WHITE PAPER

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Hydrogen Quality for the European Transport Backbone

Abstract

The establishment of a European hydrogen transport network is recognized within the Gas and Hydrogen Package as a key enabler for achieving the European Union's climate neutrality and energy security objectives. In this context, the definition of a minimum hydrogen quality for injection into regulated hydrogen networks is essential to ensure safe and reliable system operation, network interoperability and effective access for a wide range of network users. This white paper sets out the main considerations that should inform such a definition, including the expected diversity of future hydrogen uses and volumes, the technical and economic implications of hydrogen purification, and the challenges of maintaining consistent quality across production, transport and storage infrastructure. It highlights the trade-off between increasingly stringent quality requirements, overall system costs and the operational limitations of a large-scale, interconnected hydrogen network. On this basis, EIGA supports the establishment of a pragmatic minimum hydrogen quality for the regulated hydrogen backbone, while reaffirming the continued and complementary role of unregulated, private hydrogen networks in supplying users with application-specific high-purity hydrogen under the coexistence framework foreseen by the Gas and Hydrogen Package.

Rationale for a Minimum Hydrogen Quality Standard

Building a European hydrogen transportation backbone network is considered a strategic measure to achieve the continent's climate neutrality and higher energy independence.

To ensure operational safety and proper performance for final applications, it is essential to define minimum hydrogen quality requirements for hydrogen injected into future transportation backbone network.

To define the minimum hydrogen quality requirements, it is necessary to consider different key factors. The hydrogen quality required by different end users must be taken into account, as it varies depending on the final application, together with a forward-looking estimate of the percentage distribution of volumes allocated to each use. A second crucial element concerns the costs associated with hydrogen purification processes, which increase significantly as purity requirements become more stringent. Finally, the technical challenges of ensuring high and consistent purity levels across the entire supply chain, from production to storage and transport within the network, must be considered, including potential sources of contamination and infrastructure limitations.

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Hydrogen quality and volumes considerations

To ensure operational safety and proper performance for final applications, it is essential to consider the quality characteristics required by different users depending on final applications; as a reference, the technical standard ISO 14687:2025 "Hydrogen fuel quality - Product specification"[2] specifies the minimum quality characteristics of hydrogen fuel for certain applications. The following are examples of the minimum purity levels required for various applications, as listed in the standard:

- Type I, Grade A: Gaseous hydrogen, residential/commercial combustion appliances (e.g. boilers, cookers and similar applications): 98,00%
- Type I, Grade B: Gaseous hydrogen, industrial fuel for power generation and heat generation except PEM fuel cell applications: 99,90%
- Type I, Grade D: Gaseous hydrogen, PEM fuel cells for road vehicles: 99,97%

Even though the purity percentage can give an initial idea of the minimum purity level, it is not sufficient to define the minimum quality requirements. It is important to establish also the maximum levels of specific contaminants, since they are crucial for safety, equipment protection, and product quality.

To ensure that the European hydrogen transportation backbone network effectively contributes to climate neutrality and higher energy independence targets, it is essential to define a minimum quality for hydrogen injected into the network that is consistent with the requirements of the main categories of future end users. Setting a coherent quality threshold helps ensure usability across sectors while avoiding unnecessary technical and economic constraints on the network.

However, today there is no clear or universally accepted view on how hydrogen demand will be distributed across sectors in the coming decades. Forecasts for the future distribution of hydrogen consumption across sectors show significant variation and uncertainty depending on different factors such as technological assumptions, cost trajectories, policy support or sector-specific decarbonization pathways. According to the European Hydrogen Observatory[1], existing scenario studies for 2030, 2040, and 2050 present a broad spectrum of projected hydrogen demand, reflecting differences in modeling assumptions, sectoral boundaries, and narrative frameworks.

Hydrogen purification processes

A thorough analysis of the costs associated with purifying hydrogen for injection into the European hydrogen transportation backbone network is essential to determine the optimal minimum purity level. More stringent purity requirements entail significant investments in separation and treatment technologies, with a direct impact on overall system costs. Assessing these costs helps avoid overly restrictive specifications that would not deliver proportional benefits for end uses. At the same time, such an analysis ensures that hydrogen quality remains sufficient to meet user requirements without compromising the economic efficiency of the network. This approach makes it possible to strike a balance between technical performance, economic sustainability, and decarbonization objectives.

