



ENNOH

H2 Quality Monitoring Report Workshop



Brussels, 12 February

www.ennoh.eu



ENNOH: Mission and Scope

According to Regulation (EU) 1789/2024, ENNOH will be the **organisation for the cooperation** of the EU Hydrogen Transmission Network Operators (**HTNOs**).



Promote the

- **development** and proper **functioning** of the **internal H₂ market**
- **cross-border trade** of H₂



Support the **optimal management**, coordinated operation and **sound technical evolution** of the European H₂ transmission network



Contribute to the efficient and sustainable **achievement** of **EU Energy and Climate targets**

ENNOH shall cooperate closely with ENTSO-E, ENTSG and EU DSO Entity



According to EU Regulation, this cooperation will aim to:

- Identify **synergies**
- Foster **Energy System Integration** across energy vectors
- Facilitate overall **Energy System Efficiency**

Membership

26 EU Countries

36 Members

1 Associated Partner



ENNOH Tasks and Deliverables



TYNDP and related tasks

- Union-wide Ten-Year H₂ Network Development Plan
 - TYNDP 2026 by ENTSOG
 - ENNOH to take over TYNDP process in 2027
- Infrastructure Gaps Identification Report
- Single-sector Methodology
- Annual Supply Outlook and Assessment of System's Resilience
- Repurposing guidelines
- Cooperate closely with ENTSOE and ENTSOG on fostering system integration and overall energy system efficiency (Union-level Integrated Network Planning)
- Joint Scenarios with ENTSOG and ENTSOE
- Inter-linked/Integrated Market and Network Model



Cross-cutting (input from/to other areas)

- Annual Work Program
- Annual Report
- Regional Cooperation
- Provide ACER with the information ACER require to fulfil tasks described in the Regulation.
- Answer Public Consultations from EC and ACER on different aspects



Network Codes

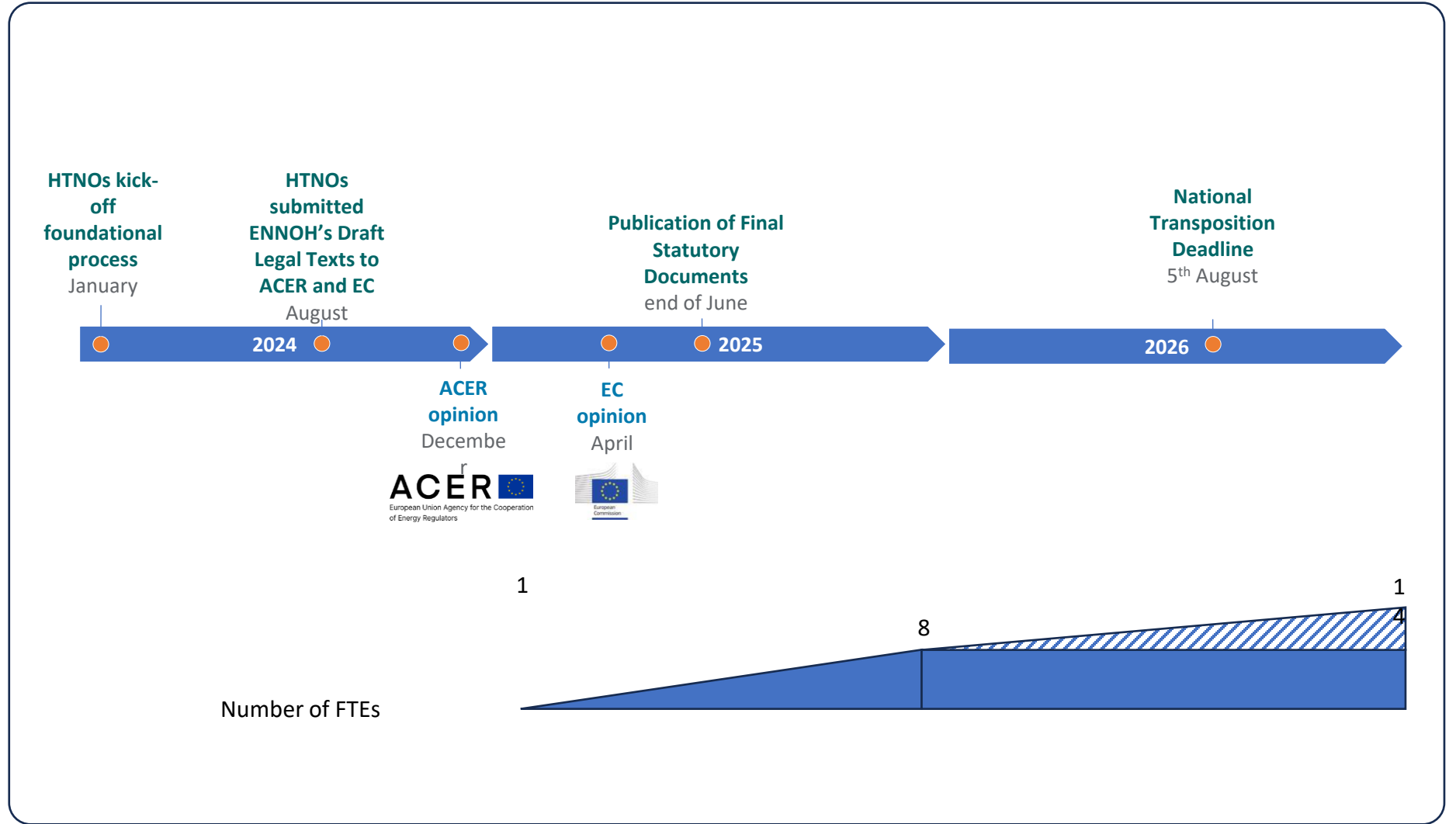
- Participate in the preparation of the Priority List
- Network Codes development:
 - Energy efficiency in H₂ networks
 - Interoperability (data exchange, transparency, H₂ quality, ...)
 - Financial compensation for cross-border investments
 - Capacity allocation (CAM), Congestion management (CMP)
 - Tariffs
 - Value of Transferred Assets and dedicated charge
 - Balancing rules
 - Inter-temporal cost allocation
 - Cybersecurity
- Monitor Implementation, Amendment of Network Codes



System Operation and Transparency

- H₂ quality monitoring
- H₂ leaks/emissions
- Cybersecurity, Security, R&D, Data Protection
- Recommendations for technical cooperation between
 - HTNOs, HDNOs, TSOs, DSOs
 - Union and 3rd countries' HTNOs
- Transparency Platform

