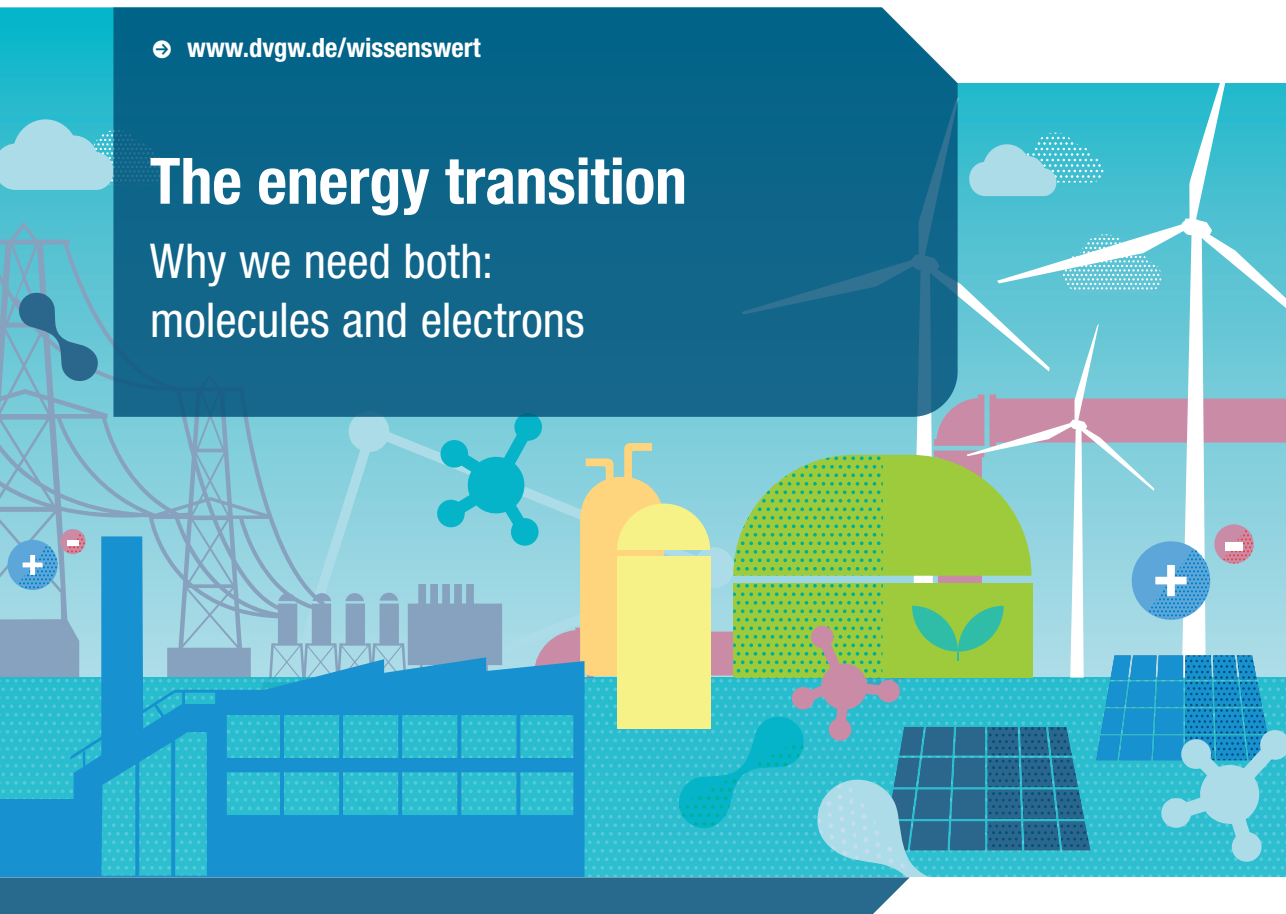


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The energy transition

Why we need both:
molecules and electrons



The energy transition requires both: molecules and electrons.