As previously stated, a comprehensive definition of the minimum quality standards for hydrogen requires not only to define the minimum purity percentage but also to establish the maximum levels of specific contaminants.

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Various industrial applications require high purity and, most importantly, unique specifications in their supply:

- Chemical industry;
- Food and beverage;
- Pharmaceuticals;
- Electronics.

These specifications are crucial for safety and product quality reasons and to ensure that the industrial processes are not hampered or contaminated by trace components. Individual users have specific requirements for trace components, which can be harmful even at very low levels (parts-per-billion range).

Although upstream purification at network entry points can limit the need for further downstream treatment, it generally entails higher costs, especially when producers are required to comply with stringent purity specifications from the outset. In addition, further purification steps may still be necessary at network exit points to guarantee the required gas quality. Conversely, downstream purification at end-user facilities provides greater flexibility for the transport network, but it leads to additional energy demand and higher operational costs for the final users that require this additional purification.

Technical challenges of ensuring

Transporting high-purity hydrogen through a European hydrogen transportation backbone network involves several technical challenges that must be taken into account for defining the minimum quality requirements:

- **Off-gas stream from purification processes**: hydrogen purification processes aimed at achieving high purity inevitably generate an off-gas stream containing residual hydrogen, making it essential to foresee on-site management/reuse solutions to avoid inefficiencies caused by hydrogen losses;
- **Converting natural gas pipelines:** converted pipelines from natural gas involve the presence of impurities that are released over time, higher in the short term but also present in the medium to long term, so it is not possible to guarantee that a high level of purity is maintained without additional purification steps at the withdrawal point;
- **Long-term storage**: large long-term storage facilities (e.g., salt caverns) can release impurities, so purification is necessary in all cases when withdrawing from these storage facilities to reintroduce into the network;
- **Compression contaminants**: when connected to a pressurized network, compression contamination (lubricating oils) must be considered;
- **Grid size and complexity**: Using large pipeline system volumes including old/existing piping and a high number of hydrogen injectors increase the risk of contamination and make it more difficult to guarantee high purity. To ensure consistently high purity, small networks of limited length dedicated to specific customers are required.

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The role of high purity existing networks

Depending on whether hydrogen is used as an energy carrier or as a feedstock, it must meet different characteristics and constraints; in addition, there are specific industrial applications (e.g. chemicals users, refineries, electronics, food and pharmaceutical purposes) that require high purity with very stringent hydrogen specifications and limited tolerance in terms of fluctuations, contaminants and pressure.

Private hydrogen pipelines, linked with dedicated hydrogen production, have been developed to serve industrial customers in a cost-efficient way, meeting stringent technical specifications for their processes and offering security of supply. These private hydrogen pipelines allow to guarantee liability in terms of safety, purity, pressure and reliability, elements that, given all the technical challenges explained in the previous paragraphs, are difficult to guarantee through the European hydrogen transportation backbone network.

Regardless of the minimum quality standard that will be established for hydrogen injection into the European hydrogen transportation backbone network, existing and future private hydrogen networks, which are often dedicated to end-users requiring high purity supply, can continue to play a vital role for the overall hydrogen ecosystem.

EIGA agrees that private hydrogen pipeline operators will retain the right to own and operate their private networks, at whatever purity (generally high) suits the private purposes.

As stated earlier in position paper EIGA PP046, a regulated public hydrogen backbone and unregulated private hydrogen pipelines should coexist under the Gas and Hydrogen Package. EIGA recalls the importance for Member States implementing rules allowing for this coexistence.

References

[1] https://observatory.clean-hydrogen.europa.eu/tools-reports/scenarios-future-hydrogen-demand

[2] ISO 14687:2025 - Hydrogen fuel quality — Product specification

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About the European Industrial Gases Association
Founded in 1923, the European Industrial Gases Association (EIGA) is a safety and technically oriented organisation representing the vast majority of European and also non-European companies producing and distributing industrial, medical and food gases. The member companies closely co-operate in technical and safety matters to achieve the highest level of safety and environmental care in the handling of gases. EIGA is in frequent touch with Standardisation and Regulatory Organisations and Authorities as well as trade and industrial organisations. EIGA's membership comprises European companies that produce or distribute industrial and/or medical gases. As such, EIGA itself does not produce or market industrial or medical gases.

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