H2-dvgw.de

Deutscher Verein des
Gas- und Wasserfaches e.V.

DVGW

www.h2vorort.de

H2 VOR ORT

Making hydrogen usable for everyone via the gas distribution networks

Publisher
DVGW Deutscher Verein des Gas- und Wasserfachs e.V.
Technical & Scientific Association
Josef-Wirmer-Str. 1–3
53123 Bonn / Germany

Tel: +49 228 9188-5
Fax: +49 228 9188-990
Email: info@dvgw.de
Web: www.dvgw.de

Contact partner
Florian Feller
florian.feller@erdgas-schwaben.de

Dr. Volker Bartsch
volker.bartsch@dvgw.de

Concept
Johanssen + Kretschmer
Strategische Kommunikation GmbH, Berlin
www.jk-kom.de

Design
mehrwert intermediale kommunikation GmbH, Cologne
www.mehrwert.de

Image credits
Jan-Schneckenhaus / iStock.com (title)

Version
November 2020

H2vorOrt
Making hydrogen usable for everyone via the gas distribution networks

H2-
dvgw.de

1 H2vorOrt Making hydrogen usable for everyone via the gas distribution networks

2 Management summary

3 Challenges on the way to climate neutrality

4 A full changeover of gas distribution networks to climate-neutral gases is both feasible and beneficial

5 Our commitments and recommendations for political decision-makers

1 H2vorOrt Making hydrogen usable for everyone via the gas distribution networks

1.1 Foreword **The European Union and the Federal Republic of Germany have set themselves the goal of achieving complete climate neutrality by 2050. This requires, among other things, a gradual changeover from fossil natural gas to climate-neutral gases as well as increased use of advanced, innovative technologies such as power-to-gas.**

In the future energy system, carbon-neutral gaseous energy sources will make a significant and indispensable contribution to a cross-sectoral, integrated energy transition. Numerous studies in recent years, such as the dena pilot study "Integrated Energy Transition" (dena-Leitstudie Integrierte Energiewende), show that: an economically efficient, sustainable future energy system that can be used by everyone requires gas distribution networks.[1] Because this system will be based not only on renewable electricity, but also carbon-neutral energy in the form of molecules. The integration of carbon-neutral gases into the existing gas infrastructure will ensure security of supply and the profitability of the future climate-neutral energy system.

In this context, the gas network offers the flexibility required for absorbing large quantities of hydrogen. In addition, it also enables the effective coupling of sectors via power-to-gas technologies that integrate electricity generated domestically from renewable sources into the gas network and gas storage structures. This allows the long-term storage and long-distance transport of electric power from renewable sources. At the same time, the scope of the necessary nationwide expansion of power grids at all voltage levels will be optimised to a level which is economically necessary and therefore socially acceptable.

Hydrogen not only ensures that numerous industrial processes can be successively decarbonised. In the heating market in particular, hydrogen offers tremendous potential for CO_2 reduction, especially in existing buildings, via a structured and transparent low-cost process. New areas of application can also be tapped in the field of mobility, opening up new prospects of utilisation and allowing the sector to become carbon-neutral.

The gas industry is already supporting a comprehensive transformation to climate neutrality with intensive research and numerous pilot projects. In doing so, is documenting its self-image and its commitment to actively enabling and shaping the climate-neutral energy system of the future.

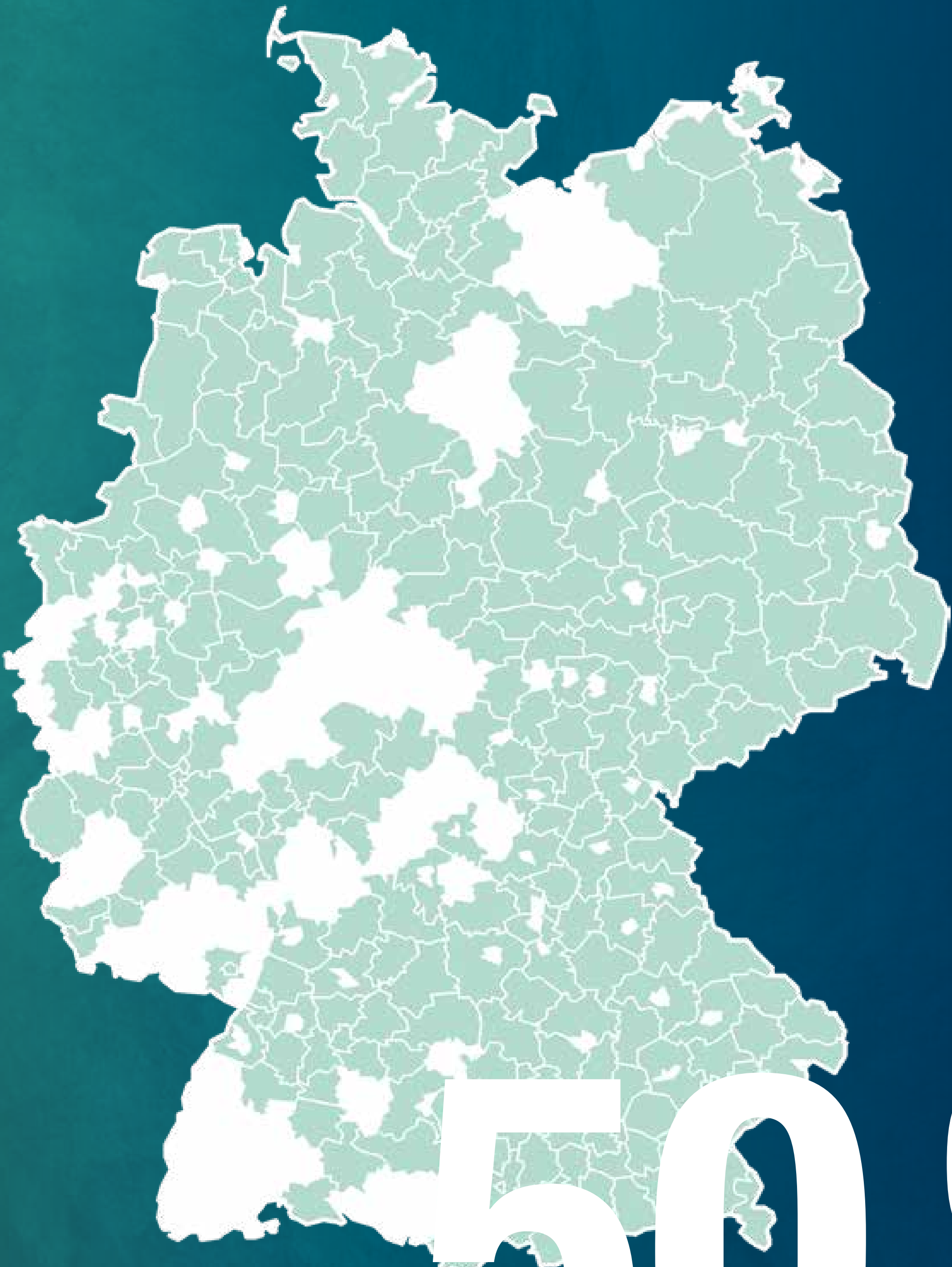
In the "H2vorOrt" project, 34 project partners have come together to determine how a secure regional supply of climate-neutral gases can be achieved throughout the country in the future and what transformation path needs to be followed to achieve this objective. The focus is particularly on hydrogen as a climate-neutral energy source and link between the sectors and infrastructures.* They have been supported by DVGW, which has provided key impetus and acted as a technical and scientific partner.

The H2vorOrt project partners are fully committed to the Paris climate protection goals and are actively working to achieve climate neutrality in all the sectors they supply now and will supply in the future by 2050.

Policy makers on all levels of government have generally recognised the potential of hydrogen as an energy source of the future and have laid the foundation for the development of a comprehensive and sustainable hydrogen economy through the European and National Hydrogen Strategy. The task now is to promote the necessary market ramp-up of hydrogen use and the associated application technologies through dialogue with users from all sectors, energy producers and infrastructure operators, and to include the heating market in the process. It is the intention of the H2vorOrt project partners to contribute to this process with this policy paper. They will be pleased to engage in constructive dialogue on this topic with both policymakers and society as a whole.

---

* *Based on the National Hydrogen Strategy[2], this policy paper focuses on "green" hydrogen produced from renewable energy sources using electrolysis. So-called "blue" hydrogen, obtained by means of "carbon capture and storage" (CCS, the separation and subsequent storage of CO_2 – often in underground storage), and "turquoise" hydrogen, which was obtained from CH_4 (e.g. from biomethane or natural gas) are considered to be carbon-neutral and, in this policy paper, viewed as enablers on the way to achieving climate protection goals. For easier reading, these gases are all referred to as "hydrogen" in this paper.*



50 %

The project partners operate approx. 50% of German gas distribution networks

2 Management summary

At present, fossil fuels, the vast majority of which are imported, cover around five-sixths of primary energy demand in Germany.[3] In order to achieve climate-neutrality by 2050 at the latest, it will be essential to rapidly and significantly increase the share of renewable energies and to make them available for industry, mobility and the heating market. Climate-neutral gases and hydrogen in particular play a special role here, as they will cover the substantial energy import requirements of the future.

