made to the scaling back of natural gas and the ramp-up of hydrogen, and may also have an impact on the required pipelines and conversion times. The resulting change in network load will significantly affect the possibility of making gas supply lines usable for hydrogen. At the same time, power plants and distribution network operators are substituting natural gas with hydrogen, which requires a corresponding hydrogen ramp-up. In the integrated gas and hydrogen network development planning process, the scenario can be adjusted taking into account the capacity requirements of the distribution network operators for natural gas and hydrogen.

According to estimates by the transmission system operators, the scope of natural gas reinforcing measures may be reduced in future network development plans. This presumed reduction in the measures required is due, for example, to the fact that a number of CHP plants and their output are included both in natural gas and in hydrogen in the planning for the hydrogen core network and in the planning for the Gas Network Development Plan 2022-2032. The aim of the transmission system operators is to resolve this double consideration in the upcoming network development plans.

In line with these developments, the determination of gas supply pipelines that can be converted to hydrogen use by 2032 is associated with uncertainties and must therefore be continuously reviewed as part of the integrated gas and hydrogen network development planning process.

Signatures of the transmission system operators

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bayernets GmbH

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Ferngas Netzgesellschaft mbH

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Fluxys Germany GmbH

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Fluxys TENP GmbH

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GASCADE Gastransport GmbH

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Gastransport Nord GmbH

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Gasunie Deutschland Transport Services GmbH

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GRTgaz Germany GmbH

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Lubmin-Brandov Gastransport GmbH

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NEL Gastransport GmbH

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Nowega GmbH

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ONTRAS Gastransport GmbH

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Open Grid Europe GmbH

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terranets bw GmbH

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Thyssengas GmbH

Appendices

Appendix 1: Explanations of cross-border interconnection points in the hydrogen core network

The integration of the German hydrogen network into a European hydrogen network is an important prerequisite for the functioning of the entire infrastructure. For the modelling of the hydrogen core network, the following assumptions were made at the cross-border IPs (see also Figure 1):

Denmark: Offshore connection to the Baltic Sea

The planned entry capacity for hydrogen from Denmark to Germany at the offshore Baltic Sea cross-border IP was agreed between the technical experts at Energinet and GASCADE as part of the coordination process. The PCI projects Interconnector Bornholm-Lubmin (HYD-N-854/HYD-N-800) and Flow (HYD-N-796) under consideration serve to realize a European hydrogen network for the transmission of hydrogen from Denmark to Germany within the meaning of Section 28q(4)(4)(d) EnWG.

Energinet has calculated an export capacity of 240 GWh per day for the upstream Danish hydrogen transport project Interconnector Bornholm-Lubmin. A capacity of 240 GWh per day was agreed with the German partners for the cross-border IP. A total entry capacity of 10 GW was therefore assumed for Lubmin for the target year 2032.

In addition to the PCI project Interconnector Bornholm-Lubmin, the PCI project Baltic Sea Hydrogen Collector (PRJ-G-277) has been submitted by Gasgrid Finland Oy (Finland) and Nordion Energi AB (Sweden). With this PCI project, hydrogen is to be shipped from Finland and Sweden to Germany. The project participants have agreed to co-operate in order to avoid duplication of infrastructure. One result could be to integrate the Bornholm-Lubmin interconnector into the Baltic Sea Hydrogen Collector between Bornholm and Lubmin, especially if the hydrogen potential on Bornholm is not fully developed by 2032. The entry capacity of 10 GW assumed for Denmark is therefore to be understood as entry capacity from the Baltic Sea region (Denmark + Sweden + Finland).

Denmark: Ellund

The network operators Energinet and Gasunie have been working on the construction of a hydrogen connection between Denmark and Germany via the Ellund cross-border IP since 2020. As part of the cooperation, the basic feasibility of a connection was examined in an initial feasibility study in 2021. In 2023, the basic market assumptions were reassessed and confirmed in the Hydrogen Market Assessment Report [Energinet, 2023]. In principle, Denmark has very good locations for the generation of renewable energy/electricity (especially offshore wind). The generation potential clearly exceeds Danish demand, so it makes sense to use this generation potential to provide hydrogen for the German market as well. Denmark's good suitability for the production of hydrogen is also confirmed by the BMWK's long-term scenarios. Denmark's generation potential is already almost fully exploited in the T45 electricity scenario as part of the Europe-wide optimization of the scenarios.

The export potential for hydrogen from Denmark currently agreed by Energinet and Gasunie is based on the Danish Energy Agency's (DEA) medium pathway for the development of electrolysis in Denmark [Analyseforudsætninger til Energinet, 2022 (DEA-AF22)]. The capacities of the hydrogen corridor confirmed as a PCI by the EU Commission on November 28, 2023, under point 9.9 in the Union list were also determined on this basis (2.5 GW in 2030; 6.5 GW in 2035).

For the test year 2032, the DEA-AF22 figures result in a capacity of 4.3 GW of entry/exit capacity, which was applied at the Ellund cross-border IP.

Norway: Offshore connection to the North Sea

The estimated entry capacity for hydrogen from Norway to Germany was agreed as part of the German-Norwegian Energy and Industrial Partnership Joint Feasibility Study on Hydrogen with the involvement of FNB Gas, dena, Gassco and Equinor. Both IPCEI and PCI applications were submitted for the Norway-Germany transmission route. The various projects applied for, *CHE-pipeline, H2T project* and *AquaDuctus,* serve to realize a European hydrogen network for the transmission of hydrogen from Norway to Germany within the meaning of Section 28q (4)(4)(b) EnWG.

