HYDROGEN RAMP-UP

A study by
Advyce & Company and
PSvdL Consulting

A cross-industry view of the hydrogen ramp-up in Germany.

April 2024

About the authors of this study

As a strategy and management consultancy, Advyce & Company stands out as an innovative solution provider with a high level of technology and digitalisation expertise in strategy, transformation, and performance management/restructuring topics. The consulting firm sees itself as a modern platform. In addition to a broad range of consulting services, it offers digital solutions, data analytics expertise as well as corporate finance and M&A consulting services for inorganic growth and divestment decisions. Advyce & Company provides services for a total of four core industries: Energy and Utilities, Mechanical & Plant Engineering, Financial Services, and the Automotive Industry.

The platform approach is based on the brand essence as a top boutique consultancy with an entrepreneurial spirit and an appreciative culture. Customised solutions for clients are developed on this solid foundation, always with the aim of sustainably increasing the value of the company through interdisciplinary teamwork on an equal footing. Since its foundation in 2014, Advyce & Company has been pursuing a continuous growth course with more than 15 partners and 100 consultants. The company has its own offices in Munich, Dusseldorf, Mannheim, Halle (Saale), Berlin, and Zurich.

PSvdL Consulting combines energy industry expertise with many years of consulting competence. Since its foundation in 2007, PSvdL Consulting has been advising and supporting energy suppliers as well as grid and storage operators throughout Germany and Europe in the management of complex business and IT projects. PSvdL Consulting sees itself as an equal partner to its customers, accompanying projects from conception to completion as a pragmatic implementer.

From the topics of market liberalisation to the challenges of the energy transition and the digitalisation of the energy industry, PSvdL Consulting always plays a leading role in the operationalisation of the major trends in the sector, combining the expertise of a strategy consultancy at board level with a hands-on mentality that guarantees effective implementation.

With its dedicated industry focus, more than 40 proven experts and locations in Dusseldorf, Munich, Berlin, and Groningen, PSvdL Consulting is one of the leading management consultancies in Germany specialising in the specific challenges of the energy industry.

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Preface

Update April 2024

This study was written with the aim of identifying current challenges in the German hydrogen market and deriving recommendations for action for stakeholders along the entire hydrogen value chain. It is based on the findings from over 50 interviews with industry representatives from all stages of the H_2-value chain. Since the interviews in the summer of 2023 and the first publication in November 2023, the dynamic in the hydrogen sector has continued at a high level.

Since the publication of the study, landmark political decisions have been made that have provided more clarity in some areas and in some cases fundamentally changed the conditions for players in the hydrogen economy.

We would like to take these changes into account by looking at the developments that have taken place since November and analysing their impact on the further course of the hydrogen ramp-up in Germany. We also draw attention to regulatory decisions that are still pending at the current time.

Unbundling of gas and hydrogen networks

On 28 November 2023, the EU Council, Parliament and Commission decided against ownership unbundling of hydrogen and natural gas grids at the distribution grid level. This means that gas network operators will also be allowed to operate hydrogen networks in the future. In our discussions, representatives of utilities in particular expressed their concern about the threat of unbundling regulations. The EU's decision should have a correspondingly positive signalling effect for the urgently needed expansion of the H_2 grid.

Infrastructure expansion

In November 2023, the German transmission system operators (TSOs) submitted the draft application for the hydrogen core network to the Federal Network Agency (BNetzA) and the BMWK. Following a consultation by the BNetzA, the TSOs now have until 21 May 2024 to submit a joint final application. The BNetzA is then expected to approve the core network before the political summer break. An important aspect of this is the financing model for the hydrogen core network. The forthcoming solution, which envisages the creation of an amortisation account to which the shortfalls and surpluses of the core network from the ramp-up phase will be booked, is generally well received by the TSOs. The level of risk sharing by the TSOs currently remains as an open point of discussion. The next step is to enshrine the financing model in law in a legally secure manner that is suitable for the capital market.

For many interviewees from different sectors a concrete target image of the hydrogen infrastructure is the basic prerequisite for their own action steps.

Joint market enquiry for natural gas and H_2 by TSOs

As part of an initial joint survey by TSOs, natural gas and hydrogen demands in Germany will be identified by 22 March 2024. Based on these demands, a first joint integrated network development plan for natural gas and hydrogen is to be developed. This should be the starting signal for the further development of the hydrogen core network into an area network and minimise the lack of transparency regarding future hydrogen requirements, which was cited as a fundamental challenge by many industry representatives in the interviews.

Expansion of H2Global

In February 2024, the BMWK approved an additional €3.53 billion for the H2Global funding mechanism. H2Global acts as an intermediary between producers and purchasers of green hydrogen via a subsidiary and compensates the difference between supply and demand prices. With the additional funding, H2Global now has funding totalling around €4.73 billion at its disposal to ensure investment security, particularly for hydrogen imports to Germany.

Many interviewees expressed their scepticism about sufficient quantities of hydrogen in the interviews. The expansion of H2Global can therefore be seen as a step in the right direction. The hydrogen import strategy announced by the German government is still pending as of March 2024.

BMWK presents key points of a carbon management strategy

At the end of February 2024, the BMWK presented the key points for a carbon management strategy and a draft law based on this to amend the Carbon Dioxide Storage Act. According to this, the transport and offshore storage of CO_2 is to be made possible through the use of carbon capture and storage (CCS) and carbon capture and utilisation (CCU) in Germany. CCS is an elementary component in the production of blue hydrogen.

Across sectors the necessity of blue hydrogen for the market ramp-up was emphasised by many interviewees, meaning that the carbon management strategy can be seen as positive. However, the BMWK's key issues paper does not explicitly state any direct implications for the production of blue hydrogen.

Approval of 24 German IPCEI projects

In mid-February 2024, the EU Commission approved a total of 24 German hydrogen projects along the entire hydrogen value chain. Thanks to their classification as an Important Project of Common European Interest (IPCEI), these projects can now receive extraordinary funding from the federal and state governments. For many projects, the decision from Brussels means the starting signal for the construction of important H_2 infrastructure, the installation of large electrolysers or the development of large H_2 storage facilities. In total, these 24 projects are expecting funding totalling around €4.6 billion.

The significant delays in the approval of the IPCEI projects were regularly assessed in the interviews as problematic for the timely expansion of the hydrogen infrastructure. The EU Commission's approval means that the projects, some of which have been delayed by many months, can now be launched.

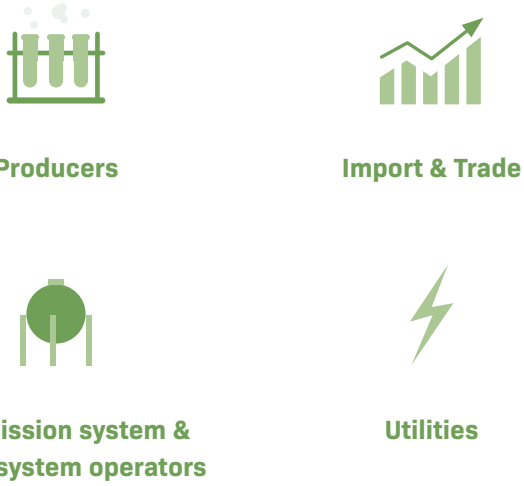
German government agrees on Power Station Strategy

At the beginning of February 2024, the German government published its Power Station Strategy. Specifically, this envisages the construction of new, hydrogen-capable gas-fired power plants, which are to be operated with natural gas for a transitional period. From 2035 to 2040, they are then to be converted to using green hydrogen, with the exact conversion dates set for 2032. The German government hopes that the adoption of the strategy will provide planning security for investors and has announced that it will support them with funding from the Climate and Transformation Fund. The Power Station Strategy can be seen by hydrogen producers as a further signal of stable demand for hydrogen in the future.

Starting signal for climate protection contracts

In mid-March 2024, the BMWK opened the first of two bidding processes for climate protection contracts for the decarbonisation of energy-intensive industries in Germany. The funding volume totalling €23 billion is intended to compensate for the additional costs of switching to climate-friendly technologies. The aim is to promote modern technologies and infrastructures that help large industrial companies to switch to environmentally friendly production methods, e.g. production facilities and pipelines for hydrogen in the steel and chemical industries. According to the BMWK, these measures should avoid around 350 million tonnes of CO_2 emissions by 2045.

The BMWK promises that the climate protection contract model will result in a significantly faster and less bureaucratic allocation of funding. The contracts are also meant to subsidise not only investment costs (CAPEX) but also operating costs (OPEX). Both aspects were repeatedly called for by industry representatives in our interviews, also in comparison with the low-bureaucracy subsidy approach of the Inflation Reduction Act (IRA) in the USA.



Chapter 01

Background and objectives of the study

Hydrogen has gained in importance worldwide in recent years and is increasingly seen as a crucial building block for a sustainable energy supply. In Germany in particular, hydrogen is seen as a promising energy source that will help to achieve ambitious climate targets. With its National Hydrogen Strategy (NWS), the German government has declared the hydrogen ramp-up to be a central element of its energy strategy. The stated goal is to make Germany a global pioneer in the hydrogen economy.

The realisation of this ambitious project has so far proven to be extremely complex and challenging. Despite the great potential of green hydrogen, there are numerous challenges that are slowing down or hindering the hydrogen ramp-up in Germany. Advyce & Company and PSvdL Consulting have discussed this situation intensively with companies from various sectors as part of their projects. Despite the obvious differences between the sectors, it emerged that individual challenges to the hydrogen ramp-up were uniformly identified across all industries. These include uncertain framework conditions for investment in hydrogen projects, high costs for green hydrogen, a lack of technological awareness and bureaucracy that hinders investment.

What is missing from the discussions, as well as from previous studies and policy statements, is a cross-industry view of the interrelationships and the steps needed to overcome these barriers. Against this background, Advyce & Company and PSvdL Consulting have joined forces to conduct this study to take a comprehensive look at the various sectors of the hydrogen economy in Germany and their respective situations. The study is based on over 50 qualitative interviews with experts, industry representatives and decision-makers from eight sectors of the hydrogen value chain.

The interviews conducted provide an insight into current company activities in the field of hydrogen. In addition, demands and proposals for the further development of the hydrogen economy become clear. The first part of the study is dedicated to a sector-specific analysis. Based on the information from the interviews the findings are used to analyse the situation in each sectors and identify the specific challenges. Recommended actions are also derived for each sector, with which the specific potential of hydrogen can be utilised in the best possible way.

Heat suppliers

Housing sector

Mobility

Industry

The sectors analysed in the study cover the entire value chain of the hydrogen economy in Germany

The second part of the study analyses the hydrogen ramp-up in Germany across all sectors. To this end, relevant overarching challenges are identified and the interfaces and dependencies between the sectors are made transparent. In combination with the first part of the study, this is intended to create transparency about the situation in the other sectors and thus reduce the sectors' own reluctance with regard to concrete implementation measures. A circumstance that describes the frequently recognisable „chicken and egg problem“ between the sectors. Finally, solutions and cross-industry recommended actions are outlined, which are primarily aimed at political decision-makers.