The political discourse regarding hydrogen is having a considerable impact across all sectors. An increasing number of applications can already be operated with hydrogen in the short term. In the future, widespread demand is to be expected. The first industrial companies are preparing to convert their processes, districts are supplied with electricity and heat via fuel cells and hydrogen CHP systems, local public transport and private transport are increasingly using hydrogen, and prototypes for hydrogen heating appliances have been presented.

Most energy consumers in the industrial, commercial, heating and power generation sectors in Germany are now connected to gas distribution networks. Gas distribution networks are therefore a key element in reliable energy supply and the backbone for Germany as a business location and for private households. Gas distribution networks offer ideal technical and economic conditions for absorbing, storing, transporting and distributing climate-neutral gases in all sectors. They will therefore develop into the leading distribution infrastructure for hydrogen. H2vorOrt describes the transformation path of this infrastructure towards climate neutrality with the expertise of the 34 project partners together with DVGW.

Biomethane and synthetic methane can already be carried by the existing gas network infrastructure without any problems. Even under the present regulations, up to 10 percent of hydrogen can be added. The injection of larger quantities of hydrogen and the changeover to 100 percent hydrogen by volume will call for the step-by-step technical modification or further development of the gas distribution networks and the customer facilities connected to them. Work must start now in order to ensure that a properly functioning system with full area coverage is available by 2050 at the latest.

The project partners

- avacon
- bayernwerk
- DEW21
- e.dis
- Energienetze Bayern – Ein Unternehmen der ESB Gruppe
- energienetze mittelrhein – Ein Unternehmen der evm-gruppe
- energienetz saar
- enso NETZ
- e.on
- erdgas schwaben
- ESWE Versorgung
- EWE netz
- GASNETZ HAMBURG
- GELSENWASSER
- Harz Energie Netzgesellschaft
- inetz – Ein Unternehmen von eins
- mainova
- MITNETZ GAS
- MVV NETZE – Ein Unternehmen der MVV
- NBB Netzgesellschaft Berlin-Brandenburg

With the use of biomethane and the admixture of hydrogen, which is already feasible, extensive large-scale CO_2 reductions can be achieved very quickly, especially in areas where oil and coal are still used today. This way, regional industrial and commercial enterprises can be offered a decarbonisation solution that is technically feasible, can be implemented by all parties and also supports local value creation. In the medium term, existing buildings can then be fully decarbonised quickly and at comparatively low cost in connection with the conversion of the network to hydrogen or other climate-neutral gases.

The project partners of "H2vorOrt – Making Hydrogen Usable for Everyone via the Gas Distribution Network" are convinced that, as a versatile energy source, hydrogen will allow effective decarbonisation and sector coupling and will therefore make a key contribution to achieving climate goals safely and economically. The decarbonisation process for gas infrastructure should therefore be tackled quickly and comprehensively.

To this end, the gas distribution network operators within H2vorOrt will continue to forge ahead with their projects and finalise their investment decisions.

Specifically, the project partners envisage a transition on three levels, simultaneously combining a supra-regional transport infrastructure with local generation and distribution potentials into an overall strategy:

1. Continued development of supra-regional and transnational transmission system operator infrastructures within a system network

The supra-regional and transnational supply of hydrogen takes place via the H_2 backbone of the transmission system operators. On the basis of current plans, this system will be implemented in three stages by 2040 at the latest, starting in north-west Germany. [4] This H_2 pipeline network will be 90 percent based on the existing natural gas network and is to have a total length of about 5,900 km when completed. It will serve as a transnational infrastructure for the transport of pure hydrogen and offers the prospect of importing large quantities of hydrogen securely and distributing it to a large number of users across Germany via the gas distribution networks. Access to gas storage facilities is also guaranteed via the backbone. The distribution network operators are committed to ensuring that the development of the H_2 backbone can be accelerated further compared with the current initial plans. The aim is for all regions of Germany to have access to climate-neutral hydrogen in the quantities required as soon as possible.

2. Boosting regional potential for power-to-gas and biomethane at an early stage

In parallel to the growth in supra-regional hydrogen supply, the local generation and use of hydrogen and other climate-neutral gases offers more than sufficient potential to initiate the decarbonisation of local gas infrastructure. This means that hydrogen can be made available at an early stage, especially in those regions

N-ERGIE netz

Netze BW

Netze Südwest

OsthessenNETZ
Ein Unternehmen der RhönEnergie Fulda

RNG Rheinische NETZGesellschaft

Schleswig-Holstein Netz

STADTWERKE BOCHUM

Stadtwerke Karlsruhe

Stadtwerke essen
Wir sind Zuhause.

SWM
Stadtwerke München

TEAG

thüga
Das große Plus der Gemeinschaft

westnetz

DVGW

that can only be connected to the H_2 backbone after 2035. As a result, there will be many hydrogen pilot regions as well as further local projects.

3. Individual transition processes of local gas distribution networks are undertaken in two phases

Every gas distribution network in Germany has its own regional characteristics. For the local energy transition to be a success, these specifics must always be taken into account. After the analysis and planning process, the first phase of upgrading the gas distribution networks or converting them to other climate-neutral gases will begin. On the basis of the analyses, individual network sections will be upgraded at an early stage as required to accommodate 100 percent hydrogen in the future. At the same time, 20 percent H_2 is already being added in certain network sections via local hydrogen generation using power-to-gas or alternative technologies. Other network sections are being converted to 100 percent H_2. In the next phase, operation of the H_2 backbone will start. This will allow larger quantities of hydrogen to be supplied while upgrades to the gas distribution network will progress rapidly until the entire gas distribution network is only used for the transport of climate-neutral gases. Network sections with 100 percent hydrogen, bio/renewable methane in pure form or with an admixture of hydrogen to bio/renewable methane can coexist. The majority of the project partners assume that we will see demand-oriented coexistence of 100 percent hydrogen network sections and other network sections that contain green methane with hydrogen admixtures in their networks. This is economically beneficial, as the cost-efficient use of existing networks enjoys a high priority in the entire transition process.

3 Challenges on the way to climate neutrality

3.1 The present structure of gas supply and the market – the impending heat shortfall

Germany currently imports more than 70 percent of its primary energy.[3]

It is clear that we must replace fossil fuels with climate neutral energy sources in order to achieve the goal of climate neutrality by 2050.

At the moment, renewable energies only cover about one-sixth of Germany's primary energy consumption.[5] In order to cover the remaining five-sixths, the wind power and photovoltaic capacity currently installed in Germany would have to increase more than tenfold[1].[6] In view of the moderate rate of expansion of renewable energies in recent years, extensive land use restrictions and acceptance problems, it is clear that Germany will have to import significant proportions of its primary energy in the future and at the same time ambitiously expand renewables. This also applies if primary energy demand falls in the future.

In the current political and public discourse, hydrogen is increasingly emerging as the preferred transport medium for the import of renewable energies. Using this energy source, CO_2 emissions can be reduced quickly and dramatically – wherever energy is needed. The existing gas infrastructure plays a decisive role here. It offers ideal conditions for absorbing, storing, transporting and distributing climate-neutral hydrogen.

The heating market in Germany consumed 1,330 TWh of energy in 2019. This corresponds to 53 percent of final energy consumption.[3] The vast majority of this was made available in the form of molecules[2], and this is unlikely to change in the long term. It is therefore essential to decarbonise these molecules.

In urban areas in particular, various infrastructures are available for achieving climate neutrality in the heating sector – the gas network, the district heating network and the electricity network. In rural areas, the options are usually less diverse. These infrastructures will also have to coexist in the future. Each has specific advantages. Gas applications are particularly advantageous in existing buildings. Even with low renovation rates, the climate targets can be achieved here via the gas network.

In addition, a "fuel switch" process from coal to gas is currently taking place in the heating and power generation sectors. In the domestic heating sector, a transition from oil to natural gas applications can already be observed. The next logical step in both cases is the increasing use of climate-neutral gases. In order to enable this step, the gas distribution networks must be upgraded.