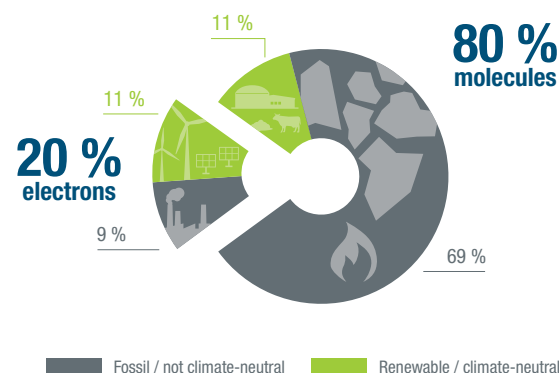
At a glance

- ➔ 80 % of Germany's final energy consumption consists of molecules, only 20 % is electricity.
- ➔ Almost all of these molecules are fossil-based and must be replaced by 2045.
- ➔ This is where renewable gases come into play, as they can provide climate-friendly energy where direct electrification is not feasible.
- ➔ Renewable gases are essential for industry, power generation and heat supply.
- ➔ To achieve a successful energy transition, the scale-up of renewable gases must be accelerated.
- ➔ This requires reliable policy frameworks, faster approvals and long-term planning certainty.

Achieving climate neutrality together: with molecules and electrons

A look at Germany's energy system shows that around half of the electricity comes from renewable sources. However, this covers only a small share of overall energy demand. The majority is still supplied through energy carriers such as natural gas, oil and coal - in other words, molecules. Overall, around **80 % of final energy consumption is provided by molecules**, while electrons accounts for only 20 %.

The energy transition cannot be achieved without molecules



Germany's final energy demand in 2025

Source: DVGW, based on data from AGEb (2026)

As the energy system transforms, some applications currently using molecules will be electrified. Nevertheless, molecules will remain essential for specific applications, such as industrial processes, securing electricity and heat supply and long-term energy storage. Fossil molecules must therefore be gradually replaced by renewable alternatives such as hydrogen, biomethane and, in the longer term, synthetic gases.

The future energy system will rely on a combination of renewable electricity and green molecules.



Primary energy and final energy: from energy source to energy use

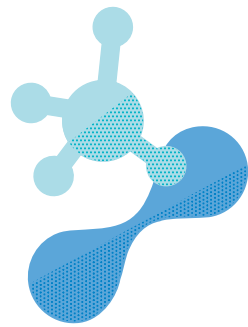
Primary energy describes energy in its original form, such as natural gas, crude oil, coal, wind or sunlight. It answers the question: Where does our energy come from?

Final energy is the energy that reaches consumers after conversion and transport. Examples include electricity from a socket, natural gas for heating or fuel in a vehicle's tank. It answers the question: What energy do we actually use?

Example: When electricity is generated in a gas-fired power plant, natural gas is the primary energy, while the electricity delivered to homes and businesses is the final energy. During the conversion process some energy is lost, mainly as heat. This means that more natural gas

is required as primary energy than the amount of electricity that is ultimately available as final energy.

The energy transition affects both, **primary and final energy**. In the future, an increasing share of primary energy will come from renewable sources such as wind and solar power. At the same time, many applications will be electrified directly, increasing the share of electricity in final energy consumption. However, because not all applications can be electrified, molecules will remain essential. The energy transition is therefore not only an electricity transition but also a transformation from fossil to renewable molecules.



A successful energy transition needs renewable gases

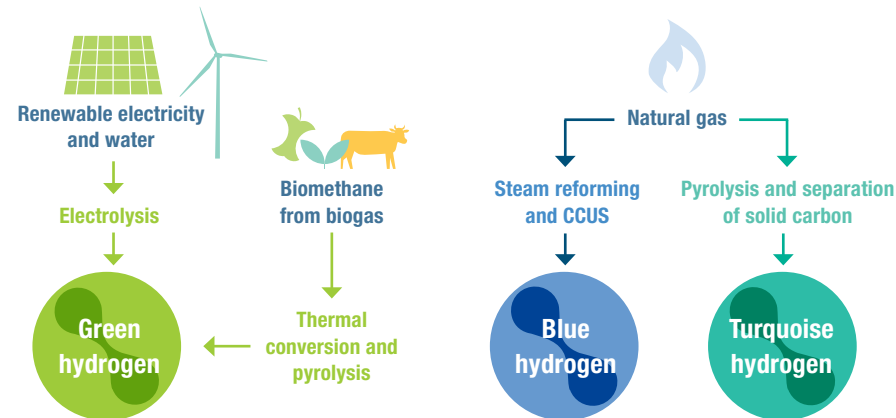
Hydrogen (H₂) is one of the key energy resources of the future. Like natural gas, it can be used as a fuel. However, instead of emitting CO₂, it releases water when burned.

