FNB Gas
DIE FERNLEITUNGSNETZBETREIBER

Gas Network Development Plan 2022–2032

Scenario Framework

Summary

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Scenario Framework

Gas Network Development Plan 2022–2032 commissioned by the German transmission system operators (TSOs)

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Executive summary

Hydrogen and green gases are playing an important role in the transformation of the energy system. The transmission system operators started work on the planning of a hydrogen infrastructure in the Gas Network Development Plan 2020–2030, in which they have shown that a hydrogen infrastructure can already be made available in the medium term.

For the Gas Network Development Plan 2022–2032, the transmission system operators conducted the second WEB and Green Gases Market Survey (Wasserstoffabfrage Erzeugung und Bedarf – hydrogen generation and demand survey), in which 500 project reports were received. In addition to the demand-based planning for the existing natural gas network, the growing importance of hydrogen and green gases demands its own modelling variant.

To model the natural gas infrastructure, the transmission system operators propose a base variant that is, from their perspective, based on suitable assumptions concerning a demand-based and forward-looking expansion of the network.

This document provides an outlook on the development of the demand for methane and hydrogen up to 2032 and beyond to 2050. The basis for this is provided by the dena-TM95 scenario, which has been adapted by the transmission system operators to the current trends in the energy sector and shows the potential of gaseous energy sources for the decarbonisation process.

In addition to the domestic demand for hydrogen of 191 TWh (low calorific value) for the period up to 2032, the demand for 2040 and for 2050 were also reported in the WEB and Green Gases Market Survey. The reported demand for hydrogen amounts to around 342 TWh (low calorific value) in 2040 and around 476 TWh (low calorific value) in 2050.

The future demand for methane shows a stable development up to the target planning year of 2032. Thus, the infrastructure for the transport of methane continues to have a great importance. The transmission system operators continue to put great importance to the secure supply of their customers and take planned additional demand and connection requests into account.

In order to achieve a more integrated network planning between the energy carriers electricity and gas in the future, adjustments to the existing processes of network development planning are necessary in addition to the prior discussions on energy and climate policy goals. The electricity and gas transmission system operators intend to continue the dialogue with the BNetzA in order to initiate the next steps for synchronising the network development planning.

1 Introduction

With a network extending approximately 40,000 km in length, the German transmission networks form the backbone of the gas infrastructure in Germany and constitute the hub at the Heart of Europe with over 30 cross-border interconnection points. The distribution networks that are fed by the transmission network are more than 470,000 km long. With gas infrastructure that is being expanded to meet demand, the German transmission system operators are making an essential contribution to a secure energy supply.

The secure supply of natural gas is crucial for Germany's energy system and its position as an economic hub especially in the short and medium term. The transmission system operators continue to address this task with a sense of great responsibility.

The existing gas infrastructure will play a decisive role in the energy system of the future, as very large volumes of renewable energy can be both shipped and stored in Germany and used to securely cover seasonal or short-term production and demand peaks. Through the integration of hydrogen and green gases in the existing infrastructure, a significant contribution can be made swiftly and cost-efficiently to the reduction of greenhouse gas emissions.

Hydrogen and green gases constitute flexible, storable and cost-efficient energy sources. Power-to-gas (PtG) in particular offers great and so far unused potential for sector coupling. By intelligently connecting gas, electricity, heating and mobility infrastructure, sector coupling is one of the crucial levers for the successful implementation of the energy transition.

The transmission system operators started planning a hydrogen infrastructure in the Gas Network Development Plan 2020–2030, in which they have shown that a hydrogen infrastructure can already be made available in the medium term.

In the view of the transmission system operators, the expansion of economic and demand-based gas infrastructure will be possible only if there is an integrated methane and hydrogen network plan. In this way, it can be ensured that the future production potential of hydrogen and green gases can be optimally combined with the potential applications of today and of the future.

For this reason, the transmission system operators conducted a new WEB and Green Gases Market Survey of green gas projects from 11 January 2021 to 16 April 2021 in order to identify the demand for transporting hydrogen. Based on this survey and other input parameters the demand for transporting methane and hydrogen will be identified and planned based on this survey and other input parameters. This procedure will create a secure planning basis for market participants and open up a variety of potential uses for hydrogen.

The primary task of gas network operators is to plan, prepare and carry out the conversion of natural gas transport systems. Various reasons can be cited for this:

- Connecting sources and sinks through pipeline infrastructure extending across state borders is the traditional task of transmission system operators.
- The choice of locations for PtG facilities has to be made by the market participants in consultation with the gas and electricity transmission system operators. In this way, plants providing grid services can be positioned optimally within both the electricity and gas grids, and the costs of expanding the grid infrastructures can be reduced.
- In the last few years, the transmission system operators have shown that integrated planning for converting L-gas to H-gas is the best way to carry out the conversion optimally, effectively and quickly.

The Gas Network Development Plan has proved successful as a central management instrument for the L-to-H-gas conversion, especially for the long-term planning of the conversion. The involvement of the relevant market participants is ensured by a variety of public consultation processes. Furthermore, the close connection between L-to-H-gas conversion and network expansion can be taken into account by mapping the L-to-H-gas conversion in the Gas Network Development Plan. The aspects relevant to the L- to H-Gas conversion can also be applied in similar fashion for the conversion to hydrogen.

With the Scenario Framework 2022, the transmission system operators fulfil their statutory duty to produce the Scenario Framework pursuant to section 15a of the Energiewirtschaftsgesetz (EnWG – German Energy Industry Act). The transmission system operators present scenarios with different development paths up to 2050 that take the political target of a climate-neutral energy transition into consideration.