Some stakeholders are campaigning for the full electrification of the heating market. The climate protection potential of gases is often underestimated as the evaluation is only based on technical efficiency parameters. As a result, overall systemic interrelationships are neglected and the solutions propagated are less than ideal in economic terms.[3] In addition, comprehensive electrification would call for a considerable additional expansion of the power grid.[7] So that the heating transition remains affordable[4], it should be decentralised and neutral with regard to technologies and applications. Full electrification entails severe risks:

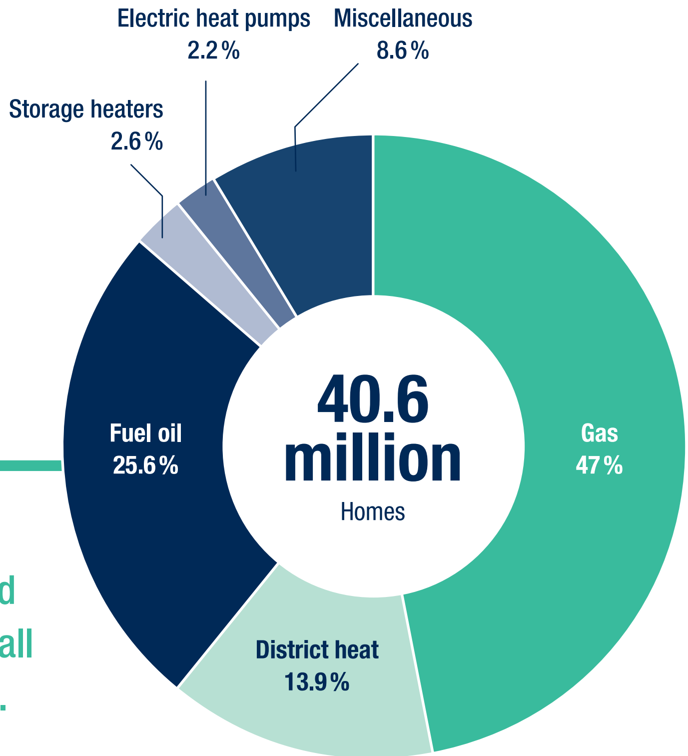
- Even assuming that the current refurbishment rate is doubled to 2 percent per year in the future, energy-related refurbishment will only have been carried out on 60 percent of buildings by 2050.
- It should also be noted that the energy-related refurbishment of an existing building involving the installation of a heat pump is significantly more complex and costly than replacing an old heating system with a climate-friendly heating system.[5] In areas without access to the gas network, extensive renovation and the use of technologies such as heat pumps are required to achieve climate neutrality. However, where there is a gas network infrastructure, the decarbonisation can be achieved independently of refurbishment – through the use of climate-neutral gases. In addition, there are already very limited capacities in the trades, which will make it much more difficult to increase energy-related refurbishment rates in the near future. It will therefore not be possible to achieve climate neutrality in the space heating sector in this way.
- As a result of the phase-out of nuclear energy and coal, the secure generation capacity in Germany is falling. The remaining generation capacity is largely volatile. Days with "dark doldrums" [6] are especially likely to occur in the winter months. These are also the days with heat demand peaks. Maximum energy demand therefore coincides with an energy shortage. As a result, the electricity shortfall also becomes a heat shortfall and is significantly exacerbated.[7] This severely jeopardises supply security in terms of electricity and heat. It is not unlikely that these relationships will also have a significant impact on energy market prices.

The German gas supply infrastructure offers a secure alternative, which involves replacing natural gas with climate-neutral gase. This would take pressure away from power grids and entail

Domestic heating structure in Germany[8]

60.9 %

Hydrogen and climate-neutral gases could already be supplied to more than 60% of all homes via gas and district heat networks.



significantly lower resource costs, especially for heat users and end users of gas. It can also be assumed that climate-neutral hydrogen will experience a considerable decrease in costs and prices in the coming years. It is therefore expected that the switch from fossil fuels to the use of hydrogen will have little effect on the operating costs of heating systems in the long term.

The climate protection goals and the legal requirements for CO_2 reduction in the industrial sector can be achieved by using the existing gas infrastructure.

In Germany, around 600 large industrial customers are supplied directly via the gas transport network. However, the overwhelming majority of gas users, about 1.6 million industrial and commercial end consumers, are connected to the distribution networks.[8] More than 50 percent of the gas consumption of large industrial customers who consume more than 100 million kWh, and power plants with more than 10 MW of generating capacity is supplied from distribution networks. This shows that hydrogen supply via transport systems alone alone will be insufficient to fully supply and decarbonise industry by a considerable margin. Ther conversion of the distribution networks to transport hydrogen will mean that it can be supplied direct to end consumers. In addition, there are many industrial and directly commercial facilities that can easily be connected to the distribution network and changed over from coal, coke or oil products to hydrogen supply. If this option remains untapped, the path of industry and the manufacturing and processing sector to climate neutrality, which is already challenging, will become significantly more difficult and costly. This would cause considerable damage to the competitiveness of Germany as an industrial location.

In mobility, hydrogen can be made available as fuel at a rapidly growing number of filling stations via converted gas distribution networks.

3.2 The potential of climate-neutral gases and gas distribution networks for climate protection

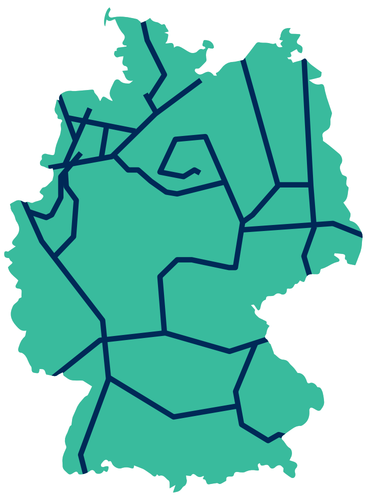
With biomethane, synthetic methane from green hydrogen and climate-neutral hydrogen, three options are available for carbon-neutral gas supplies with great potential for reducing CO_2. Biomethane and synthetic methane can already be absorbed by the existing gas network infrastructure without any problems. Hydrogen requires the step-by-step modification or further development of the gas network infrastructure, but is the gaseous energy source of the future in view of the considerable scalability of international production and its efficiency advantages compared with synthetic methane.

With the presentation of the “visionary hydrogen network” in January 2020, the gas transmission grid operators have described an important first step towards developing a nationwide hydrogen supply system for Germany via the gas infrastructure.[4]

The “H_2 backbone” shown here can supply the distribution networks with H_2 in a highly efficient manner. Together with the increasing amounts of hydrogen produced at decentralised locations, the distribution networks can then supply the H_2 to hundreds of thousands of industrial and commercial users as well as many millions of households.

The National Hydrogen Strategy (NWS) also makes it clear: the expansion of the H_2 infrastructure is expected to proceed in a similar way to the expansion of the natural gas infrastructure.[2] Specifically, this means that local H_2 conversion will be driven mainly by industrial demand. As in the case of natural gas, it will be beneficial to make hydrogen available to other gas users as the distribution network will be changed over in any case. They will then benefit from climate neutrality in the same way as industrial consumers. In addition to the decarbonisation of industry, this

The prospective H_2 backbone will be a key element in ensuring adequate hydrogen supplies in the future.



Source: own presentation on the basis of FNB Gas and European Hydrogen Backbone[4, 9] will also allow the successive decarbonisation of other businesses and the supply of heat to households. In addition to converting distribution networks to 100 percent hydrogen, hydrogen 20 percent (see 3.3) with the methane currently being supplied to customers.

The interest of consumers as well as heating appliance and system manufacturers in the use of H_2 is increasing rapidly. There are currently clear trends in the development of appliances that show that the German appliance and component industry will be able to provide the technologies required for achieving climate neutrality with gases in sufficient quantities and at competitive prices in good time.[10]

From the point of view of the H2vorOrt project partners, the construction and further development of the German H2 backbone needs to be consistently pursued. At the same time, the German gas distribution network operators must ensure that they are able to supply industrial, commercial and domestic customers with 100 percent H_2 as soon as possible, but no later than 2050. This will be beneficial for the following reasons:

- **LOWER COSTS:** It is foreseeable that it will not be possible to largely replace present energy imports with energy generated domestically it will therefore continue to be necessary to import large quantities of energy and transport it within Germany. The cost of upgrading the German gas distribution network is only a fraction of the cost that would be incurred for the construction of a similar H_2 infrastructure or the ambitious necessary expansion of the electricity transmission, distribution and generation infrastructure which would otherwise be necessary.[11]

- Strengthening **SECURITY OF SUPPLY / RESILIENCE:** H_2-ready[12] gas networks strengthen the resilience of the energy system on two levels:
  - To achieve climate-neutrality, it is beneficial not to rely on a single energy source.
  - The transition to H_2 readiness will allow distribution networks to transport all decarbonised gases. They will be able to transport both H_2 and climate-neutral methane and therefore react flexibly to future supply and demand.

- **EARLIER CO_2 REDUCTION OFFERS VALUABLE CLIMATE PROTECTION BENEFITS:** On the way to climate neutrality, the early reduction of GHG emissions is necessary in order to reduce global warming to a minimum. The time required to upgrade the distribution grids for H_2 readiness is significantly lower than that for extensive electrification. With the use of climate-neutral gases (such as biomethane and locally generated H_2) by admixing them with gas in the existing gas network, large-scale and extensive CO_2 reductions can be achieved quickly. In the medium term, the existing buildings can be completely decarbonised quickly and at comparatively low cost to consumers by switching to H_2 or other climate-friendly gases within network sections. In this way, locally and regionally based industrial and commercial enterprises are also offered a decarbonisation solution that is technically feasible, can be implemented by all parties and also drives local value creation.

In 2018, the World Energy Council[6] already forecast a global market potential of up to 20,000 TWh per year for green synthetic fuels (this corresponds to around 50 percent of the global demand for crude oil). We assume that the paradigm shift that is currently taking place in connection with the use of hydrogen and its derivatives will result in even greater market potential. This development is supplemented by the domestic generation potential of climate-neutral gases (see 4.2) and the import of climate-neutral, but not green, gases.