Foundational Process



ENNOH Upcoming Event

Team members



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ENNOH Newsletter

System Operation and Transparency

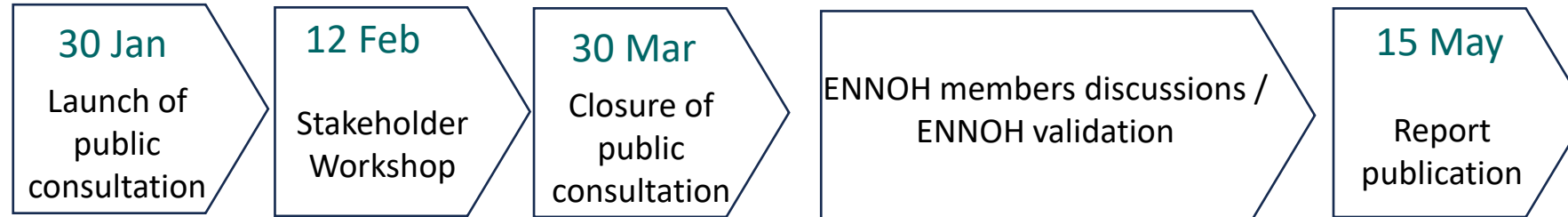
- H₂ quality monitoring
- Transparency Platform
- H₂ leaks/emissions
- Innovation/R&D
- Cybersecurity and Data Protection
- Recommendations for technical cooperation



Forthcoming Network Code on Interoperability

1st ENNOH Hydrogen Quality Monitoring Report

Process & Timeline



***Hydrogen quality to be monitored by
ENNOH every 2 years***

Report

1. *Framework*
2. *State-of-the-art/ongoing studies*
3. *ENNOH members overview*
4. *Public consultation feedback*
5. *Conclusion/agreed principles*

Public Consultation: 2 months from 30 January to 30 March



- ✓ The consultation process shall accommodate stakeholder comments before the final adoption of the proposal, with the aim of identifying the views and proposals of all relevant stakeholders during the decision-making process
- ✓ All interested parties are eligible to participate in the consultations (market participants, organisations representing groups of stakeholders, NGOs, technical and scientific bodies, etc.)
- ✓ Unless specified otherwise by the respondent, ENNOH typically treats responses as non-confidential.
- ✓ The consulted parties will have the right to decide whether their response (or parts of it) is confidential or not. Whatever the consulted party claims to be confidential shall be treated as such.
- ✓ Once the public consultation is closed, ENNOH considers all responses received and be mindful of the stakeholders' comments, trying to accommodate as much as possible the comments received before the final adoption of the proposal.
- ✓ ENNOH allows for confidential responses but will disregard anonymous contributions.

Public Consultation: 2 months from 30 January to 30 March



ENNOH publishes:

- a) all minutes of meetings related to the consultation. ENNOH might publish an aggregated summary of inputs received for the informal meetings and interactions held with stakeholders.***
- b) all the non-confidential responses received to formal consultations and the total number of responses received.**
- c) a list with the names of all respondents (unless the respondent requests to be kept anonymous), anonymising any sensitive personal data of any respondent.**

ENNOH prepares and publishes a document evaluating the responses received. The document will include an aggregated summary of all the responses received and reasoning as to why contributions were considered (or not).

When using content from a confidential answer, ENNOH will explain why that information cannot be disclosed.

Public Consultation: 2 months from 30 January to 30 March



Materials provided for the consultation:

Groundwork document

+

Questionnaire

<https://www.ennoh.eu/ennohs-public-consultation-on-hydrogen-quality>



ENNOH HYDROGEN QUALITY MONITORING REPORT 2026: PUBLIC CONSULTATION GROUNDWORK DOCUMENT

1. INTRODUCTION

Article 59 of the 2024/1789 (EU) Regulation on the internal markets for renewable gas, natural gas and hydrogen tasks ENNOH to adopt a hydrogen quality monitoring report and every 2 years thereafter, including developments and forecasts for the expected developments of hydrogen quality parameters, as well as information on cases related to differences in hydrogen quality specifications and how such cases were settled.

This groundwork document collects the more recent information available on that topic, in particular an overview of studies ordered by bodies such as European Commission or Easee-Gas. It includes also a synthetic view gathered from ENNOH members on the regulations already in force, as well as current issues related to hydrogen quality.

Hydrogen networks in Europe are currently structured as clusters, which should be interconnected through an European backbone in the upcoming years. Hydrogen flows are therefore confined to limited areas, rendering any forecast modelling pointless. However, it is important to have today hydrogen quality specifications as close as possible in Europe in order to facilitate the achievement of an unified pan-European quality specification target. In addition, Article 50 of the 2024/1788 (EU) Directive on common rules for the internal markets for renewable gas, natural gas and hydrogen tasks hydrogen network operators to be responsible for providing to the operator of other networks or systems with which its system is interconnected sufficient information,

Public Consultation: setting the scene

Regulatory framework:

2024/1789 (EU) Regulation: ENNOH tasked to adopt a H2 quality monitoring report (Art. 59)

2024/1788 (EU) Directive:

- H2 quality definition (Art. 2): H2 purity and contaminants in line with applicable hydrogen quality standards for the hydrogen system.

- Adjacent HTNOs responsible for providing sufficient information, including on H2 quality, to develop interoperability (Art. 50).

CEN/CENELEC TC234 standardization work

DG ENER study

EASEE-GAS work

GIE position paper

Public Consultation: ENNOH members initial inputs



Some countries already have started regulation activities:

Austria (ÖVGW G B210 and ÖVGW H B100), Czech Republic (Decree No. 108/2011), Germany (DVGW standard G 260, upcoming European standards), the Netherlands (indicative HyNetwork quality specification), Denmark (preliminary H2 specification by Energinet).