Classification of the National Hydrogen Strategy

The National Hydrogen Strategy (NWS) of the Federal Republic of Germany assumes a total hydrogen demand including derivatives of 95 to 130 TWh in Germany by 2030. The current hydrogen demand in Germany is 55 TWh and is mainly covered by grey hydrogen from fossil fuels. The NWS formulates the goal of significantly expanding the domestic production of green hydrogen by creating an electrolysis capacity of 10 GW by 2030.

Due to the limited production possibilities in Germany, 50-70 % of the hydrogen requirement will have to be imported. To this end, a corresponding hydrogen import strategy will be developed by the end of 2023, in which reliable guidelines for the import of hydrogen are to be created. The import strategy will focus on both European and non-European partners. Pipelines and shipping routes are to be considered at transport level.

The NWS uses incentives and funding mechanisms to focus on areas of application in which there is no alternative to the use of hydrogen. This applies in particular to the steel and chemical industries as well as the transport sector. The NWS comprises a large number of measures to secure Germany a pioneering position in the international competition for hydrogen technologies and to establish hydrogen as an essential building block for the energy transition. This includes the development of a domestic hydrogen core network, various research projects on production processes and the establishment of hydrogen applications.

In addition, suitable framework conditions should be created through coherent legal requirements at national and international level to support the hydrogen ramp-up. This includes the short-term development of a Hydrogen Acceleration Act, which should help to significantly shorten the planning and approval times for hydrogen projects.

Chapter 02

Sector-specific view of the hydrogen ramp-up

PRODUCERS

Classification of the sector and current situation

The further development of the national hydrogen strategy (NWS) from summer 2023 has created greater transparency with regard to domestic electrolysis capacities and the permitted methods of producing hydrogen. The ambitious goal is to increase electrolysis capacity for green hydrogen to at least 10 GW by 2030. In addition to the previous emphasis on green hydrogen, it now also opens up the possibility of promoting blue, turquoise and orange hydrogen variants as bridging technologies to ensure the hydrogen ramp-up. At the time the study was written, however, the specific design of the funding mechanisms for these hydrogen variants had not yet been finalised.

Hydrogen producers see the further development of the NWS as a positive political signal. At the same time, they point to the lack of a specific structure, which also needs to be harmonised with European requirements. From an industry perspective, the necessary framework conditions for investment decisions are therefore still lacking.

Sector perspective on the development of the hydrogen ramp-up

Producers have a mixed view of the overall hydrogen system. In the transport sector, the planned hydrogen core network and the resulting feed-in points are seen as a positive development. However, producers see a need to catch up in the development of hydrogen storage facilities. In the natural gas business, market participants are used to high flexibility, which is made possible by pipeline buffers and storage capacities. This is a major challenge for the supply of hydrogen. Overall grid stability must also be considered, as hydrogen has never been used on the scale envisaged for the future. In addition to these overarching points, the producers name the following key challenges for their own industry.

KEY CHALLENGES FOR THE HYDROGEN RAMP-UP FROM THE PRODUCERS' PERSPECTIVE:

1. Overly optimistic assumption about the availability of green hydrogen

2. Lack of investment conditions for blue hydrogen projects

3. Lack of technological openness

1. Green hydrogen production in Germany requires sufficient renewable electricity

The European guidelines, like the German hydrogen strategy, focus on the production of green hydrogen through the electrolysis of water using renewable electricity. The most efficient production of this green hydrogen takes place where renewable energy is available on a large scale and at competitive prices.

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„The German plans for green hydrogen could prove to be too optimistic. This is another reason why no upper limit should be set for blue hydrogen.“

Due to the electrification of numerous sectors, electricity demand in Germany will double to around 1,000 TWh by 2040. The EEG 2023 provides for greenhouse gas neutrality in the power supply for the period after the coal phase-out (currently 2038). This results in the need to quadruple electricity generation from renewable energies by around 2040. In view of this ambitious target, some producers are expressing concerns about the availability of sufficient quantities of renewable electricity to produce green hydrogen.

According to the interviewees, a trend towards a more realistic assessment by political decision-makers can be recognised in the NWS, as blue, turquoise and orange hydrogen variants are now increasingly being considered.

2. The current policy framework for blue and turquoise hydrogen is inadequate

Many market participants regard the production of blue and turquoise hydrogen as an essential bridging technology to green hydrogen. Based on the available quantities, a functioning ecosystem of producers and consumers can be formed that can be gradually converted to the increasing quantities of green hydrogen.

From the producers' perspective, it should be noted that the investment horizon for projects to produce blue and turquoise hydrogen is at least 20 years. In this context, the EU Renewable Energy Directive (RED III) is perceived as a significant obstacle due to the rapidly increasing quotas for green hydrogen in the industry. Specifically, RED III envisages a hydrogen share from renewable energy sources in the industrial sector of 42 % in 2030 and 60 % in 2035 – these quotas conversely represent an upper limit for blue and turquoise hydrogen. Based on the current situation, some producers believe that the quotas are increasing too quickly. In addition, there are no quotas at all for the period after 2035, which is also relevant for investment decisions. Potential producers and industrial customers therefore do not have the necessary planning certainty to be able to produce or purchase blue or turquoise hydrogen over a longer period of time. Long-term purchase agreements, which form the basis for producers' investment decisions, are therefore currently not being concluded. Specifically, there is a risk that the necessary production infrastructure for the ramp-up of urgently needed blue and turquoise hydrogen will not be developed to the extent required.

**Analogous statement from a sector representative*

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„Investments in green hydrogen are too low. Blue hydrogen should also be given a much higher priority.“

With regard to the targeted hydrogen ramp-up, political decisions must be made promptly and formulated in concrete terms so as not to further delay necessary investments in generation capacities. At the same time, political decisions must take into account the long-term planning horizon of the projects. The strong focus on the long-term ramp-up of green hydrogen must not stand in the way of securing the quantities required for the short- term ramp-up.

OPEN QUESTION TO THE POLITICAL DECISION MAKERS:

Which strategic steps are German policymakers taking to provide producers and consumers of blue or turquoise hydrogen with the necessary certainty for long-term production and sales planning – a certainty that is currently not sufficiently guaranteed by RED III?

3. Technological requirements prevent investment and innovation

Representatives of the industry speak of overregulation in connection with the fixed allocation of hydrogen quantities and colours to certain branches of the industry. A positive example of a market-driven approach is the Inflation Reduction Act (IRA) in the USA. It emphasises incentives over bans and requirements. The IRA focuses on the goal of CO_2 savings, but not on a specific hydrogen colour or quotas for individual sectors. The technology with the highest CO_2 savings receives the highest funding quotas. Projects for the production of green and blue hydrogen are also subsidised by the IRA in a relatively uncomplicated way, according to industry representatives.

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„Nobody knows how technology will develop until 2030 or 2040. Therefore, detailed specifications for these periods are of little practical value.“

The IRA's open-technology approach also leads industry representatives to assume that innovations in the field of hydrogen will primarily develop in the USA in the coming years. It is also expected that the IRA will influence the investment decisions of many technology companies active in the hydrogen sector that would have invested in Germany or Europe under different conditions.

Recommended actions for the sector

Achieving planning certainty and realistic consideration of the quantities of green hydrogen that are actually available are essential for producers. In addition, they need reliable investment conditions for blue and turquoise hydrogen projects and accelerated approval procedures for their implementation. The following recommended actions can be formulated for producers, taking into account the current framework conditions.

1. Utilising extended funding opportunities for the construction of electrolysis capacities

With the revision of the NWS, the German government has increased the target for domestic electrolysis capacity for the production of green hydrogen from 5 GW to at least 10 GW by 2030. In order to achieve this target, the BMWK has developed an „instrument mix“, which includes the direct promotion of electrolysers. Producers with ambitions in the field of green hydrogen production can benefit from these support measures.

2. Initiating clusters with anchor customers

Federal funding opportunities are also available at municipal level for the decentralised production of green hydrogen. These are supplemented by funding programs at state level, such as the Bavarian funding program for electrolysers, which has a budget of €150 million and was published in July 2023.

If the subsidies on the generation side are combined with subsidies for industrial customers on the demand side, clusters with competitive framework conditions can be created. Due to the guaranteed purchase by anchor customers and the early planning of the infrastructure, such clusters offer an environment in which hydrogen production projects can be realised with significantly reduced risk.

3. Repeatedly emphasising the importance of blue hydrogen

Across all sectors, blue hydrogen is seen as elementary for the hydrogen ramp-up. The political framework conditions are diametrically opposed to this. There is no planning certainty for producers, and concrete actions from the NWS are still pending. Against this backdrop, it is essential that producers contribute to shaping policy by increasingly addressing the challenges to political decision-makers. In addition to direct dialogue with political representatives, involvement in associations is also suitable. Both should take place at national as well as European level.

IMPORT AND TRADE

Classification of the sector and current situation

With the foreseeable move away from natural gas as a fossil fuel, hydrogen will take on a central role for import and trading companies as a new and alternative line of business. The relevance of hydrogen imports will be strengthened by the „import strategy“ announced in the update of the national hydrogen strategy. It is assumed that 50-70 % of demand in Germany will have to be covered by imports in the form of hydrogen and corresponding derivatives. The aim of the strategy is to open up diversified import channels and avoid dependency on individual partner countries. There is no question that traders want to continue their established business model in the hydrogen market. The situation is reminiscent of the early days of the commodity market for natural gas in the early/mid-2000s. On the other hand, importers are faced with the challenging task of establishing new transport and logistics structures for hydrogen.

The parallels with the established natural gas business suggest that the existing expertise and business models should be transferred. Initial talks with producers and trading partners are already underway. Large-scale projects for hydrogen and ammonia synthesis have not yet been initiated by the interviewed companies themselves but are being observed with great interest worldwide. Blue hydrogen also plays an important role in all considerations and activities. The industry representatives are convinced that both green and blue hydrogen are necessary for the ramp-up to succeed. On a small scale, the first hydrogen admixtures into the natural gas grid are already being sold to end customers via certificates. Trading in physical quantities is expected to take place from 2024 with regional production; hydrogen imports are considered possible from 2028 by the sector. Overall, it is clear that companies want to build up their hydrogen portfolio in two ways. On the one hand, through imports and, on the other, through in-house production via electrolysis, resulting in vertical integration within the companies.

Sector perspective on the development of the hydrogen ramp-up

The industry sees two key challenges in developing and establishing a liquid market for hydrogen imports and trading.