3.3 Total hydrogen supply coverage via the distribution network is technically feasible

In a first step, DVGW sees admixture of 20 percent H_2 in the existing network as technically possible.

Over the past few years, DVGW has carried out research projects on H_2 blending options and the H_2 compatibility of materials and gas appliances in the existing network. In first studies, a hydrogen compatibility of up to 10 percent and in further DVGW research projects up to a blending concentration of 20 percent could be confirmed.[13, [10, 11, 12]] These positive results were verified by a practical test.[13] The Federation of the German Heating Industry (BDH) also confirms that the appliances available on the heating market can be operated safely and efficiently with a hydrogen share of 10 percent without major technical modifications, and assumes that 20 percent can be achieved within a few years.

However, it is also possible to switch to operation with 100 percent H_2 with an upgrade.

In the ongoing DVGW research project “Roadmap Gas 2050”, gas appliances, components and materials are being investigated to determine their tolerance limits with hydrogen admixtures and 100 percent hydrogen. Similar projects are currently underway across Europe. [14] The testing and certification bodies are working on new test gases and conditions in order to be able to safely approve devices for the use of hydrogen mixtures or pure H_2 for the market. Standards with requirements and tests being are drawn up by the industry and manufacturers are developing new technologies to allow the use of these renewable gases.

As regards the upgrading of distribution networks to supply 100 percent H_2, a distinction must be made between point objects (stations etc.) and line objects (pipes). In principle, point objects can be replaced more quickly and with less planning effort. Equipment designed for methane must be upgraded or replaced for operation with 100 percent H_2. Nowadays, gas pipelines consist almost solely of plastic and steel pipes. Plastic lines and steel pipes commonly used in distribution networks are H_2-compatible, which means that the majority of the pipe components in distribution networks are already H2-compatible.[14] Although a large proportion of components are already H_2-ready a significant upgrading work will still be needed to replace the remaining components and to ensure technically safe operation with 100 percent H_2.

For a higher hydrogen admixture of well over 20 percent by volume or pure hydrogen supply via the upgraded gas distribution network, end consumers' gas appliances will either need to be converted or replaced by new appliances. With the transition of the market area from low calorific value (group L natural gas) to high calorific value gas (group H natural gas) that is currently in progress, the German gas industry is currently proving very impressively that it can implement major organisational, logistical and technical projects safely, efficiently and according to plan. About 5.5 million gas appliances in the north and west of Germany are being converted in connection with this changeover. This process will be completed by 2030.

DVGW is convinced that the technical challenges which still face the conversion of gas distribution networks to 100 percent H_2 to a certain extent will be solved in the medium term while complying with strict safety requirements. Intensive work has already started on the relevant regulations.

3.4 The gas distribution network in a European context

Europe is on track for a future with hydrogen. In this context, the United Kingdom, the Netherlands and Portugal, where political decision-makers are consistently promoting the large-scale use of hydrogen, should especially be mentioned. The UK, for example, is giving priority to the decarbonisation of the heating sector using hydrogen and is planning the largest projects in Europe. Depending on the geographical location, projects with H_2 admixtures or pure hydrogen distribution networks are being pursued.

In its National Hydrogen Strategy, the federal government in Germany has also stated its intention to make greater use of hydrogen and hydrogen technologies. The federal government has even formulated the ambition that Germany should become a world leader in hydrogen technologies, and sees enormous economic opportunities in this context. The German government is therefore acting in line with the European context at the same time as claiming a leadership role that must now be underpinned with concrete implementation measures. With its gas distribution network, which is already outstandingly well-developed, Germany has the best prerequisites and a wide range of options for transporting hydrogen to the regions.

At the same time, in the DVGW codes of practice, Germany has technical standards that are highly respected by European partners. The DVGW codes of practice already allow up to 10 percent H_2 admixture to the network. In a European comparison, these codes of practice are very progressive.

As in Germany, industrial customers and CHP plants in many European countries are mainly connected to the gas distribution networks. This once again makes it clear that the distribution grids throughout Europe are an important asset for achieving climate neutrality and that they can make local decarbonisation possible. It is now important for the right political foundations to be laid as rapidly as possible. The associations Eurogas, CEDEC, GEODE, GD4S and MARCOGAZ are committed to these efforts at the European level.

4 A full changeover of gas distribution networks to climate-neutral gases is both feasible and beneficial

4.1 Why we should start now

Our vision

The H2vorOrt project partners see the existing gas networks as the leading distribution infrastructure for hydrogen in Germany. They see themselves in a position to meet the resulting technical and organisational requirements by reallocating the existing infrastructure and building new network sections. The use of the existing gas infrastructure for cross-sectoral decarbonisation with hydrogen will make it possible to achieve the CO_2 targets for 2030 discussed within the framework of the European Green Deal and climate neutrality for 2050 without delay and cost-effectively.

However, these advantages on the way to climate-neutrality can only develop their full positive effects if decarbonisation and the energy transition using climate-neutral gases are understood as a regional and local process – in line with the title of this project. This means that the transition towards climate-neutral energy supply with gases should always be implemented taking into consideration local conditions and in a process of dialogue with local consumers and local politicians. While some regions will rapidly switch to 20 percent and 100 percent H_2, biomethane or methane from renewable energies will be more important for the local energy supplies in other regions.

The market for climate-neutral gases must be placed on the right track so that growing demand can be met at all times and there is no shortage. However, it is important for the political decisions required to be taken now in a consistent manner.

In the conversion of German distribution network sections to hydrogen, local industry can in many cases act as an initial driving force for the decarbonisation of network section areas. Increasing admixtures of up to 20 percent and a switch to 100 percent H_2 make it possible to forge ahead with the decarbonisation of industry that is required at the same time as making the local heating market and all the customers who are supplied with gas climate-neutral.

We need to start now

It is crucially important for the decarbonisation potential the gas supply to be leveraged, consistently and at an early stage. A transition to pure electricity or electricity generation will be insufficient for achieving climate neutrality in the envisaged time frame. Without without the use of climate-neutral gases in the heating market this approach would also lead to significantly higher costs for many consumers. The project partners are convinced that the versatile medium of H_2 will effectively enable sector coupling and thus make a decisive contribution to ensuring that the climate protection goals for 2030 and 2050 are achieved reliably and economically.

The construction of large-scale hydrogen generation plants and applications is described as a political goal in the National Hydrogen Strategy, as well as in the EU Hydrogen Strategy.[15] These should form the core of an emerging extensive local hydrogen economy. Early initiation of the infrastructure modifications that are required at the local level will be an essential prerequisite. We support this objective as distribution network operators and want to start now in order to have a fully functional overall system in good time.

4.2 The three pillars of climate-neutral gas supply and their specific local implementation

It is important to the project partners, as distribution network operators, it will be important to provide both an overview of the nationwide gas distribution network and an insight into specific local conditions in individual network areas and sub-networks. For this reason, the three pillars of decarbonisation of the gas distribution network which are central from the project point of view are considered first. These three pillars are:

1. The supra-regional supply of hydrogen through the backbone
2. The decentralised generation of hydrogen in Germany
3. Biomethane and climate-neutral synthetic methane

The specific local decarbonisation process is then discussed. In order to achieve climate neutrality, the project partners are convinced that it is important to give equal priority to decentralised “bottom-up” development and an overall systemic “top-down” approach. This combination of approaches will create a functional overall structure that can take into consideration the specific conditions and requirements that apply both at the level of the overall system and with regard to the decentralisation that is required. In order to ensure the connectivity of the target concept presented here, the project participants are involved in a continuous and constructive process of dialogue with transmission system operators and representatives of appliance manufacturers.