General views of ENNOH members regarding H2 quality:

- **Ensuring trust** in hydrogen economy, **facilitate** market ramp-up, importance of **stable** quality conditions.
- Importance to achieve a **standardization** process leading to a **unified** set of specifications in Europe.
- **Overcoming the purity level/contaminants dilemma.**

Workshop agenda

09:00 – 10:00

Registration, welcome coffee & networking

10:00 – 10:10

Opening remarks

- Abel Enríquez (ENNOH)

10:10 – 10:30

ENNOH H₂ Quality Monitoring Report: Consultation process, on-going work & next steps

- Daniel Bonnici (ENNOH)

10:30 – 10:35

Questions & Answers

10:35 – 11:30

H₂ quality in dedicated infrastructure & standardisation

- Ruta Baltause (European Commission)
- Nicolai Romanowski (CEFIC)
- Grzegorz Pawelec (Hydrogen Europe)
- Markus Hössel (Gascade)

11:30 – 12:00

Questions & Answers

12:00 – 13:00

Lunch break

Workshop agenda

13:00 – 14:10

EASEE-gas work on H₂ quality

- Michael Sostmann (EASEE-gas)
- Peter van Wesenbeeck (EASEE-gas)
- Sebastian Cichowski (RWE)
- Wolfgang Ott (EIGA)
- Geir Solvi (Yara International)
- Nikolas Moneos (GIE)

14:10 – 14:30

Questions & Answers

14:30 – 15:00

Coffee break

15:00 – 15:55

Key additional insights on H₂ quality

- Christina Würtz Bjerre (Energinet)
- Ulrich Duda (H2eart for Europe)
- Tobias van Almsick (CEN-CENELEC)
- Robert Judd (GERG)
- Clara Furlan (HDF Energy)

15:55 – 16:15

Questions & Answers

16:15 – 16:20

Conclusions & closing of the workshop

- Daniel Bonnici (ENNOH)
- Abel Enríquez (ENNOH)

Hydrogen quality in dedicated infrastructure & standardisation

Ruta Baltause, DG ENER

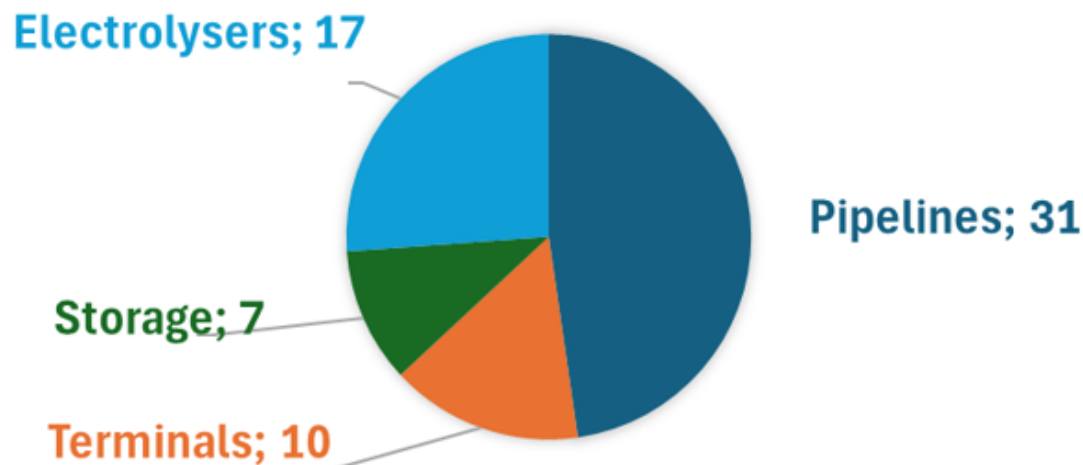
12 February 2026

Setting the scene (1)

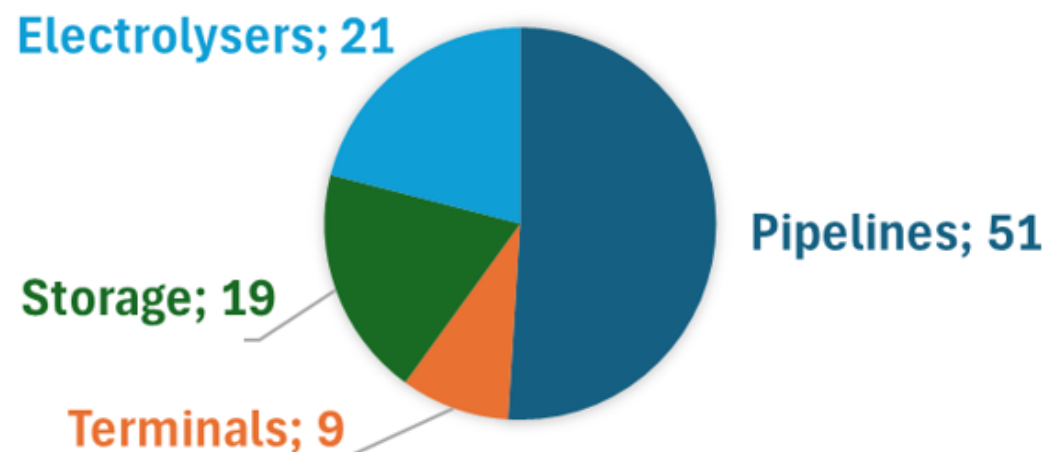
Hydrogen quality standardisation urgency

2nd PCI/PMI list under TEN-E
Guidelines – adopted 1 Dec 2025

1ST HYDROGEN PROJECTS



2ND HYDROGEN PROJECTS



- 100 projects on the 2nd List , 65 projects on the 1st list
- 35% more hydrogen projects on the Union list
- ² Significant increase in storages and pipelines

Study on hydrogen quality in dedicated infrastructure and standardisation

Main objectives of the Directorate-General for Energy for this study:

- 1) Technical assistance to the European Commission on preparation and adoption of a standardisation request to the CEN/CENELEC
- 2) Facilitating the consensus finding among all actors during the standardisation process



Published on DG Energy website:

https://energy.ec.europa.eu/publications/study-hydrogen-quality-dedicated-infrastructure-and-standardisation_en



Project overview:

- **Literature analysis:** influence of different supply chain elements on hydrogen gas composition and implications of varying purity levels for end-users
- **Overview **standardisation landscape**:** existing hydrogen gas quality standards and current developments in 12 EU Member States
- **Stakeholder consultation:** gathering of positions of actors of future hydrogen markets via survey and interviews (N~50)
- **Understanding hydrogen quality **specification needs, including underground storages**:** three quality specifications (incl. limits for key contaminants), rational behind + recommendation for further standardization efforts / gaps derived based on stakeholders' feedback
- **Modular purification cost assessment:** purification efforts and associated costs for purity cases
 - at 98 mol% (CEN/ TS 17977), 99.5 mol% (indicative-NL HyNetwork), and 99.97 mol% (EN 17124)
 - (i) specific purification costs
 - (ii) analysis for different steps along supply chain (modular approach)
 - (iii) scenario-based cost analysis
- **Outlook - next steps towards standardisation**

Setting the scene (1)

