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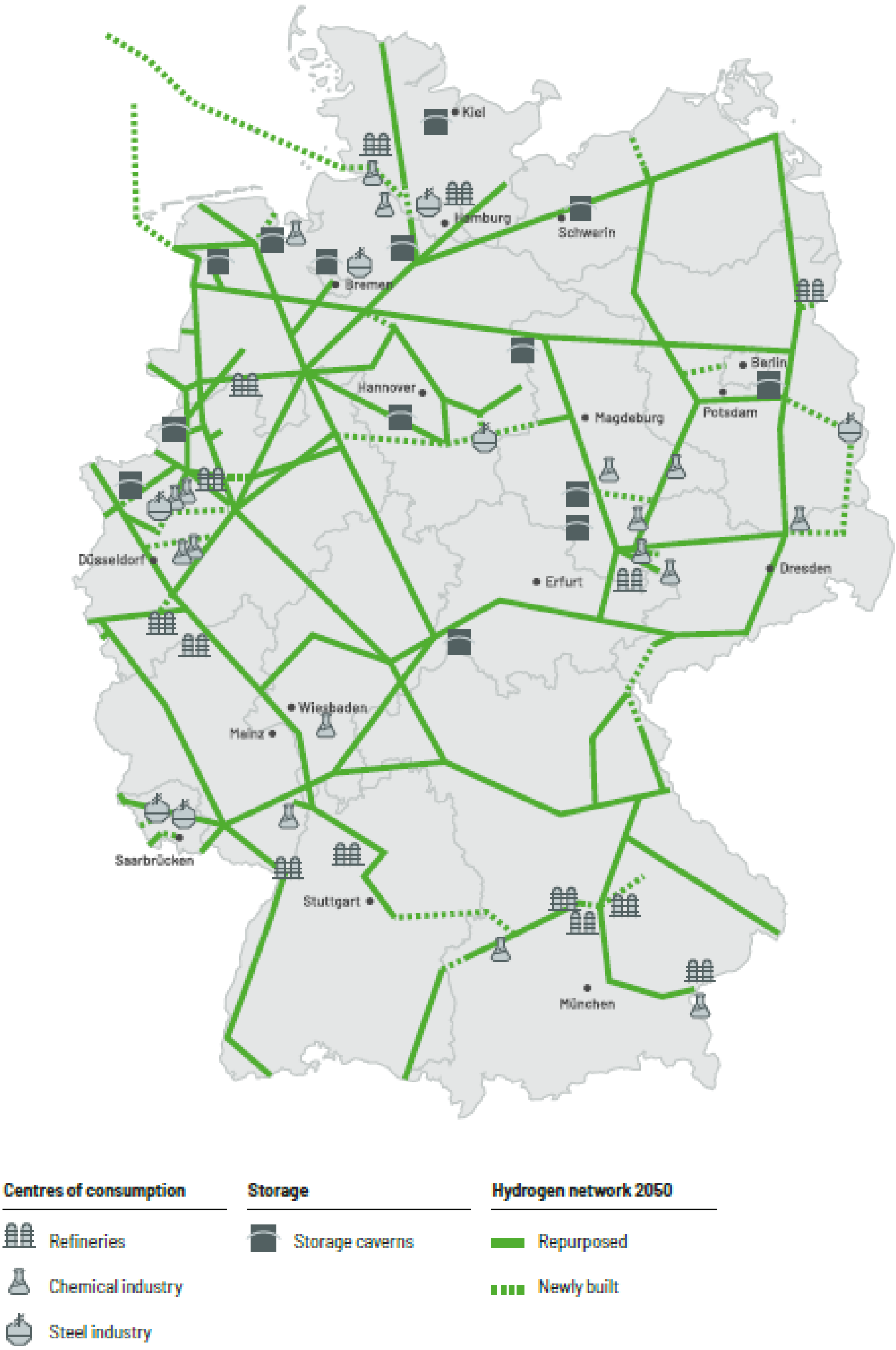
# Hydrogen network 2050: for a climate-neutral Germany



With their hydrogen network for a climate-neutral Germany (**H2 network 2050**), the German gas transmission system operators (TSOs) demonstrate that they can build an efficient and reliable national network at moderate investment costs. The H2 network 2050 has been developed from the "*Visionary Hydrogen Network*" published by the TSOs in January 2020. That first vision of the future incorporated many considerations, but it did not include network simulation to determine future hydrogen transmission capacity requirements. The H2 network 2050 on the other hand is based on more detailed network planning.