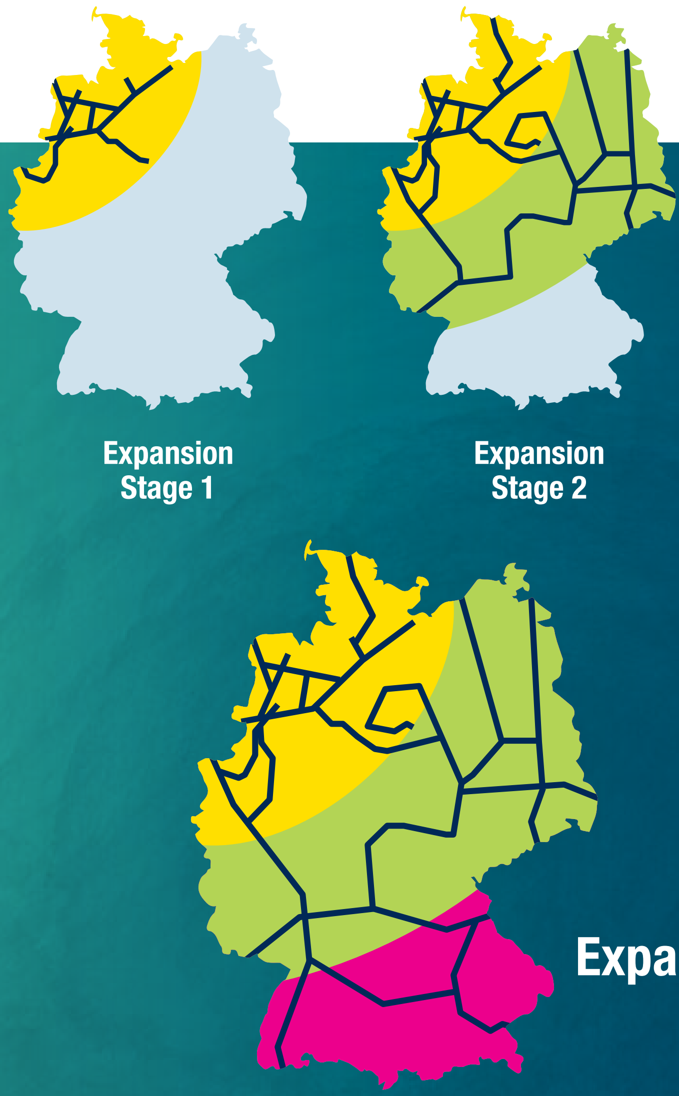
The supra-regional supply of hydrogen through the backbone

The possibility and the intensity of gas supplies to the distribution network via the backbone will depend on progress with the expansion of the backbone. On the basis of an initial evaluation of publications available, three expansion stages are outlined below:

The current target is to reach level one by 2030. This roughly corresponds to the content of the current draft in the gas network development plan. Expansion stage two is to be achieved by 2035 and expansion stage three by 2040. The availability of hydrogen to distribution networks via the backbone will be staggered regionally in three geographical areas (yellow, green, magenta from the northwest to the south-east of Germany). This means that the options for the physical delivery of hydrogen by 2040 will differ from region to region. It will be extremely important to ensure that individual companies do not suffer any disadvantages as a result of their location, for example if physical delivery is only possible to a limited extent. Such disadvantages could be prevented by the use of decarbonised gases for offsetting. The first production verification systems for this purpose are already being developed (e.g. the CertifHy system).

As with the current supply of fossil natural gas, the majority of decarbonised gas in the gas distribution networks will also be supplied via the existing gas pipeline infrastructure and in particular via the H_2 backbone in the future. For the rapid decarbonisation of industry, commerce and the existing buildings, it will therefore be important for the demand-oriented expansion of the backbone to be implemented as quickly as possible.

This way, it will be possible to create the infrastructure required for ensuring adequate availability of hydrogen throughout Germany



The area supplied with hydrogen via the gas distribution networks will grow in line with the three expansion stages of the proposed H_2 backbone

Approx. 2030 | Approx. 2035 | Approx. 2040 no later than 2040. In this context, the gas demand of the industrial and commercial enterprises that are supplied via the distribution network must be added to the previous volume projections in the gas network development plan. In addition, the quantities needed to serve the heating sector and thus prevent a heat shortfall must be taken into account. It is therefore very important for the H_2 generation capacities that are required to be created and used.

Furthermore, the establishment of an appropriate legal framework will be crucially important for creating the prospective demand and investment security required by exporters of hydrogen and methane from renewable sources from potential supplier countries. Here, too, a high level of ambition with rapid implementation will be extremely important for the success of local decarbonisation in the individual distribution network areas.

The decentralised generation of hydrogen in Germany

In addition to centralised supply, the decentralised generation and use of H_2 will be very important for the success of local decarbonisation and transformation. The DVGW potential study on power-to-gas systems in German distribution networks has shown that over half of the more than 11,000 municipalities in Germany have medium or high potential for the construction and operation of power-to-gas systems.[16]

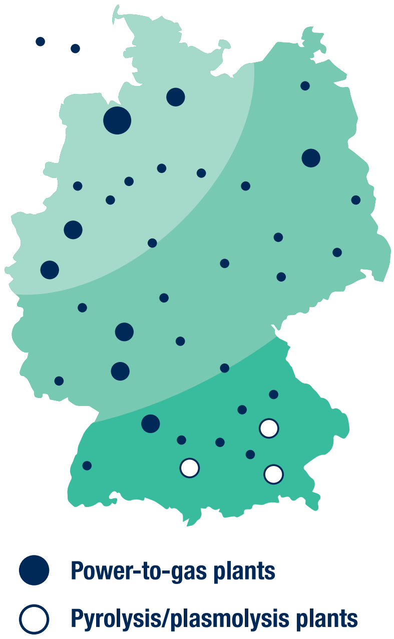
Overall, the study indicated an installation potential of up to 40 GW of electrolysis capacity at the distribution network level. Assuming an average of 3,500 annual full-load hours, 140 TWh of hydrogen can be generated in this way. This figure corresponds to around 14 percent of current natural gas consumption in Germany. The achievement of this potential will call for the rapid and extensive expansion of electricity generation using wind power and photovoltaic systems, so that sufficient renewable power is available at low purchase prices.

Provided that sufficient progress is made with research in this area, pyrolysis[15] may become a useful additional option for the early decarbonisation of regional industry and the surrounding network section, especially in areas that only gain access to the H_2 backbone at a later date.

Biomethane and climate-neutral synthetic methane

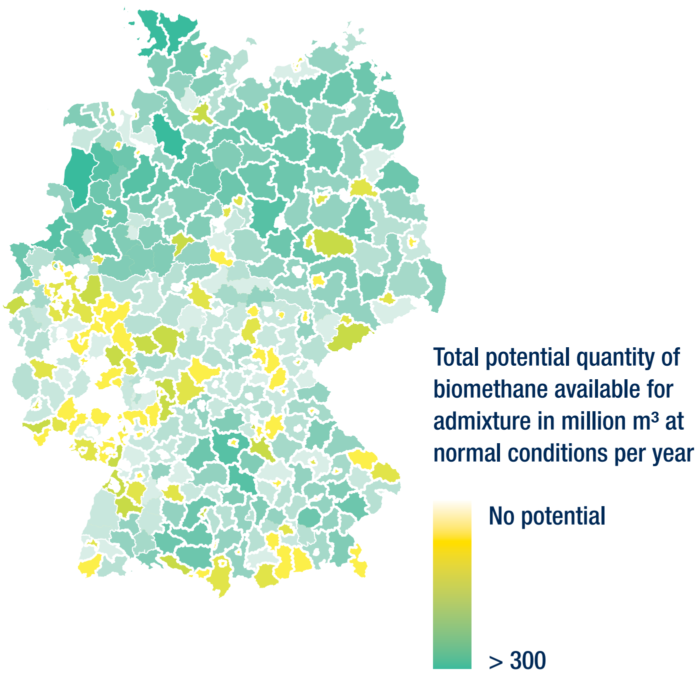
Around 9,500 biogas plants are currently in operation in Germany.[17] The biogas produced is currently used mainly for direct local power generation. Nevertheless, around 200 plants can already feed approx. 9 TWh of processed biogas into the gas network as biomethane.[18] Biomethane is therefore already present as an energy source in various sectors. In mobility, for example, around half of the gaseous fuel used is made from biomethane and is therefore climate-neutral.

The decentralised generation of H_2 will transform individual grid areas into local hydrogen islands at an early stage.



Source: Own presentation based on [16]

Germany has significant biomethane potential.



For the first time, 14 energy companies and regional suppliers have developed a model for a future energy and infrastructure system for the eastern states of Germany in the study "Commit to Connect 2050". Investigations focused on the development of an economically optimised target concept for a fully decarbonised energy system in eastern Germany in 2050. For this purpose, 19 clusters were formed in eastern Germany and analysed with regard to their energy requirements and their generation potential with a view to defining an optimum plant fleet and an appropriate distribution network infrastructure. The study also examined how the individual regions could be connected by transport network capacities and what storage capacities would need to be made available for the new energy system. A key result of the investigation: hydrogen will supplement the electricity system and serve as an inexpensive transport medium between the regions. In order to optimally integrate the various energy sources into a system, both biomethane and hydrogen will play a central role. Together, they will account for energy supply of about 200 TWh and completely replace fossil natural gas.[19]