KEY CHALLENGES FOR THE HYDROGEN RAMP-UP FROM THE PERSPECTIVE OF IMPORTERS AND TRADERS:

1. Chicken and egg problem of supply and demand

2. Challenging pricing for hydrogen

1. Clarity on the supply and demand side as the starting signal

The industry is facing a classic chicken-and-egg problem when it comes to the question: „What has to come first, supply or demand?“ At the moment, it seems as if the various players are watching each other and waiting for the other side to make the first move. From the sector’s perspective, the question of the future distribution of hydrogen to end consumers in particular has not been sufficiently clarified. If access to hydrogen presents too great a challenge, actual demand will lag behind expectations and requirements. Import and trading companies therefore see the need to ensure access via a revised market design.

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„We tell our customers that if they want green hydrogen in 2028, they have to tell us today so that projects, including financing, can start. However, the feedback from many is that this is not possible at current forecast prices. This price gap must be closed.“

Larger quantities of hydrogen must be imported from countries such as Saudi Arabia, Algeria or Chile. There, hydrogen can be produced at low cost using PV electricity from solar energy. The financing of such production and import projects is enormously complex and often requires investment volumes of > €1 billion. However, in order for hydrogen to be imported in seven years at the latest, the producers' financing decisions must be made promptly, i.e. in the next one to two years. The industry therefore recognises the need to „get started“ now so that sufficient quantities of hydrogen are available in the future. Typically, offtake agreements are expected for project financing and hedging, in which the buyer commits to pay in advance, irrespective of the supply („take-or-pay“).

On the retail side, there is therefore double uncertainty: when quantities are available and what quantities are in demand. The sector therefore sees it as the duty of end customers (companies, industry, etc.) to quantify and actively formulate their requirements. Secondly, it expects politicians to provide a transparent and predictable framework. This is because there is currently a complicated political environment at federal and state level, which means that, among other things, planning approval procedures are unintentionally protracted, making it harder to plan for trade volumes. This is bound to have a negative impact on end customers. In order to support the demand assessment, intelligent incentive systems are required that allow the customer side to actively plan with hydrogen as an energy source.

**Analogous statement from a sector representative*

2. A liquid hydrogen market and its pricing is new territory

The current framework conditions in the hydrogen market are leading to uncertainties at all stages of value creation. On the import and trading side, this leads to the question of how price agreements on hydrogen supply can be reached between two parties in the current situation. High hydrogen prices per se, enormous financing requirements for production projects and the political framework are still putting the brakes on many projects for economic reasons and ultimately leading to an illiquid market. In addition, new hydrogen production projects and the provision of transport capacities require security from buyers to conclude long-term contracts.

OPEN QUESTION TO THE POLITICAL DECISION MAKERS:

Are there plans to support standardised trading, comparable to EFET contracts for natural gas, and if so, how?

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„We don't expect liquid hydrogen markets before 2035. Today, the cost of trading a small amount of hydrogen is still as high as that of 2 TWh of natural gas.“

The industry believes that bilateral, individual contracts will be necessary in the next ten years or more. The main reason for this is the lack of infrastructure, which makes pricing particularly difficult due to the lack of calculation values. There are currently pricing formulas that vary greatly in terms of CAPEX and OPEX shares. A standardisation of contracts, such as is common for natural gas via the European Federation of Energy Traders („EFET contracts“), is not expected in the coming years. The players in the hydrogen market are currently in uncharted territory when it comes to pricing. A liquid and therefore standardisable hydrogen market is not expected until the mid-2030s.

Recommended actions for the sector

For the purpose of driving forward the hydrogen ramp-up in Germany, both political and entrepreneurial efforts are required to solve the chicken-and-egg problem and overcome the challenges that have so far stood in the way of the effective use of hydrogen as an energy carrier. The following recommended actions can be formulated for importers and traders.

1. Collaborate with other importers and traders to define initial standards

In order to facilitate trade and help shape important framework conditions, it is advisable to join forces with other importers and traders. This enables the definition of initial standards, similar to what is happening in the European Federation of Energy Traders, EFET. This cooperation will help to establish an efficient and standardised trading structure for hydrogen and support the ramp-up.

2. Secure (import) quantities early on

To prevent future bottlenecks and competitive disadvantages, companies should ensure the purchase of (import) quantities of hydrogen at an early stage. This enables competitive advantages for trade relations between producers and suppliers. In addition, possible risks such as supply fluctuations and transport problems can be managed better.

3. Helping to shape the national import strategy

The development of the national import strategy offers the opportunity to contribute one's own expertise through active participation in discussions and working groups and thus to help shape the objectives and procedures. At the same time, there is an opportunity to consolidate one’s role in the hydrogen economy.

4. Support the design of entry points for imports

To ensure that their own import and trade plans are optimally supported, importers and traders are encouraged to participate in decision-making processes to determine the entry points and contribute their expertise. Future business opportunities can be supported by taking long-term plans and strategic developments into account when choosing a location.

5. Build up expertise in the field of hydrogen origination

In view of the lack of a hydrogen market trend, the challenge is to offer customers tailored hydrogen products and services. The early and comprehensive establishment of contacts with potential suppliers, partners and customers is crucial for this. Facilitating access to hydrogen sources and transport options supports the business.

TRANSMISSION AND STORAGE SYSTEM OPERATORS

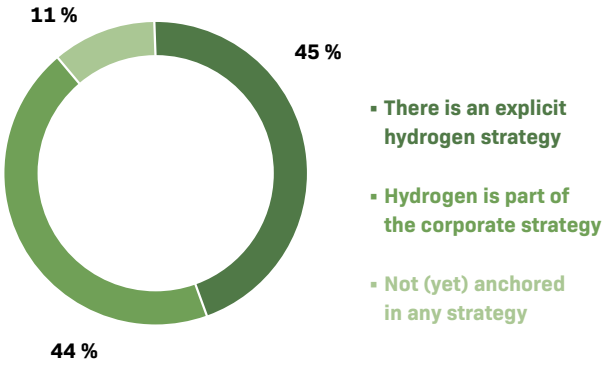
Classification of the sector and current situation

In November 2023, the transmission system operators (TSOs) published the updated planning status for a 9,700 km trans-regional hydrogen core network by 2032. The hydrogen core network is part of the National Hydrogen Strategy (NWS) and is intended to connect large producers with large consumers. The expansion plan will take place in several stages. The first hydrogen network sections will be realised in 2024/2025 in large-scale projects such as GET H_2 Nukleus or Flow. By 2027/2028 1,800 km are to be completed, which are part of the European funding program IPCEI. The BMWK and the Association of Gas Transmission System Operators (FNB Gas) assume that the German hydrogen core network will consist of around 60 % converted natural gas pipelines and around 40 % new pipelines.

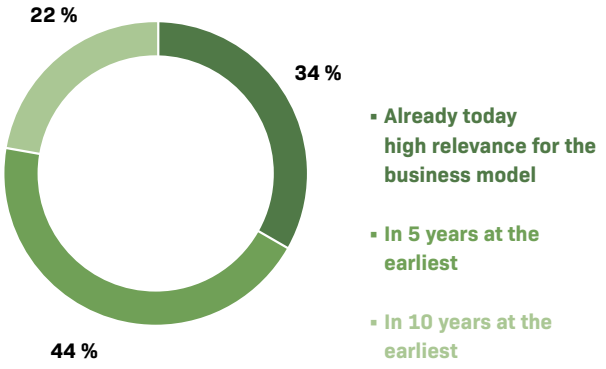
A hydrogen core network is also to be developed at EU level. There are plans to build a hydrogen network of around 32,600 km across Europe by 2030. It is assumed that the new construction and conversion of existing natural gas pipelines will take place in roughly equal proportions.

The target paths for hydrogen storage facilities and their operators are not specifically described in the NWS. For the time being, a concept for the gradual conversion of existing gas storage facilities and the necessary construction of new hydrogen storage facilities is to be developed.

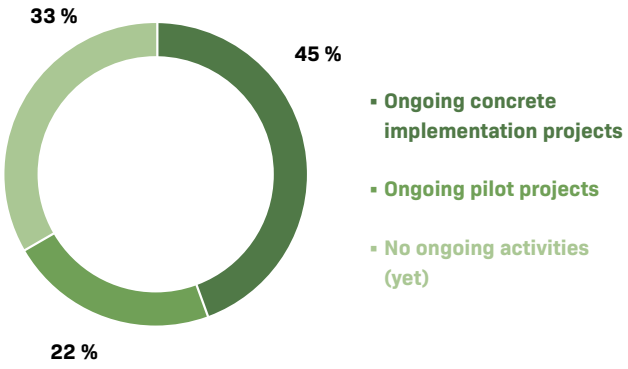
How is hydrogen strategically anchored in your company?



How do you rate the relevance of hydrogen for your business model over time?



What is the status of hydrogen activities in your company?



Interview results on strategic anchoring, relevance and activities in the field of hydrogen for transmission and storage system operators

Sector perspective on the development of the hydrogen ramp-up

The interviewees agree on the fundamental importance of the positive decision in favour of a hydrogen core network. This perspective was also shared by interviewees from other areas of the value chain. Nevertheless, the industry sees three key challenges.

KEY CHALLENGES FOR THE HYDROGEN RAMP-UP FROM THE PERSPECTIVE OF TRANSMISSION AND STORAGE SYSTEM OPERATORS:

1. Slow planning and approval procedures

2. Lack of technological openness

3. Lack of a financing model

1. Slow planning and approval procedures delay investment decisions

From the TSOs/SSOs perspective, faster planning and approval procedures as well as faster funding decisions are necessary for a timely network expansion. The current procedures delay necessary investment decisions on the one hand and the physical construction of the hydrogen core network on the other. As an example, some TSOs/SSOs cite an overly detailed review by the BNetzA at individual project level.

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„The construction of the LNG terminals has shown that a 'new German speed' can be achieved. This approach must be transferred to the expansion of the hydrogen infrastructure.“

Operators of natural gas storage facilities are faced with the challenge of having to build hydrogen storage facilities in parallel to their core business. This involves managing the conflict of objectives between a secure supply of natural gas and the development of the required hydrogen storage capacities. According to the EnWG, no natural gas storage facilities may be decommissioned - not even for a conversion to hydrogen. This is one of the reasons why storage operators and other market players consider the target of 5 TWh of storage capacity in 2030 to be too ambitious.

OPEN QUESTION TO THE POLITICAL DECISION MAKERS:

Is it assumed that the speed achieved in the construction of the LNG terminals can also be transferred to the development of the hydrogen infrastructure?

2. Technology requirements prevent a more efficient transformation of the energy supply

The interviewees are in favour of an open-technology approach to achieving climate targets and see a need to educate citizens, industry and politicians. One example is the use of hydrogen in the heating market, which some TSOs believe is possible, even if not on a large scale.