Hydrogen quality challenge

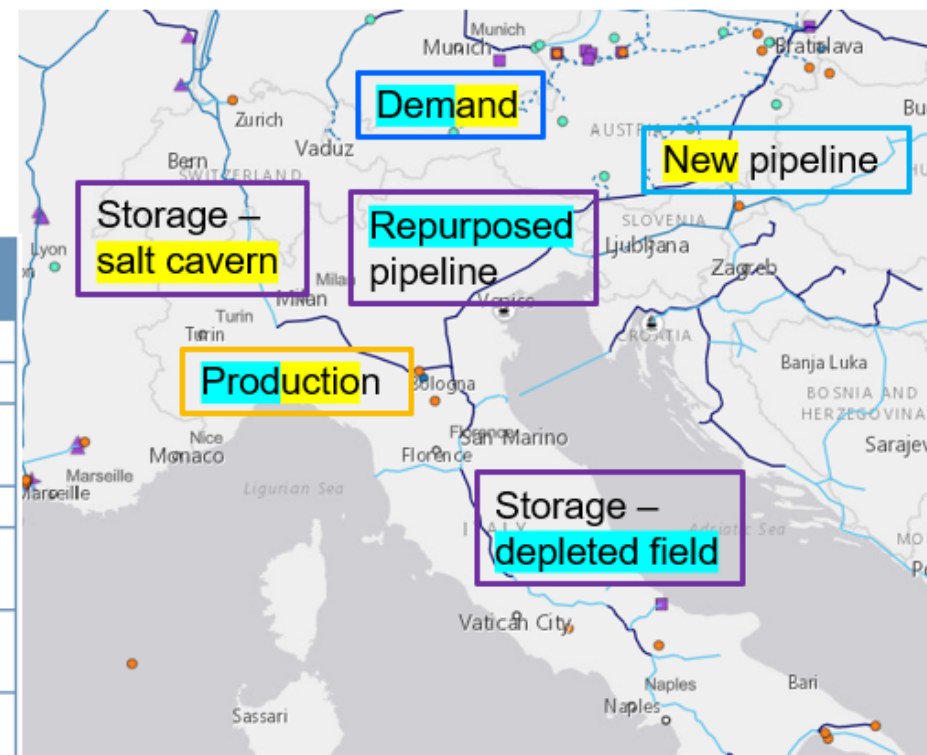
Supply chain elements	Potential sources	Potential Impurities / contaminants
Production	Electrolysis - AEL	Nitrogen (+), water (o), oxygen (o), cations (o), argon (-)
	Electrolysis - PEMEL	Nitrogen (o), water (o), oxygen (o), carbon dioxide (-)
	Steam reformation (SMR) + (PSA)	Carbon monoxide (++), nitrogen (+), methane (o), water (o), argon (o), formaldehyde (-)
Conversion	Ammonia cracking	Ammonia (+), nitrogen (+)
Transmission	Converted natural gas pipelines	Typical associated gas components, condensate components (decreasing over time)
	Operations and maintenance	Nitrogen (purging) Lubricants / compressor oils (piston compressors)
Storage	Underground storage	Water, methane, sulphur compounds, higher hydrocarbons
	Operations and maintenance	Lubricants / compressor oils (piston compressors) Glycol (dehydration processes)

Probability: (++) frequent, (+) possible (o) rare (y) very rare (based on terminology used in Bacquart 2018).

No probability analysis performed for cases without rating.

Category	Technology	Bandwidth of minimum hydrogen purity level %						
		97.0	98.0	98.5	99.0	99.5	99.9	99.99
Power	Gas turbine							
Industrial heat	Burner							
Oil refinery	Various processes							
Ammonia / fertilizer	Haber-Bosch process							
Steel	Blast furnace, DRI							
Chemical feedstock	Methanol, peroxides, etc.							
Chemical (others)	Food, coolant							
Mobility	Fuel cell							

Note: in bright blue: additional / deriving requirements based on literature data.



Source: GIE Hydrogen Infrastructure map

CEN/CENELEC and ISO technical standards in place

- ❖ CEN/ TS 17977 – Hydrogen quality in rededicated gas systems
- ❖ EN 17124: 2022 – Hydrogen fuel quality for fuel cell vehicles
- ❖ ISO 14687:2025 - Hydrogen fuel quality for the use in a range of applications



Mismatch between hydrogen quality specification supply (production+pipelines+UGS) and demand (end-use applications)

Quality requirements by sector / application		≥ 98 mol% H ₂ = "low" quality	≥ 99 mol% H ₂ = "medium" quality	≥ 99.97 mol% H ₂ = "high" quality
Building (low temperature heat)		(✓)	(✓)	✓
Energy / power generation		(✓)**	(✓)**	✓
Mobility	ICE	✓	✓	✓
	PEM FC	Not suitable	Not suitable	✓
PtX		Not suitable	✓	✓
Industry (examples)	Construction aggregates (Stones and soils)	✓	✓	✓
	Paper	✓	✓	✓
	Glass and ceramic	✓**	✓**	✓
	Iron and steel	✓*	✓*	✓
	(Petro-) chemistry (feedstock / non-energy use)	Not suitable	✓*	✓

Source: Adapted based on DBI GUT & Frontier (2022)². Low- and high-quality specifications referring to DVGW G260 Group A & D.