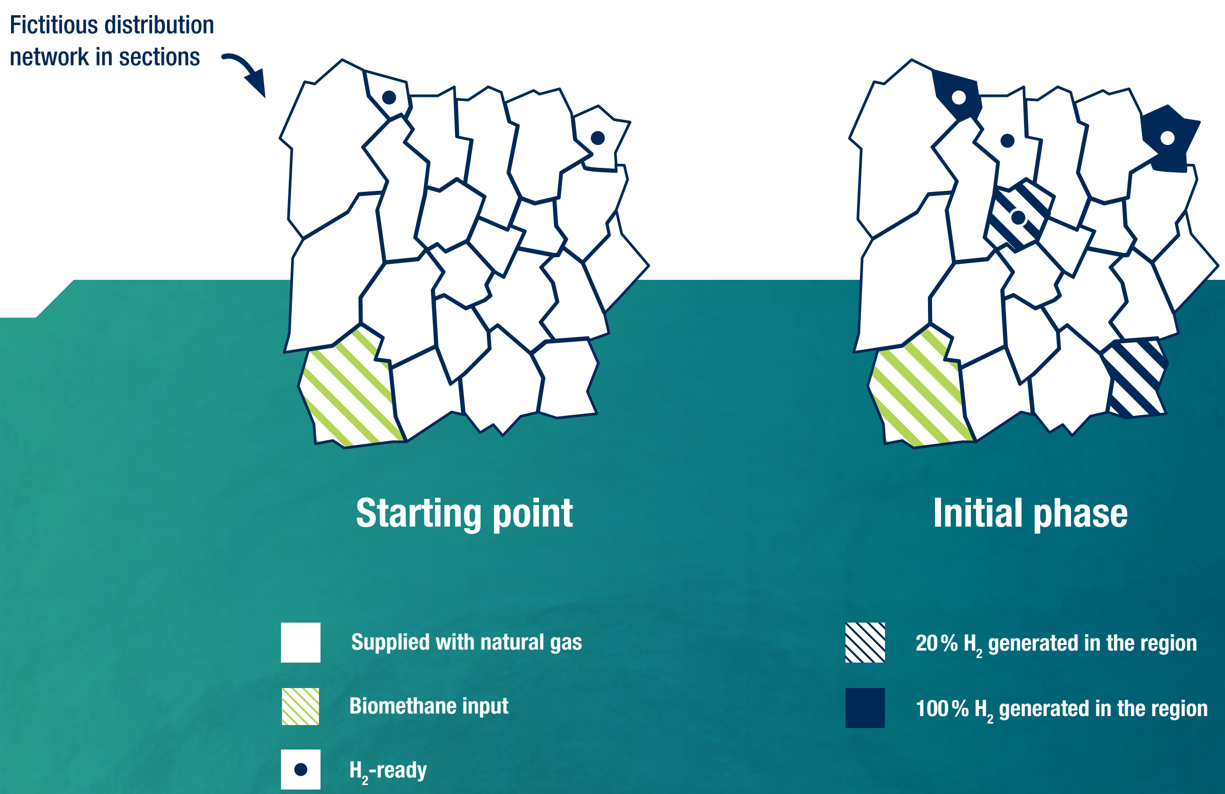
Biomethane allows immediate entry to climate-neutral gas supply. In this context there is considerable green gas potential that can be activated quickly. In order to achieve this objective, like all climate-neutral gases, biomethane needs to be made market-ready (see Section 5.1).

Large additional quantities of biomethane and methane from renewable sources can be produced quickly and fed to the network by converting biogas plants located close to the gas network whose subsidy period under the Renewable Energy Act has expired, merging smaller plants and combining them with an on-site electrolysis unit. This corresponds to a total potential of up to 169 TWh.[17] Many of the German states offer suitable locations for plants in this context.

In addition, electrolytic hydrogen produced outside Germany may be methanised in the country of origin in a CO_2-neutral manner[18] and liquefied. In this way, existing LNG infrastructure could be used to transport the gas to Germany, where it could directly replace fossil natural gas.

The route to local ckimate neutrality

Example transition route of a fictitious gas distribution network area, split into sections



H2vorOrt – from isolated island solution to broad-based climate neutrality

Every gas distribution network in Germany has its own regional characteristics. For the local energy transition to be a success, these specifics must always be taken into account. There will be no detailed one-size-fits-all solution for all distribution networks; the regional production and consumption structures of the local players must always be taken into account and reconciled.

It will therefore be crucially important for distribution network operators to engage in a continuous dialogue with users, producers, politicians and other stakeholders such as plumbers, heating equipment manufacturers, etc. in the near future and to conduct this dialogue continuously and on a long-term basis. In this context, it will be particularly important to work with local businesses to develop decarbonisation solutions that are effective, targeted and widely accepted. These specific regional solutions and transition paths must be enabled and supported by suitable laws and regulations at the national level.

The route to local climate neutrality

The initial phase: The first step will be to upgrade the distribution network for the long-term exclusive use of climate-neutral gases and to make it H_2-ready in accordance with local plans. At the same time, individual network sections will be converted to 20 percent or 100 percent H_2 at an early stage, and as required, using local H_2 production from electrolysis or alternative technologies. The use of local biomethane will also contribute to decarbonisation. Over 90 percent of the H2vorOrt project partners have already identified potential demonstration areas for this process or have isolated networks that are suitable for early conversion.

Expansion phase (from 2030/35/40*): By this point, the backbone will have been developed and larger quantities of H_2 will be available locally. Further network sections will be converted to 20 percent or 100 percent hydrogen. The upgrading of the gas distribution networks will proceed rapidly. Over 95 percent of the project partners already believe that it will be technically feasible to convert to hydrogen on a network section basis.

The target situation by 2050: The entire gas ditribution system in the network area should now be climate-neutral or only transport climate-neutral gases and have been fully upgraded in terms of infrastructure. Network sections with 100 percent H_2, bio/renewable methane in its pure form and sections with the addition of about 20 percent hydrogen to other climate-neutral gases may coexist. The majority of the project partners assume that we will see the demand-oriented coexistence of 100 percent H_2 network sections and network sections that contain green methane with H_2 admixtures in their networks. Almost 25 percent assume that by 2050 they will only operate gas lines that transport 100 percent hydrogen.

* Depending on the location of the network area in expansion stages 1–3 of the backbone

Expansion phase
From 2030/2035/2040

20% H_2 backbone

100% H_2 backbone/with backbone

Target situation
By 2050

Biomethane with 20% H_2

100% renewable methane from backbone H_2 and bio-CO_2

80% renewable methane from backbone H_2 and bio-CO_2, with 20% backbone H_2

The process of transition to climate-friendly gases is widely accepted.

The initial experience of the project partners from pilot projects in the heating sector (in the context of H_2 admixtures in the gas distribution network) makes it clear that the continued use of gas applications and the gas distribution network with climate-neutral gases is widely accepted by consumers and all other end users. This way, consumers and municipalities can achieve full climate neutrality without significantly more costly and complex infrastructure investments, for example involving a changeover from gas-powered appliances and equipment to other technologies and energy sources.

4.3 Further development of the gas distribution network as a valuable asset for affordable, reliable and climate-neutral energy supply

Tangible added value at local level

The H_2 readiness of a network section will become a location advantage for industrial plants and commercial facilities. Future fitness and sustainability is becoming a factor for a growing number of municipalities when it comes to positioning themselves as a business location. In addition, H_2 readiness will support the local energy transition by facilitating the establishment of local H_2 production facilities such as electrolysis or pyrolysis plants by making it possible to transport hydrogen.

However, the gas distribution network will also create significant local and regional value in network sections that are supplied with synthetic, climate-neutral methane in the medium or long term. The German gas distribution network has an economic replacement value of several hundred billion euros[19] and its operators are continuously investing in this asset. Annual investments and expenditure throughout Germany currently total about 2.5 billion euros.[20] A large part of these investments flow into the respective regions and have therefore ensured employment and local value creation for decades. Most of the more than 700 German distribution network operators have municipal shareholders and, in this context, make significant and continuous contributions to the financing and security of numerous municipal budgets.

The gas distribution networks as facilitators of Germany-wide climate neutrality

As can be seen from the information given in Chapters 1– 4 of this policy paper, the gas distribution networks in Germany can become an infrastructure enabler for a climate-neutral energy system of the future. Climate-neutral gases, especially hydrogen, are decarbonisation and sector coupling media that are easy to store and transport. Hydrogen is therefore becoming a key energy source in the context of the decarbonisation of industry, mobility and, in particular, the building and heating sector. In this way, climate neutrality can be achieved for all users of the gas network in way that is reliable, predictable and cost-efficient however, this will only be possible if the gas distribution network is technically upgraded for full H_2 readiness. The next stage will involve the step-by-step conversion of gas distribution networks to the exclusive use of hydrogen or other climate-neutral gases.

The energy transition is taking place in a decentralised way in the various regions and must be designed to take regional specifics into account. The vast majority of industrial companies, CHP plants, and especially private and commercial heat users are connected to the gas distribution network.[17] This is why the transformation to gas distribution networks that only contain climate-neutral gases plays such an important role for achieving the climate protection targets for 2030, 2040 and 2050.

5 Our commitments and recommendations for political decision-makers

The 34 partner companies involved in the H2vorOrt project and DVGW acknowledge their responsibility for achieving the climate targets. They therefore want to step up their efforts as quickly as possible to accelerate the transformation of the gas distribution network. Together they have drawn up an agenda of eight points, which is stated at the end of this chapter.

However, it will only be possible to implement this eight-point agenda if legislative and executive bodies, especially at the national level, take decisions and lay foundations in the near future to facilitate the transformation of gas distribution networks that is required and to significantly accelerate this process. In many respects, the legislative framework is by no means H2-ready or energy-transition-ready as far as gas distribution networks are concerned.

The 34 project partners of H2vorOrt have therefore formulated six specific recommendations for action by political decision-makers together with DVGW.

