FNB Gas
DIE FERNLEITUNGSNETZBETREIBER

Gas Network Development Plan 2022–2032

Consultation

Summary

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| Legal disclaimer

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Date: 21 December 2022

Foreword

Dear Reader,

The Russian war of aggression in Ukraine is profoundly changing the energy situation in Germany and Europe. There is talk of a new era, not only in terms of security policy, but also in terms of energy policy. The changed situation makes it necessary to diversify our energy sources to a much greater extent and to further accelerate the transition from natural gas to green and carbon-neutral gases such as hydrogen. Consequently, new supply sources such as liquefied natural gas (LNG) will have to be integrated into the transmission network. Furthermore, load flows will be partially or even completely reversed, while the use of conventional natural gas will be reduced and gradually replaced by green gases such as hydrogen. These changes will have a significant impact on gas network development planning. In consultation with the Bundesnetzagentur (BNetzA – Federal Network Agency), the transmission system operators have considered these new challenges in the present Gas Network Development Plan (NDP) 2022–2032 by incorporating the LNG and LNGplus security of supply variants and the hydrogen variant.

In July 2022, the transmission system operators had already published an interim status on the Gas Network Development Plan 2022–2032. It included the basic variant based on the Scenario Framework confirmed in January 2022 as well as the LNG security of supply variants for partial replacement of Russian natural gas volumes. The hydrogen variant was also already part of the NDP interim status.

In September 2022, the transmission system operators supplemented their scenario framework to reflect a current gas demand development and the complete replacement of Russian natural gas volumes with LNG and hydrogen in their network modelling. After consulting, parts of the scenario framework were revised by the BNetzA.

Due to the special circumstances, the current Gas Network Development Plan 2022–2032 is not a normal network development plan in scope and nature. Generally, the planning process is not designed to provide short-term answers to current events. Instead, it usually represents a medium- to long-term perspective of network development planning. Due to the particular challenges of the time, the transmission system operators are striving to provide initial answers to the current crisis with this Gas Network Development Plan.

The transmission system operators are working intensely to adapt the transmission network as quickly as possible to the changed geopolitical and energy sector conditions. Their goal is to continue to ensure secure and, in the future, carbon-neutral gas transport. The development of the hydrogen infrastructure is particularly important in this regard. The transmission system operators are ready to further advance the development of the hydrogen infrastructure. A lack of regulatory framework conditions, especially in connection with financing of the infrastructure, and the avoidance of introducing integrated hydrogen and gas network planning are increasingly proving to be impede the development of the urgently needed infrastructure.

Without networks, the ramp-up of the hydrogen economy and thus the carbon-neutral supply of our industries cannot succeed. Other sectors, such as the heating market and the transport sector, are also affected by it. The existing gas infrastructure at the transmission level and at the distribution network level lays the foundation for development of this hydrogen infrastructure. It functions as the backbone for the rapid and socially acceptable achievement of our ambitious climate targets. The objective of gas network development planning is to pave the way for this transition from natural gas to hydrogen and other green gases. In this regard, the transmission system operators propose a concept in Chapter 10 on how the climate policy goals can be reflected even better in the future within the gas network development planning. In this sense, the transmission system operators will also be actively involved in the process of developing the German government's system development strategy. One of our expectations of the process is the introduction of an upstream energy scenario process. It should provide a common scenario basis in the form of uniform assumptions and thus consistent input parameters, e.g. for demand forecasts and targets as well as for electricity and gas (hydrogen and methane) network planning. The respective scenario frameworks for the electricity network development plan and gas network development plan (hydrogen and methane) could then be based on these energy scenarios in the future. The transmission system operators have presented additional concept proposals for future integrated hydrogen network planning in their Hydrogen Report published on 1 September 2022.

This document is a summary; the binding document is exclusively the German version of the consultation document of the Gas Network Development Plan 2022–2032.

Lastly, the transmission system operators would like to thank the other potential hydrogen network operators for their active participation and Prognos AG for its support.

Best regards,

Your transmission system operators

Executive Summary

In this consultation document on the Gas Network Development Plan 2022–2032, the transmission system operators present the results of the Network Development Plan and thus fulfil the requirements of the Energiewirtschaftsgesetz (EnWG – Energy Industry Act) and the Gasnetzzugangsverordnung (GasNZV – Gas Network Access Ordinance). This Gas Network Development Plan is based on the scenario framework prepared by the transmission system operators and confirmed by the BNetzA on 20 January 2022. It is also based on the scenario framework supplemented by the transmission system operators with three modelling variants, which was also publicly conferred and confirmed by the BNetzA in a decision on 11 November 2022.

By expanding the already confirmed scenario framework with a supplemented scenario framework, the transmission system operators decided to adjust the gas demand development for additional modelling variants against the backdrop of geopolitical developments and the ongoing decarbonisation of energy supply. Overall, a 20 % decrease in natural gas consumption was assumed over the period under consideration until 2032.

Due to the significant changes in physical load flows in the German and European transmission system compared to the previous Gas Network Development Plan, the focus of the Gas Network Development Plan 2022–2032 is on ensuring security of supply and diversification of import sources, in particular the short-term and accelerated connection of LNG terminals.

Therefore, three LNGplus security of supply variants, three LNG security of supply variants, one hydrogen variant and the base variant were considered in the Gas Network Development Plan 2022–2032.

In the previous network development planning, the required network expansion measures were determined for the fifth and tenth year in the respective Network Development Plan. Deviating from this procedure, the transmission system operators have determined the required network expansion measures of the LNGplus security of supply variants for the year 2032 in accordance with the new partial decision for the confirmation of the Scenario Framework 2022 and, on the basis of the existing regulatory framework, assumed the fastest possible commissioning for them. Network expansion measures can be completed much faster if the conditions for accelerated project progress are met, e.g., by inclusion in the Gesetz zur Beschleunigung des Einsatzes verflüssigten Erdgases (LNGG – Act to Accelerate Use of Liquefied Natural Gas). However, this has not yet been the case for all LNGplus measures.

In the new partial decision of the Scenario Framework 2022, the BNetzA instructed the transmission system operators to determine the solution with the lowest possible network expansion while simultaneously implementing the necessary network expansion measures as quickly as possible.

Security of supply variant LNGplus A has significantly higher network expansion costs compared to security of supply variants LNGplus B and C. Moreover, implementation of parts of the necessary network expansion measures can only take place later. Furthermore, the performance and volume balances show that the requested 182 GWh/h for LNG terminals are not required for the supply of Germany and the neighbouring European countries. Therefore, security of supply variant LNGplus A cannot be considered as a network expansion proposal.

Security of supply variants LNGplus B and C differ with regard to Germany's supply routes. In the LNGplus B security of supply variant, Germany is increasingly supplied via direct LNG imports from the North Sea and Baltic Sea coasts. Conversely, in the LNGplus C security of supply variant, Germany is increasingly supplied via LNG capacities from neighbouring European countries.

The goal of the security of supply variants LNGplus is to quickly increase the available entry capacity and simultaneously identify an efficient and sustainable network expansion. The transmission system operators meet this objective with a view to the current status of LNG terminal planning. The network expansion measures for the provision of LNG capacities should be largely realised by 2026. Full implementation of all network expansion measures is planned by 2028. The prerequisite for an accelerated project development are significantly shorter approval procedures. This can be achieved, for example, by including the measures in the LNGG. owever, this has not yet been the case for all LNGplus measures.