Hydrogen can be produced in different ways. For the energy transition, **green**, **blue** and **turquoise** hydrogen are particularly relevant.

The European Union has introduced strict rules for what qualifies as green hydrogen under its Renewable Fuels of Non-Biological Origin (RFNBO) framework. The electricity

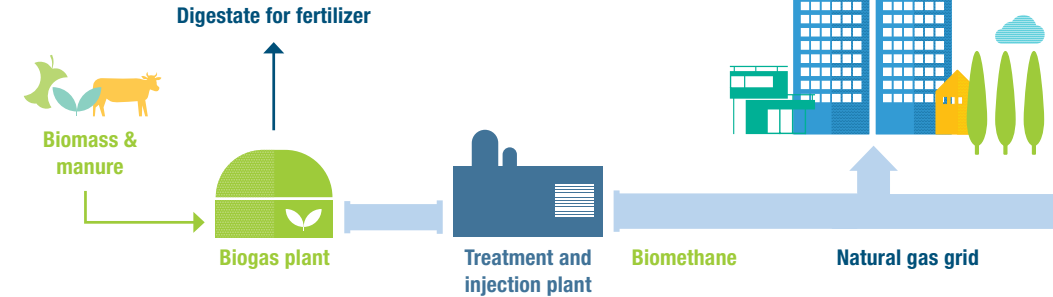
used to produce it must come from new renewable energy sources and be generated at roughly the same time as the hydrogen. This increases production costs and makes it more challenging to scale up the hydrogen market.

Hydrogen derivatives such as ammonia, methanol and synthetic fuels are produced from hydrogen. They are often easier to transport and store than pure hydrogen but involve additional energy losses.



Simplified overview of hydrogen production pathways

Biogas treatment and injection into the gas grid



Another climate-friendly gas is **biomethane (CH₄)**. It is produced from biogas which is made from organic residues, manure and other biological waste. By 2045, Germany's biomethane potential is estimated at 100 to 200 TWh per year, which would cover around 12 % to 24 % of current natural gas demand. Further quantities could be imported.

The existing gas infrastructure can continue to be used with renewable gases.

Because its properties are nearly identical to natural gas, biomethane can be transported directly through today's gas networks. For hydrogen transport, components need to be adapted, yet 99 % of existing pipelines are already suitable.

How much hydrogen and biomethane will be used in the future depends on technological developments, resource availability, economic factors and regulatory frameworks.

Initiatives such as *AK Netztransformation*, *H2vorOrt* and first pilot regions are developing and testing concepts for transforming local gas networks. They are assessing where pipelines can be converted to hydrogen, what role biomethane can play in the future and where networks may eventually have to be decommissioned. The hydrogen core network and Germany's *Gas and Hydrogen Network Development Plan (NEP)* provide the strategic framework. However, important legislation and financing instruments are still missing. This creates uncertainty and delays urgently needed investments.

Renewable gases are needed for industrial applications

Germany's industrial sector faces the challenge of making its processes sustainable without sacrificing competitiveness. Renewable gases play a central role in this transition, serving both as substitutes for fossil fuels and as raw material.