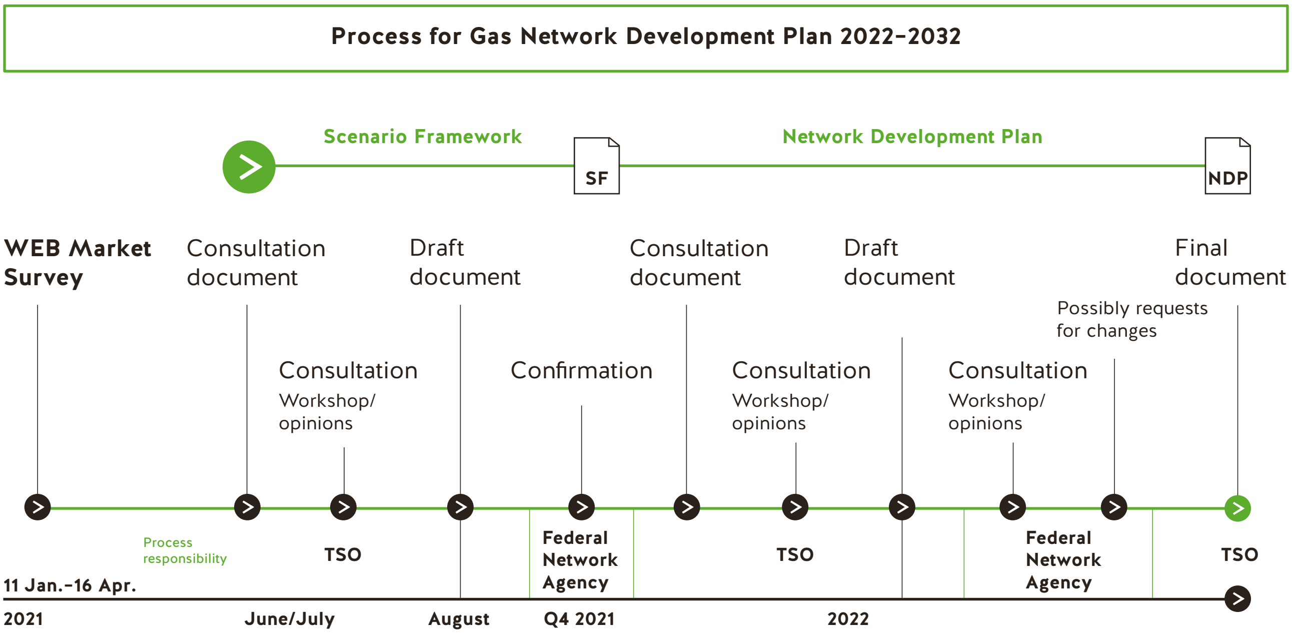
With this Scenario Framework, the transmission system operators create the basis for their modelling of flows and the network expansions measures that will be derived from that. The proposed modelling variants build in principle on the Gas Network Development Plan 2020–2030. A hydrogen variant is again examined in addition to the base variant.

The Scenario Framework 2022 was open to consultation from 21 June 2021 to 16 July 2021. In revising the Scenario Framework 2022, the transmission system operators added the section “Consideration of the results of the public consultation” to the document. Key areas of the consultation included the WEB and Green Gases Market Survey and the implementation of the hydrogen variant, the selection of gas demand scenarios and their consideration in the modelling and the integrated network planning.

2 Process workflow Scenario Framework and the Gas Network Development Plan 2022–2032

With the publication of the consultation document for the Scenario Framework 2022 on 21 June 2021, the transmission system operators have reached an important milestone on the path to the Gas Network Development Plan 2022–2032. The Scenario Framework 2022 was published for consultation from 21 June 2021, to 16 July 2021, when the general public and the market will be given the opportunity to express their views on it. The consultation workshop was additionally held on 1 July 2021. The figure below shows the next steps in the process to draw up the Gas Network Development Plan 2022–2032:

Figure 1: Overview of the Scenario Framework for the Gas Network Development Plan 2022–2032



Source: Transmission system operators

In order to achieve a more integrated network planning between the energy carriers electricity and gas in the future, adjustments to the existing processes of network development planning are necessary in addition to the prior discussions on energy and climate policy goals (cf. dena Network Study III). The electricity and gas transmission system operators intend to continue the dialogue with the BNetzA in order to initiate the next steps for synchronising the network development planning.

3 Capacity demand pursuant to sections 38/39 GasNZV – WEB and Green Gases Market Survey

The transmission system operators published criteria for taking capacity reservations/capacity expansion claims pursuant to sections 38/39 GasNZV and projects from the WEB and Green Gases Market Survey into consideration on the website of FNB Gas on 11 January 2021.

Existing and new power plants, storage facilities, LNG facilities, production plants and green gas projects from the WEB and Green Gases Market Survey are taken into consideration in the Scenario Framework 2022. Some of the new gas power stations in southern Germany that are taken into consideration in the Scenario Framework are used as special network operating equipment. The current plans of the project developers are taken into consideration in accordance with the criteria. For example, the project owner of the LNG plant in Wilhelmshaven has withdrawn the capacity reservation pursuant to section 38 GasNZV. The project developers of the LNG facilities in Stade and Brunsbüttel are continuing with their plans.

The transmission system operators have conducted the WEB Market Survey for hydrogen and green gases for the Scenario Framework 2022. 500 project reports were submitted in the period from 11 January 2021 to 16 April 2021. These are presented in the appendix 2 of the Scenario Framework 2022. Moreover, there were 121 other feedback reports and 42 duplicate reports that were not subsequently considered. Table 1 below provides a full overview of the reported projects per federal state.

The transmission system operators have classified the feedback as follows:

- Category 1: Reports of projects for 2022 to 2050 from project owners and distribution system operators of relevance for the transmission network,
- Category 2: Reports of storage projects,
- Category 3: Reports of other projects from DSO,
- Category 4: Reports of projects from abroad,
- Category 5: Reports of projects on the distribution system not of relevance for the transmission network,
- Category 6: Other project reports (incomplete project reports, zero reports and reports that were not approved for publication).

The number of project reports (PR), sorted in accordance with the classification by federal state, exit / entry and gas type, is presented in table 1.