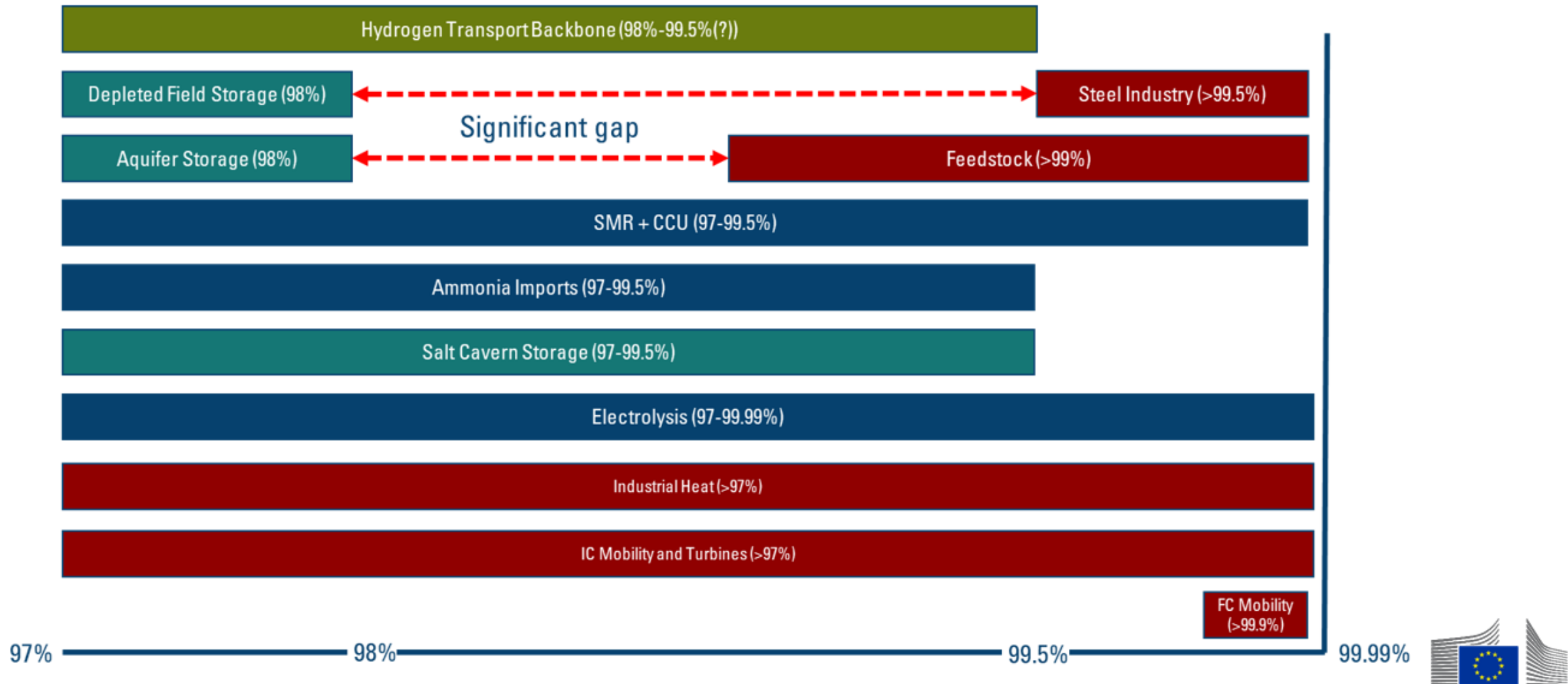
Please note: parathesis () indicate that suitability depends on type of use or specific contaminant / trace component

*Dependent on the composition of trace components.

**Dependent on stability of the Wobbe index over time.

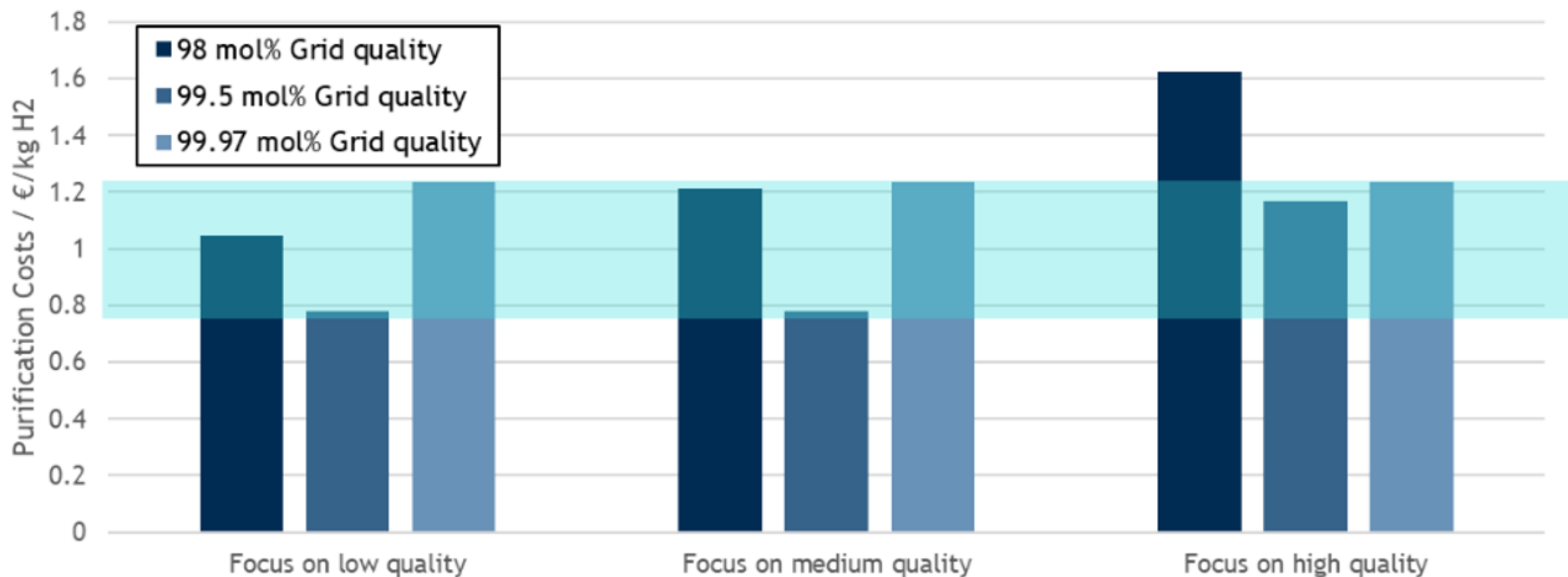


Mismatch between hydrogen storage capabilities and end-use requirements for certain applications



Mismatch of purification costs between different infrastructure settings and end-use profiles

Comparison of costs with different weighting of end users



What to do about it?

1) Cooperation and coordination:

- between economic operators, network operators, regulators and legislators at both – the national and EU level

yes/ no/ how?

2) Regulation:

- splitting or no-splitting of hydrogen quality responsibilities at a regional/ national level by regulators (centralised/ decentralised purification)
- purification cost sharing at system level (production – pipelines – storages) – at national/ regional level

yes/ no/ how?

3) Standardisation:

- real-life data collection and knowledge sharing beyond regulation
- specific measures to ensure active involvement of all stakeholder groups along the supply and demand chain – at all stages of standardisation

yes/ no/ how?

- gradual increase of quality over time in the standard?

yes/ no/ how?

- specific boundaries/ additional specifications (entry and exit points/ pipelines and storages/ pipeline networks and storages)

yes/ no/ how?