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„The use of hydrogen is being discussed for too few applications. An ideological predefinition of an all-electric energy system must be avoided, as an electricity grid expansion for ‚everyone and everything' will not work."

An open approach should also be taken to the production of hydrogen. According to the TSOs, there will not be a sufficient amount of green hydrogen available in the coming years. Blue hydrogen is therefore an important bridging technology that should be promoted in the same way as green hydrogen.

Some TSOs have a similar view of biomethane. They believe that there will be certain regions in the future where the use of biomethane will be the better alternative to switching to hydrogen. Biomethane should therefore be taken into account when considering the overall system.

3. Need for a sustainable financing model

In the view of the TSOs and SSOs, a sustainable financing model is lacking if the hydrogen infrastructure is to be rolled out on a large scale. The income from the regulated natural gas business is not sufficient to finance the development of the hydrogen infrastructure.

The TSOs therefore see a financing framework based on the dena model as a possible alternative. In simplified terms, the dena model consists of private-sector financing of the grid expansion by the grid operators, a fixed grid fee and a state guarantee of the investment or profitability. Direct investment by the state is not necessary with this model.

**Analogous statement from a sector representative*

Recommended actions for the sector

The interviews have shown that both TSOs and SSOs are in the starting blocks for the development of the required hydrogen infrastructure. Legislators and regulators at German and European level in particular are now called upon to create a framework that enables timely implementation through the right mix of incentives, pragmatism and trust. In order to promote this process, the following recommended actions can be made to the TSOs and SSOs.

1. Intensify exchange between projects and stakeholders

Numerous TSOs are currently involved in regional projects that are driving forward the development of the hydrogen core network and are grappling with the same challenges and issues, such as the design of the market model. An intensified dialogue between these projects could release considerable synergy effects and should therefore be sought. If the exchange between certain players is currently not possible or only possible to a limited extent under cartel law, it is advisable to involve politicians in developing the legal requirements for such an exchange. However, the plans for a Germany-wide hydrogen core network presented on 14th of November 2023 are likely to be followed by a more intensive exchange in the near future.

2. Develop a storage roadmap

Without the development of sufficient storage capacities for hydrogen, the German hydrogen economy will face major flexibility problems. The currently foreseeable shortage of storage facilities must be emphasised more strongly by the players. One option would be to draw up a development plan for storage facilities similar to the gas network development plan.


40
60
80
20
0
100
H2
bar

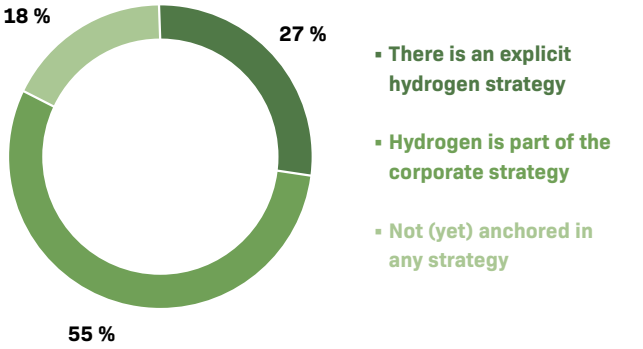
UTILITIES

Classification of the sector and current situation

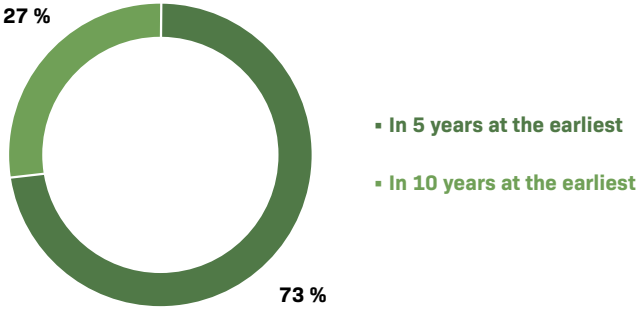
The utilities sector includes both large, trans-regional energy suppliers as well as regional municipal utilities and distribution network operators (DSOs). Due to the diverse range of tasks, the sector plays a central role within the energy market transformation in Germany. As a result, utilities are confronted with very different demands. Industrial customers expect transparency about the timing and costs of a future supply of hydrogen. Transmission system operators are pursuing the goal of integrated network planning, for which they require forecasts, including for future hydrogen demand, from the regionally based DSOs. At municipal level, utilities are called upon to contribute their expertise to municipal heat planning and to help shape the significance of hydrogen in the heating sector.

The relevance of hydrogen within the utilities is largely characterised by the geographical location of the grid with the possibility of connecting to the hydrogen core network as well as the existence of regional industrial clusters. Depending on these factors, some utilities have already developed a clear hydrogen strategy, while others are observing the topic for the time being or are treating it in a delayed manner. The industry has already initiated a large number of pilot projects. These projects cover a broad spectrum, from the production of hydrogen with electrolysers, to the supply of industrial companies and petrol stations, to the use of hydrogen vehicles or the supply of heat to end customers.

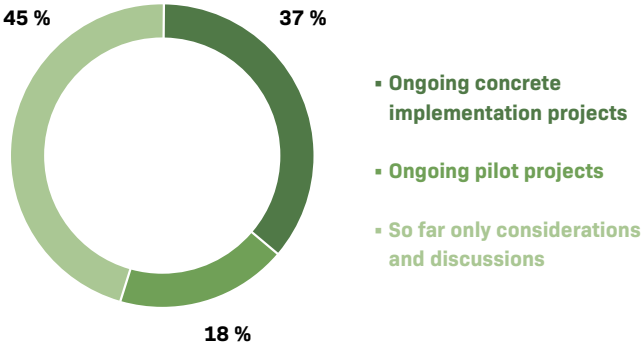
How is hydrogen strategically anchored in your company?



How do you rate the relevance of hydrogen for your business model over time?



What is the status of hydrogen activities in your company?



Interview results on strategic anchoring, relevance and activities in the field of hydrogen at utilities

Sector perspective on the development of the hydrogen ramp-up

Due to their integrated role in the energy system, utilities are active at several levels of the value chain in the hydrogen economy. As producers, infrastructure operators, traders and distributors, the sector sees the ramp-up from different perspectives. Ultimately, what counts for utilities is the economic viability of investments, which is currently not given in any of the areas mentioned. In addition to economic viability, the sector identifies further key challenges.

KEY CHALLENGES FOR THE HYDROGEN RAMP-UP FROM THE PERSPECTIVE OF UTILITIES:

1. Lack of availability and access to hydrogen

2. Lack of transparency about the hydrogen ramp-up

3. Danger of misdirected European unbundling regulations

1. Delayed connection of individual regions can lead to competitive disadvantages

The industry assumes that there will initially be a moderate increase in the supply of hydrogen through local production and imports to Germany until 2030. Only from 2030 onwards a significant increase in supply and demand is expected, partly as a result of the development of the hydrogen core network.

A similar establishment of hydrogen as a commodity, as is currently the case with natural gas, is not expected until the period between 2040 and 2050. Due to electrification in all areas, the quantities purchased will be lower in the long term than is currently the case for natural gas.

*//**
„What can we offer the industry in remote regions? We need to find an answer to this question.“

Regional clusters can already play a decisive role at an early stage. Local hydrogen production or an early connection to the first sections of the hydrogen core network are of great importance here. Equally important is the existence of sufficient industrial customers who, as anchor customers, can exert a significant influence on further developments in favour of hydrogen in a cluster.

The utilities emphasise the significant temporal link between the local availability of the hydrogen core network and the possibility of converting industrial processes to hydrogen. This dependency should also be taken into account by policymakers when setting targets for the decarbonisation of the industry. Regions and the industrial companies located there that are only connected to the hydrogen core network or other hydrogen infrastructure at a late stage must not be penalised. If this factor is not considered, some utilities fear that individual regions will be at a considerable competitive disadvantage, which could even lead to companies relocating.

**Analogous statement from a sector representative*

OPEN QUESTION TO THE POLITICAL DECISION MAKERS:

Are support measures already planned by politicians for regions and for the companies based there if they can only be supplied with hydrogen late or not at all?

2. The necessary transparency for concrete implementation planning is currently lacking in many areas

Energy supply companies are faced with the task of aligning their business model and assets with the ramp-up of hydrogen. A clear overview of which quantities of hydrogen are required in which stages of the value chain is of crucial importance here.

*// **
„We need an estimation for the production ramp-up in comparison with the goals and needs at different sectors and expansion levels.“

Due to their central position between upstream and neighbouring grid operators, hydrogen and biogas producers, industrial companies, the housing sector, heat suppliers, filling stations, end customers and, last but not least, local authorities, utilities have the greatest need for transparency of all the sectors concerned. In order to fulfil the upcoming transformation task of the grids and customer supply, utilities need a clear picture of future hydrogen requirements and the time at which hydrogen can be made available by existing grid operators. In the next step, this picture must be compared with any locally available production capacities for hydrogen and bio-methane, the municipal heating plans and an assessment of when hydrogen will be economically viable and transferred into a transformation strategy tailored to the individual utility.

3. Far-reaching unbundling would have a paralysing effect on the transformation of the networks

The horizontal unbundling currently being discussed at EU level, which would prohibit the operation of a hydrogen network while a network operator simultaneously operates a natural gas network, jeopardises the efficient and timely expansion of the hydrogen infrastructure in the view of the interviewees.

*// **
„Who is building or upgrading a net today that can't be operated tomorrow!“

In addition to foreseeably higher transformation costs, the utilities also point to staff shortages, particularly in the technical environment, which would be caused by the separation and cannot be compensated for by hiring new staff in view of the general shortage of skilled labour.

Recommended actions for the sector

The interviews have shown that utilities are currently concerned with two questions in particular. When and where will hydrogen sources and sinks emerge in the future and how will the economic viability of hydrogen projects develop? The following recommended actions can help to answer these questions. At the same time, they are to be understood as „no-regret measures“ for which the risk of stranded investments appears to be relatively low, despite the currently still uncertain environment.

1. Initiate regional hydrogen clusters

Regional clusters are recommended for the exchange of knowledge and experience between all relevant stakeholders. These include local authorities as well as regional and state politicians. If pilot projects have already been initiated, initial experiences can already be shared within the clusters. Once a common understanding has been established, the aim is to agree on common goals and develop a coordinated roadmap for implementation.

2. Building expertise and resources

Hydrogen is a new topic for utilities as well as for their customers and other stakeholders such as municipalities and investors. It is advisable for utilities to start building up knowledge within their own organisation today. Knowledge building is particularly relevant in the areas of strategy, procurement/trading, regulation, project development incl. approvals, new technologies (e.g. electrolysis, petrol stations, densification) and sales. In the future, sales will also focus on advising industrial and SME customers in the sense of technical sales on their individual decarbonisation roadmap (including hydrogen) and offering suitable products.