Table 1: Overview of the reports for the WEB and Green Gases Market Survey

Federal state	PR 2022–2050	PR Storage facilities	Other PRs in the DSO network	PR Interna-tional	PR DSO network	Feed in (source)	Withdrawal (sink)	Hydrogen	Synthetic methane	Biome-thane	Electro-lyser
BW	20	–	43	–	3	11	55	62	–	4	7
BY	24	1	9	2	6	14	32	39	–	3	6
BE	2	–	1	–	1	1	3	3	–	1	–
BB	9	–	1	–	–	5	5	9	–	1	4
HB	1	–	–	–	–	1	1	1	–	–	1
HH	8	–	3	–	1	4	8	11	–	1	2
HE	9	–	10	–	–	3	17	19	–	–	3
MV	12	–	5	–	1	13	5	17	–	1	9
NI	68	3	14	3	2	44	51	88	1	2	26
NW	101	3	71	–	8	42	154	175	–	8	26
RP	8	–	8	–	2	2	16	16	–	2	–
SH	13	–	1	1	–	12	3	15	–	–	11
SL	–	–	1	–	2	1	2	3	–	–	1
SN	2	–	6	–	1	2	7	9	–	1	2
ST	9	–	5	–	4	8	10	15	–	3	4
TH	1	–	5	–	–	–	6	6	–	–	–
Total	**287**	**7**	**183**	**6**	**31**	**163**	**375**	**488**	**1**	**27**	**102**

BW: Baden-Württemberg, BY: Bavaria, BE: Berlin, BB: Brandenburg, HB: Free Hanseatic City of Bremen, HH: Free and Hanseatic City of Hamburg, HE: Hesse, MV: Mecklenburg-Vorpommern, NI: Lower Saxony, NW: North Rhine-Westphalia, RP: Rhineland-Palatinate, SH: Schleswig-Holstein, SL: Saarland, SN: Saxony, ST: Saxony-Anhalt, TH: Thuringia

Source: Transmission system operators

The table below shows the total entry and exit capacities and volumes for the various gas types as well as the sum of the reported electrolysis capacity.

Table 2: Results of the WEB reports of all projects

	Unit	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2040	2050
Hydrogen entry capacity	GW_{th}	0.1	0.3	0.8	2.2	4.9	14.3	20.2	24.9	38.3	42.8	47.1	97.8	153.1
Hydrogen entry volume per year	TWh	1	1	3	11	23	82	106	131	196	216	233	467	783
Hydrogen exit capacity	GW_{th}	0.9	1.4	2.7	5.2	6.7	10.1	12.2	15.7	29.4	36.8	56.9	116.4	181.8
Hydrogen exit volume per year	TWh	5	7	12	26	34	54	63	85	145	180	231	427	598
Synthetic methane entry capacity	GW_{th}	–	–	–	–	–	7.8	7.8	8.4	8.4	9.0	9.0	9.7	11.6
Synthetic methane entry volume per year	TWh	–	–	–	–	–	68	68	74	74	79	79	85	102
Biomethane entry capacity	GW_{th}	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
Biomethane entry volume per year	TWh	1	1	1	2	2	2	2	2	2	2	3	3	3
Electrolysis capacity	GW_e	0.2	0.4	0.8	3.0	4.6	7.8	10.8	13.4	24.5	26.7	28.9	47.9	56.3

Source: Transmission system operators

The results are presented in aggregate in the Scenario Framework 2022 based on the categories and the further procedure planned as part of the modelling of the Gas Network Development Plan 2022–2032 is outlined. A complete list of the project reports can be found in appendix 2 of the Scenario Framework 2022.

4 Gas demand

The consumption of natural gas initially declined from 2010 to 2014, but subsequently rose quite significantly up to 2019. The increase was caused primarily by the rise in gas-fired power generation, but also by the consumption in private households. Around half of all German apartments are currently using natural gas for heating purposes.

On 29 April 2021, the German Federal Constitutional Court ruled that constitutional objections to the German Climate Protection Act can be successfully upheld in part. Against this background, the federal government decided on 12 May 2021 to increase the German climate targets. National greenhouse gas emissions are now set to be reduced by 65% (previously 55%) from 1990 levels by 2030. The target of greenhouse gas neutrality is accordingly to be reached as early as 2045.

In the Scenario Framework 2020, the dena-TM95 scenario was examined in greater detail as a possible vision of the future. The dena-TM95 scenario is a recognised technology mix scenario, in which a high use of methane is assumed, while hydrogen still plays a limited role. From today's perspective, however, hydrogen will play a more significant role in the course of the energy transition. The transmission system operators have therefore decided to adjust the dena-TM95 scenario for the Scenario Framework 2022 with the support of the consulting firm FourManagement.

The transmission system operators have analysed both the supply and the demand side in light of a heavier use of hydrogen. Various studies were consulted and numerous discussions were held with experts in order to answer detailed questions.

Ultimately, hydrogen will be increasingly used in place of methane, as the production of hydrogen represents a more energy-efficient solution in comparison with synthetic methane. Imports of hydrogen will make a significant contribution when it comes to covering demand.

Many of the existing energy and gas demand scenarios do not yet take these new framework conditions in energy and climate policy into account. Renowned studies and publications on the future development of gas demand and gas supply in Germany have been analysed for the Scenario Framework 2022. The focus is placed in principle on the scenarios that achieve at least an emission reduction of 95% by 2050 compared to the 1990 levels. Gas demand is understood in the following to be the demand for methane (natural gas, biomethane as well as synthetic gases) and hydrogen.