For the upstream Norwegian hydrogen transmission projects *CHE-pipeline* (HYD-N-1249) and *H2T project* (HYD-N-884, HYD-N-1339), Equinor and Gassco have stated a total capacity of 820 GWh per day for their PCI applications. A capacity of 480 GWh per day was calculated for the AquaDuctus project, which is to be connected to the Norwegian PCIs. For imports to Germany, the German-Norwegian Energy and Industrial Partnership Joint Feasibility Study on Hydrogen estimated a capacity of 5 GW for the test year 2032.

For the connection of offshore hydrogen production in the German EEZ and the import of hydrogen from the countries bordering the North Sea (Norway, the United Kingdom, the Netherlands or Denmark), an offshore pipeline is sufficient from the perspective of the transmission system operators. Due to its IPCEI status, AquaDuctus (SEN-1 up to the German coast near Wilhelmshaven) was considered an offshore pipeline in the hydrogen core network. In addition to the 5 GW of import capacity assumed for 2032, the expansion stage of AquaDuctus included in the hydrogen core network can provide a prospective capacity of 20 GW for the intake of hydrogen from the North Sea. Additional densification (not part of the hydrogen core network) can further increase the import capacity to up to 30 GW.

In December 2022, an application was submitted to the EU Commission for the AquaDuctus project to be granted Project of Common Interest (PCI) status with section-by-section commissioning by 2035. In March 2023, section 1 of the AquaDuctus project (Bunde to SEN-1) was pre-notified by the BMWK and formally included in the IPCEI notification process for the Hy2Infra wave. At the time, the focus was on connecting the SEN-1 area and transporting the hydrogen volumes produced there from 2030, as well as the possibility of expanding the pipeline (both in terms of capacity and space) at a later date depending on expansion requirements. The project parameters of the AquaDuctus project were defined in consultation with BMWK.

On November 28, 2023, the PCI process was completed by the EU Commission with the result that AquaDuctus was granted PCI status.

Netherlands: Vlieghuis

The planned capacity for hydrogen from the Netherlands to Germany was agreed between Gasunie/Hynetwork Services B.V. (Netherlands) and Thyssengas GmbH (Germany) as part of the applications for the 6th list of Projects of Common European Interest (PCI). The proposed PCI projects "Hydrogen network phase 1" (NL) (HYD-N-468) and "Vlieghuis-Ochtrup" (DE) (HYD-A-906) serve to realize a European hydrogen network for the transport of hydrogen from the Netherlands within the meaning of Section 28q (4)(4)(b) EnWG.

The projects are combined in Group HI WEST 26 ("Interconnection Netherlands-Germany at Vlieghuis"). Gasunie/Hynetwork Services and Thyssengas have calculated a capacity of 14.4 GWh per day from 2027 for the Vlieghuis cross-border IP for the joint PCI application. From 2029, a capacity of 19.2 GWh per day was reported, and from 2031 a capacity of 31.2 GWh per day. The proposed PCI "Vlieghuis-Ochtrup" (HYD-A-906) is part of the German hydrogen core network. Therefore, an entry and exit capacity of 1.3 GW was assumed in Vlieghuis for the test year 2032.

Netherlands: Oude Statenzijl/ Bunde

The planned entry capacity for hydrogen from the Netherlands to Germany at the Oude Statenzijl/Bunde cross-border IP was agreed between the technical experts from Hynetwork Services and Gasunie Deutschland as well as OGE as part of the coordination processes. The Dutch Hydrogen Backbone, HyPerLink I and H2ercules projects under consideration serve to establish import opportunities for hydrogen from the Netherlands to Germany within the meaning of Section 28q (4)(4)(d) EnWG. In order to ensure European integration, the services at the cross-border IPs with the Netherlands were selected consistently with the planning of GTS and Hynetwork Services. A capacity of 4 GW for 2032 was agreed with the German partners for the Oude Statenzijl/Bunde cross-border IP.

Netherlands: Elten

The planned entry capacity for hydrogen from the Netherlands to Germany at the Elten cross-border IP was agreed between the technical experts from Hynetwork Services and Open Grid Europe as part of the applications for the 6th list of Projects of Common European Interest (PCI). The Dutch Hydrogen Backbone and H2ercules projects proposed serve to realize a European hydrogen network for the transmission of hydrogen from the Netherlands to Germany within the meaning of Section 28q (4)(4)(b) EnWG.

For the upstream Dutch hydrogen transport project Dutch Hydrogen Backbone, HYD-N-468, Hynetwork Services has calculated a capacity of 76.8 GWh per day for the PCI application. For the Elten cross-border IP, a capacity of 76.8 GWh per day was agreed with the German partners for the H2ercules Network North-West project, HYD-N-1075, which is directly connected to the Elten cross-border IP. The proposed PCI H2ercules is part of the German hydrogen core network. For this reason, a total entry capacity of 3.2 GW was assumed in Elten for the test year 2032.

Netherlands: Vreden

The planned entry capacity for hydrogen from the Netherlands to Germany at the Vreden cross-border IP was agreed between the technical experts at Hynetwork Services and Open Grid Europe as part of the coordination process. The projects under consideration, Dutch Hydrogen Backbone and conversion of pipeline 27 Vreden-Dorsten, serve to improve the import possibilities of hydrogen from the Netherlands to Germany within the meaning of Section 28q (4)(4)(d) EnWG.