3. Participation in municipal heat planning

In August 2023, around 11,000 municipalities were required by law to draw up a municipal heating plan. The plan is intended to provide citizens and industry with important information for their investment decisions on cost-efficient, climate-friendly heating. Municipalities with a population of up to 100,000 must draw up the plan by 30th of June 2028, larger municipalities two years earlier.

It makes sense for utilities to proactively support municipalities in the creation of municipal heating plans. DSOs can provide important data on gas, electricity, and heating grids and in this way also gain more transparency about the future importance of their existing gas grids. In addition, hydrogen should also be included in the consideration of municipal heating planning to sensitise the municipality to the topic at an early stage – regardless of whether hydrogen is taken into account in the subsequent municipal heating plan or not.

4. Launch of pilot projects – ideally with potential anchor customers

In addition to the opportunity to build up knowledge, pilot projects also provide a basis for gaining initial anchor customers for the topic of hydrogen. These can provide important impetus for the hydrogen transformation in a region and ensure the demand required for the hydrogen ramp-up. In the majority of cases, pilot projects are not economically viable and should therefore be combined with suitable funding measures. It is advisable not to focus exclusively on federal funding programs. Depending on the project content, EU funding or programs at state level – such as the Bavarian funding program for electrolysers, which has a budget of €150 million and was published in July 2023 – sometimes offer more attractive funding conditions.

5. Creating transparency about hydrogen volumes and time periods in the region

The utilities are predestined for the exchange with upstream and downstream stages of the value chain about the required hydrogen quantities and timeframes per region. No other industry will be able to provide the required transparency as well and efficiently as the utilities with their local networks. It is therefore advisable for utilities to continue to work towards increased transparency and to actively promote the transformation process by participating in transparency-promoting organisations such as the Gas Grid Transformation Plan (GTP).

HEAT SUPPLIERS

Classification of the sector and current situation

The use of hydrogen in decentralised heat supply is assigned a rather subordinate role in the National Hydrogen Strategy (NWS). This is primarily due to the fact that various decarbonisation paths exist in this area. The focus here is on electrification through the use of heat pumps and photovoltaics or the supply of district heating. Both paths are currently considered more profitable due to the high hydrogen prices, the less mature technology of hydrogen heating systems and against the background of competition for use with the industrial and transport sectors.

More interesting is the use of hydrogen for the heat supply of large customers from the industrial, commercial or healthcare sectors (e.g. hospitals) via combined heat and power (CHP) or for the operation of power plants for the provision of district heating. Against this backdrop, the heating suppliers surveyed are currently focusing their attention on implementing pilot projects and preparing both new and existing plants for the integration of hydrogen (H_2 readiness). The development of a comprehensive and specialised strategy is being postponed for the time being, as this depends on clear regulatory and political decisions that have yet to be made.

Sector perspective on the development of the hydrogen ramp-up

Heat suppliers are currently still playing a wait- and-see role in the hydrogen market. Their reluctance to develop concrete hydrogen strategies is primarily due to the following two challenges in addition to the regulatory issues mentioned above.

KEY CHALLENGES FOR THE HYDROGEN RAMP-UP FROM THE PERSPECTIVE OF HEAT SUPPLIERS:

1. Lack of availability and access to hydrogen

2. Unforeseeable economic viability of hydrogen projects

1. Municipal heat planning should bring much-needed planning security

Industry representatives from the heating supply sector do not see themselves as first movers in the hydrogen market. Like the German government, the heating suppliers surveyed also predict that hydrogen will play a subordinate role in decentralised heat supply. The focus for hydrogen is therefore increasingly on those areas in which other energy sources encounter obstacles in the heat supply.

Hydrogen is particularly suitable for customers who draw electricity and heat simultaneously via combined heat and power plants (CHP plants) or who require high temperatures as process heat, such as hospitals, industrial customers and larger commercial customers. The heat suppliers expect that up to 40 % of the heat demand could be covered by hydrogen in the future by supplying industrial and district heating customers using CHP.

*//**
„For certain customers, such as e.g. in hospitals, it is important to think about electricity and heat together. Hydrogen is predestined for combined heat and power generation, which is the best solution in such cases. A combination of photovoltaics and heat pumps could not achieve this in this form.“

In addition, stored hydrogen proves to be valuable for flexibility in coping with peak loads at times of low renewable electricity generation. This flexibility would be lost if traditional CHP customers had to switch to a combination of heat pumps and photovoltaic systems.

Industry representatives attach great importance to municipal heat planning for the future use of hydrogen in the heat supply. According to the German Building Energy Act (GEG), this must be developed at municipal level by 2026 (or 2028 for smaller municipalities). As the implementation of these adjustments will take at least another five years, heating suppliers do not consider hydrogen to be relevant for their business model until 2030. They expect the introduction of exclusively hydrogen-fueled power plants from 2035.

The interviewees emphasise that adjustments to power plant parks require planning certainty for at least 20 years. Here they express the hope that municipal heat planning will make a significant contribution to creating this planning certainty.

In general, hydrogen is not seen as a „100 % solution“ for heat supply, but as an option alongside various other technologies, electrification and other green gases such as biomethane. For the latter, no changes to the existing transport networks or plants would be necessary, although a planned conversion of the preceding transport networks to hydrogen would result in the restriction that only parallel gas networks could be used for biomethane.

*//**
„From our point of view, we need the clear statement from the grid operators: Yes, we will operate these grids with hydrogen.“

Against this backdrop, representatives of heating suppliers are also demanding clarity from distribution network operators about which networks will be operated with which gases in the future. This information is crucial for them in order to create a reliable planning basis for producers and consumers. When converting power plants and transport grids to hydrogen, the integration of private households must also always be taken into account, provided they are connected to the same grid lines.

**Analogous statement from a sector representative*

2. Promotion can incentivise both the supply and demand side

In addition to the questionable availability for the heating market, industry representatives see the current lack of price competitiveness for hydrogen in the heating supply as one of the biggest challenges. In view of the high costs of pilot projects, they consider financial support to be essential at the present time. However, the competitiveness of hydrogen in the heat supply is also closely linked to the cost analysis for the use of alternative fuels in CHP plants, in which the development of the CO_2 price will be a particularly relevant aspect.

Depending on the political objective for the use of hydrogen in the heat supply, suitable instruments are required to ensure sufficient availability at competitive costs. On the customer side, incentives to increase demand could be created by subsidising operating expenses (OPEX).

On the supply side, the use of hydrogen in CHP plants could be promoted through suitable regulatory measures within the framework of the Renewable Energy Sources Act or the Combined Heat and Power Act as well as through investment cost subsidies.

OPEN QUESTION TO THE POLITICAL DECISION MAKERS:

Are there concrete plans to promote hydrogen in the heating sector, for example for use in CHP plants?

Recommended actions for the sector

With their position between the upstream networks and a mix of industrial and private customers, heat suppliers find themselves in a complex environment. This sometimes leads to contradictory demands, especially in view of the differences between industrial and private customers. Heat suppliers must harmonise this range of requirements with the specifications of municipal heat planning and future legal and regulatory requirements.

1. Participation in municipal heat planning

Active participation of heat suppliers in municipal heat planning ideally represents a win-win situation for them and the municipalities. The companies gain influence on the design of plans and strategies for heat supply at municipal level. This enables them to strengthen their position and presence in relation to hydrogen and drive forward the implementation of relevant measures. The municipalities, in turn, benefit from the expertise described in point 1 and the insights into the available options for decarbonising their neighbourhoods.

2. Examination of the potential for expanding local and district heating

There are various decarbonisation paths available to heat suppliers. Heat suppliers should take a proactive role in examining the potential for expanding local and district heating to hydrogen. Through their analysis of costs, conversions, and timeframes as well as transparent illumination of the alternatives, heat suppliers can provide important decision-making aids for political players, municipalities and industrial customers.

3. Launch of pilot projects to decarbonising the heat supply

Where circumstances allow, pilot projects are an important signpost for all stakeholders involved. Heat suppliers should continue to drive forward pilot projects, be it in hydrogen-fueled CHP or in projects for the H_2 readiness of power plants. Pilot projects create visibility, ideally provide companies with in-depth insights and are often the door opener for expanded activities.

4. Testing the H_2 readiness of the power plants

When converting power plants to hydrogen, heat suppliers should be able to provide reliable information on the effort, costs and timescales involved. Ideally, the necessary tests should be carried out promptly so that they can be taken into account in municipal heating planning.


H2
HYDROGEN
HYDROGEN

HOUSING SECTOR

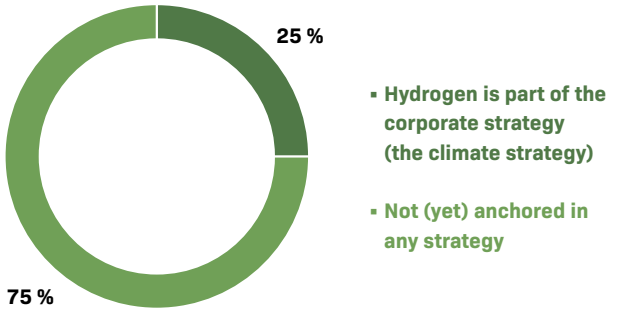
Classification of the sector and current situation

The housing sector is one of the sectors with a significant dependence on fossil fuels. Around half of homes in Germany are heated with natural gas and a further 25 % with oil. For this reason, this sector must ask itself which energy sources will be used in individual properties in the future in order to become climate-neutral by 2045, as planned by policy makers.

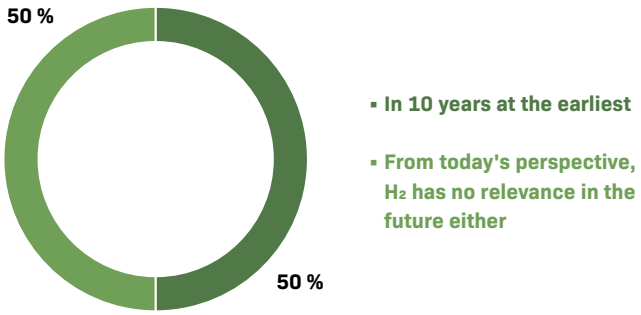
From the perspective of the national hydrogen strategy, the use of hydrogen in decentralised heat supply will play a subordinate role. However, hydrogen remains a technology option if buildings are not connected to heating networks or heat pumps cannot be operated efficiently.

Almost 70 % of the necessary CO_2 reductions in the housing sector are expected to come from the use of renewable energy sources. When it comes to possible options, availability, prices, and dependencies are crucial for the sector. Hydrogen is seen as one of the possible options, which could be combined with heat pumps in the form of peak load boilers, among other things. Initial pilot projects are currently in the test phase and feasibility studies are to analyse their suitability. However, the industry is increasingly reluctant to research the use of hydrogen, as political support has been withdrawn. Accordingly, hydrogen only plays a subordinate role at a strategic level within the industry and is – if at all – only anchored as an option in companies' climate strategies.