The LNGplus security of supply variants LNGplus B and C describe network expansion measures in which the capacity of new LNG terminals as well as existing capacities via western cross-border interconnection points can be used. The transmission system operators point out that, depending on the actually implemented LNG systems and their planned entry capacities, the required network expansion may change due to the framework conditions, which have not been conclusively clarified, as well as due to future political decisions. In addition to future political decisions, this dynamic is particularly attributable to the fact that only some of the implementation schedules for the capacity expansion requirement under section 39 GasNZV have been completed to date. From today's perspective, the completion of the outstanding implementation schedules is still subject to uncertainties and strongly influences the respective LNG locations and the associated network expansion measures.

The results of the LNGplus security of supply variants are broken down as follows:

Table 1: Results of the LNGplus security of supply variants until the end of 2032

Summary of the results of the LNGplus variants	LNGplus variant A	LNGplus variant B	LNGplus variant C
Pipeline [km]	1,062	805	805
Compressor stations (additional capacity and necessary reversals) [MW]	249	165	175
Investments [in EUR billion]*	5.4	4.1	4.2
– Network expansion measures from the Gas Network Development Plan 2020–2030 (without LNG)	1.8	1.8	1.8
– LNG measures	3.2	1.9	1.9
– Further new network expansion measures from the Gas Network Development Plan 2022–2032	0.4	0.4	0.4

*rounded values

Source: Transmission system operators

Since security of supply variants LNGplus B and C require similar investment costs in the transmission network, the transmission system operators are initially refraining from formulating a specific network expansion proposal. For the time being, they would also like to put the network expansion measures of security of supply variants LNGplus B and C out for consultation.

The transmission system operators plan to formulate a network expansion proposal, taking into account the consultation results and other comments on the draft document of the Network Development Plan Gas 2022–2032.

The L-to-H-gas conversion planning is well advanced and has already been finalised to a large extent. The development of the L-gas supply was also assessed against the background of a security of supply scenario. The transmission system operators are still in close contact with the respective distribution system operators, the BNetzA and the Bundesministerium für Wirtschaft und Klimaschutz (BMWK – German Federal Ministry of Economics and Climate Protection).

Furthermore, the hydrogen variant in the Gas Network Development Plan 2022–2032 was created and modelled jointly by the transmission system operators and other potential hydrogen network operators in an open and transparent process. Based on the demand reports from the survey 'Wasserstoffabfrage Erzeugung und Bedarf und Grüne Gase ('Hydrogen Generation and Demand and Green Gases Market Survey; WEB Market Survey) carried out in spring 2021, a demand-oriented Germany-wide hydrogen network was determined. An annual transport demand of 165 TWh can be met by the modelled network. This is accomplished by including more than 250 projects with whose project sponsors the transmission system operators or other potential hydrogen network operators have concluded Memoranda of Understanding (MoU). The results of the hydrogen modelling are presented in the table below:

Table 2: Results of hydrogen modelling

	Until end of 2027	Until end of 2032
Mainline compressor	0–25 MW	0–245 MW
Lead compressor	0 MW	0–100 MW
Pipelines	2,900–3,000 km	7,600–8,500 km
Investments	**EUR 2.3–2.8 billion**	**EUR 8.1–10.2 billion**

Source: Transmission system operators and other potential hydrogen system operators

Taking into consideration that there is a tenfold increase in hydrogen transport demand compared to the last Gas Network Development Plan, the hydrogen network 2032 presents a significant advancement. This requires investments of up to EUR 2.8 billion by 2027 and up to EUR 10.2 billion by 2032.

These plans are a specific proposal for a domestic and, in the long term, European hydrogen network. However, realisation of this hydrogen network is still subject to a change in the existing legal and regulatory framework. Nevertheless, the transmission system operators consider the development of a hydrogen infrastructure to be more urgent than ever.

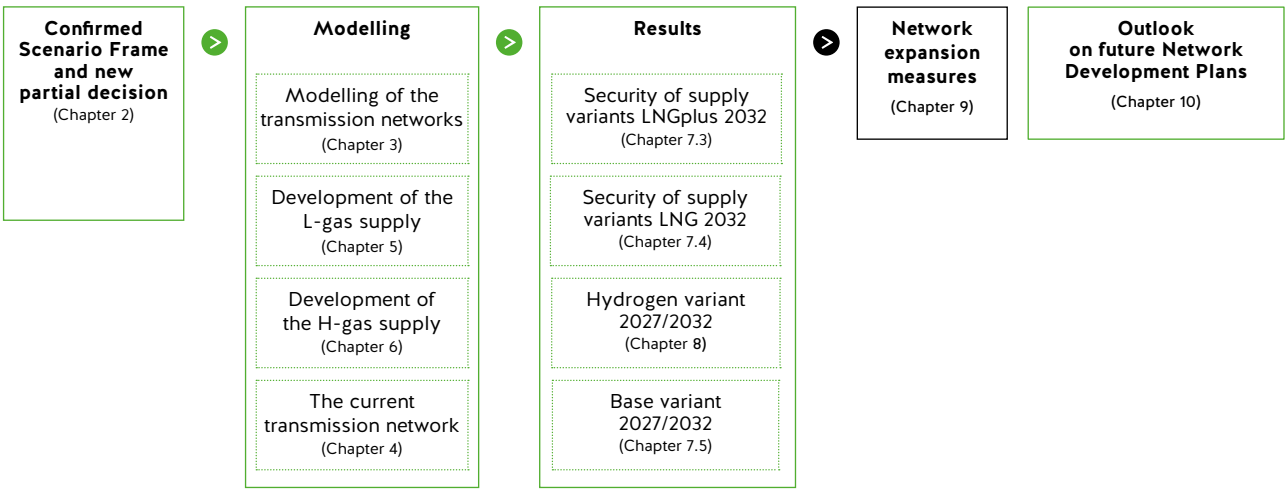
1 Introduction

Pursuant to section 15a of the Energiewirtschaftsgesetz (EnWG – Energy Industry Act), the German transmission system operators are mandated to prepare a joint Network Development Plan (NDP) in every even calendar year and to submit it to the Bundesnetzagentur (BNetzA – Federal Network Agency) as the competent national regulatory authority.

The consultation document for the Gas Network Development Plan 2022–2032 was published on the FNB Gas website (www.fnb-gas.de) on 16 December 2022. In a public consultation from 16 December 2022 to 31 January 2023, the public and the market are given the opportunity to comment. The transmission system operators are planning to hold a web-based workshop on 24 January 2023, during which the the Gas Network Development Plan 2022–2032 will be explained.

The transmission system operators provide the public with a database containing input data for modelling, measures and further details on the Gas Network Development Plan 2022–2032 at www.nep-gas-datenbank.de. The following figure shows an overview of the basic structure of the Gas Network Development Plan 2022–2032.

Figure 1: Overview of the basic structure of the Gas Network Development Plan 2022–2032



Source: Transmission system operators

2 Confirmed Scenario Framework for the Gas Network Development Plan 2022–2032 and new partial decision

The BNetzA confirmed the draft Scenario Framework [FNB Gas, SR 2021a] revised by the transmission system operators following the consultation, with amendments and conditions on 20 January 2022 [BNetzA 2022].