Industries such as **glass, ceramics and cement production** are difficult to electrify directly because their processes require extremely high temperatures, ranging from 800°C to over 1,600°C. Hydrogen and biomethane can provide these temperatures in a climate-friendly way. In addition, many medium-sized businesses also rely on renewable

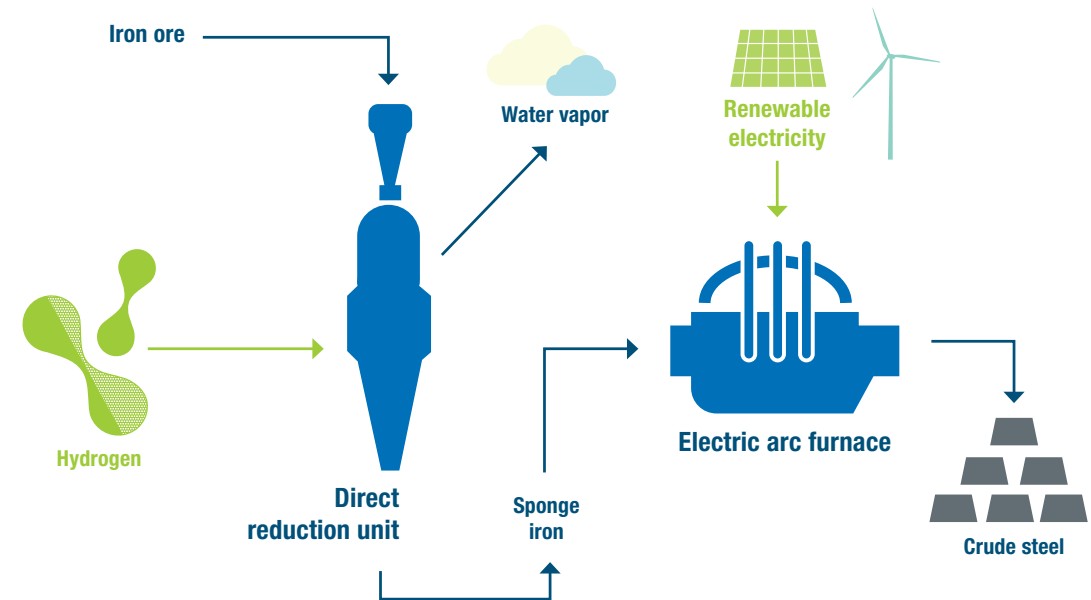
gases for their processes, including paper mills, bakeries, food-processing facilities and industrial laundries.

There are around 5,600 industrial sites in Germany which **rely on gas to generate the high temperatures needed for their production processes**. Together, they use 192 TWh of energy each year. In addition, more than one million commercial businesses use another 12 TWh. To become climate-neutral, these companies need reliable access to renewable gases. This requires a nationwide hydrogen distribution network.

Hydrogen plays a key role in making **steel production** more sustainable. When using hydrogen instead of coke in the iron ore reduction process, the process produces water instead of CO₂ emissions. Hydrogen-based direct reduction is thus regarded as one of the most important levers for decarbonizing steel production.

In the **chemical industry**, hydrogen is an essential raw material. It is used to make products such as ammonia and methanol and is needed for many everyday products and industrial processes.

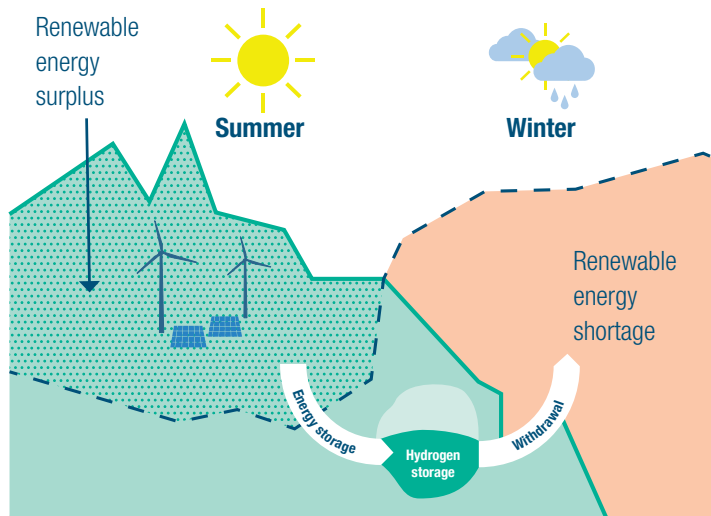
The path to green steel: How fossil-free crude steel production works



Renewable gases strengthen security of supply

Renewable gases are also essential for **security of supply** and for **safeguarding electricity and heat supply** in an increasingly volatile energy system. As wind and solar energy depend on the weather, renewable electricity is not always generated when it is needed.