Hynetwork Services has calculated an export capacity of 76.8 GWh per day for the upstream Dutch hydrogen transmission project Dutch Hydrogen Backbone. For the Vreden cross-border IP, a capacity of 76.8 GWh per day was agreed with the German partners for the conversion of pipeline 27 Verden-Dorsten, which is directly connected to the Vreden cross-border IP. The conversion of pipeline 27 Vreden-Dorsten is part of the German hydrogen core network. Therefore, a total entry capacity of 3.2 GW was assumed in Vreden for the test year 2032.

Belgium: Eynatten

The planned entry capacity for hydrogen from Belgium to Germany was agreed between the technical experts from Fluxys and Open Grid Europe as part of the applications for the 6th list of Projects of Common European Interest (PCI). The confirmed Belgian Hydrogen Backbone and H2ercules projects serve to realize a European hydrogen network for the transmission of hydrogen from the Belgian network to Germany within the meaning of Section 28q (4)(4)(b) EnWG.

For the upstream Belgian hydrogen transport project Belgian Hydrogen Backbone, HYD-N-1311, Fluxys has calculated a capacity of 91.2 GWh per day for the PCI application. For the Eynatten cross-border IP, a capacity of 91.2 GWh per day was agreed with the German partners for the H2ercules Network West project, HYD-N-1038, which is directly adjacent to the cross-border IP. The confirmed PCI H2ercules is part of the German hydrogen core network. An entry capacity of 3.8 GW was therefore set in Eynatten for the test year 2032.

France: Medelsheim

The planned entry capacity for hydrogen from France to Germany was agreed between the technical experts from GRTgaz, GRTgaz Deutschland and Open Grid Europe as part of the applications for the 6th list of Projects of Common European Interest (PCI). The confirmed projects H2Med, HY-FEN and H2ercules serve to realize a European hydrogen network for the transmission of hydrogen from Portugal, Spain and France to Germany within the meaning of Section 28q (4)(4)(b) EnWG. The Hydrogen Corridor was confirmed as a PCI by the EU Commission on November 28, 2023, under point 9.1 in the Union list.

For the upstream French hydrogen transmission project HY-FEN (H2 Corridor Spain-France-Germany connection), HYD-N-569, GRTgaz has calculated a capacity of 200 GWh per day, which is divided between the Franco-German cross-border IP and the smaller mosaHYc and RHYN projects close to the border. For Medelsheim, a capacity of 192 GWh per day was agreed with the German partners for the H2ercules Network South

project, HYD-N-1052, which is directly adjacent to the cross-border IP. The proposed PCI H2ercules is part of the German hydrogen core network. An entry capacity of 8 GW was therefore set in Medelsheim for the test year 2032.

France: Fribourg

The planned entry capacity for hydrogen from France to Germany was agreed between GRTgaz and terranets bw as part of the applications for the 6th List of Projects of Common European Interest (PCI). The RHYn and RHYn Interco projects applied for serve to realize a European hydrogen network for the transmission of hydrogen from Portugal, Spain and France to Germany within the meaning of Section 28q (4)(4)(b) EnWG. The project was confirmed as a PCI by the EU Commission on November 28, 2023, under point 9.2.1 in the Union list.

For the upstream French hydrogen transmission project RHYn, HYD-N-969, GRTgaz has calculated a capacity of 12 GWh per day for the PCI application, which will be shipped via the new cross-border IP at Freiburg. For Freiburg, a capacity of 12 GWh per day was agreed with the German partners for the RHYn Interco project, HYD-N-1096, which is directly connected to the new cross-border IP. The confirmed PCI RHYn Interco is part of the German hydrogen core network. Therefore, an entry capacity of 0.5 GW was set in Freiburg for the test year 2032.

Austria: Überackern

The planned capacity for hydrogen from Austria to Germany was agreed between the technical experts from Gas Connect Austria and bayernets as part of the applications for the 6th list of Projects of Common European Interest (PCI). The proposed projects H2 Backbone WAG + Penta-West (HYD-N-757) and HyPipe Bavaria – The Hydrogen Hub (HYD-N-642) serve to realize a European hydrogen network for the transmission of hydrogen from North Africa via Italy and Austria to Germany within the meaning of Section 28q (4)(4)(b) EnWG as part of the SoutH2 Corridor initiative. In addition, within the scope of the H2EU+Store initiative, the proposed projects also enable the transmission of hydrogen from Ukraine via Slovakia and Austria to the Überackern cross-border IP.

For the upstream Austrian hydrogen transmission project H2 Backbone WAG + Penta-West, Gas Connect Austria has determined and agreed an entry capacity of 150 GWh per day for the PCI application with the partners of the initiatives for the German-Austrian cross-border IP Überackern. The hydrogen corridor was confirmed as a PCI by the EU Commission on November 28, 2023, under point 10.1 in the Union list. The confirmed PCI HyPipe Bavaria – The Hydrogen Hub is part of the German hydrogen core network. An entry capacity of 6.25 GWh/h was therefore assumed at the Überackern cross-border IP for the test year 2032.

Czech Republic: Waidhaus

The planned entry capacity for hydrogen from the Czech Republic to Germany was agreed between the technical experts from GRTgaz Deutschland, Net4gas and Open Grid Europe as part of the applications for the 6th list of Projects of Common European Interest (PCI). The confirmed Central European Hydrogen Corridor and H2ercules projects serve

to realize a European hydrogen network for the transmission of hydrogen from Ukraine via Slovakia and the Czech Republic and from North Africa via Italy, Austria, Slovakia and the Czech Republic to Germany within the meaning of Section 28q (4)(4)(b) EnWG. The hydrogen corridor was confirmed as a PCI by the EU Commission on November 28, 2023, under point 9.1.6 (German part) and point 10.2.1 (Czech part) in the Union list.