Due to geopolitical developments, the BNetzA issued a new partial decision on the confirmed Scenario Framework 2022 on 11 November 2022. Accordingly, the transmission system operators were asked to calculate three further modelling variants (LNGplus variants). The basis of the LNGplus security of supply variants are the input parameters of the confirmed Gas Scenario Framework 2022, however, no injection of Russian gas volumes is assumed for the supply of Germany as well as for transits from Russia. Sufficient supply to neighbouring countries must be ensured in the LNGplus supply security variants. To compensate for the Russian gas volumes, entry capacities from German LNG terminals and at Western European cross-border interconnection points are to be assumed. In addition, a 9.4 % decrease in the exit capacity of the distribution system operators and industrial customers is to be assumed for 2032 compared to 2021 in accordance with the new partial decision. Furthermore, an additional reduction in natural gas consumption through the substitution of methane with hydrogen must be taken into account. The LNGplus security of supply variants are the focus of the Gas Network Development Plan 2022–2032. The summary therefore concentrates on presenting the results of these modelling variants.

The transmission system operators have taken the BNetzA's requirements into account in the Gas Network Development Plan 2022–2032.

3 Modelling of the transmission system

The transmission system operators have further developed the methodology that was jointly designed in the previous Network Development Plans for the Germany-wide modelling of the transmission system in the Gas Network Development Plan 2022–2032.

Starting point for every modelling variant is determining the relevant input parameters for the network modelling. The conversion areas are subsequently identified and the L-gas capacity and quantity balance is drawn up in the course of the analysis of the L-gas supply. The next step involves drawing up the H-gas capacity balance and, as a result, determining the additional H-gas capacity demand. Based on the results of the distribution of H-gas sources, the required additional H-gas demand is subsequently allocated to the regions and, using certain criteria, to the cross-border interconnection points. The network modelling of the transmission system operators is then carried out on the basis of these values.

The input parameters for the network modelling include basic data that is taken from a variety of sources. The capacity reservations and capacity expansion claims available to the transmission system operators pursuant to sections 38 and 39 GasNZV as well as the WEB Market Survey for hydrogen projects play an important role. Other important input variables is the capacity demand of the distribution system operators, power plants/industry, storage facilities, the volume of biomethane, hydrogen and synthetic methane, the capacities at German cross-border interconnection points/LNG terminals and the H-gas source distribution.

Modelling variants

The Gas Network Development Plan 2022–2032 focuses on the LNGplus security of supply variants, these are described in the following table.

Table 3: Overview of the modelling variants

Modelling variant	LNGplus variant A	LNGplus variant B	LNGplus variant C
Calculation	complete 2032		
Reference date (capacity provision)	31 December 2032		
Distribution system operator (internal orders)	Start value of internal orders 2022; capacity reduction until 2032 related to the start value of internal orders according to Chapter 3.2.1		
H-gas sources	LNG and western cross-border interconnection points completely replace Russian injections, approach according to Chapter 6.1		
IP/VIP	no Russian natural gas transits; supply of South Eastern Europe via IP to the Czech Republic, approach according to chapter 6.1	No exit capacity at IP to Belgium, France, Denmark and the Netherlands; no Russian natural gas transits; supply of South Eastern Europe via IP to the Czech Republic, approach according to chapter 6.1	
MBI deployment	No calculation		
L-to-H-gas conversion	Modelling of the conversion areas including conversions until 2033 to determine the required network expansion measures until 31 December 2032		
Underground gas storage	Existing capacity according to database cycle '2022 – NDP Consultation', new storage facilities according to Chapter 3.2.4: 100 % bFZKtemp		
Power plants	Existing capacity according to database cycle '2022 – NDP Consultation', interruptible Directly connected system-relevant power plants and new power plants according to Chapter 3.2.2, 100 % fDZK		
LNG	Full consideration of all requests pursuant to sections 38/39 of the GasNZV as of 30 September 2022	Prioritised, needs-based consideration of German LNG capacities in accordance with Chapter 3.2.6	Prioritised, needs-based consideration of additional capacities at western cross-border interconnection points according to Chapter 3.2.6
Production	Inventory according to database cycle '2022 – NDP Consultation', taking the BVEG forecast according to Chapters 2 and 5 into consideration		
Industry	Capacity reduction according to Chapter 3.2.3		
Biomethane and synthetic methane	Inventory according to database cycle '2022 – NDP Consultation', new construction according to Chapters 6 and 8		
Hydrogen	Inventory according to database cycle '2022 – NDP Consultation'		

Source: Transmission system operators

4 The current transmission system

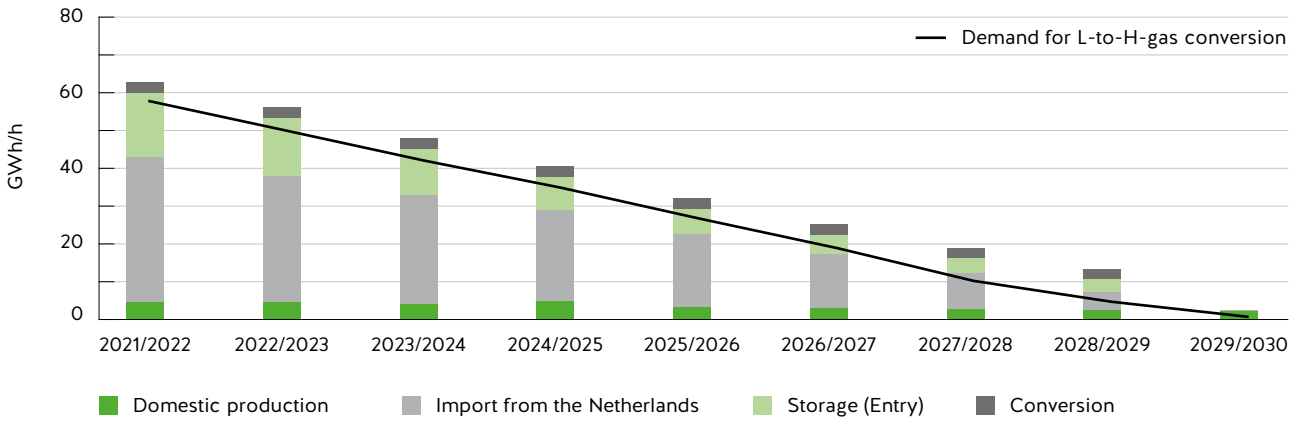
This chapter describes the current transmission system. In addition, and in accordance with Section 15a (2) EnWG, the implementation status of already confirmed NDP measures of the previous Gas Network Development Plan (reporting date: 1 January 2022) are shown. In the course of this update on the implementation status, a total of 123 measures were considered. In the Gas Network Development Plan 2022–2032, a total of 49 measures met the requirement for inclusion in the initial network. Compared to the 2021 implementation report, 27 measures have been commissioned and 17 measures are currently under construction. For 10 measures, there was a planned change in the commissioning date. For 16 measures, delays that had occurred and were foreseeable were reported.

5 Development of the L-gas supply

Part of the German gas market is supplied with low calorific value natural gas (L-gas). L-gas originates entirely from production in Germany and the Netherlands. The decline in Germany's domestic production and strongly declining supplies from the Netherlands result in reduced availability of L-gas on the German market, in terms of both the annual quantities available in Germany as well as the entry capacities. On this matter the German transmission system operators take part in regular meetings with all involved parties, in particular with the Dutch transmission system operator Gasunie Transport Services B.V. (GTS), in order to harmonise and update the planning assumptions for future L-gas imports.

The transmission system operators updated th Germany-wide L-gas capacity balance (cf. Figure 2).