Hydrogen and underground storage facilities can store renewable energy generated in summer and make it available during winter.



This is where power-to-gas technology comes into play. Surplus renewable electricity can be converted into hydrogen and stored over long periods of time. In this way, seasonal fluctuations can be balanced and electricity and heat supply can be secured during periods with little wind and sunshine.

Hydrogen can be stored in underground facilities, much like natural gas today. Existing storage facilities can be converted for this purpose. However, additional storage capacity will also be required to meet future demand. Since the conversion and construction of new storage facilities can take up to ten years, investments must be initiated early.

Energy storage is indispensable for providing flexibility and ensuring a stable and resilient energy system.

--- Electricity demand
— Solar and wind power generation

Challenges on the road to scaling up renewable gases

Renewable gases still face major challenges. Available volumes remain limited and costs are often higher than those of fossil alternatives. Moreover, production facilities, storage infrastructure, networks and end-use applications still need to be developed. This creates a classic chicken-and-egg challenge: companies are reluctant to invest without reliable supply of new gases, yet new production facilities will only be built if there is sufficient demand.

Long permitting procedures and regulatory uncertainty further delay investments and reduce planning certainty.

For hydrogen and biomethane to gradually replace natural gas, reliable policy frameworks, faster permitting procedures and substantial investments in production, storage and infrastructure are required.

Supply, transport and demand must grow together. Only then can a robust market for renewable gases emerge and enable a successful energy transition.

A climate-neutral energy system requires not only green electricity, but also renewable molecules to transform industry processes, provide flexible heat and power generation and ensure security of supply.



Real-world examples: hydrogen in industrial applications

At the **Dillinger steelworks in Saarland**, a hydrogen-ready direct reduction plant is being built as part of the **Power4Steel** project. The plant will produce around two million tonnes of direct reduced iron per year. Together with new electric arc furnaces, it will form the heart of the company's transition to green steel production. By the early 2030s, CO₂ emissions are expected to fall by up to 55 %, reducing emissions by around 4.8 million tonnes per year.

“The energy transition needs strong industrial flagship projects. With our new direct reduction plant, we will save large amounts of CO₂. To unlock this potential, we need hydrogen in sufficient quantities and at competitive conditions.”

Konrad Wohlfarth

Head of Hydrogen Strategy, Stahl-Holding-Saar

The hydrogen needed for the plant will be supplied through the cross-border **mosaHYc hydrogen network**. The companies involved and the German and French network operators have already signed the necessary agreements. Hydrogen deliveries are expected to start no later than 2029, enabling more climate-friendly steel production at the site.