For the Scenario Framework 2022, the transmission system operators decided to consider the following scenarios in more detail:

- **Scenario I: dena-TM95 scenario with adjustments by TSOs / FourManagement (dena-TM95 / TSO)**
  This scenario is based on the dena-TM95 scenario. The technology mix scenario assumes a broad variation in the technologies and energy sources used. In this scenario, a 95% reduction in greenhouse gases from 1990 levels is achieved by 2050. The dena-TM95 scenario was already included as an element of the Scenario Framework 2020. It has now been adapted by the transmission system operators in cooperation with the FourManagement consulting firm in order to do justice to the increasing importance of hydrogen, which is also reflected in the federal government's National Hydrogen Strategy. The total gas quantity structure in the dena-TM95 scenario was essentially kept constant here and a shift from methane demand towards hydrogen demand was carried out. Furthermore, shares accounted for by oil were substituted by methane and hydrogen, while it was assumed that hydrogen was used in the production of primary energy and district heating on a pro rata basis. Scenario I takes a high gas proportion into consideration, including a high share of hydrogen in particular, and is therefore relevant for the design of the gas infrastructure. The scenario was included by the transmission system operators, as it reflects the potential of gas in the decarbonisation process.
- **Scenario II: NECP scenario with climate protection programme (NECP KSP)**
  The goal of the integrated National Energy and Climate Plan (NECP) is to improve the coordination of European energy and climate policy in order to achieve the climate targets in 2030. In accordance with the regulations, all EU member states have to draw up an NECP for the period from 2021 to 2030. Against this background, the NECP scenarios are of a great importance at the European level. In this scenario, a reduction of around 87.5% in greenhouse gases from 1990 levels is achieved by 2050. The importance of hydrogen also increases in this scenario, but the development lags behind the targets of the National Hydrogen Strategy. The transmission system operators assume that the increasing importance of hydrogen will also be reflected in the future NECP process.

The tables below show the total gas usage in the scenarios examined, which is presented in terms of low calorific value (H_i) in each case. It is broken down into methane (natural gas, biomethane as well as synthetic gases) and hydrogen.

Table 3: Development of German gas demand in Scenario I, temperature-adjusted, presented as calorific value (H_i)

Gas consumption by sector	2019	2022	2027	2032	2040	2050
	TWh H_i					
Synthetic methane	**913**	**925**	**940**	**903**	**697**	**529**
Final energy consumption	602	578	550	523	434	342
Private households/commerce, trade and services	377	349	314	278	212	138
Industry	223	223	221	182	131	114
Transport	2	6	16	63	92	91
Non-energy consumption	40	53	69	83	42	5
Transformation sector	271	294	320	297	221	182
Hydrogen	**0**	**3**	**27**	**92**	**315**	**504**
Demand sectors	0	3	25	86	217	321
Private households/commerce, trade and services	0	0	1	3	15	22
Industry	0	2	21	75	142	204
Transport	0	1	2	8	60	95
Non-energy consumption	0	0	0	1	68	136
Transformation	0	0	2	4	30	47
Total gas	**913**	**928**	**966**	**995**	**1,012**	**1,033**
Demand sectors	602	581	576	609	652	663
Private households/commerce, trade and services	377	349	315	281	227	159
Industry	223	225	242	257	273	318
Transport	2	7	18	71	152	186
Non-energy consumption	40	53	69	84	110	141
Transformation	271	294	322	301	251	229

Source: BDEW / AG Energiebilanzen, calculation of the transmission system operators (temperature-adjusted values), dena 2018, transmission system operators / FourManagement 2020

Table 4: Development of German gas demand in Scenario II, temperature-adjusted, presentation as calorific value (H_i)

Gas consumption by sector	2019	2022	2027	2032	2040	2050
	TWh H_i					
Synthetic methane	**913**	**908**	**881**	**777**	**570**	**286**
Final energy consumption	602	547	483	429	301	171
Private households/commerce, trade and services	377	343	302	257	176	101
Industry	223	198	167	149	100	53
Transport	2	5	14	23	26	17
Non-energy consumption	40	32	33	32	24	18
Transformation sector	271	329	366	316	245	97
Hydrogen	**0**	**1**	**7**	**11**	**40**	**68**
Demand sectors	0	1	2	7	38	67
Private households/commerce, trade and services	0	0	0	0	0	0
Industry	0	0	0	2	26	43
Transport	0	1	2	5	11	24
Non-energy consumption	0	0	0	0	0	0
Transformation	0	0	5	4	2	1
Total gas	**913**	**909**	**889**	**788**	**610**	**354**
Demand sectors	602	547	486	436	339	238
Private households/commerce, trade and services	377	343	302	257	176	101
Industry	223	198	167	151	126	96
Transport	2	6	16	28	38	41
Non-energy consumption	40	32	33	32	24	18
Transformation	271	329	370	320	248	98

Source: BDEW / AG Energiebilanzen, calculation of the transmission system operators (temperature-adjusted values), BMWi 2020

Scenario I shows gas demand increasing slightly overall and it is assumed that only renewable gases are used in 2050. Demand for hydrogen will increase significantly. In this scenario, the demand for hydrogen develops up to 2030 in the order of magnitude shown by the National Hydrogen Strategy, which sees hydrogen use of around 90 TWh to 110 TWh up to 2030.

In scenario II, on the other hand, gas demand declines over the long term. The importance of hydrogen also increases in this scenario, but the development lags behind the targets of the Hydrogen Strategy.

Based on the assessment of the transmission system operators, hydrogen and green gases will play a key role in the decarbonisation of the energy supply required to meet the climate protection targets. Their increasing importance is also shown in the results of the WEB and Green Gases Market Survey. Against this background, the transmission system operators have decided to use scenario I for the long-term planning of a robust gas infrastructure.

A distinction has to be drawn in principle between the terms scenario and modelling variant. Two scenarios for the development of gas demand in Germany are presented in the Scenario Framework 2022. The modelling variants, which are described in chapter 9, form the basis for the modelling in the Gas Network Development Plan 2022–2032. There is currently no connection between the gas demand scenarios presented here and the modelling variants for the Gas Network Development Plan 2022–2032 presented in chapter 9, as the transmission system operators use concrete demand developments for their modelling variants as a result of the requirements of the BNetzA. Among other things, the internal orders and long-term forecasts of the distribution system operators are used for this purpose.