Figure 2: Germany-wide capacitive L-gas balance



Source: Transmission system operators

Overall, the conversion volume implemented in Germany since 2015 corresponds to an annual consumption volume of around 89 TWh and a capacity of 24 GWh/h (reporting date: 1 October 2021).

The further conversion planning up to 2030 takes into account the available detailed plans of the distribution system operators. It was concretised in full and on a year-by-year basis. As a result, conversions of more than half a million appliances a year are planned for the next few years. Up to 2030, the L-gas supply area will be strongly reduced and will then only entail areas close to German production. An overview of the conversion planning is included in the Gas Network Development Plan. Further details are published in the NDP gas database.

6 Development of the H-gas supply

The framework conditions for network planning in Germany have changed fundamentally in 2022. Specifically, the replacement of Russian gas imports and the political objective of building LNG terminals in Germany will have a considerable impact on future network planning. Accordingly, due to the current geopolitical situation, which will change the energy system in the long term, as well as the requirement of the BNetzA in accordance with the partial new decision to confirm the 2022 Scenario Framework, the transmission system operators have carried out network calculations within the scope of the LNGplus security of supply variants.

For the different modelling variants, H-gas power balances were prepared and presented in the Gas Network Development Plan 2022–2032. In the LNGplus security of supply variants, the consideration of German LNG terminals and additional FZK capacities at cross-border interconnection points in the year 2032 varies (see table 4).

Table 4: LNGplus variants – capacity approach in 2032

Entry points of the LNGplus variants	LNGplus variant A	LNGplus variant B	LNGplus variant C
	GWh/h		
Bunde/Oude	–	0.6	12.2
Ellund	–	–	2.3
Eynatten/Raeren/Lichtenbusch	–	4.0	8.2
Medelsheim	–	4.2	4.2
LNG – Wilhelmshaven	48.1	26.0	26.0
LNG – Lower Elbe	61.1	27.5	27.5
LNG – Baltic Sea	72.8	29.7	11.6

Source: Transmission system operators

7 Results of the modeling variants

The results of the LNGplus security of supply variants are composed as follows:

Table 5: Results of the LNGplus security of supply variants until the end of 2032

Summary of the results of the LNGplus variants	LNGplus variant A	LNGplus variant B	LNGplus variant C
Pipeline [km]	1,062	805	805
Compressor stations (additional capacity and necessary reversals) [MW]	249	165	175
Investments [in EUR billion]*	5.4	4.1	4.2
– Network expansion measures from the Gas Network Development Plan 2020–2030 (without LNG)	1.8	1.8	1.8
– LNG measures	3.2	1.9	1.9
– Further new network expansion measures from the Gas Network Development Plan 2022–2032	0.4	0.4	0.4

* rounded values

Source: Transmission system operators

The resulting network expansion measures are listed in detail in the NDP gas database and are presented in full in the Gas Network Development Plan 2022–2032.

Necessary regulatory requirements

The preparation and modelling of the Gas Network Development Plan 2022–2032 is currently heavily overshadowed by the geopolitical events in Europe due to Russia's war of aggression on Ukraine. Since the adoption of the Scenario Framework in January 2022, politicians and the BNetzA have repeatedly defined new and fundamentally effective supply premises to be solved. The ultimate goal is to completely avoid imports of Russian natural gas.

Even though the final expansion programme of the Gas Network Development Plan 2022–2032 is far from being fixed, it is already clear at this point that the transmission system operators will face extraordinary challenges to make multi-billion euros investments as quickly as possible in order to substitute the natural gas deliveries from Russia that have so far arrived at Germany's eastern border with LNG deliveries at the northern and western German borders. This will require a massive conversion of the German natural gas system in order to continue to guarantee the security of supply in Germany.

At the same time, the transmission system operators are facing another challenge: The increasingly ambitious climate protection goals in Europe and Germany make it seem certain that natural gas transport on its current scale will no longer be in demand from 2045 onwards while maintaining the 'CO_2-net-zero target'. However, the current regulatory system of the EnWG and the Gasnetzentgeltverordnung (GasNEV - Gas Network Charges Ordinances) provides for imputed amortisation periods of 55 to 65 years for steel pipelines. A pipeline whose construction has thus gone into operation by 2022 can therefore only expect full amortisation by 2077 – depending on the year of commissioning. This example illustrates that transmission system operators run the risk of no longer being able to amortise their assets – at least if they cannot be expected to be used for hydrogen transport. In the meantime, the BNetzA has addressed this issue. With its definition of imputed useful lives of natural gas pipeline infrastructures ('KANU') (BK9-22/614), the agency has permitted significant flexibility to the useful lives for all assets that will be capitalised from 2023 onwards. For LNG connection facilities, this applies to all assets capitalised from 2022 onwards. The transmission system operators expressly welcome this move, although a corresponding flexibility is also necessary for existing facilities.

The investment measures are intended to create the transport capacities to facilitate technical and physical transfer of the LNG volumes to the gas transmission system within the meaning of section 39b(3) sentence 2 GasNZV. Additionally, they are intended to bring them to all demanders at any time in the German entry/exit transport system. Consequently, it is necessary to confirm that the expansion projects are permanently necessary for operation as defined in the EnWG and are assessed as permanently efficient network expansion by the BNetzA. The latter is also highly relevant, since these expansions must not be at the expense of the efficiency of the expanding network operators, even after a possible settlement of the war activities and the associated possible resumption of the gas supply from the Russian Federation or other producing regions. Although such a development may seem difficult to imagine today, it can by no means be ruled out given the very long payback period.