5.1 Specific recommendations for political decision-makers

The H2vorOrt project partners recommend that political decision-makers ...

1. **state the goal of climate-neutrality and a specific target for the proportion of climate-neutral gases in the gas mix in legislation.**
   For the electricity sector, a specific target for green electricity is already set in the coalition agreement and in the Renewable Energy Act (EEG): By 2030, the share of renewable energies in electricity consumption is to be 65 percent. A target for climate-neutral gases should also be defined by politicians and laid down in legislation. The further development of gas networks must then be oriented towards this goal and that of climate-neutrality. Investments must be aligned accordingly.

2. **implement the six most urgent measures of the National Hydrogen Strategy promptly to initiate investments in H_2 generation and H_2 network infrastructure.**
   Specifically, this relates to the Renewable Energy Act levy exemption for electrolysis electricity after 01.01.2021 and in particular the following measures of the National Hydrogen Strategy:
   18: Promotion of highly efficient fuel cell heating appliances
   19: Consideration of subsidies for H_2-ready CHP systems
   20: Definition of recommendations for action (dedicated lines, adaptation / conversion and H_2 readiness), regulatory basis for H_2 infrastructure
   21: Making process with the sector coupling of electricity, heat and gas infrastructures
   35: Cooperation with partner countries in a hydrogen alliance

3. **create a regulatory framework for the use of hydrogen networks on the basis of the existing framework for gas networks.**
   In this context, the legal framework should be adapted in such a way that investments in H_2 readiness are adequately taken into account and do not lead to disadvantages in terms of efficiency comparisons and existing gas network structures. It should be made clear that the existing and proven regulatory framework for gas will include hydrogen in the future. Early investments in the H_2 readiness of gas distribution networks should should also be taken into account in full in the regulatory framework in order to advance the transformation of the gas network at an early stage and to send a clear starting signal.

4. **establish a climate bonus for progressive gas end users that encourages the use of climate-neutral gases.**
   Similar to the procedure for the multiple counting of charging current for battery vehicles set out in RED II, the purchase of climate-neutral gases for end users on gas networks should be counted twice for offsetting CO_2 in connection with the CO_2 tax laid down in BEHG (Fuel Emissions Trading Act). This mechanism would stimulate the market ramp-up of climate-neutral gases and thus allow rapid and effective climate protection. This mechanism is to expire in 2030.

5. **introduce an H_2 conversion bonus for progressive gas end users, which promotes the conversion of customer systems to H_2.**
   In the future, the income from CO_2 pricing in gas supplies to end users under the Fuel Emissions Trading Act (BEHG) will mainly be used to decarbonise gas supply on the user side. A fund, which is to be financed from the proceeds of the CO_2 pricing in national emissions trading, should support gas end users and allow the full conversion of gas-supplied regions to hydrogen. Specifically, customer-side measures that enable customer systems to be converted to H_2 supply are to be supported.

6. examine whether fund financing can remove obstacles to upgrading the network and also stimulate the economy.
   Network operators must be able to make investments promptly in the H_2-readiness and transition to 100 percent H_2 of the gas distribution networks. For this purpose, the gas network operators must receive adequate capital resources to cover their conversion investments. These could, for example, be provided through innovative instruments offered by KfW.

5.2 Our commitments: the gas industry as an enabler of the energy transition and climate neutrality

Provided that these recommendations for action are implemented, the 34 project partners of H2vorOrt, together with DVGW, commit to the following agenda:

The project partners ...

1. **as local infrastructure operators, are committed to durably enabling and strengthening regional value creation.**

2. **will, from now on, be focusing on the installation of H_2-ready components.**
   With immediate effect, the project partners intend only to install gas network components that are H2-ready, as soon as the certificates required are available and such installation work as possible in accordance with their plans. This way, the entire gas distribution network in Germany will be continuously upgraded.

3. **will lay the technical foundations for the infrastructure transformation required via DVGW in 2021.**
   In 2021, DVGW will answer key questions relating to the approval, construction, testing, commissioning and operation of gas distribution networks and appliances in the context of hydrogen. This will allow the start of planning and the first pilot projects at the local level. At the same time, a comprehensive revision of all the codes of practice for gas systems will be undertaken. The future codes of practice should aim for a target value for hydrogen injection of around 20 percent by volume (admixture). To ensure that a future-oriented system of codes of practice for the entire hydrogen process chain is available soon, the existing documents are to be supplemented by a new set of documents for 100 percent hydrogen. In order to complete this process quickly, DVGW will provide resources to accelerate and intensify the standardisation process.

4. **will initiate a "Gas Network Area Transformation Plan" (GTP) within DVGW.**
   - In order to provide the best possible support for the nationwide energy transition with regard to the technical conversion of gas networks to hydrogen and climate-neutral gases, it will be necessary to carry out regional hydrogen target network planning work covering specific regional supply and demand structures.
   - For this purpose, DVGW will create a platform to condense the individual plans of the gas network operators into a gas network area transformation plan (GTP). This plan will consider H_2 readiness, the technical changes to individual network sections required, and other concepts for achieving climate neutrality. It will be a structured, institutionalised process for developing a coordinated, cross-network plan that will serve as a guideline/support for technical implementation andprovide input for the Network Development Plan (NDP).
   - This "GTP" will develop the previously static exchange of planning between distribution and transmission system operators and initiate an active dialogue between them. Bidirectional comparison of the plans (GTP and NDP) will lead to a holistic network concept for hydrogen. The various user groups will be actively involved in this process.

5. **are committed to developing plans for the establishment of H_2-readiness by 2025.**
   These plans will be developed in a continuous dialogue with upstream and downstream network operators as well as key user groups. They will be based on the long-term objective of climate-neutral gas supply. The plans will form part of the GTP.

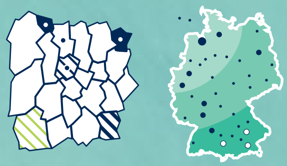
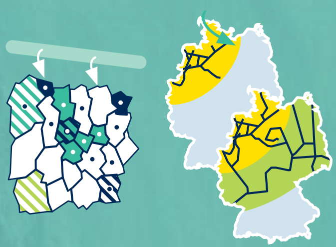
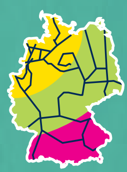
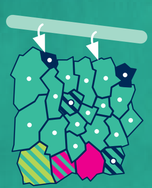
6. **intend to have implemented the first regional pilot applications powered by hydrogen in distribution networks by 2030.**

7. **will make a significant contribution to the energy transition and greenhouse gas reduction in their network sections by 2040, taking into consideration national decarbonisation targets[20], by**

   - upgrading the network sections they operate for the distribution of 100 percent H_2
     or
   - submit a detailed regional plan for the decarbonisation of defined network sections the decarbonisaton of by 2050 also with other climate-neutral gases. Alternatively, local decarbonisation may be implemented using other energy sources as part of integrated energy transition planning.

8. **will ensure the distribution of all climate-neutral gases within the distribution network on a long-term basis from 2050 onwards.**

The route to local climate neutrality at a glance

Development of the gas infrastructure	The project partners ...
Now 	1. as local infrastructure operators, are committed to durably enabling and strengthening regional value creation. 2. will focus more strongly on the installation of H2-ready components with immediate effect.
2021	3. will lay the technical foundations for the infrastructure transformation required via DVGW in 2021. 4. will initiate a "Gas Network Area Transformation Plan" (GTP) in DVGW.
2025 	5. are committed to developing plans for the establishment of H_2-readiness by 2025.
2030 	6. intend to have implemented the first regional pilot applications powered by hydrogen in distribution networks by 2030.
2040 	7. will make a significant contribution to the energy transition and greenhouse gas reduction in their network sections by 2040, taking into consideration national decarbonisation targets[21].
2050 	8. will ensure the distribution of all climate-neutral gases within the distribution network on a long-term basis from 2050 onwards.

End notes

1 The World Energy Council takes into account forecasts of 630 TWh/a to 3,000 TWh for German electricity demand in the future. With a consumption of 1,000 TWh, a six-fold increase in the renewable energy generation capacity currently installed is envisaged. IWith reference to 3,000 TWh, this would correspond to an eighteen-fold increase.[6] However, the higher forecasts if gas is used mainly for power generation do not give adequate consideration to seasonal demand peaks (electrified heating market in the winter) and the volatility of renewable power generation as these figures consider energy quantities and not system capacity. Expansion requirements may therefore be considerably higher.

2 Currently in the form of fossil natural gas, petroleum products, coal, biomass or district heating, in the future increasingly in the form of climate-neutral molecular energy sources such as hydrogen or biomethane.

3 The dena pilot study "Integrated Energy Transition" showed that, even without taking into account the significant additional costs for retrofitting industry, full electrification scenarios burden the economy with over € 500 billion more than comparable technology-neutral scenarios[1]

4 In particular, the specific investment decisions and opportunities of building owners are decisive for the success of the energy transition in the space heating sector. The limited financial resources available must also be taken into account, as well as the fact that the corresponding investments will compete with other possible or necessary acquisitions and expenses.