For the upstream Czech hydrogen transmission project Central European Hydrogen Corridor (CZ part), HYD-N-990, Net4gas has calculated a capacity of 144 GWh per day at the Waidhaus cross-border IP. This capacity was agreed with the German partners for the H2ercules Network South project, HYD-N-1052, which is directly adjacent to the cross-border IP. The confirmed PCI H2ercules is part of the German hydrogen core network. An entry capacity of 6 GW was therefore set in Waidhaus for the test year 2032.

Czech Republic: Deutschneudorf

The planned capacity for hydrogen from Germany to the Czech Republic and the return feed-in from the Czech Republic to Germany in Waidhaus was agreed between Net4Gas, GASCADE and Open Grid Europe as part of the applications for the 6th list of Projects of Common European Interest (PCI). The submitted projects Flow East, CGHI and H2ercules South serve to realize a European hydrogen network for the transmission of hydrogen, initially from Denmark and in later years from Sweden and Finland to Germany within the meaning of Section 28q (4)(4)(b) EnWG. In addition, the PCI projects in Deutschneudorf also offer the possibility of feeding hydrogen from the Czech Republic into the German hydrogen network.

Net4Gas has calculated a capacity of 144 GWh per day for the Czech hydrogen transmission project CGHI for the PCI application. A capacity of 144 GWh per day was therefore assumed for Deutschneudorf, as the capacity is limited by the proposed PCI CGHI. The proposed PCI Flow East is part of the German hydrogen core network. Therefore, an exit capacity of 6 GW was assumed in Deutschneudorf for the test year 2032.

Poland: Oder-Spree, Uckermark

As part of the determination of the hydrogen core network, two different cross-border IPs on the state border with Poland were considered: in the Oder/Spree district near the town of Eisenhüttenstadt and in the Uckermark district near the town of Schwedt.

The planned capacity for hydrogen from Poland to Germany for both cross-border IPs was discussed between GAZ-SYSTEM and ONTRAS as part of the applications for the 6th list of Projects of Common European Interest (PCI). The proposed projects Polish Hydrogen Backbone Infrastructure HYD-N-983 (connection to the Polish hydrogen network near Schwedt) and Nordic-Baltic Hydrogen Corridor HYD-N-1310 (connection to the Polish hydrogen network near Eisenhüttenstadt) serve to realize a European hydrogen network for the transmission of hydrogen directly from Poland and from the North-East Europe region via the Baltic States and Poland to Germany within the meaning of Section 28q (4)(4)(b) EnWG. The Nordic-Baltic Hydrogen Corridor was confirmed as a PCI by the EU Commission on November 28, 2023, under point 11.2 in the Union list.

As part of the Polish hydrogen transport project Polish Hydrogen Backbone Infrastructure of GAZ-SYSTEM, there are plans for feed-in of hydrogen in West Pomerania along with its export to Germany via a connection in Schwedt. The further development of the project was agreed in a joint MoU between the network operators GAZ-SYSTEM and ONTRAS with the H2 producer. A capacity of 0.8 GWh per hour was initially set as realistic for the cross-border IP near Schwedt for the year 2032.

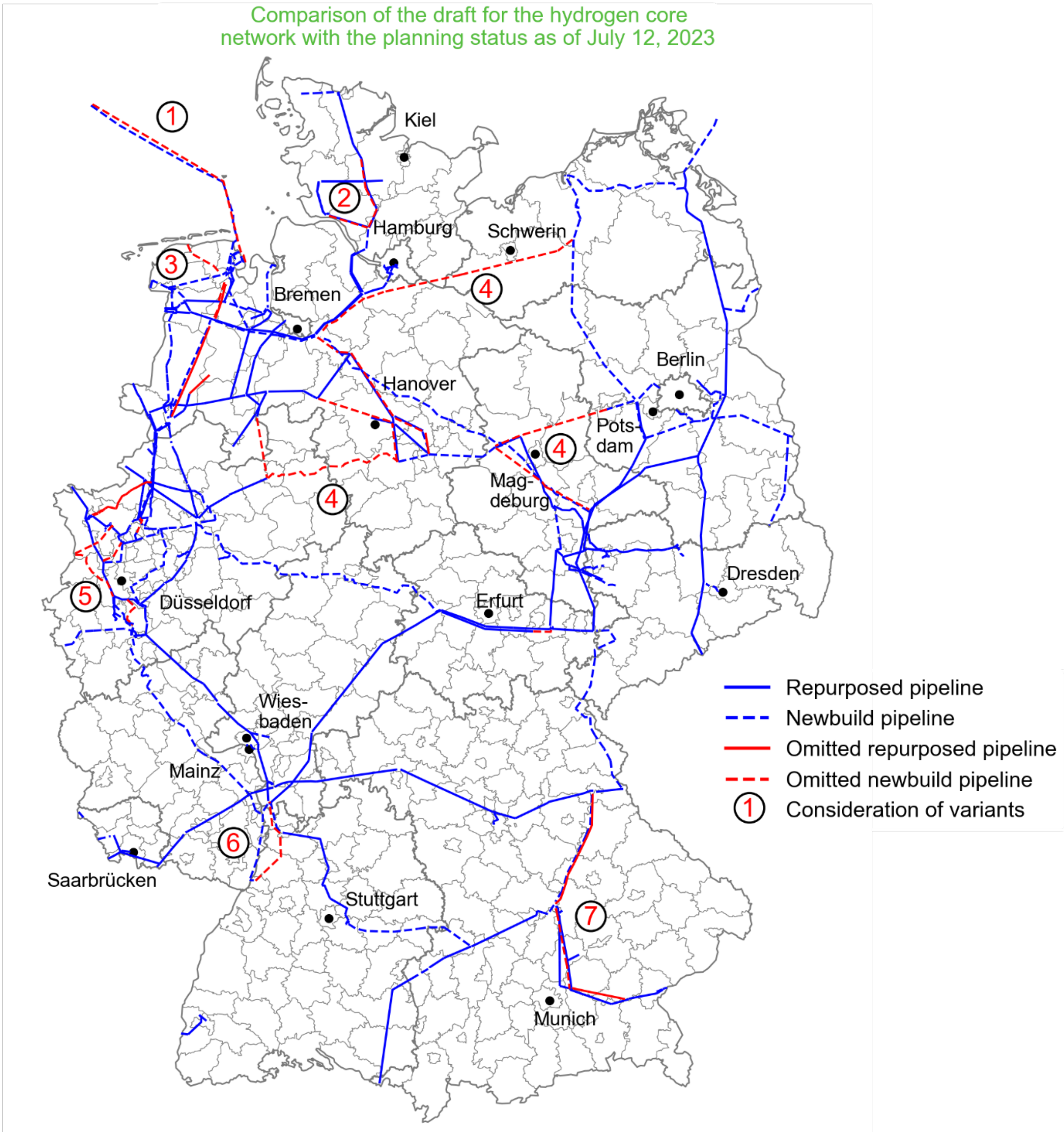
For the Nordic-Baltic Hydrogen Corridor hydrogen transmission project, GAZ-SYSTEM and ONTRAS have each calculated a capacity of 200 GWh per day for the PCI application. For the cross-border IP near Eisenhüttenstadt, a capacity of 48 GWh per day was estimated as realistic for the year 2032. An entry capacity of 2 GW was therefore assumed for this cross-border IP for the test year 2032.