8 Hydrogen variant

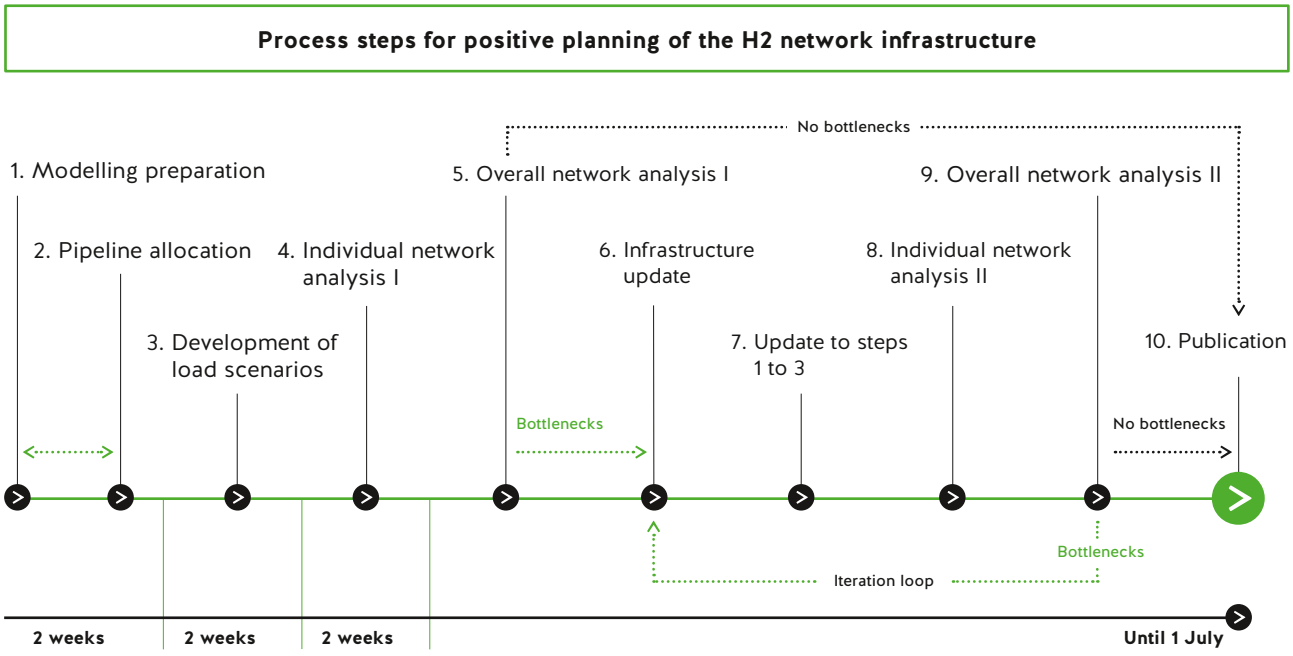
Basic procedure

In order to exploit existing infrastructure potential as early as possible, the transmission system operators have invited other potential hydrogen network operators via several calls to actively participate in the modelling of a national hydrogen network. In this way, as much of the existing infrastructure as possible is included in the hydrogen network modelling process.

The determined hydrogen network of the hydrogen modelling is based on the underlying MoU demands (cf. Appendix 2). It is also aligned with the results of the Gas Network Development Plan 2020–2030 and the pipeline reports of the transmission system operators and other potential hydrogen network operators as well as with existing parallel pipeline systems in the transmission network. Based on this information, an examination was carried out to determine which routes are suitable for the construction of a hydrogen network.

The entire process flow from modelling preparation to publication of the results is shown in schematic form in Figure 3:

Figure 3: Process steps for positive planning of the hydrogen network infrastructure



Source: Transmission system operators and other potential hydrogen network operators

Modelling for the hydrogen variant

The modelling for the hydrogen variant was carried out for the years 2027 and 2032. This summary concentrates on the year 2032 in the presentation of results.

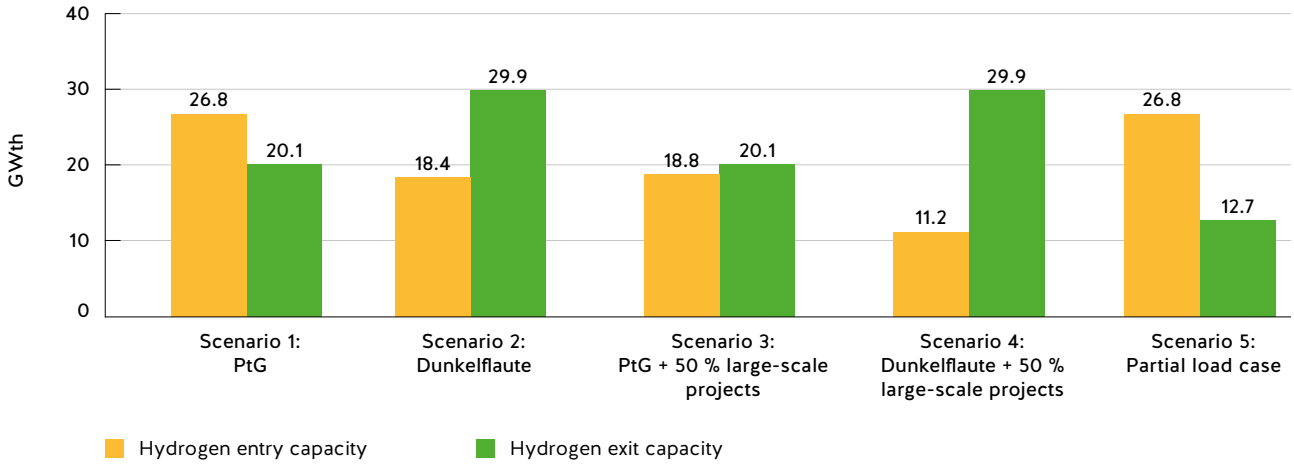
A review of scenarios is necessary for the design of the hydrogen network for strongly changing load situations. Based on the results of the WEB Market Survey with concluded MoU published in Appendix 2 [FNB Gas, SR 2021b], the transmission system operators, in coordination with the other potential hydrogen network operators, have defined the following five scenarios for preparation of the hydrogen balances in addition to the results of the WEB Market Survey according to Appendix 2 [FNB Gas, SR 2021b]:

- Scenario 1: PtG,
- Scenario 2: Dunkelflaute,
- Scenario 3: PtG + 50 % large-scale projects,
- Scenario 4: Dunkelflaute + 50 % large-scale projects,
- Scenario 5: Partial load case.

Key assumptions for the load situations are either the existence of an electricity surplus, so that hydrogen can be produced, or a power shortage (‘Dunkelflaute’) resulting in low hydrogen production from electrolysers.

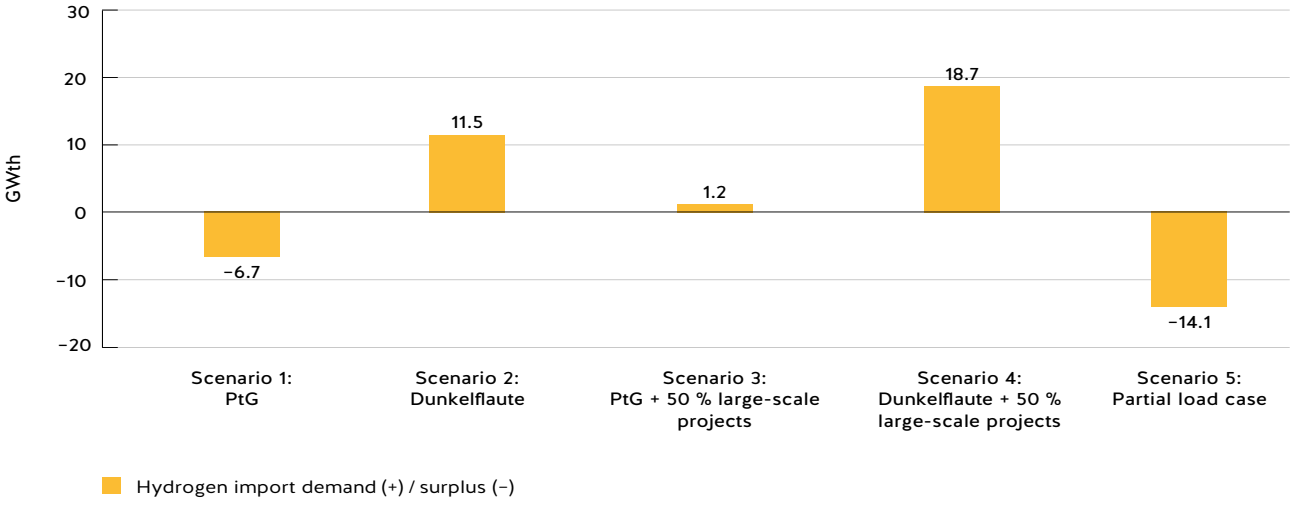
The respective entry and exit capacities in the corresponding scenarios for the largely interconnected Germany-wide hydrogen network in the year 2032 are presented in the following Figure. The scenarios represent a broad spectrum of balance surplus and shortfalls, with the balance shortfall being greatest in scenario 4 (‘Dunkelflaute’ + 50 % large-scale projects).