Objectives of the Hydrogen and Decarbonised Gas Market Package – efficiency, stability and end-user needs

- **DIRECTIVE (EU) 2024/1788:**

- (94) [...] In that sense, it is important for the hydrogen system to **transport, store and handle hydrogen of a high grade of purity taking into account hydrogen end-users' quality requirements**, as opposed to hydrogen blended into the natural gas system. It is also important **that hydrogen quality standards provide further criteria to determine the commonly acceptable hydrogen purity levels**. It is necessary for a bandwidth of acceptable hydrogen purity levels and other relevant hydrogen quality parameters, for example contaminants, to be defined by means of a technical standardisation process by European standardisation bodies.
- (95) In some cases, depending among others on the topography of hydrogen networks and the population of end-users connected to the hydrogen networks, hydrogen quality management by hydrogen network operators could become necessary (for example, purification). Therefore, regulatory authorities should task hydrogen network operators with ensuring efficient hydrogen quality management in their networks where necessary for system management. When undertaking such activities, **hydrogen network operators should ensure stable hydrogen quality for end-users, including in hard-to-decarbonise sectors, by complying with applicable hydrogen quality standards**

- **REGULATION (EU) 2024/1789:**

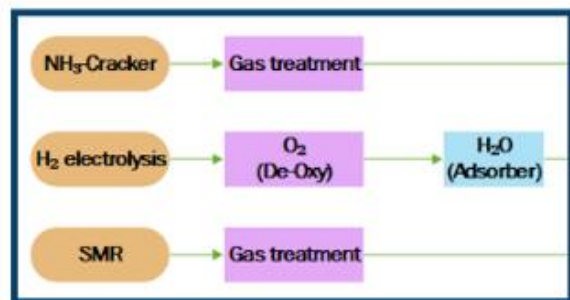
- (99) In order to fully take into account the quality requirements of hydrogen end-users, **technical specifications and standards for the quality of hydrogen in the hydrogen network should take into account already existing standards** setting such end-user requirements, for example, the standard **EN 17124**.



The analysis of purification needs at each hydrogen supply system step

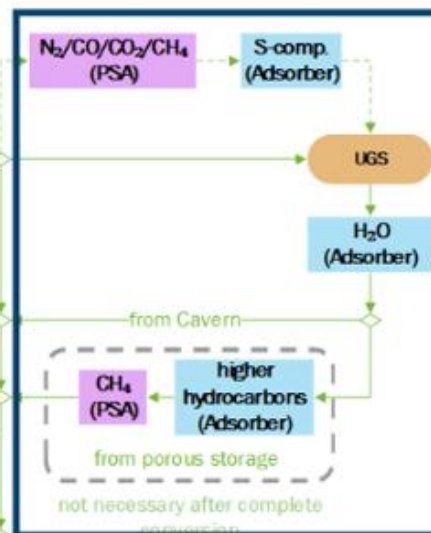
Explanation (1/2)

H₂ production
(exemplary pathways)
+ purification steps

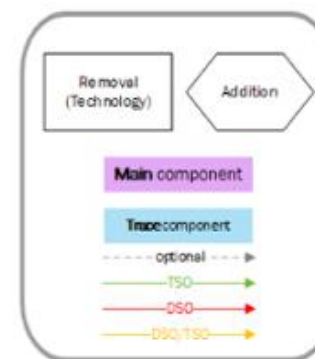
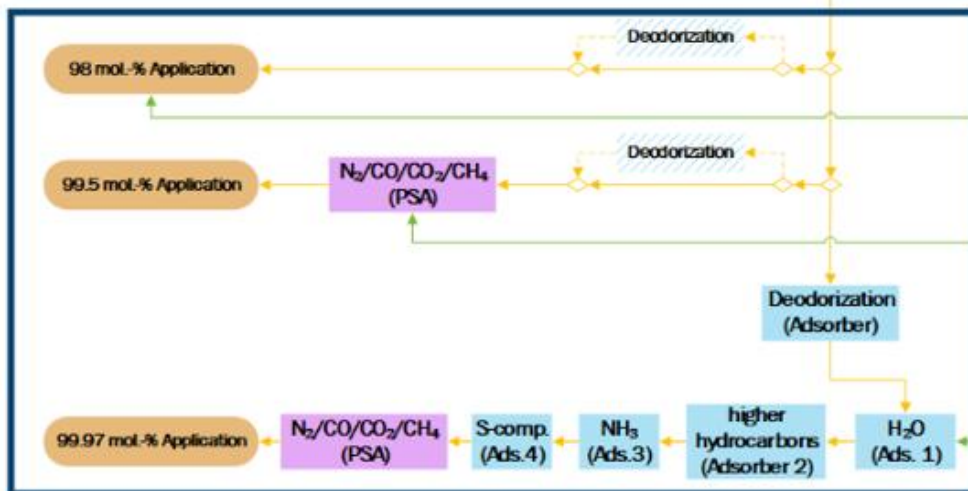


H₂ storage
(in salt caverns
and porous media)

+ pre & post-
purification



H₂ end uses +
purification steps



Legend

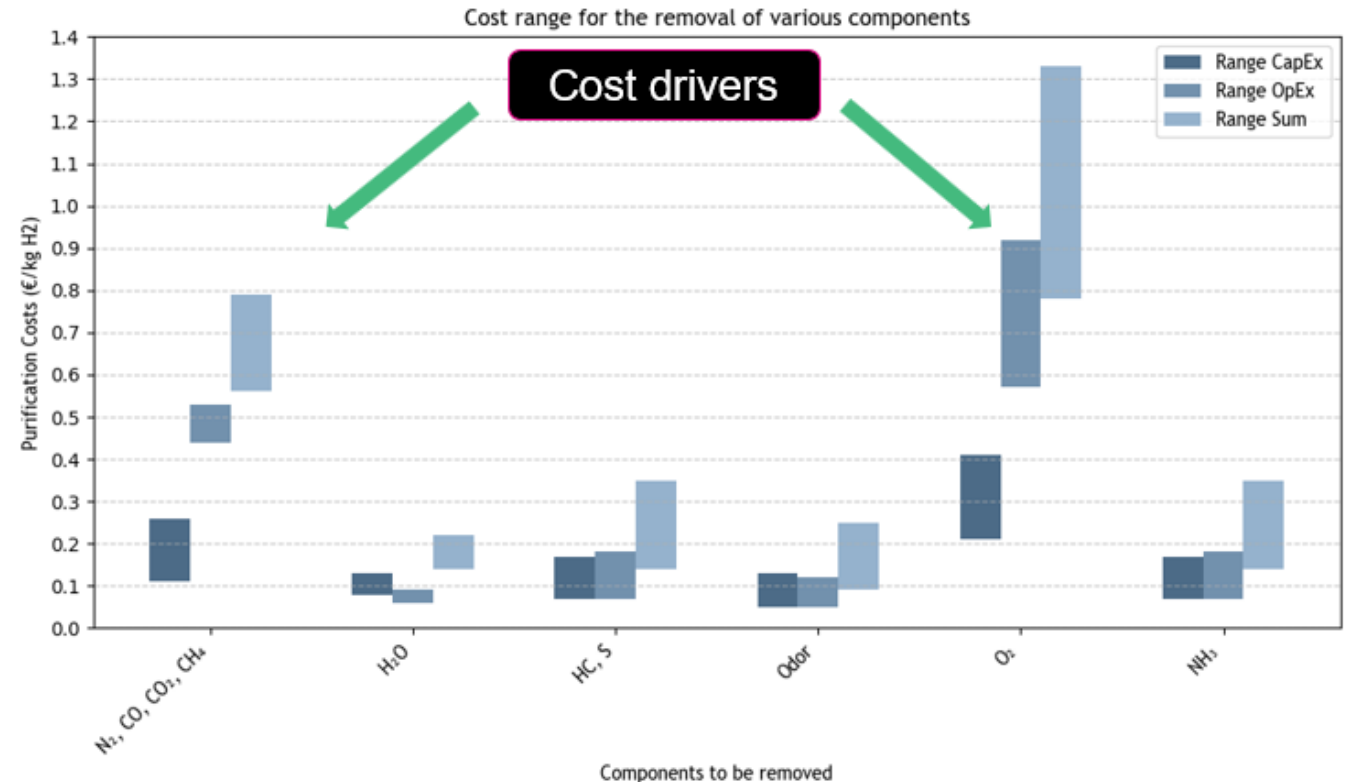
Main purification cost drivers - oxygen removal and PSA (for N₂, CO, CO₂ & CH₄)