5 Gas supply

Domestic production of natural gas, the generation of biomethane as well as hydrogen are taken into consideration in the assessment of the trends in the gas supply in Germany up to 2032.

Natural gas production

The forecast of the regional natural gas production in Germany up to 2032 is based on the current projection of the BVEG for the two most important production regions (Elbe-Weser excluding “Altmark” and Weser-Ems excluding “Ostfriesland”) as well as for Germany as a whole.

Table 5: German natural gas production in various units

Natural gas production in Germany Scenario I and II	Unit	2019	2022	2027	2032	Change 2027 from 2019	Change 2032 from 2019
Conventional gas	billion m^3*	6.1	4.9	3.3	2.0	−46%	−67%
Conventional gas	TWh H_s	59	47	32	19		
Conventional gas	TWh H_i	54	43	29	18		

* Quantities relate to natural gas with a uniform high calorific value (H_s) of 9.7692 kWh/m^3.

Source: Prognos AG, BVEG 2021

The current BVEG forecast shows a significant decline in German L-gas production from 2021 onwards, which in turn falls noticeably short of the forecast values of the last few years. The effects of the BVEG’s new production forecast on the Germany-wide L-gas quantity balance are analysed by the transmission system operators in the course of the modelling of the Gas Network Development Plan 2022–2032. It seems conceivable at the moment, however, that this decline currently forecast by the BVEG could have an impact on the security of supply in L-gas.

Injection of biomethane

The state analysis and assessment of the development of the injection of biomethane has been carried out using the current 2020 monitoring report of the Federal Network Agency and of the Bundeskartellamt (German competition authority) and the injection atlas for biomethane injection published by Deutsche Energie-Agentur GmbH (dena – German Energy Agency).

Table 6: Injection of biomethane in Germany

	Unit	2019	2022	2027	2032	Change 2027 from 2019	Change 2032 from 2019
Injection of biomethane	TWh H_s	9	10	11	11	15%	18%
Injection of biomethane	TWh H_i	8	9	10	10		

Source: Prognos AG, dena 2021, BNetzA / BKartA Monitoring report 2020, WEB Market Survey

In addition, requests for biomethane facilities totalling 2.4 TWh for 2027 and 2.9 TWh for 2032 (each in high calorific value) were received in the course of the WEB and Green Gases Market Survey.

Hydrogen

It is assumed in the Scenario Framework 2022 that the hydrogen of around 14 TWh specified in the National Hydrogen Strategy will be generated as a minimum in Germany in 2030, with this volume rising to around 20 TWh by 2032.

Injection volumes for synthetic methane have been reported in the WEB and Green Gases Market Survey from 2027 onwards. At this point, synthetic methane is not included, since in the dena-TM95 scenario no synthetic methane is used until 2030.

The results of the WEB and Green Gases Market Survey show that there are currently project reports for electrolysers totalling around 21 GW_e for Germany up to 2030. This value exceeds by a considerable amount the 5 GW_e mentioned in the National Hydrogen Strategy. For 2050, the value derived from the reported domestic projects is 49 GW_e. The hydrogen injection volume of the projects reported in the WEB and Green Gases Market Survey amounts to 607 TWh (high calorific value) in 2050.

Total gas supply

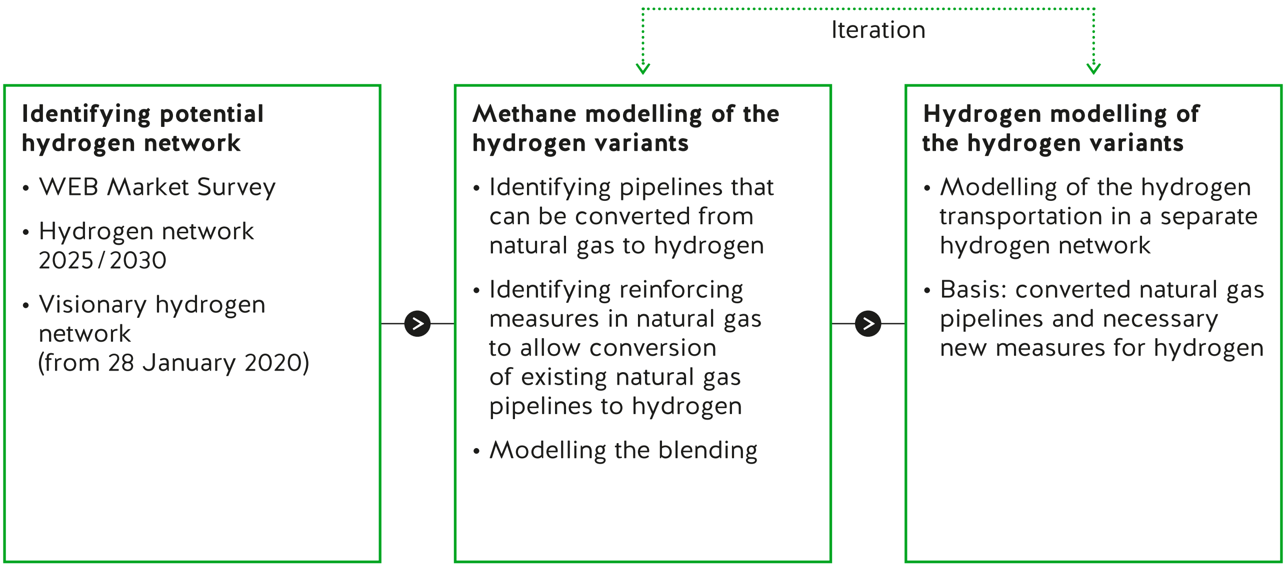
The total regional gas supply from domestic production, biomethane and green gas production in 2032 and its change from 2022 is dominated by a sharp decline in conventional natural gas production. In contrast, a slight increase in the injection of biomethane and considerable growth in the gas supply from hydrogen can be expected.