Figure 4: Hydrogen balance – entry/exit capacities 2032 for the Germany-wide network



Source: Transmission system operators and other potential hydrogen system operators

Figure 5: Hydrogen balances – entry/exit capacities 2032 by scenario



Source: Transmission system operators and other potential hydrogen system operators

In the 'Dunkelflaute + 50 % large-scale projects' scenario, the additional hydrogen demand in Germany is around 18.7 GW. Since it can be assumed that the German entry potential was reported by the project developers and storage operators in the WEB Market Survey, the additional demand must be covered by imports.

The following information sources were analysed to assess and evaluate the neighbouring potential countries for hydrogen imports:

- The comments submitted during the consultation on the Scenario Framework of the Gas Network Development Plan 2022–2032,
- The project registrations from abroad submitted as part of the WEB Market Survey,
- Information from existing studies on potential supply sources, in particular the European Hydrogen Backbone Initiative (EHB) study,
- Information from discussions with potential project sponsors and foreign transmission system operators,
- Information from press releases and other publications.

Based on this information, the following assessments were made with regard to consideration of neighbouring countries in the hydrogen source allocation:

- Denmark: 2.0 GW,
- Norway: 5.0 GW,
- Netherlands: 5.9 GW,
- Belgium: 3.8 GW,
- Czech Republic 2.0 GW.

For the years 2027 and 2032, additional subnetworks were modelled, individually examined and subjected to a balance analysis and a fluid mechanics analysis.

Results of the hydrogen variant

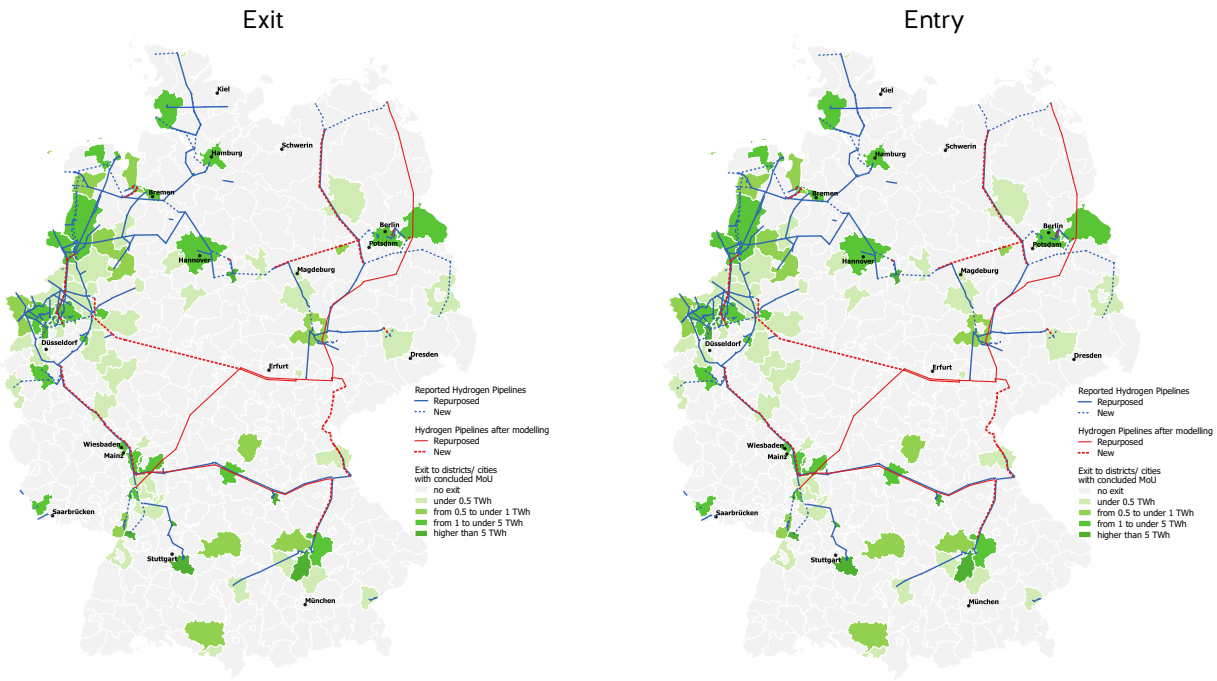
Overall, the hydrogen modelling leads to the following results.

Table 6: Results of the hydrogen modelling

	Until end of 2027	Until end of 2032
Mainline compressor	0–25 MW	0–245 MW
Lead compressor	0 MW	0–100 MW
Pipelines	2,900–3,000 km	7,600–8,500 km
Investments	**EUR 2.3–2.8 billion**	**EUR 8.1–10.2 billion**

Source: Transmission system operators and other potential hydrogen system operators

Figure 6: Network expansion measures hydrogen variant 2032



Note: Alternative expansion measures to fulfil the same transport task within a hydrogen corridor are not shown in the expansion maps. However, they are described in Appendix 3.

Source: Transmission system operators and other potential hydrogen system operators, schematic form

9 Network expansion proposal

In order to reduce Europe's dependence on Russian gas imports and to build the necessary transport infrastructure for LNG imports, the measures to expand the transport network require considerable financial resources, which must be provided by the transmission system operators. The costs arising from the network expansion are passed on via the network charges. All those involved in the development of the Gas Network Development Plan must therefore pay particular attention to ensuring that the network expansion makes overall economic sense from a long-term perspective. They must also ensure that it remains economically reasonable for the investing companies in light of the ever shorter commitment periods of transport customers. Above all, this requires a stable and sustainable regulatory framework with a risk-adequate interest rate and appropriate depreciation periods.

This Chapter considers the network expansion measures identified by the transmission system operators as part of the Gas Network Development Plan 2022–2032. The measures required to connect the LNG terminals to the transmission network are shown for information purposes only. Therefore, the associated costs for the LNG connection measures are in addition to the investment amounts shown in Table 7.

In the previous network development planning, the required network expansion measures were determined for the fifth and tenth year in the respective Network Development Plan. Deviating from this procedure, the transmission system operators have determined the required network expansion measures of the LNGplus security of supply variants for the year 2032 in accordance with the new partial decision for the confirmation of the Scenario Framework 2022 and, on the basis of the existing regulatory framework, assumed the fastest possible commissioning for them. Network expansion measures can be completed much faster if the conditions for accelerated project progress are met, e.g., by inclusion in the LNGG. However, this has not yet been the case for all LNGplus measures.

In the new partial decision of the Scenario Framework 2022, the BNetzA obligated the transmission system operators to determine the solution with the lowest possible network expansion while simultaneously implementing the necessary network expansion measures as quickly as possible.

Security of supply variant LNGplus A has significantly higher network expansion costs compared to security of supply variants LNGplus B and C. Moreover, implementation of parts of the necessary network expansion measures can only take place later. Furthermore, the capacity and quantity balances show that the requested 182 GWh/h for LNG terminals are not required for the supply of Germany and the neighbouring European countries. Therefore, security of supply variant LNGplus A will not be considered as a network expansion measures.

Security of supply variants LNGplus B and C differ with regard to Germany's supply routes. In the LNGplus B security of supply variant, Germany is increasingly supplied via direct LNG imports from the North Sea and Baltic Sea coasts. Conversely, in the LNGplus C security of supply variant, Germany is increasingly supplied via LNG capacities from neighbouring European countries.

With approximately EUR 4.1 billion, the **LNGplus B security of supply variant** is slightly cheaper than the LNGplus C security of supply variant with a cost of approximately EUR 4.2 billion, since it requires less investment in the transport infrastructure.