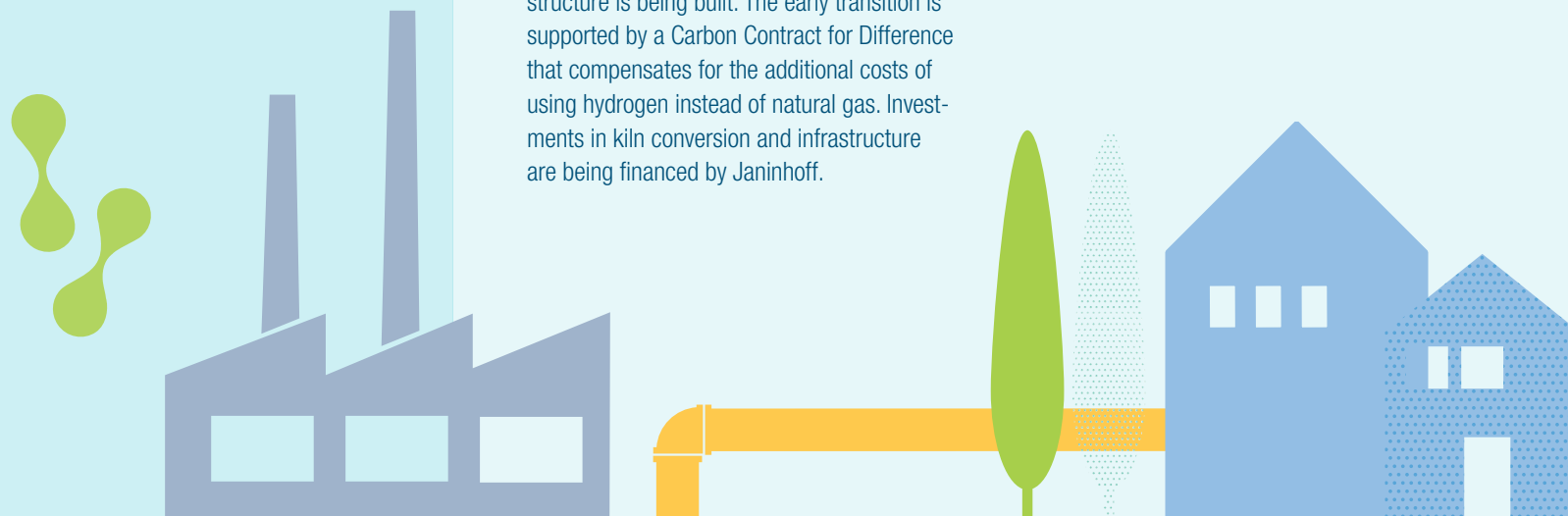
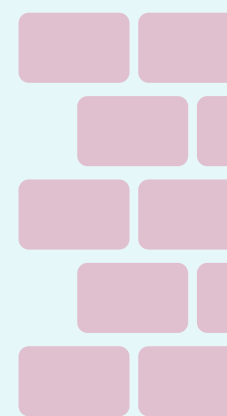
Janinhoff GmbH & Co. KG, based in Münster, aims to become Germany's first clinker brick manufacturer to switch its production from natural gas to green hydrogen. The production of clinker bricks requires very high temperatures of around 1,100°C. Fully electrifying the process is not a viable option for Janinhoff, as it would affect the distinctive colours and qualities of the bricks.

Hydrogen enables the continued use and further development of the existing tunnel kiln while maintaining the high product quality the company is known for. To make this possible, burners, pipelines, and control systems are being adapted and a hydrogen supply infrastructure is being built. The early transition is supported by a Carbon Contract for Difference that compensates for the additional costs of using hydrogen instead of natural gas. Investments in kiln conversion and infrastructure are being financed by Janinhoff.

“For clinker brick production, we require consistently high temperatures and maximum control over quality and colour. Green hydrogen gives us the opportunity to combine both: the climate-friendly transformation of our production and the preservation of the product characteristics that have defined our products for generations.”

Dr. Caroline Foyer-Clitheroe

Managing Director, Janinhoff GmbH & Co. KG



DVGW Wissenswert: Specialist knowledge made simple

Hydrogen is set to play a central role in achieving climate neutrality and driving Germany's energy transition. For more than a decade, DVGW has engaged in hydrogen research and innovation. Our research institutes are working on numerous projects to advance the production, transport, distribution and application of hydrogen. In addition, many of the DVGW codes of practice have already been adapted to cover hydrogen.

More information at: www.dvgw.de/wissenswert

With "DVGW Wissenswert", we present this expertise in a compact and accessible format. We explain current research findings, technological developments and regulatory frameworks across the energy and water sectors. If you are interested in the latest developments in renewable gases and water, you can find the information here – in brochures, short studies, webinars, fact sheets and audio or video features.

Published titles in the series (in English):

- ➔ Energy storage – but how? Ensuring a reliable energy supply with the right storage mix
- ➔ From natural gas to hydrogen: transforming distribution networks
- ➔ Enough hydrogen – or is legislation restricting potential?
- ➔ Hydrogen: Demand and Procurement Pathways
- ➔ Largely H₂-ready now: grids, storage facilities, components
- ➔ Hydrogen reduces the CO₂ footprint – in many ways

Further information



on hydrogen production pathways



on the hydrogen readiness of gas infrastructure



on biomethane, priority regions and current challenges *(in German)*



on the role of process heat and the importance of hydrogen distribution networks *(in German)*



on energy storage



on hydrogen storage *(in German)*



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