Results of literature & market analysis:

- Costs for removing various impurities were analyzed (CAPEX and OPEX)
- Examined contaminants: N₂, CO, CO₂, CH₄, H₂O, hydrocarbons (HC), sulphur compounds (S), odorants, O₂, and NH₃

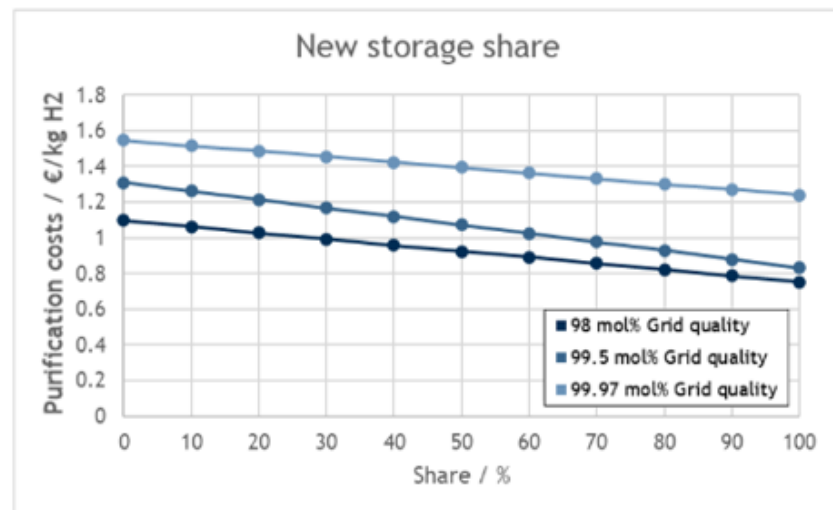
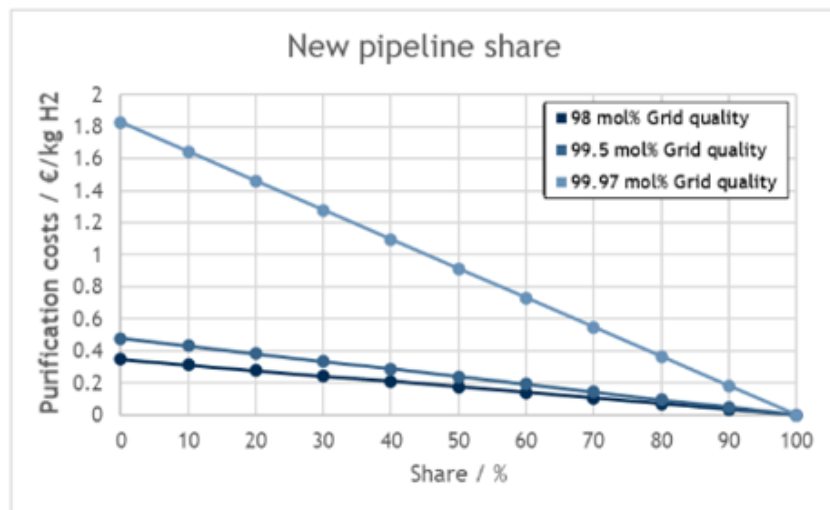
Key findings of cost analysis:

- Highest costs: oxygen removal and PSA
- Lowest costs: Removal of odorants and H₂O
- Cost drivers:
 - Varying complexity
 - Resource intensity / energy demand
 - Scaling effect

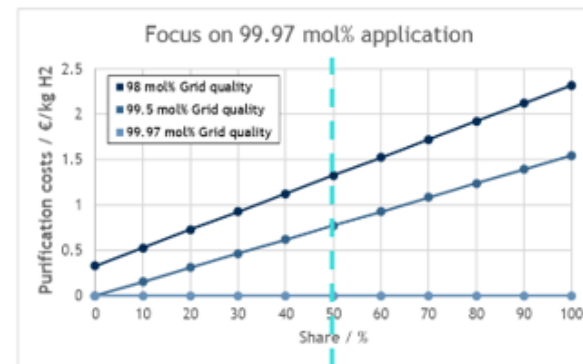
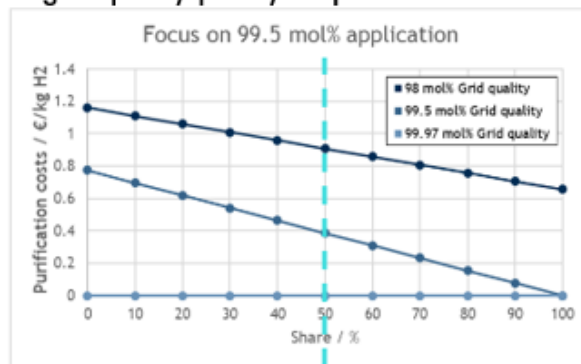
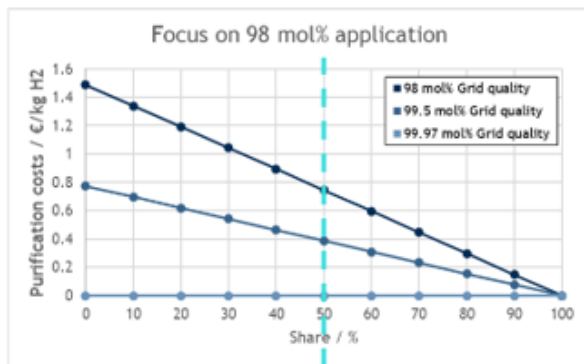