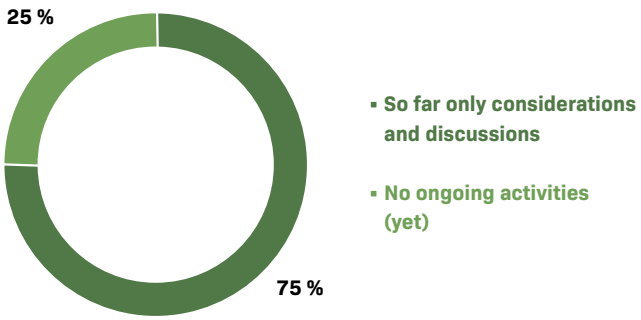
How is hydrogen strategically anchored in your company?



How do you rate the relevance of hydrogen for your business model over time?



What is the status of hydrogen activities in your company?



Interview results on strategic anchoring, relevance and activities in the field of hydrogen in the housing sector

Sector perspective on the development of the hydrogen ramp-up

Also driven by the fact that the housing sector has not been given any superordinated importance in the political plans for the hydrogen ramp-up to date, there are three key challenges that are currently slowing down activities in this area from the sector's perspective.

KEY CHALLENGES FOR THE HYDROGEN RAMP-UP FROM THE PERSPECTIVE OF THE HOUSING SECTOR:

1. Unforeseeable economic viability of hydrogen projects

2. Slow planning and approval procedures

3. Lack of availability and access to hydrogen

1. Increasing the energy efficiency of hydrogen production improves the position compared to other heating alternatives

At the moment, the low efficiency speaks against the use of hydrogen in decentralised gas heating systems. Compared to a heat pump, around five to six times as much electrical energy is required to produce the green hydrogen needed for the same calorific value, which is reflected in the energy costs. The industry therefore expects that hydrogen will only be of minor importance by 2035 without a significant technological leap. Due to the inefficiency of decentralised, property-related supply, this is referred to as „case-by-case efficiency". In order to change this, it is necessary to either increase efficiency or reduce the costs of generation.

*// **
„From today's perspective, hydrogen will not play a role in property-related heat supply, as more efficient and economical solutions are available."

At the moment, the combination of heat pump and photovoltaic system appears to be the most economical alternative for the sector – at least for the housing sector. However, the electricity grids will have to be expanded and upgraded accordingly. Without a technological leap, the use of hydrogen is conceivable in sub-grids or when using peak-load boilers to support decentralised heat pumps.

2. Hydrogen availability – in terms of time and geography – increases chances of use

The industry sees the availability of hydrogen as an inhibiting factor – both in terms of the lack of a procurement market and the strong dependence on location. It is assumed that piped hydrogen will only be available at a few locations. The lack of availability will therefore have an impact on municipal heat planning, which will dictate to the housing sector the energy sources that are suitable for the respective locations. Increasing geographical availability, for example by utilising gas distribution networks, would increase the chance of hydrogen being used as a heating medium.

**Analogous statement from a sector representative*

Furthermore, the unpredictable availability results in a de-prioritisation of hydrogen use for the industry, which is also desired by politicians according to the stakeholders. The available hydrogen is primarily planned for industrial production, which is dependent on hydrogen for decarbonisation.

3. Acceleration of planning and approval processes enables hydrogen to be considered again as a possible alternative for the own climate targets

The existing pressure for energy-efficient refurbishment, which is being further increased by stricter climate protection targets, is already prompting the industry to make an intensive start on decarbonisation. However, the conversion of residential units is increasingly taking place without the involvement of infrastructure operators due to excessively lengthy or missing line connection projects. It is becoming clear that fast planning and approval processes are crucial, especially for the housing sector, so that hydrogen can be considered as an option for decarbonisation. There is an appeal to politicians to formulate the regulations transparently, clearly, and reliably in order to guarantee planning security. In addition, housing companies are demanding to be included in municipal heating planning and to be taken into account in the planning processes at an early stage.

*// **
„Our appeal to politicians is to stick to the truth when it comes to energy prices in the event of complete decarbonisation. We consider a doubling or tripling compared to the level before the energy crisis to be realistic.“

It can be concluded that, according to current estimates, affordable hydrogen would only be available too late for the housing sector to fulfil its own CO_2 targets. The picture that is emerging is that companies are focusing on other options, such as a combination of heat pumps and photovoltaics, based on existing knowledge and circumstances. Irrespective of technological developments and the energy sources that will be used to supply heat to buildings in the future, the industry expects heating costs to double or triple compared to the level before the energy crisis.

OPEN QUESTION TO THE POLITICAL DECISION MAKERS:

How can hydrogen solutions be enabled to provide the best possible support for a climate-neutral heat supply against the backdrop of significantly rising energy costs?

**Analogous statement from a sector representative*

Recommended actions for the sector

With a view to existing challenges, the following recommended actions can be formulated for the housing sector in order to utilise the potential of hydrogen and exploit opportunities.

1. Closing ranks with politicians and continue to monitor developments

It is recommended to actively seek contact with political players and to continue to closely follow developments in the hydrogen sector. This includes participating in political discussions and supporting the development of funding regulations and legislation in order to take into account and ensure the needs of the housing sector for hydrogen projects in Germany.

2. Thinking energy concepts holistically and self-sufficiently

Energy concepts should be considered holistically and in an „autarkic sense“. The combination of generation and storage options makes it possible to create long-term plannable and self-sufficient energy supply solutions. By integrating different energy sources and storage technologies, the housing sector can become less dependent on upstream sources such as energy suppliers and react more flexibly to its energy needs. This also supports the integration of hydrogen into the energy supply.

3. Participate in municipal heat planning

In order to strengthen their position and presence in relation to hydrogen and to drive forward the implementation of relevant measures, it is advisable for housing companies to actively participate in municipal heat planning. This enables active participation in the design of plans and strategies for heat supply at municipal level. By participating in this process, they can strengthen their own position and gain clarity on property-related heat supply.

MOBILITY

KEY CHALLENGES FOR THE HYDROGEN RAMP-UP FROM THE PERSPECTIVE OF THE MOBILITY SECTOR:

1. Insufficient infrastructure development

2. Unforeseeable economic viability of hydrogen projects

3. Lack of legal and regulatory framework

Classification of the sector and current situation

The integration of hydrogen as an energy carrier in the field of mobility requires customised adaptation to the specific requirements of each individual means of transport. Factors such as the required range per tank filling, the size and weight of the hydrogen tank and the availability of the necessary infrastructure play a decisive role in the suitability of hydrogen for various applications. In principle, hydrogen in the mobility sector is in competition with other non-fossil alternatives such as electromobility, synthetic fuels or bio-LNG. According to the interviewees from the transport, logistics and motorised private transport sectors, heavy goods transport will increasingly rely on hydrogen in the future. Hydrogen will also play a significant role in (inland) shipping, alongside synthetic fuels and LNG. In the air transport sector, there are also a number of considerations ranging from electromobility to synthetic fuels and hydrogen.

Sector perspective on the development of the hydrogen ramp-up

The players in the mobility sector are faced with the challenging task of planning their current investment decisions for means of transport, infrastructure, and vehicle fleets in the context of the coming decades. Existing challenges make it difficult to anticipate legal, technological, and market-related developments with foresight.

1. Promotion of infrastructure expansion as a prerequisite for hydrogen in the mobility sector

It is crucial that the infrastructure required for refuelling is taken into account in addition to the vehicles, which can greatly increase the overall complexity of individual technologies.

The interviewees strongly emphasise the need for government support in setting up the infrastructure for a successful market ramp-up. Particularly in areas such as logistics, the interviewees see a lack of sufficient funding, which can hinder market entry and the ramp-up. According to the national hydrogen strategy (NWS), government support is planned in the refuelling station infrastructure.

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„If nobody builds a hydrogen filling station, nobody will build a hydrogen truck.“

2. Competitiveness of hydrogen essential for market ramp-up

It is currently difficult for market participants to accurately estimate the development of profitability, which in turn inhibits necessary investments. Risk minimisation models, such as price caps for hydrogen depending on the price of diesel, could effectively mitigate this problem. The toll relief for hydrogen trucks announced in the NWS can be cited as a positive example. At the same time, some manufacturers (OEMs) are piloting pay-per-use models on the market in order to minimise the price risk for their customers and thus facilitate investments.

3. A reliable, EU-wide legal and regulatory framework would accelerate the use of hydrogen

A reliable, EU-wide legal and regulatory framework is necessary in order not to slow down the hydrogen ramp-up in the logistics and mobility sector. This framework must take into account and transparently address the diverse composition of market participants and the complexity resulting from the numerous technology options.

For example, the framework for shipbuilding to run on hydrogen or transport hydrogen is still undefined. According to the NWS, the corresponding regulations for this are expected from 2025. Ships can only be built on a large scale from this date. With a construction time of around five years, this example shows the consequences of delayed requirements.

*// *
„If logistics and transport are not established, many potential customers will not receive hydrogen.“*

With regard to the development of infrastructure for heavy goods transport, there is currently uncertainty about how hydrogen is treated and taxed in various European countries. There is particular criticism of the different regulations for hydrogen deliveries via pipelines compared to deliveries by trucks. This leads to inconsistent tax regulations, some of which also apply to end customers. Electromobility has successfully overcome these challenges as part of the development of charging infrastructure for cars, also thanks to coordinated efforts at EU level. A similarly successful approach is also desired for the hydrogen sector.

OPEN QUESTION TO THE POLITICAL DECISION MAKERS:

Are concrete measures such as price caps planned to minimise the risk of future cost developments with hydrogen as a fuel?

**Analogous statement from a sector representative*

Recommended actions for the sector

The mobility sector is characterised by dependencies and interactions between vehicle manufacturers, infrastructure operators for filling stations, vehicle users and providers of mobility solutions (e.g. in local public transport). The following recommended actions are aimed at creating suitable framework conditions that enable these players to work together smoothly. Due to the diversity of stakeholders, certain recommendations may only be relevant for specific groups of stakeholders.

1. Development of the refuelling infrastructure

The development of the refuelling infrastructure is a key element for the implementation of hydrogen in the mobility sector. Extensive and at the same time easy access to hydrogen is of crucial importance, whether for heavy goods transport or shipping. In this context, companies in the sector should examine whether involvement in the development of the refuelling infrastructure could represent a potential business area. The development of the charging station infrastructure in the electromobility sector, which is increasingly being driven forward by car manufacturers, illustrates the opportunities that can arise here. The use of local clusters with their own electrolysis capacities and infrastructure also opens up business opportunities in the area of refuelling infrastructure at a regional level.