6 Hydrogen and green gases

Basic procedure relating to hydrogen and green gases

The hydrogen variant consists of the methane modelling and the hydrogen modelling. In the methane modelling, for example, it is reviewed, which pipelines of the existing transmission system can be converted from natural gas to hydrogen based on a reduced natural gas demand. The transport of hydrogen in a separate hydrogen network is examined in the hydrogen modelling. The starting point for identifying the potential hydrogen network is provided by the results of the WEB and Green Gases Market Survey, the hydrogen network identified in the Gas Network Development Plan 2020–2030 and the visionary hydrogen network published by FNB Gas on 28 January 2020. The procedure for modelling the hydrogen variant is illustrated in the figure below.

Figure 2: Modelling procedure



Source: Transmission system operators

Distribution of hydrogen sources

As the demand for hydrogen cannot be covered exclusively by the entry capacity reported and recognised in the WEB and Green Gases Market Survey and in the Electricity Network Development Plan, it is necessary to use other supply sources to balance the hydrogen demand. The transmission system operators will therefore use additional sources of hydrogen supply to bridge the gap in demand. These are:

- Imports of hydrogen,
- Domestic production of "green" hydrogen through the use of onshore wind farms not anymore eligble for the renewable energy sources subsidy,
- Storage facilities, especially for structuring volatile sources and for covering peak loads.

Outlook for hydrogen 2040 and 2050

In addition to the demand for hydrogen for the period up to 2032, the demand for 2040 and for 2050 were also reported in the WEB and Green Gases Market Survey. Although these two years are not an integral part of the modelling, the reported demand enables a comparison with scenario I presented in the document. The reported demand for hydrogen shown by the WEB and Green Gases Market Survey amounts to around 342 TWh (low calorific value) in 2040 and to around 476 TWh (low calorific value) in 2050. These values are thus within the order of magnitude of scenario I.

7 Gas exchange between Germany and its neighbouring countries

Incremental capacity

Regulation (EU) 2017/459 (NC CAM) stipulates a European process for incremental capacity at cross-border interconnection points. By using this instrument, the capacity demand of the shippers is intended to be included in a sustainable further development of the gas transmission infrastructure in a market-based process using this instrument.

In the 2019–2021 incremental capacity cycle, incremental entry and exit capacity were offered in the annual auction on 5 July 2021 (see www.fnb-gas-capacity.de). The auctions will take place during the consultation phase of the Scenario Framework 2022.

With the annual auctions on 5 July 2021, the 2021-2023 incremental capacity cycle began. Its results will be included at the earliest, however, in the Scenario Framework for the Gas Network Development Plan 2024–2034.

Distribution of H-gas sources

The decline in its own production and the conversion from L-gas to H-gas mean that the import demand for H-gas will increase in Germany in the coming years.

The transmission system operators used a model to be able to estimate the effects of future extensions of the infrastructure for importing H-gas into Europe on the German transmission networks for the first time as part of the Gas Network Development Plan 2013, which then continued to be developed in the subsequent Network Development Plans. By taking the current TYNDP into consideration, it is assessed from which regions additional natural gas can be transported to Europe and Germany. According to all three scenarios of the TYNDP 2020, gas demand in Europe will decline both up to 2030 and up to 2040.

The middle path of the TYNDP – the "Distributed Energy" scenario – forms the basis for drawing up the balance for the demand side. On the supply side, the mean value from each of the minimum and maximum scenarios derived from the "Distributed Energy" scenario for pipeline deliveries is taken as the basis, while the LNG supply is assumed to be constant across all years at the level of the base year of 2020 that is assumed in the planning.

For the year 2030, this results in a planned additional import demand of around 189 TWh (around 18 bcm / a) in relation to the base year. The import demand is reduced to around 41 TWh (around 4 bcm/a) for the 2032 modelling year, before an surplus is produced in the subsequent years. In comparison, the additional import demand in the Gas Network Development Plan 2020–2030 was around 57 bcm/a for 2030.

As the assessment of the TYNDP 2020 shows, the forecasted gas demand in Europe can be covered by the existing import infrastructure, including the Nord Stream 2 and TAP projects already taken into account in the Gas Network Development Plan 2020–2030.

The assumptions on the distribution of H-gas sources that were made in the Network Development Plan 2020–2030 have proved to be robust when set against the infrastructure assumptions in the TYNDP 2020.