Security of supply variant LNGplus B thus meets the BNetzA's objective from the new partial decision of the Scenario Framework 2022 to determine the most efficient solution from a network perspective from security of supply variants LNGplus B and C. From the BNetzA's point of view, this means choosing the lowest possible network expansion while simultaneously implementing the necessary network expansion measures as quickly as possible.

The direct LNG import options for Germany are higher than in security of supply variant LNGplus C. Moreover, higher eastern LNG injection is favourable for utilisation of the existing transport infrastructure in Germany.

With approximately EUR 4.2 billion, the **LNGplus C security of supply variant** is slightly more expensive than the LNGplus B security of supply variant with a cost of approximately EUR 4.1 billion.

By increasing cross-border capacities to our neighbouring countries in Western Europe, the LNGplus C supply security variant largely uses existing infrastructure and LNG terminals in the respective neighbouring countries. Because of the geographically widely distributed Western European cross-border interconnection points and German LNG injections in the LNGplus C security of supply variant, the transmission system operators see an advantage over the larger LNG injections limited to the three clusters Wilhelmshaven, Unterelbe and Ostsee in the LNGplus B security of supply variant in terms of flexibility and diversification of the various import routes, security for critical infrastructure and thus also for security of supply.

Since security of supply variants LNGplus B and C require similar investment costs in the transmission network, the transmission system operators are initially refraining from formulating a specific network expansion proposal and would like to put the network expansion measures of security of supply variants LNGplus B and C out for consultation.

The transmission system operators plan to formulate a network expansion proposal, taking into account the consultation results and other comments on the draft document of the Network Development Plan Gas 2022–2032.

The goal of the security of supply variants LNGplus is to quickly increase the available entry capacity and simultaneously identify an efficient and sustainable network expansion. The transmission system operators meet this objective with a view to the current status of LNG terminal planning. The network expansion measures for the provision of LNG capacities should be largely realised until 2026. Full implementation of these network expansion measures is planned by 2028. The prerequisite for an accelerated project development are significantly shorter approval procedures. This can be achieved, for example, by including the measures in the LNGG. However, this is so far not the case for all LNGplus measures.

Security of supply variants LNGplus B and C describe network expansion measures in which the capacity of new LNG terminals as well as existing capacities via western cross-border interconnection points can be used. The transmission system operators point out that, depending on the actually implemented LNG systems and their planned entry capacities, the required network expansion may change due to the framework conditions, which have not been conclusively clarified, as well as due to future political decisions. In addition to future political decisions, this dynamic is particularly attributable to the fact that only some of the implementation schedules for the capacity expansion requirement under section 39 GasNZV have been completed to date. From today's perspective, the completion of the outstanding implementation schedules is still subject to uncertainties and strongly influences the respective LNG locations and the associated network expansion measures.

The detailed cost breakdown for the expansion of the transport infrastructure is as follows:

Table 7: Network expansion measures of the transmission system operators until the end of 2032

Summary of the results of the LNGplus variants	LNGplus variant A	LNGplus variant B	LNGplus variant C
Pipeline [km]	1,062	805	805
Compressor stations (additional capacity and necessary reversals) [MW]	249	165	175
Investments [in EUR billion]*	5.4	4.1	4.2
– Network expansion measures from the Gas Network Development Plan 2020–2030 (without LNG)	1.8	1.8	1.8
– LNG measures	3.2	1.9	1.9
– Further new network expansion measures from the Gas Network Development Plan 2022–2032	0.4	0.4	0.4

*rounded values

Source: Transmission network operators

A list of the network expansion measures can be found in Appendix 6. All details on the network expansion measures, connection measures and the initial network measures are contained in the NDP gas database in the cycle '2022 – NDP Consultation'.

Further aspects of the network expansion proposal

Brunsbüttel and Stade LNG terminals

The provision of transport capacity for the LNG terminal in Brunsbüttel and/or Stade requires expansion measures in the GUD network in the form of a pipeline connection between Elbe South (Elbe Süd) and Achim and the creation of new compressor capacity at the Achim/Embsen site. Only the dimensioning of the transport pipeline and the compressor station depends on whether only one or both terminals are built on the specified scale.

Commissioning one year earlier than the designated commissioning date is possible for the above measures under favorable conditions, in particular by including the pipeline in the LNGG or enabling comparable acceleration potential.

Lubmin LNG terminal

For the LNG entry in Lubmin, measures with identical dimensioning are planned to provide the transport capacities due to the special location in relation to the NEL and EUGAL pipelines. Consequently, depending on market demand, a higher and earlier entry is possible, which is deviating from the capacity utilisation assumed in the modelling for the LNGplus B and C security of supply variants.

Wilhelmshaven LNG terminal

For the onward transport of LNG quantities from Wilhelmshaven beyond Etzel additional transport capacities are required. These will be created with the Etzel-Wardenburg pipeline including the construction of the Wardenburg GPCM station and the expansion of the Friedeburg-Horsten 1 GPCM station as well as the Wardenburg-Drohne pipeline including the Drohne 2 GPCM station.

Considering the usual project duration, the commissioning of the Etzel-Wardenburg pipeline and the GPCM stations will take place at the end of 2026. A significantly earlier commissioning, at the earliest in winter 2024/2025, is possible under favorable conditions, in particular through the inclusion of the pipeline in the LNGG or the enabling of comparable acceleration measures.

Considering the usual project duration, the commissioning of the Wardenburg-Drohne pipeline and the GPCM stations, will take place at the end of 2027. A significantly earlier commissioning, at the earliest in winter 2025/2026, is possible under favorable conditions, in particular due to the inclusion of the pipeline in the LNGG or the enabling of comparable acceleration measures.

Medelsheim/VIP France–Germany cross-border interconnection point

The cross-border interconnection point, which until 2022 was only operated as an exit point in the direction of France, has been used for the physical transport of gas from France since October 2022 as part of the diversification of gas sources.

In France, natural gas is odorised with a sulphur-containing substance at all network levels, whereas in Germany it is only odorised at distribution level. For a transitional period until 30 April 2024, the BNetzA, in its determination BK9-22/606-1 ('VOLKER') dated 8 November 2022, granted transmission system operators recognition of possible damages in the German network resulting from the deviation of the odorized gas from the gas quality standard DVGW G260 as volatile costs. After this period, it may be necessary to clean, (in other words, deodorise) the gas quantities to be taken over from France using a technical system.

For security of supply variants LNGplus B and C of the Gas Network Development Plan 2022–2032, the transmission system operators in question, GRTgaz Deutschland and Open Network Europe, are planning to build a deodorisation facility at the Medelsheim site. It will be designed for a constant gas flow of around 400,000 m^3/h, which corresponds to 4.2 GWh/h or 100 GWh/d. However, the two transmission system operators will only be able to make a final investment decision when the following conditions are met:

1. The deodorisation facility is required if the relevant national stringent sulphur limits in Germany (which are prescribed for the 2nd gas family by the DVGW G260 worksheet dated September 2021) are maintained permanently beyond 2023 and remain relevant for gas transport. Permanent operation of the deodorisation system must be technically feasible based on the present conditions. The remaining gas specifications of European gas quality standard EN 16726 are in full compliance for the gas to be taken over from France.

2. In France, a technical capacity within the meaning of Regulation (EU) 715/2009 article 2(18) in the amount of at least 4.2 GWh/h is created and offered in the direction of Germany.