2. Pointing out the necessary political decisions

The establishment of hydrogen in the mobility sector requires coordinated and preferably standardised regulation that applies across the member states of the European Union. In order to increase the acceptance of hydrogen in heavy goods transport, for example, politicians should take targeted measures such as the introduction of standardised taxation of hydrogen as a fuel in all EU countries. This taxation should also aim to strengthen the competitiveness of hydrogen as a fuel. Incentives for CAPEX and OPEX subsidies, such as investment grants, purchase premiums and toll exemptions, should also be coordinated and organised at European level. The above proposals relate specifically to heavy goods transport, but similar issues also arise in the shipping and aviation sectors.

Even at a national level, mobility issues are often highly interwoven. This complexity makes it necessary to consult political players on the interdependencies and effects and to make proposals for concrete implementation measures. In addition to direct discussions with political representatives at national and European level, involvement in industry associations also appears to be a sensible step towards achieving these goals.

3. Participation in municipal mobility concepts

Municipalities are increasingly striving to decarbonise their vehicle fleets. In this context, hydrogen can be the fuel of choice for buses or refuse collection vehicles. There are many opportunities for cooperation at municipal level for the various players in the mobility sector. Relevant examples here could be partnerships with operators of electrolysers and depots for the provision of hydrogen refuelling. The resulting clusters also offer an optimal basis for the implementation of pilot projects in which different funding can be combined.


H2

INDUSTRY

Classification of the sector and current situation

This chapter highlights the hydrogen ramp-up in Germany's industry, focussing on the manufacturing SMEs, plant engineering and the process industry. This view explicitly does not include the chemical industry and steel production, which are often portrayed as prototypical for German industry in the public debate. The other industrial players also play key roles in the hydrogen agenda: as consumers, in some cases even as major consumers of energy and heat, as structurally affected parties and contributors to the European decarbonisation agenda, as providers of technologies and plants for hydrogen ramp-up and for hydrogen-based transport solutions in traffic.

As globally recognised developers of application solutions, German industrial companies are predestined to play a central and global role in the hydrogen economy. Technologies for fuel cells, direct combustion, automation solutions and numerous other applications, including urban transport, heavy goods transport, regional rail and inland waterway vessels, have been tested, implemented on a pilot basis and are already in operation. The national hydrogen strategy (NWS) focuses on large-scale industry, for which hydrogen is the only decarbonisation option. For industry based on production processes, the NWS aims to stimulate innovation through funding mechanisms, thereby increasing the demand for green products.

Sector perspective on the development of the hydrogen ramp-up

As industrial consumers, all the companies surveyed have defined a CO_2 reduction agenda, whereby the means of choice are largely limited to green electricity, their own solar and biogas plants or offsetting emissions – hydrogen does not currently play a role here. For the potential of hydrogen for the decarbonisation of industry to be realised, three key challenges need to be addressed from an industry perspective.

KEY CHALLENGES FOR THE HYDROGEN RAMP-UP FROM THE INDUSTRY'S PERSPECTIVE:

1. Unforeseeable economic viability of hydrogen projects

2. Lack of a political development plan for hydrogen in industry

3. Lack of availability and access to hydrogen

1.Without price advantages, retrofitting is not considered

On the part of industrial consumers, the use of hydrogen to generate electricity and heat is unattractive from an economic perspective. Instead, the focus is on the electrification of production facilities and the purchase of electricity from renewable energy sources, for example via Power Purchase Agreements (PPAs). Even if the positive CO_2 effects are considered, hydrogen is currently not a profitable option for the players for cost reasons, neither as an energy source for electricity nor for heat.

*//**
„Hydrogen currently does not play a role for companies in the manufacturing industry, as the costs in the application case of a hydrogen consumer are significantly uneconomical.“

The demand is therefore to reduce the price of hydrogen by comprehensively utilising all possible means and at the same time to keep it stable. This is necessary to make hydrogen competitive and increase its attractiveness as an energy source in the industry sector. Effective cost reduction plays a decisive role here in order to utilise hydrogen profitably in industrial processes in the long term.

OPEN QUESTION TO THE POLITICAL DECISION MAKERS:

From a political perspective, how should the German SME industry be supported on the transformation path for the use of hydrogen?

2. Companies can plan and work with a clear hydrogen agenda

Hydrogen offers great potential for decarbonising the supply chains of industrial companies in particular. There are numerous potential applications for the use of hydrogen, both in heavy goods transport and for the so-called „last mile“. Obvious solutions have already been successfully tested in pilot projects, and similar progress has been made in regional rail transport, for example. With a binding development plan on the part of politicians and municipal players, there is the potential to achieve a significant expansion in these areas in a short space of time.

There are also a wide range of applications for hydrogen in internal transport. An outstanding example of this is the BMW plant in Leipzig, where hydrogen is used to transport parts using fuel cell-powered forklift trucks and tugger trains, among other things. These examples show the versatile potential of hydrogen in production-related processes and the successes already achieved in implementing this technology in operational processes. However, political support is needed to expand this further and to bring it into widespread use.

3. Availability of hydrogen on site as a mandatory criterion

Local availability is essential for effective hydrogen utilisation. The interviewees are of the opinion that hydrogen will be irrelevant for many regions without nationwide availability beyond the existing regional clusters, such as in North Rhine-Westphalia or in the chemical triangle in Saxony-Anhalt. This means that many companies will not have the opportunity to decarbonise their plants and processes with the help of hydrogen.

*// **
„The currently foreseeable connection points to a hydrogen supply are too far away for the majority of industrial companies.“

The players in the industry sector therefore want politicians to discuss the geographical availability of hydrogen, coupled with a nationwide overall view of the hydrogen market. This would be of crucial importance in order to create clarity and planning security for all parties involved and to ensure that hydrogen can be used as an energy source across the board. The planned hydrogen core network is a good first step towards bringing hydrogen to the regions, but there is also a need for expansion to realise the specific connections.

OPEN QUESTION TO THE POLITICAL DECISION MAKERS:

Are there any political plans to fulfil the industry's wishes for a „supply discussion“?

Recommended actions for the sector

The industry is currently largely in observation mode. In the current situation, hydrogen is not seen as the decisive breakthrough energy carrier for the German industry. Below are recommendations for the industry sector on how it can play a leading role in the hydrogen ramp-up.

1. Seeking proximity to politics and shaping together

A close relationship with politicians enables companies to actively participate in the design of funding regimes and other political measures. It is advisable to develop a clear development plan together with political decision-makers, an agenda for the hydrogen sector itself and for hydrogen utilisation. This enables coordinated political support tailored to the needs of the sector and accelerates the implementation of hydrogen projects and decarbonisation.

2. Taking the first step and piloting

The industry should have the courage to take the first step and launch pilot projects. These pilot projects not only serve to build up knowledge, but also to establish a strong position in the future hydrogen economy, as well as in the regional energy supply.

3. Entering cooperations and partnerships

In order to support the hydrogen ramp-up, it is advisable for companies to enter targeted cooperations and partnerships with other industries and competitors. Joint projects can be set up and implemented to pool resources, utilise synergy effects and increase success and profitability.

4. Taking care of the future energy supply

It can be assumed that a company's own energy costs will have a greater impact on its competitiveness in the future. Companies should therefore consciously develop decentralised and self-sufficient energy concepts in order to ensure a favourable energy supplier in the long term. Hydrogen can be a building block here, which should be tackled with local suppliers in particular.

5. Talk to energy suppliers at an early stage

It is advisable to initiate discussions with local energy supply companies at an early stage. This means that cooperation opportunities and concepts for hydrogen utilisation can be discussed directly. In addition, companies should also participate in municipal heat planning to strengthen the position of the industry and ensure that their needs are taken into account as part of the planning process. This enables active participation in shaping the regional energy supply and promotes the integration of hydrogen solutions.


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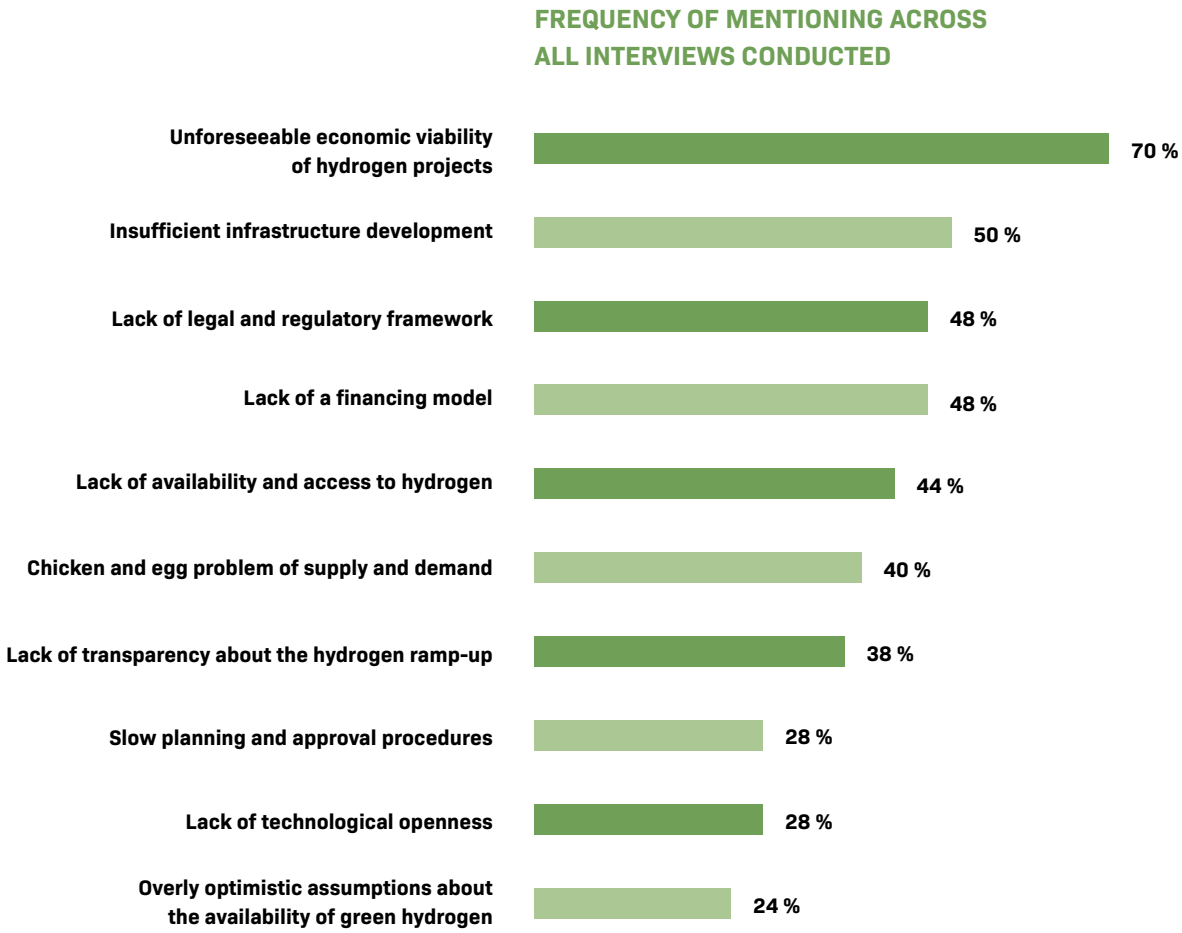
Chapter 03

Cross-industry view and conclusion

This concluding part of the study summarises the cross-industry findings from the more than 50 interviews and creates an overall picture of the hydrogen ramp-up in Germany. Solutions are outlined and recommended actions are formulated for the political players, which are derived from the cross-industry analysis.