Appendix 2: Comparison of the hydrogen core network with the planning status as of July 12, 2023 – comparison of alternatives pursuant to Section 28q (2) EnWG

The transmission system operators have carried out a comparison of alternatives in accordance with Section 28q (2) EnWG. This was already carried out in the draft application of November 15, 2023, in comparison to the planning status of July 12, 2023. The results of this comparison of alternatives are presented below and remain valid.

The following Figure 13 shows the pipelines of the hydrogen core network in dark blue. At the same time, pipelines that have been omitted compared to the planning status of July 12, 2023, are shown in red.

Figure 13 Comparison of the hydrogen core network with the planning status as of July 12, 2023



Source: Transmission system operators

The pipelines omitted compared to the planning status of July 12, 2023 (hereinafter referred to as the planning status), are generally alternative pipelines, which are described below. The numbering of the variants in the following description corresponds to the presentation in Figure 13.

In addition to the variants described below, there are other smaller pipeline sections that are not required in the modelling to cover the demand. These changes are not explained in detail as they are not alternatives pursuant to Section 28q (2) EnWG.

For pipeline selection where alternative pipelines are available, the following criteria were taken into account in the order shown:

1. PCI authorization and/or IPCEI application is available, in contrast to the alternative.

2. Investment costs lower than with the alternative.

3. Priority given to conversion of existing pipelines over new pipelines in order to reduce the impact on nature and the environment.

1. Offshore North Sea
Two offshore pipeline routes were shown in the planning status. In the view of the transmission system operators, one offshore pipeline is sufficient to connect offshore hydrogen production in the German Exclusive Economic Zone (EEZ) and the import of hydrogen from the countries bordering the North Sea (NO, UK, NL or DK). Accordingly, the pipeline shown in Figure 13 with number 1 could be omitted. Due to its IPCEI status, AquaDuctus (offshore area SEN-1 to the German coast near Wilhelmshaven and from there onshore to Bunde) was included in the hydrogen core network as an offshore pipeline.

2. Schleswig-Holstein
In the planning status, a new pipeline running in a north-south direction was planned for the transmission of hydrogen. In the current draft application, an existing pipeline was used to transport hydrogen instead and a corresponding natural gas reinforcing measure was taken into account to maintain security of supply in natural gas. The background to this is the assessment that this pipeline would not be required in subsequent network planning if methane transport requirements – in particular exports to Denmark – could be reduced by mutual agreement. Denmark is already planning to be self-sufficient in its supply from 2027 through an increase in biomethane production and reduction in demand.

The natural gas transport would be realized via an existing pipeline of a distribution network operator. Planning for this solution has already begun with the network operator.

It was possible to dispense with a new pipeline to Brunsbüttel with the notification of an existing pipeline from a potential hydrogen network operator compared to the planning status.

3. Wilhelmshaven area
In the planning status, the Wilhelmshaven area showed various pipeline projects that were intended to fulfil the transmission task. In the area shown in Figure 13 marked with the number 3, a sensible solution was found as part of the iterations to optimize the hydrogen core network. For example, various project ideas for transporting the hydrogen output from Wilhelmshaven and Schillig (offshore landfall) were examined. Ultimately, two pipeline projects from the Etzel area in the direction of Barßel were cancelled. One pipeline project, which has IPCEI status, was relocated towards Bunde (application ID KLN046-01) instead of towards Barßel within the H2ercules project in agreement between the companies concerned and the responsible authority. An important alternative to the pipelines from Wilhelmshaven or Etzel to Barßel set out in the planning status is a pipeline from the Wilhelmshaven area to Wardenburg (application ID KLN029-01), which is required to cope with the considerable transport demand to the east. In addition, a

connection from Barßel in the direction of Wardenburg is required (application ID KLN024-01). This solution is much more favourable compared to the original planning approaches, as several partially parallel project ideas could be bundled here and a technical solution was found that corresponds with the planning of the west-east connections.