5 Elaborate insulation measures as well as the installation of underfloor heating and automatic ventilation systems are necessary in most cases. The high costs for this then lead to a considerable increase in the ancillary housing costs, which often become the "second rent". In some buildings, these renovation requirements for conversion to electric heat pumps cannot be met due to monument protection regulations or structural conditions.

6 Periods with little solar irradiation, little wind and therefore little renewable electricity generation.

7 Like volatility, power transmission is a problem at peak times. The HVDC projects currently under construction will not be sufficient to cover the capacity currently provided by the gas networks for heat generation, as well as the current contribution of fuel oil via electricity transmission from north to south. Further power line construction projects would be required.

8 In 2018, the distribution grids supplied end consumers with 754.5 TWh (479.3 TWh thereof to industry and power generation), and 173.6 TWh to the transmission grids.[18]

9 See also National Hydrogen Strategy (Measure 8), National Innovation Program for Hydrogen and Fuel Cell Technology and funding at the state level (e.g. Bavaria).

10 A) Development of new 100 percent H_2-ready applications: industrial use e.g. in steel works, chemical industry; appliances for 100 percent H_2 heat supply have already been presented and will be available in large quantities in a few years; H_2 filling station infrastructure; Gas turbines for 100 percent hydrogen; CHP devices (fuel cells and CHPs);

B) Checking the existing appliances with regard to 20/30 percent

H_2 tolerance; C) Development of conversion kits for appliances to increase H_2 tolerance to up to 100 percent H_2 compatibility.

11 See 3.1, End Note 3.

12 For the purposes of this publication, a gas network is H2-ready if it has been technically upgraded so that it can be switched from natural gas/methane to 100% hydrogen distribution.

13 Exceptions are gas meters and pipeline sizing. For gas metres, weights and measures laws only allow the admixture of 5 percent. For pipeline sizing, only 10 percent is currently possible. The gas industry is currently working on technical solutions in these areas both nationally and internationally and new developments that enable the injection of up to 20 percent hydrogen or pure hydrogen.

14 Approx. 78 percent of domestic service lines and 62 percent of gas lines up to 16 bar pressure are now made up of plastic pipes, which are suitable for up to 100 percent H_2. Most the steel pipelines used in pipelines of these types are made from low-alloy steel, which is regarded as unproblematical with respect to H2 compatibility. In the case of steel pipes with pressures >16 bar, which, however, only account for 5 percent of the pipes in the gas distribution network, a case-by-case analysis is required depending on the steel grade. Many of these steel grades are also suitable for H_2. Research on the H_2 readiness of steel pipelines is currently in progress.

15 During pyrolysis, methane is separated into hydrogen and carbon in a high-temperature process. This means that no CO_2 is emitted and the so-called "turquoise" hydrogen that is created can then be used in a climate-neutral manner.

16 The bio-CO_2 generated in addition to the biomethane can be used to methanise the green H_2 of the electrolysis unit, producing climate-neutral methane purely from renewable energy sources.

17 This corresponds to a good 17 percent of German natural gas consumption in 2019.

18 Here, CO_2 is taken directly from the air using renewable electricity by means of "direct air capture" (DAC). When the gas is burned, the CO_2 is then released again – the total amount of CO_2 in the air does not increase. Alternatively, another source of climate-neutral CO_2 can be used, e.g. biogas plants.

19 DVGW estimates amount to over € 270 billion.

20 In 2018, this amounted to € 1,273 million in investments in new lines, expansion and development and € 475 million in maintenance and renewal.
In addition, there were expenses of € 1,078 million for maintenance and repair.[18]

21 See Chap. 4.2. H2vorOrt.

Bibliography

[1] Deutsche Energie-Agentur (2018): Integrierte Energiewende. Online at: https://www.dena.de/themen-projekte/projekte/energiesysteme/dena-leitstudie-integrierte-energiewende/

[2] Federal Ministry for Economic Affairs and Energy (2020): Die Nationale Wasserstoffstrategie. Online at: https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/die-nationale-wasserstoffstrategie.pdf

[3] Federal Ministry for Economic Affairs and Energy (2020): Energiedaten: Complete edition, update on 22.6.2020. Online at: https://www.bmwi.de/Redaktion/DE/Binaer/Energiedaten/energiedaten-gesamt-xls.xlsx

[4] FNB Gas (2020): Vision für ein H_2-Netz. Vereinigung der Fernleitungsnetzbetreiber Gas e.V., Berlin. Online at: https://www.fnb-gas.de/media/fnb_gas_vision_fuer_ein_h2_netz_karte.jpg

[5] AG Energiebilanzen (2020): Energy consumption in Germany, data for the 1st to 3rd quarters 2020. Online at: https://ag-energiebilanzen.de/index.php?article_id=29&fileName=quartalsbericht_q3_2020.pdf

[6] Frontier Economics and World Energy Council (2018): International Aspects Of A Power-To-X Roadmap. Study commissioned by the World Energy Council Germany. Online at: https://www.weltenergierat.de/wp-content/uploads/2018/10/20181018_WEC_Germany_PTXroadmap_Full-study-englisch.pdf

[7] J. Büchner, J. Katzfey. O Flörcken, A. Moser, H. Schuster, S. Dierkes, T. van Leeuwen, L. Verheggen, M. Uslar and M. van Amelsvoort (2014): Moderne Verteilernetze für Deutschland. Study commissioned by the Federal Ministry for Economic Affairs and Energy (BMWi), research project no. 44/12. Online at: https://www.bmwi.de/Redaktion/DE/Publikationen/Studien/verteilernetzstudie.pdf

[8] Bundesverband der Energie- und Wasserwirtschaft e.V. (2019): Wie heizt Deutschland 2019? Online at: https://www.bdew.de/media/documents/Pub_20191031_Wie-heizt-Deutschland-2019.pdf

[9] OGE, ONTRAS, et al. (2020): European Hydrogen Backbone. Online at: https://www.ontras.com/fileadmin/Dokumente_Newsroom/Presseinformationen/20200715_European_Hydrogen_Backbone_Report.pdf

[10] Deutscher Verein des Gas- und Wasserfachs e.V. DVGW (2013): Entwicklung von modularen Konzepten zur Erzeugung, Speicherung und Einspeisung von Wasserstoff und Methan ins Erdgasnetz, DVGW Research Project G 1/07/10. Online at: https://www.dvgw.de/medien/dvgw/forschung/berichte/g1_07_10.pdf

[11] Deutscher Verein des Gas- und Wasserfachs e.V. DVGW (2014): Wasserstofftoleranz der Erdgasinfrastruktur inklusive aller assoziierten Anlagen, DVGW Research Project G 1/02/12.

[12] Deutscher Verein des Gas- und Wasserfachs e.V. DVGW (2016): Mögliche Beeinflussung von Bauteilen der Gasinstallation durch Wasserstoffanteile im Erdgas unter Berücksichtigung der TRGI, DVGW Research Project G 201615.

[13] Deutscher Verein des Gas- und Wasserfachs e.V. DVGW (2016): Untersuchungen zur Einspeisung von Wasserstoff in ein Erdgasnetz – Auswirkungen auf den Betrieb von Gasanwendungstechnologien im Bestand, auf Gas-Plus-Technologien und auf Verbrennungsstrategien, DVGW Research Project G 201205.

[14] Deutscher Verein des Gas- und Wasserfachs e.V. DVGW (2020): Hydrogen research projects. Online at: https://www.dvgw.de/medien/dvgw/leistungen/publikationen/dvgw-h2-wasserstoff-forschungsprojekte-broschuere.pdf

[15] European Commission (2020): A hydrogen strategy for a climate-neutral Europe. Online at: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

[16] Deutscher Verein des Gas- und Wasserfachs e.V. DVGW (2019): Potenzialstudie von Power-to-Gas-Anlagen in deutschen Verteilungsnetzen, DVGW-Forschungsprojekt G 201617. Online at: https://www.dvgw.de/medien/dvgw/forschung/berichte/g201617-ptg-potenziale-verteilnetze-abschlussbericht.pdf

[17] Fachverband Biogas e.V. (2019): Branchenzahlen 2018 und Prognose der Branchenentwicklung 2019. Online at: https://www.biogas.org/edcom/webfvb.nsf/id/BDYD8L-DE-Biogasbranche-zeigt-sich-besorgt-Klimaschutzbeitrag-in-Gefahr-/$file/Biogas_Branchenzahlen-2018_Prognose-2019.pdf

[18] Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen und Bundeskartellamt (2019): Monitoring Report 2019. Online at: https://www.bundesnetzagentur.de/SharedDocs/Mediathek/Berichte/2019/Monitoringbericht_Energie2019.pdf

[19] Wagner, Elbling & Company (2020): Commit to Connect 2050. Zielbild Infrastrukturen für Ostdeutschland, Wien. Online at: https://www.ontras.com/fileadmin/Bilder/Commit_to_Connect_2050/2020_04_21_CTC2050_Abschlussbericht.pdf

H2vorOrt –
Making hydrogen usable for everyone
via the gas distribution networks

www.h2vorort.de