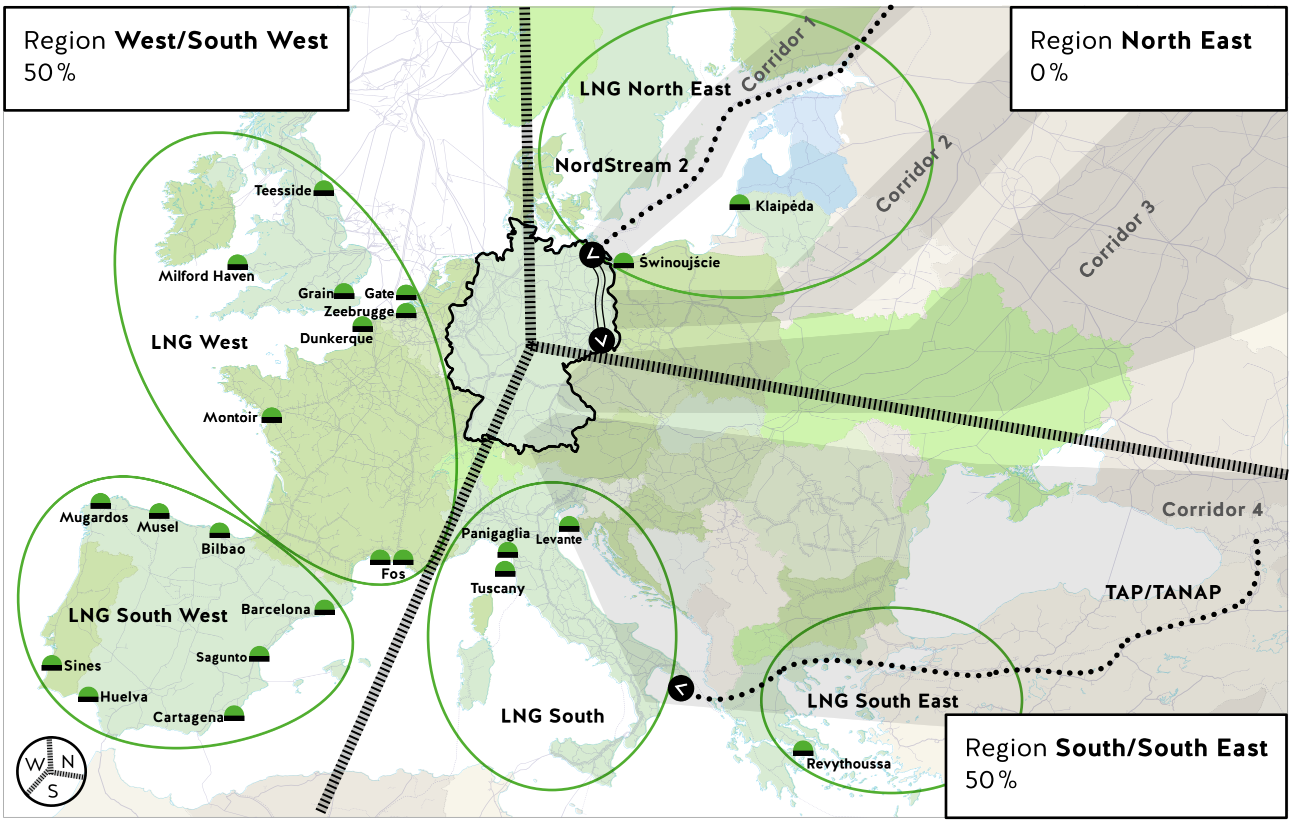
The transmission system operators therefore propose to take over the assumptions made as part of the distribution of H-gas sources in the Gas Network Development Plan 2020–2030 as the basis for the Gas Network Development Plan 2022–2032, whereby the stability and continuity of the previous planning assumptions are guaranteed.

The transmission system operators expect that, similar to the assumptions of the Gas Network Development Plan 2020–2030, the additional German demand can be covered by the "West / South-West" region and the "South / South-East" region, with each accounting for around 50%, via the Nord Stream 2 and TAP / TANAP pipeline projects and also the well-developed European LNG infrastructure.

Overall, the following percentage distribution by region is produced (cf. figure 3):

- North East region share: 0%
- West / South West region share: 50%
- South / South East region share: 50%

Figure 3: Distribution of H-gas sources



Source: ENTSOG, TSO

LNG Region · LNG Terminal · Pipeline projects · EUGAL · Corridor

Cross-border interconnection points

The German transmission system operators have also examined the trends at the cross-border interconnection points in the Scenario Framework 2022 and described how the individual German cross-border interconnection points are taken into consideration within the framework of the distribution of H-gas sources in the modelling of the Gas Network Development Plan 2022–2032.

Virtual interconnection points

In accordance with Article 19(9) of Regulation (EU) 2017/459 (NC CAM), the transmission system operators are required to set up virtual interconnection points (VIP) at the market area borders where shippers can book capacity. Available capacity at the physical cross-border interconnection points of the transmission system operators involved is marketed at the VIP. The transmission system operators provide an overview of the current status of the VIPs and their future development in the Scenario Framework 2022.

8 Security of supply

In line with section 15a (1) EnWG, assumptions concerning the impact of conceivable disruptions of supply are made in the Scenario Framework. The transmission system operators have continually conducted detailed assessments of various disruption scenarios and security of supply scenarios since the Gas Network Development Plan 2012. This includes the market area conversion from L-gas to H-gas.

The BMWi published the "Report on the status and on the development of security of supply in the area of the supply of natural gas" (monitoring report pursuant to section 63 EnWG), which was updated in June 2020. One of the conclusions was "[...] that the security of supply concept in Germany has proven its worth."

The transmission system operators see the necessity of further fleshing out the in-depth conversion plans up to 2030 on account of the future reduction in the availability of L-gas for the German market. Furthermore, the availability of H-gas needs to be examined and presented in an up-to-date H-gas balance up to 2032.

Development of the L-gas supply

L-gas production in Germany is in continual decline. Where possible, the remaining German L-gas reserves will continue to be extracted and injected into the natural gas transmission network. The decline in L-gas production has significant impacts in terms of both the annual volumes available in Germany and the capacity that is available. The L-gas capacity available from the Netherlands has additionally experienced a steady decline since October 2020.

Situation involving gas imports from the Netherlands

In order to take the risks arising from natural gas production into consideration, the Dutch Ministry of Economic Affairs and Climate Policy announced that the regular production of natural gas in the Groningen area would be suspended from 2022 onwards. The Groningen field remains active with minimal production so as to be able to safeguard the security of supply also in particular situations at the same time.

The Dutch Ministry of Economic Affairs and Climate Policy has set a production volume of 8.1 billion m^3 for the 2020/2021 gas year, while the prospect of a figure of around 4 billion m^3 is held out for the subsequent 2021/2022 gas year.

The transmission system operators maintain close contacts with GTS in this connection and also in order to coordinate the relevant plans in the Netherlands and Germany. Since 2019 in particular, there have also been exchanges at the international level through the "Task Force Monitoring L-Gas Market Conversion".

Domestic production

The current BVEG forecast shows a significant decline of up to 17% in German L-gas production from 2021 onwards. This forecast deviates considerably from the previous forecast and leads to a shortfall in regional capacity balances. It seems conceivable at the moment that this decline currently forecast by the BVEG could have an impact on the security of supply in L-gas.

The transmission system operators point out that a reliable production forecast forms the basis for the long-term conversion planning. A response in terms of network planning to the massive decline as early as 2021 is therefore not possible.