Furthermore, due to the choice of landing point, the originally planned connection to the North Sea in Dornum has been cancelled.

4. West-east connections

In the planning variants, it was identified that a powerful east-west system in northern and central Germany supports the entire network very efficiently. The east-west connections bring flows to the efficient northeast-southwest existing system (Lubmin-Radeland-Bobbau-Rückersdorf-Reckrod-Lampertheim). An efficient north-south transport component is also realized with the east-west connections. The high-capacity connections will also achieve the desired meshing in the hydrogen core network and a very resilient structure in terms of the location of entry and exit capacity.

The transmission system operators analysed various options in order to develop a combination of high-capacity east-west connections. In principle, a combination of a new pipeline from Achim to Bobbau and another new pipeline from Werne to Eisenach was considered. As an alternative to this combination, a new pipeline from Achim to Groß Tessin and several new pipelines to reinforce the existing infrastructure between Achim/ Weser/ Drohne/ Bielefeld and Bobbau/ Brandenburg a. d. Havel were considered.

In later iterations, the new construction of the Achim-Hallendorf, Ahlten-Kolshorn and Achim-Groß Tessin pipeline connections offered little added value for a high-capacity connection between eastern and western Germany and were therefore discarded as possible options. A conversion of existing infrastructure could still be used to supply the Hanover region with hydrogen. It was also possible to dispense with the construction of the new connecting pipelines between Wefensleben-Bobbau and Wefensleben-Brandenburg a. d. Havel.

The new Wefensleben-Brandenburg a. d. Havel pipeline was not considered further in the network modelling, as the direct connection of an east-west link from Wefensleben to Bobbau leads to a lower pressure loss and thus better supports transport to the south.

In the course of the assessment of alternatives, the transmission system operators were able to identify the east-west connections Achim-Bobbau (KLN027-01, KLN-030, KLN012-01) and Werne-Eisenach (KLN098-01) listed in the planning status as the most efficient combination. The investments for this combination totalling approx. 2,038 million euros are offset by investments totalling approx. 3,586 million euros for the alternative combination (Achim to Groß Tessin and Achim/Weser/Drohne/Bielefeld to Bobbau/Brandenburg a. d. Havel).

Table 6 Investment for the alternative combination Achim to Groß Tessin and Achim/Weser/Drone/Bielefeld to Bobbau/Brandenburg a. d. Havel

	Pressure level	**Diameter**	**Length**	**Investment**
Pipeline section	PN in barg	DN in mm	in km	in EUR m
Achim - Groß Tessin	PN 80	DN 1200	257	1,086
Achim - Luttum	PN 80	DN 600	25	61
Luttum - Peine	PN 80	DN 1200	114	484
Peine - Sophiental	PN 80	DN 500	15	34
Sophiental - Hallendorf	PN 70	DN 400	22	8
Cluster Ahlten - Kolshorn	PN 80	DN 800	5	15
Weser - Lehrte	PN 80	DN 1200	63	267
Bielefeld - Lehrte	PN 80	DN 1200	135	569
Drohne - Ummeln	PN 80	DN 1000	51	184
Wefensleben - Bobbau	PN 80	DN 1200	102	432
Wefensleben - Brandenburg a. d. Havel	PN 80	DN 1200	106	446
Total investment				**3,586**

Source: Transmission system operators

5. Ruhr region

In North Rhine-Westphalia, particularly in the Ruhr region and the Cologne area, the planning status of the hydrogen core network also offered several alternatives to fulfil the transport requirements. In the course of the modelling, the most suitable pipeline projects were selected, less efficient projects were withdrawn, and the selected projects were adjusted in terms of nominal width to meet requirements. The withdrawn projects are also shown in Figure 13 in red.

No demand could be assigned to the **Gescher Süd-Wardt** conversion pipeline (as a dual pipeline between Bergerfurth and Wardt) in accordance with the agreed scenario. Due to the pipeline dimensioning in DN 200, the transport capacity is limited and would not be able to replace any other pipeline project between Coesfeld and Krefeld. The transport task from the developed load cases can be taken over by pipelines located further south (e.g. Dorsten-Hamborn pipeline). The pipeline will only be considered in the hydrogen network if the regional demand along the pipeline route can be covered.

The **Dorsten-Boy** pipeline was not included in the hydrogen core network, as the transport task is performed by part of the H2ercules project and the Dorsten-Recklinghausen connection. The pipeline rights are limited to DN 400, and a design with a larger nominal diameter seemed ambitious due to the dense development in this area. Around 17 km of new construction (around 33 million euros) can be saved, and the demand in Gladbeck allocated to the hydrogen core network can be met.

There were two alternative routes for creating a connection between **Oberhausen and Duisburg Nord.** Here, the pipeline route via Dinslaken was given preference, as it already integrates the Dorsten-Hamborn pipeline as an IPCEI project and the further route

appears easier to realize than the variant through the densely built-up area in the north of Duisburg.

There were also two possible routes for the necessary new connection between **Duisburg North and Krefeld.** The southern route with a Rhine crossing near Krefeld was chosen. A feasibility study is already available for this route.

The **Venlo-Scholven** and **Venlo-Glehn** connections were not taken into account. With the Zevenaar cross-border interconnection point and a NETG pipeline, there is a nearby import point with a transport pipeline that is cheaper to convert and just as efficient. This transmission route is supplemented by the Krefeld-Duisburg Nord-Hamborn-Dorsten-Scholven connection. This potential was given preference over the Venlo cross-border interconnection point. Investments totalling around 43 million euros can be avoided on the German side alone.