## Underlying assumptions for H2 network 2050

The gas TSOs began their scenario analyses and planning work for the future hydrogen transmission network in spring 2020. The work is based on a scenario for the production and use of hydrogen in Germany **developed together with the consulting firm 4Management on the basis of the recognised dena pilot study I (TM95)**.[1]

The network plans take account of the hydrogen transmission capacities needed for a climate-neutral Germany in 2050. However, the hydrogen pipelines required for a climate-neutral energy system could be built as early as 2045 by adjusting the relevant planning periods accordingly.

The TSOs have further developed the TM95 scenario with support from 4Management. Given Germany's hydrogen strategy and emerging market demand, they assumed a more dynamic development with an increase in demand from industry (notably steel and chemicals), a slight increase in hydrogen use by the transport sector and a moderate use in power generation – especially CHP plants – and in the heating sector. At the distribution level, the TSOs assumed hydrogen blending into gas grids and, in the long term, the conversion of entire network areas to pure hydrogen.

## H2 network 2050 parameters

The total length of the H2 network 2050 is about **13,300 km**, some **11,000 km** of which are repurposed natural gas pipelines. The underlying scenario continues to assume for the future that the demand for "green" methane will be similar to the demand for hydrogen. In a scenario where less methane is used (as described, for example, in the recently published dena pilot study Towards Climate Neutrality), further optimisation potential could be leveraged by converting more pipelines to pure hydrogen.

The planned hydrogen transmission network can provide an **energy quantity of 504 TWh** (net calorific value) at a **peak demand of around 110 GWh/h**. More recent studies such as the follow-up study conducted after dena's pilot study I (Towards Climate Neutrality) confirm the order of magnitude of the assumed future H2 demand.

The cost estimate for the hydrogen infrastructure shows that an efficient hydrogen transmission system can be built at comparatively low cost. According to this estimate, total **investments until 2050** would amount to some **18 billion euros**. The estimate includes investment spending for hydrogen transmission at supra-regional level. It does not include, for example, the costs associated with the conversion of storage infrastructure, offshore pipelines or pipelines to connect individual generation plants and individual consumers to the grid. The development of the hydrogen infrastructure is complementary to the expansion of the electricity infrastructure, which is also

[1] FNB Gas (2021): Scenario Framework of the Gas NDP 2022-2032, p. 39

necessary and which according to the Electricity NDP is expected to require investments of around 72 - 76.5 billion euros[2] until 2035 alone. Integrated network planning can help to optimise overall network expansion. The hydrogen infrastructure would enable and significantly accelerate the integration and storage of renewables where electrolysers can be built in close proximity to generation sites. Moreover, hydrogen pipelines offer many times the transmission capacity of HVDC lines and could therefore efficiently handle large parts of the energy imports into Germany that will continue to be needed in the future.

## H2 network planning details

The H2 network 2050 is based on a simulation of the fluid mechanics. For this purpose, the TSOs defined specific capacities at all entry and exit points of the future network, which meant regionalising the capacities assumed in the scenario for the industrial sector based on existing sites and production volumes currently available. Consumption in the transport sector was regionalised on the basis of the existing refuelling station network and vehicle registrations. For the heating market this was done mainly on the basis of population figures.

In the simulations, future hydrogen demand is primarily met by imports. The capacities at the cross-border IPs are based on the assumed hydrogen production potential in the different regions. Following on from the assumptions underlying the dena pilot study I TM95 scenario, the TSOs included approx. 63 GW of electrolyser capacity for 2050, most of which is located in northern Germany.

For the design of the network, the TSOs considered different load scenarios depending on the availability of renewables and cavern storage capacity connected to the pipeline network.

## Outlook

In addition to their work on the current Gas Network Development Plan 2022-2032, which includes modelling a demand-based hydrogen transmission network for 2032 using the results of the Hydrogen Generation and Demand Market Survey, the gas TSOs will continue to develop their scenario-based models of the hydrogen network for the target year 2045 and beyond, taking into account new findings and studies.

With their detailed scenario-based analysis involving network simulations, the TSOs are also setting the political course for an efficient national hydrogen transmission infrastructure and for capturing early decarbonisation opportunities through the use of hydrogen.

*Disclaimer: The maps are schematic representations of pipeline routes in which several pipelines can also run in parallel. Pipeline routes on which both repurposed gas pipelines and newly built hydrogen pipelines are installed in parallel are shown as repurposed pipeline routes.*

[2] Grid Development Plan Power 2035, p. 176