In the interviews, many challenges were mentioned that are currently slowing down the hydrogen ramp-up from the perspective of representatives from all stages of the hydrogen value chain. There are various overlaps across all the discussions held, regardless of the industry. The following overview shows the ten most common responses to the open question about the main challenges.



Ten most common answers to the open question (i.e. without answer options) about the main challenges to hydrogen ramp-up from the interviewees' perspective

Overall picture across all sectors

The central and cross-industry challenges are discussed below. This provides a cross-industry overall picture of the hydrogen ramp-up in Germany and identifies interfaces and dependencies between the sectors.

Uncertain framework conditions inhibit investment in hydrogen projects

Improving investment security is of crucial importance for stakeholders across all sectors, as technical projects often have long lead times and investment cycles of up to 20 years. A clear idea of expected returns over time is essential.

Depending on the positioning in the value chain, there are various investment scenarios, from the construction of generation plants and grid expansion to the conversion of industrial processes.

On the producer and consumer side, investments are already being made in particular where proximity to the core hydrogen network is foreseeable and/or political support is available. Examples of political focus are the energy-intensive industries or the transport sector. The prospect of reduced additional costs due to the use of hydrogen is particularly favourable. Where political decisions have yet to be made, e.g. on the use of blue hydrogen or in the context of municipal heat planning, investments are hardly ever made.

On the infrastructure side, the lack of regulation for the development of the grid and storage facilities is hampering investment, e.g. regarding grid fees. A transparent picture of hydrogen sources and sinks would also make it easier for market participants to make investment decisions.

Across all sectors, investment decisions are made where there is a clear picture of the infrastructure connection, the available quantity of hydrogen, the political target, and the financing.

Lack of hydrogen infrastructure as a barrier to growth

Potential customers expect challenges across all sectors in terms of the future regional availability of hydrogen. Although a hydrogen core network is currently being defined, the integration of customers via the distribution network structure remains open. A good supply situation is assumed for large customers located along the core network. For companies located away from the core network or generally in more remote regions, there are considerable uncertainties regarding the supply of hydrogen. According to some interviewees, this situation can put entire regions at a disadvantage.

Inland waterways and the rail network could be used as an alternative to pipeline-based supply, although this only makes sense for access to large industrial customers or clusters. The so-called „last mile“ would have to be provided by other transport solutions, the economic viability of which appears questionable. „On-site“ solutions and electrolysers could be useful additions, but are ultimately an individual issue for companies.

In addition to transport, the design of the storage infrastructure is an open question. A storage strategy has not yet been the focus of political attention. However, the revised national hydrogen strategy (NWS) envisages a concept for hydrogen storage.

High production costs as a competitive disadvantage for green hydrogen

So far, the price trend for green hydrogen produced in Germany is hardly foreseeable. There are doubts in the sectors as to whether this will be available in sufficient quantities and at competitive costs at the quotas and times specified by politicians. Across all sectors, it is expected that green hydrogen will not be able to compete with other energy and decarbonisation technologies in terms of price in the foreseeable future either. Customers are therefore reluctant to switch to hydrogen in the future. Conversely, this means that it is not possible to plan sales volumes in this environment.

The production of green hydrogen is economically feasible in Germany in times when sufficient surplus green electricity is generated. At the same time, the actual expansion of electricity generation and the transport of renewable energies in Germany is lagging behind the targets.

In order to increase the use of green hydrogen, many market participants are calling for instruments that make its use more attractive. The Inflation Reduction Act in the USA, for example, directly addresses the production costs of green hydrogen. These are reduced by subsidies, taking into account the CO_2 savings. Initial studies assume that green hydrogen can be produced at competitive costs in the USA as early as 2025. Carbon Contracts for Differences (CCfD) are also mentioned by many interviewees as an effective instrument. It relieves customers of the additional operating costs that can be associated with a switch to hydrogen.

Lack of technological openness limits demand

There is a desire across all sectors to be able to decide for themselves which path to decarbonisation to take. In particular, the current strong focus on green hydrogen is seen as a limiting factor for supply and demand. Opening up to other types of hydrogen production is therefore seen as necessary by most companies. From the market participants' point of view, more supply, e.g. through blue hydrogen, would encourage investment, also on the customer side.

For many market participants, hydrogen is an option for decarbonisation that must be weighed up against alternatives such as electrification or alternative fuels. There is therefore a desire for an open-technology discussion without ideological predefinitions.

Bureaucratic challenges slow down hydrogen projects

Faster approval procedures and reducing bureaucracy are called for across all sectors. Planning and approval processes for hydrogen projects are described as lengthy, partly due to the complex interplay between the various political levels. This not only delays investment projects, but also threatens to make them uneconomical if calculated costs for assets and services continue to rise until projects are approved.

There is a desire for faster decision-making processes, with the LNG Acceleration Act often cited as a positive reference example in this context. Hopes are therefore pinned on the targeted implementation of the Hydrogen Acceleration Act.

Final investment decisions must be able to be made at short notice so that a supply of hydrogen can take place in the foreseeable future. Preventing this through bureaucratic processes would further extend the already long realisation periods.

Incentives and subsidies are insufficient to support the hydrogen ramp-up

The interviewees would like to see an improvement in the current funding landscape across all sectors. Points of criticism include the high level of complexity at national and EU level as well as insufficient funding instruments for certain sectors. Some funding appears to be targeted at individual measures on a small scale instead of being aligned with an overarching hydrogen system. In addition, long decision- making processes, as currently observed in the IPCEI projects, lead to delays of several years in some cases. In this context, the Inflation Reduction Act from the USA was once again cited as a more pragmatic counterexample.

In essence, an acceleration and simplification of the funding processes, as well as focusing on the areas relevant to the overall system, is considered imperative.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Recommended actions to the political players

The creation of favourable framework conditions is fundamental for a functioning and timely hydrogen ramp-up. This requires adequate policy measures to incentivise investment in hydrogen technologies and to create a legal and regulatory framework that facilitates the integration of hydrogen into existing energy systems. In addition, policymakers are called upon to promote international partnerships in order to support trade and the exchange of knowledge. To enable policymakers to set the right course in their steering role, this study provides six recommended actions for political players.

1. Designing the funding regime for maximum effectiveness

Policymakers should ensure that the funding landscape is geared towards promoting important investments for the overall system and creating a framework for profitable business models. In addition, easy access to funding should be ensured and the associated processes should be designed to be as lean and efficient as possible. Small-scale funding criteria that leave too little room for adaptation to changes in practice should be avoided.

2. Developing the National Hydrogen Strategy (NWS) further and implementing projects

The NWS serves as a central element for promoting the hydrogen economy in Germany. In order to further establish the NWS, it is necessary to develop concrete concepts for the approaches it contains, plan their realisation on the time axis and drive forward their implementation. Then approaches such as the import and storage strategy or the Hydrogen Acceleration Act can develop into important drivers for a successful hydrogen ramp-up in Germany.

3. Taking a holistic view of the hydrogen economy

In order to ensure reliability and avoid regulatory challenges and contradictory regulations, the structure of the hydrogen economy must be viewed holistically. This requires an overarching view of the entire energy system and a departure from the small details. Until now, discussions and regulations have often got lost in individual issues. This can also mean breaking down existing laws and regulations on individual topics and reorganising them on a more holistic level.

4. Create incentives for investment

To accelerate the ramp-up of hydrogen and remove obstacles, stronger incentives and safeguards for investments must be created. This can be achieved through the targeted use of instruments such as subsidies, funding, tax concessions or the assumption or mitigation of risks. In addition to infrastructure development, they should be implemented in particular where there is no alternative to the use of hydrogen. A positive example is the „dena model“ for securing investments in grid expansion, which ensures that the risks are shared between grid operators, future grid users and the state.

5. Designing the ramp-up to be technology-open

The focus of political activities should shift away from prescribed technologies and towards the necessary CO_2 savings. More incentives and fewer requirements should be the credo. This includes the promotion of different hydrogen colours and a fundamentally open framework for realising the targeted CO_2 savings. Control should subsequently be achieved by setting clear decarbonisation targets, as is the case in the USA with the Inflation Reduction Act. This approach enables technological competition and prevents the suppression of innovations through early political stipulations.

6. Involvement of all stakeholders and joint definition of objectives

It is crucial to listen to and take into account the perspectives of all stakeholders. This requires the involvement of all relevant actors along the hydrogen value chain, including business, politics, investors, regulators, and associations.

On this basis, a cross-industry target picture should be derived which, among other things, shows the infrastructure development as well as hydrogen sources and sinks over time. The transparency resulting from such an overall picture would enable market participants to better prepare for future developments and to plan and coordinate their activities and investments more effectively.

Chapter 04

Outlook

The findings from this study emphasise the fact that the hydrogen ramp-up in Germany is not only shaped by political and regulatory requirements, but also to a large extent by the market participants. Most companies in the sectors analysed are currently in an orientation phase. While concrete steps are already being taken in some sectors, such as network operators, the challenges identified in other sectors are omnipresent and require immediate solutions in order not to slow down the hydrogen ramp-up.

The hydrogen sector in Germany harbours great potential as a key component of a sustainable and emission-free energy future. In the current phase, it is necessary for all relevant players – from producers, suppliers and consumers to politicians and regulators – to join forces. This requires close cooperation in a spirit of partnership and the consistent implementation of the recommended actions set out in this study.

We look forward to deepening the knowledge gained in discussions with representatives from industry and politics and thus further advancing the sustainable hydrogen ramp-up in Germany.

Chapter 05

Study participants

This study is based on over 50 interviews with representatives from all relevant sectors along the hydrogen value chain. We would like to thank all of the companies, organisations and experts who contributed to this study. Without their expertise and commitment, this comprehensive analysis would not have been possible.

The following companies and others took part in the study:

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