The **Merkenich-Kalscheuren** connection (DN 700) was rejected as the Glehn-Kalscheuren (DN 400) and Glehn-Brühl (DN 900) transmission routes offer sufficient alternatives in terms of capacity. The Glehn-Kalscheuren transmission route can be realized to a considerable extent via conversion. Rights of way and approvals have already been obtained for some of the sections that need to be completed and will shorten the realization period. Around 13 million euros in investments will be avoided.

6. Ludwigshafen-Karlsruhe area

The planning status in the Ludwighafen-Karlsruhe area originally included two connections (DN 800) from Lampertheim north of Ludwigshafen to Karlsruhe on both sides of the Rhine. In the course of modelling, it turned out that a new pipeline would be sufficient to fulfil the transport task in the direction of Karlsruhe. The transmission route on the left bank of the Rhine via Ludwigshafen (KLN013-01) was favoured for this, as it is shorter and therefore cheaper than the alternative, omitted connection on the right bank of the Rhine east of Mannheim. In addition, the chosen option ensures an optimal regional balance, as the new Lampertheim-Heidelberg pipeline (KLN082-01) is already planned as a suitable measure for developing the main consumption centres of the right bank of the Rhine in the Rhine-Neckar region. In addition, the planning status originally included two shorter connections to the existing pipelines converging in Lampertheim (KLU078-01, KLU021-01), one of which could be omitted. Overall, it was possible to reduce the pipeline lengths in the Ludwigshafen-Karlsruhe area by approx. 102 km and the investment volume by around EUR 318 million in the course of the optimization.

7. Bavaria

As part of the optimization of the hydrogen core network planning, part of the entry capacity of 6.25 GWh/h at the Überackern cross-border IP was allocated to the southern Bavarian demand centres (including the chemical industry in Burghausen and Ingolstadt, as well as the greater Munich area). Compared to the planning status in July, this has a relieving effect on the connection of the southern Bavarian region to the MEGAL in Rothenstadt (see Figure 13). The inclusion of the pipeline infrastructure notifications 405-Finsing-Ismaning North (AND088-01) and 406-Ismaning North-Münchsmünster (AND089-01) also relieves the transmission route Haiming-Forchheim-Finsing.

Due to an adapted design of the new compressor station to be built in Forchheim, the regional allocation and the consideration of the aforementioned VNB pipeline infrastructure notification, the new construction measure between Forchheim and Finsing

and the conversion of the Gröben-Finsing pipeline have been omitted compared to the planning status of the hydrogen transport network.

The planning status of the hydrogen core network revealed a very high transmission requirement for the connection to southern Bavaria via the Rothenstadt-Forchheim route. The conversion of one of the two existing natural gas pipelines alone was not sufficient for this, which made it necessary to build a new pipeline in addition to the conversion. This situation has been alleviated by the above-mentioned relief.

However, there are more than ten natural gas customers connected to the pipeline to be converted who would then have to be connected to another natural gas pipeline, so around EUR 100 million would have to be invested in the conversion costs of around EUR 52 million as natural gas reinforcing measures. This means that the costs for a conversion and a smaller new pipeline would exceed the costs for the solution proposed here of a single DN 1000 new pipeline. Hence, for the aforementioned economic reasons, a pipeline conversion on the Rothenstadt-Forchheim route in the time horizon up to 2032 has been dispensed with in favour of the new pipeline.

The pipeline systems listed and the design of the compressor station in Forchheim ensure targeted, high-capacity transport in and through Bavaria.

Appendix 3: Addresses of other potential hydrogen network operators

Table 7: Addresses of the other potential hydrogen network operators

	Company	Address
1	badenovaNETZE GmbH	Tullastraße 61, 79108 Freiburg i. Br.
2	Creos Deutschland GmbH/Creos Deutschland Wasserstoff GmbH	Am Zunderbaum 9, 66424 Homburg
3	Gasnetz Hamburg GmbH	Ausschläger Elbdeich 127, 20539 Hamburg
4	Mainova AG	Solmsstr. 38, 60486 Frankfurt am Main
5	Mitteldeutsche Netzgesellschaft Strom mbH	Industriestr. 10, 06184 Kabelsketal
6	NBB Netzgesellschaft Berlin-Brandenburg mbH & Co. KG	EUREF-Campus 1-2, 10829 Berlin
7	N-ERGIE Netz GmbH	Sandreuthstraße 21, 90441 Nuremberg
8	Netz Leipzig GmbH	Arno-Nitzsche-Str. 35, 04277 Leipzig
9	Netze BW GmbH	Schelmenwasenstraße 15, 70567 Stuttgart
10	Raffinierie Heide GmbH	Postfach 1440, 25734 Heide
11	RheinEnergie AG/Rheinische Netzgesellschaft ...	Parkgürtel 24, 50823 Cologne
12	SachsenNetze GmbH	Rosenstraße 32, 01067 Dresden
13	Schleswig-Holstein Netz AG	Schleswag-HeinGas-Platz 1, 25451 Quickborn
14	SWM Infrastruktur GmbH & Co. KG	Emmy-Noether-Straße 2, 80992 Munich
15	Wasserstoff-Netz Burgenlandkreis GmbH (WNBG)	Schönburger Str. 41, 06618 Naumburg
16	Westnetz GmbH	Florianstraße 15-21, 44139 Dortmund

Annexes

Annex 1: Project overview for the hydrogen core network scenario

The scenario for the hydrogen core network was described in section 4. The projects that fulfil the criteria of the hydrogen core network scenario are shown in the annex. The transmission system operators have divided Annex 1 into three parts. The upper section of the spreadsheet up to line 1468 (project ID 762) shows the projects included in the modelling. From row 1470 (project ID 009) to row 1549 (project ID 672), the projects that were not included are listed because they are more than 20 kilometres away from the hydrogen core network and are not CHP projects. From line 1551 (project ID 763), projects are listed that were reported as part of the BNetzA consultation of the draft application by January 8, 2024, and whose connected customers were not included in the modelling, but which can be connected to the hydrogen core network.