A confirmation of the measure should be made by the BNetzA in the amendment request to the Gas Network Development Plan 2022–2032 under the aforementioned conditions.

Further additions to the draft document

For efficient and demand-oriented construction of a future hydrogen transport network, it had already become apparent in the last Network Development Plan that it is necessary to carry out network expansion measures in natural gas so that pipelines that are currently being used in natural gas can be rapidly converted to hydrogen use. These network expansion measures were not opposed or removed by the BNetzA in the request for amendment on 19 March 2021 to the Gas Network Development Plan 2020–2030. The transmission system operators were instructed to implement these measures with ancillary provisions so as not to cause any delays for the rapid market ramp-up, which was politically defined and desired in the National Hydrogen Strategy.

In light of multiple adjustments and changes in the preparation process of the Gas Network Development Plan 2022–2032 and the corresponding time and procedural delays, the transmission system operators initially focused in this consultation document on the necessary network expansion measures in natural gas to maintain the security of supply with natural gas. The transmission system operators will therefore deal with the network expansion measures required in natural gas for the conversion of currently used natural gas pipelines to hydrogen in the period up to the submission of the draft document.

10 Outlook on future Network Development Plans

The restructuring of the energy supply in Germany also places new demands on network development planning. In the future, this must be done in a more cross-sectoral manner and within the scope of a holistic view of energy scenarios that take electricity and gas, including hydrogen, into account. This is the only way to facilitate an economically advantageous interconnection of the energy infrastructures under consideration of the energy and climate policy objectives.

Developing the hydrogen infrastructure

The ramp-up of the hydrogen market in the EU is a central building block in the development of a carbon-neutral and secure energy system. The current geopolitical situation makes it all the more urgent to accelerate this market ramp-up. The basic prerequisite for this is the rapid availability of an efficient hydrogen infrastructure.

The development of a hydrogen economy requires a growing hydrogen infrastructure at the transport level, which connects the production centres in Germany and abroad with the storage facilities and consumers in Germany. The development of this hydrogen transport infrastructure must be fully integrated into the gas network development planning, as large parts of the existing methane network can be used by converting to hydrogen and supplemented by closing gaps or building new ones. This enables cost-optimised and resource-efficient development of a hydrogen infrastructure in Germany. The conversion of methane pipelines for hydrogen transport requires integrated and iterative modelling of the transmission networks within the framework of the Gas Network Development Plan. This is necessary because, in addition to the hydrogen ramp-up, the supply of methane, transits and, in the future, increasingly the supply of biomethane, synthetic methane and LNG must be ensured. A separate Network Development Plan for hydrogen is therefore not expedient and would be economically inefficient. In this respect, the transmission system operators are clearly in favour of introducing an integrated planning process for the methane and hydrogen networks. Hence, in order to continue to use existing synergies with the proven processes in the Gas Network Development Plan in the future, they have developed a corresponding concept for integrated gas network planning within the framework of the Hydrogen Report pursuant to section 28q EnWG.

For a quicker conversion to hydrogen and efficient development of the hydrogen infrastructure, the transmission system operators consider it necessary to create a stable regulatory framework beyond the existing transitional regulation, in which the necessary long-term investments can be safely implemented. Joint regulation and financing of the gas and hydrogen infrastructure is the best and quickest way to achieve this objective. It can avoid prohibitively high charges and enable predictable, plannable tariffs in the market ramp-up phase of the hydrogen market as well as in the phase of declining methane demand.

In order to ensure efficient and resource-saving development of the hydrogen infrastructure, it is absolutely necessary that the existing and proven unbundling rules for gas are transferred to hydrogen. Uniform unbundling rules create plannability for the transmission system operators for investments in the hydrogen infrastructure and enable efficient use of synergies. The ITO model, which has proven itself in the gas sector, must also be permanently possible for hydrogen network operation, and the horizontal unbundling requirements must allow for network operation of hydrogen and methane networks in the same company. Moreover, the horizontal unbundling regulations (e.g. informational unbundling) must be revised to enable integrated methane network planning for methane and hydrogen.

Hydrogen Report pursuant to section 28q EnWG

One component of the EnWG amendment of July 2021 is the report on the initial preparation of the Hydrogen Report pursuant to section 28q EnWG. Hydrogen network operators who have submitted a declaration pursuant to section 28j (3) EnWG must submit the Hydrogen Report to the BNetzA together with the transmission system operators by no later than 01 September 2022. Hydrogen network operators who have not submitted a declaration pursuant to section 28j (3) EnWG must cooperate to the extent necessary for proper preparation of the report. Primarily, they must provide the information required for the preparation. Based on the report, the BNetzA may make recommendations for the legal implementation of a binding network development plan for hydrogen.

The transmission system operators submitted the Hydrogen Report to the BNetzA on time on 1 September 2022 and subsequently published it. The report was presented to the interested public in a webinar held jointly with the distribution system operators on 25 October 2022.

Holistic view of the energy system for electricity and gas (methane and hydrogen)

Against the background of energy and climate policy objectives, the holistic consideration of energy supply infrastructures is of utmost importance. The transmission system operators are dealing intensively with this topic at various points and are also in close communication with other transmission system operators (gas, hydrogen and electricity). For example, Chapter 10.4 of this consultation document on the Gas Network Development Plan 2022–2032 contains a concept on how climate policy goals can be reflected in the future as part of network development planning. Furthermore, within the context of the Hydrogen Report (cf. Chapter 10.2), the transmission system operators describe a corresponding process for a holistic consideration of the energy system. Among other things, it considers the central interfaces and interactions between electricity and gas network planning (methane and hydrogen).

Concept for appropriate consideration of the legally stipulated climate targets

The transmission system operators have developed a concept for how the requirements of the Climate Protection Act, in particular with regard to the climate neutrality to be achieved by 2045, can be taken into account in the future network development plan. Important aspects are, for example:

- the integration of the demand-based with a scenario-based capacity approach,
- the use of capacity products in network planning,
- the further handling of the long-term forecasts of the distribution system operators,
- the further development of integrated network planning (hydrogen and methane),
- the consideration of the pipeline conversion process from methane to hydrogen, and
- the network-optimal allocation of electrolysers.

Conclusion

The areas of activity presented in this chapter illustrate the clear vision of the transmission system operators and the ideas on how they can use their infrastructure to make a significant contribution to implementing the requirements of the Climate Protection Act and achieving climate neutrality by 2045 and beyond. The conversion of methane networks to hydrogen can ensure the security of supply, economic efficiency as well as environmental compatibility of the energy supply in the long term. The geopolitical situation not only highlights the importance of these three factors, but also emphasises the relevance of a fourth dimension: the speed of transformation. Germany will only succeed in continuing to guarantee a secure, low-cost and environmentally compatible energy supply if the transformation of the methane networks, both for the development of new sources and for the transport of hydrogen, is expedited as much as possible.

The scope for action of the transmission system operators is currently limited by the existing legal framework. Thus, the implementation of many of the proposed measures or processes is not possible. It is therefore even more important that politicians and legislators promptly create a clear framework for implementing the measures described in this chapter. To this end, with the publication of the Hydrogen Report, the transmission system operators have developed 12 specific recommendations to the BNetzA as well as to the legislator. The rapid implementation of these recommendations is a prerequisite for the success of the decarbonisation of the network-based energy infrastructure and the ramp-up of the hydrogen economy. For a detailed description of this transformation and planning process, the transmission system operators refer to the Hydrogen Report published on 1 September 2022 pursuant to section 28q EnWG.