Development of the H-gas supply

The transmission system operators see a need in the Gas Network Development Plan 2022–2032 to continue also to examine the availability of H-gas alongside the reduced L-gas availability.

9 Modelling and modelling variants

This Scenario Framework forms the basis for the creation of the Gas Network Development Plan 2022–2032. The transmission system operators envisage the following selection and specification for the modelling in the Gas Network Development Plan 2022–2032 (cf. table 7). In addition to the base variant, a NewCap calculation, a hydrogen variant and a design variant for Baden-Württemberg are proposed for the modelling. Furthermore, the security of supply scenarios in L-gas and H-gas are updated.

The discussions between the BNetzA and the transmission system operators on developing criteria and designing the coal phase-out variant were finalised by the end of the consultation on the Scenario Framework. After consultation with the BNetzA, the coal phase-out variant will be dealt with outside of the Gas Network Development Plan.

Table 7: Modelling variants in the Scenario Framework 2022

<table>
<tr><th>Modelling variant</th><th>Base variant
2027</th><th>Base variant
2032</th><th>L-gas balance
2032</th><th>H-gas balance
2032</th><th>NewCap
Base variant</th></tr>
<tr><td>Designation</td><td>B.2027</td><td>B.2032</td><td>L.2032</td><td>H.2032</td><td>N.2027, N.2032</td></tr>
<tr><td>Calculation</td><td>Complete 2027</td><td>Complete 2032</td><td>Balance analysis</td><td>Balance analysis</td><td>NewCap calculation</td></tr>
<tr><td>Reporting date</td><td>31.12.2027</td><td>31.12.2032</td><td>01.10.2032</td><td>01.10.2032</td><td>01.10.2027, 01.10.2032</td></tr>
<tr><td>Distribution system operators (internal orders)</td><td>Initial value:
Internal orders 2022, development 2023–2027: the 10-year forecast of the DSOs, the plausibility of which has been verified.</td><td>Development 2028–2032: constant updating.</td><td rowspan="12">Security of supply scenario L-gas 2032, analysis of the long-term L-gas balances up to 2032</td><td rowspan="12">Security of supply scenario H-gas 2032, analysis of the long-term H-gas capacity balance up to 2032</td><td rowspan="12">Calculation of the costs of the market-based instruments (MBI) for the base variant up to 2032</td></tr>
<tr><td>H-gas sources</td><td colspan="2">Additional demand in accordance with chapter 8.2 of the Scenario Framework 2022</td></tr>
<tr><td>IP / VIP</td><td colspan="2">Inventory according to “2022 – SF” database cycle, need for expansion in line with chapter 8 of the Scenario Framework 2022 in due consideration of the TYNDP</td></tr>
<tr><td>Use of MBIs</td><td colspan="2">Use of market-based instruments for planning purposes</td></tr>
<tr><td>L-to-H-gas conversion</td><td colspan="2">Modelling of the conversion areas, including conversions up to 2033 in order to identify the necessary network expansions measures up to 31 December 2032</td></tr>
<tr><td>Underground gas storage facilities</td><td colspan="2">Inventory according to “2022 – SF” database cycle, new build according to chapter 3.3.2: 100% temperature-dependent capacity (TaK)</td></tr>
<tr><td>Power plants</td><td colspan="2">Inventory according to “2022 – SF” database cycle, systemically important power plants currently directly connected on an interruptible basis according to chapter 3.2.1, new build according to chapter 3.2.2, 100% firm dynamically allocable capacity (fDZK)</td></tr>
<tr><td>LNG</td><td colspan="2">New build in accordance with chapter 3.4</td></tr>
<tr><td>Production</td><td colspan="2">Inventory according to “2022 – SF” database cycle, taking into account the current BVEG forecast in accordance with chapters 5 and 9, new build in accordance with chapter 3.5</td></tr>
<tr><td>Industry</td><td colspan="2">Existing capacity is constantly updated until 2032, consideration of the additional demand according to chapter 10.9, freely allocable capacity approach (FZK)</td></tr>
<tr><td>Biomethane and synthetic methane</td><td colspan="2">Inventory according to “2022 – SF” database cycle, new build according to chapter 10.2</td></tr>
<tr><td>Hydrogen</td><td colspan="2">Inventory according to “2022 – SF“ database cycle</td></tr>
</table>

Modelling variant	Hydrogen variant 2027	Hydrogen variant 2032	Design variant for Baden-Württemberg 2032 (only terranets)	Coal phase-out variant
Designation	**H.2027**	**H.2032**	**A.2032**	**K.2030**
Calculation	Complete 2027	Complete 2032	Complete 2032	cf. chapter 10.6
Reporting date	31.12.2027	31.12.2032	31.12.2032	
Distribution system operators (internal orders)	Initial value: Internal orders 2022, development 2023–2027: the 10-year forecast of the DSOs, the plausibility of which has been verified.	Development 2028–2032: constant updating upon growth. Plausible declines are taken into account.	Initial value: Internal orders 2022, development 2023–2032: the 10-year forecast of the DSOs of terranets in Baden-Württemberg, the plausibility of which has been verified	
H-gas sources	As base variant		Updates on the basis of the additional demand from terranets compared with the base variant	
IP / VIP	As base variant			
Use of MBIs	No calculation			
L-to-H-gas conversion	As base variant		As base variant	
Underground gas storage facilities				
Power plants				
LNG				
Production				
Industry	Existing capacity is constantly updated until 2032, consideration of the additional demand according to chapter 10.9, freely allocable capacity approach (FZK); the substitution of methane by hydrogen identified in the course of the MoU discussions is recognised in the methane modelling of the hydrogen variant on the basis of the reduction it produces.			
Biomethane and synthetic methane	As base variant			
Hydrogen	Inventory according to "2022 – SF" database cycle, Consideration of concrete projects in the WEB Market Survey if an MoU is in place by 1 October 2021 (in accordance with chapter 3.6), modelling in accordance with chapter 10.3			

Source: Transmission system operators