Annex 2: Pipelines reported by other potential hydrogen network operators

In section 5 the transmission system operators described the process with regard to pipeline notifications from other potential hydrogen network operators. In Annex 2, the transmission system operators present the pipeline notifications received for the hydrogen core network and show which pipelines were included in the hydrogen core network and which were not. This decision is justified in Annex 2. Accordingly, this annex shows which pipelines of other potential hydrogen network operators the transmission system operators propose for consideration in the hydrogen core network. The additional information received from the other potential hydrogen network operators as part of the survey of transmission system operators is also presented in Annex 2. The transmission system operators have divided Annex 2 into three parts. The upper section of the spreadsheet up to line 65 (application ID AND119-01) shows the pipeline notifications taken into account for the hydrogen core network. From line 67 (application ID AND001-01), the pipeline notifications that were not taken into account are listed. Line 96 onwards (application ID AND008-01) lists pipeline notifications that were withdrawn by the other potential hydrogen network operators.

Annexes 3 to 5: Lists of measures of the transmission system operators

The measures identified for the hydrogen core network are described in detail in Annexes 3 to 5. The following measures are included in the annexes:

- Annex 3: New construction measures
- Annex 4: Conversion measures
- Annex 5: Natural gas reinforcing measures

In these three annexes, the transmission system operators set out the technical parameters of their measures for the hydrogen core network. According to Section 28q (4) EnWG, a hydrogen network infrastructure must meet certain requirements in order to be an approvable part of the hydrogen core network. To demonstrate these requirements, the transmission system operators, in consultation with BNetzA, have included corresponding columns in this annex in which the hydrogen core network measures are assigned to the statutory requirements, in particular with regard to Section 28q (4) sentence 4 EnWG.

The transmission system operators point out that the list of measures is to be understood as including accessories and ancillary facilities necessary for operation.

The transmission system operators also point out that it is only possible to clearly assign the individual measures to the legal requirements in a few exceptional cases. The hydrogen core network will be built resiliently and should enable free allocability between entry and exit areas. To this end, the transmission system operators have modelled several load cases for the hydrogen core network, as described in section 6.4, in order to test the hydrogen entry and exit capacities for free allocability. The load flows within the hydrogen core network are therefore only clear for a few pipeline sections. Moreover, it must be possible to connect every feed-in point to every exit point for balancing purposes, which will contribute directly to the decarbonization of all branches of industry. This also applies to the same extent to the pipelines and pipeline sections that connect these feed-in points. A "transmission pipeline", which is located in the middle of the hydrogen core network, is also necessary for a large-scale supply and therefore fulfils a large number of the requirements specified in the law. A more specific allocation, for example to individual customer groups, is only possible for a "regional pipeline", which is located at the edge of the hydrogen core network and does not connect any feed-in points.

A clear allocation of the measures to the legal requirements therefore brings uncertainties. In particular, the allocation of measures in the hydrogen core network to the specific hydrogen entry and exit projects (see Annex 1) is not possible for the reasons mentioned.

Annex 6: Detailed map of the hydrogen core network

Annex 6 provides a detailed cartographic representation of the pipelines of the transmission system operators considered as a result of the modelling of the hydrogen core network as well as the pipelines of the other potential hydrogen network operators considered. The map has a high resolution and contains a search function for locating the individual pipeline sections using their ID numbers from Annexes 2 to 4.

Glossary

bar(g)	Pressure referred to sea level
BDEW	German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft e.V.)
BKAmt	Federal Chancellery (Bundeskanzleramt)
BMF	Federal Ministry of Finance (Bundesministerium der Finanzen)
BMWK	Federal Ministry of Economics and Climate Protection (Bundesministerium für Wirtschaft und Klimaschutz)
BNetzA	Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen)
CEF	Connecting Europe Facility
CHP	Combined heat and power generation
CO_2	Carbon dioxide
DSO	Distribution system operator
e	electric
EEZ	Exclusive Economic Zone
EnWG	Energy Industry Act
EU	European Union
EU Commission	European Commission
FAC	Firm freely allocable capacity
FNB Gas	Association of German Transmission System Operators (Vereinigung der Fernleitungsnetzbetreiber Gas e.V.)
GPRM	Gas pressure regulating and metering systems
HPD 2021	(Market survey) Hydrogen production and demand *("Marktabfrage – Wasserstoff Erzeugung und Bedarf" (WEB))*
IP	Cross-border interconnection point
GW	Gigawatt
GWh	Gigawatt hour
IPCEI	Important Project of Common European Interest
MW	Megawatt
NDP	Network development plan
NHS	National Hydrogen Strategy
No.	Number
Para.	Paragraph
PCI	Projects of Common Interest

PMI	Projects of Mutual Interest
PtJ	Project Management Organization Jülich
SEN	Other North Sea energy production area, area earmarked for the production of hydrogen from wind power
SLP	Standard load profile
th	Thermal
TWh	Terawatt hour
TSO	Transmission system operator

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