*Cost range considers the full range of treatment costs in the different cases, as well as the inclusion of different plant sizes

Modular approach for the analysis of costs and “no-regret” options over time



Share of end-user groups by purity requirements/ Wobbe index



X-axis: variation in share of end-user group requiring 99.97 mol% hydrogen (with equal split among the other two end-user groups)

See table above



Project team recommendations

- (1) **Systematic collection of data** on H₂ quality and purification costs in H₂ network, including pipelines and storages
→ better understanding of all elements connected to (future) grid
- (2) **Economic assessment** to ensure cost-effective grid operation – also considering major contaminants and risk of unsuccessful harmonisation process on cross-border trade (**alternative option: step-wise approach**)
- (3) **Foster EU wide harmonisation for market development**, preventing costly market fragmentation and stranded investments / adaptation needs for end-users
- (4) Facilitate **fair distribution of financial burden and responsibility** for gas quality (i.e. market design in EU MSs)

→ Project team recommendations to the European Commission ...

- to provide security for planning and investment by upcoming standardisation request
- to ensure market development within EU, business models & private investments, safety and optimisation of a European hydrogen market (technological & economic perspective)
- to develop & moderate process for a common EU grid quality standards



Three exemplary specifications by the project team – derived based on stakeholders' input and existing standards and serve as basis for cost assessment

98%: derived from CEN TS17977:2023

99.5%: based on HyNetworks indicative spec

99.97%: based on (private) industrial pipeline

The specifications are a combinations of **stakeholder input and existing standards**

This approach may allow for **quick alignment with real market practices** since these standards are already well-known, and the changes in purification infrastructure are more limited

Important: No recommendation for future standard but only example for cost assessment!

Property	Example Specifications		
H ₂	>98 %	>99.5 %	>99.97 %
Wobbe Index	41.89– 45.89 MJ/m ³ , (15 °C/15 °C)	43.45-45.89 MJ/m ³ , (15 °C/15 °C)	n/a
ΔWobbe index	<0.5 MJ/m ³ minute		n/a
Water	<250 ppm at <10 bar <60 ppm at >10 bar		<5 ppm
Water Dewpoint	<-8 °C at 70 bar		
Hydrocarbons	<20,000 ppm	<5,000 ppm	< 2 ppm
Oxygen	<10 ppm		
CO and CO ₂	<40 ppm (20 ppm each)		<2 ppm (total)
Ammonia	<10 ppm		<0.1 ppm
Inert Gases	<20,000 ppm	<5,000 ppm	< 300 ppm
Halogenated Compounds	<0.05 ppm		
Dust and Particulates	<1 mg/kg		
Total Sulphur	<7 ppm	<3 ppm	<0.05 ppm
Formaldehyde	<10 ppm		<0.01 ppm
Formic acid	<0.2 ppm		
Hydroxides (KOH, NaOH)	<2 ppm		

Thank you!

Ruta.Baltause@ec.europa.eu



Chemical Industry Views on Hydrogen Quality



Nicolai Romanowski

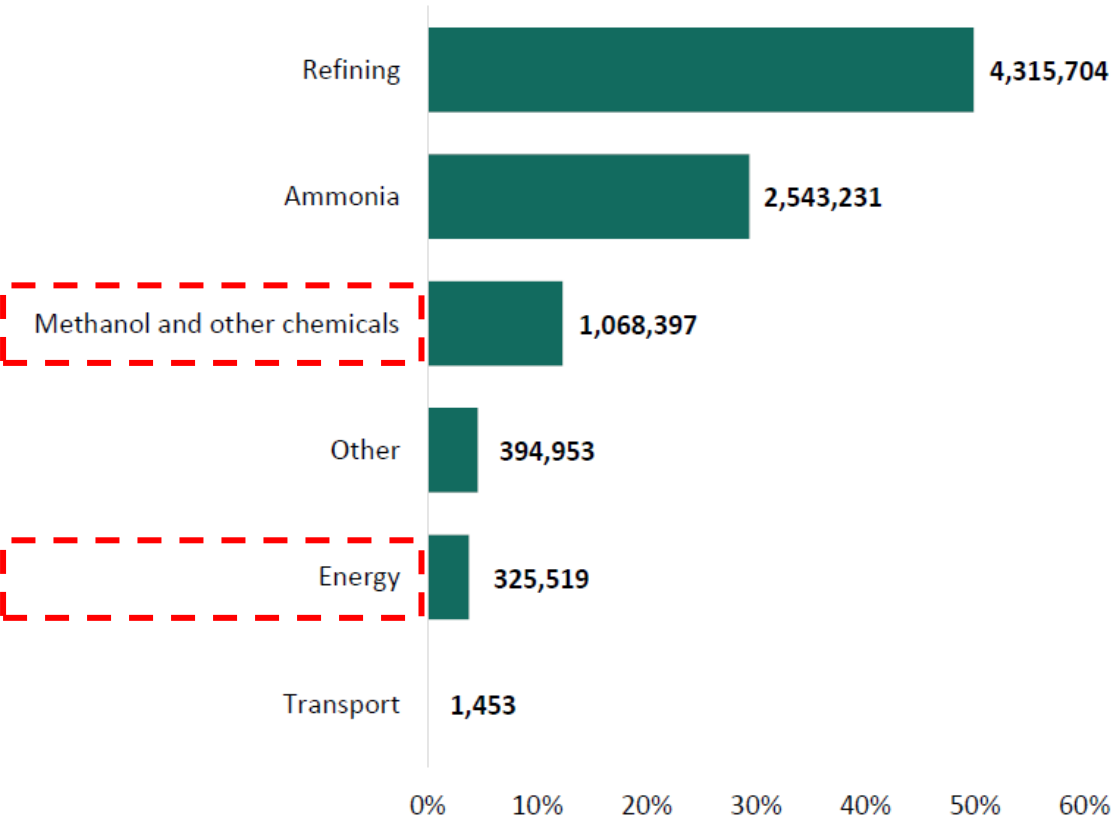
Senior Energy Manager

Cefic



Hydrogen Consumption in the Chemical Industry

Hydrogen demand by consumer sector (tons)



Conventional hydrogen demand by country and end-use

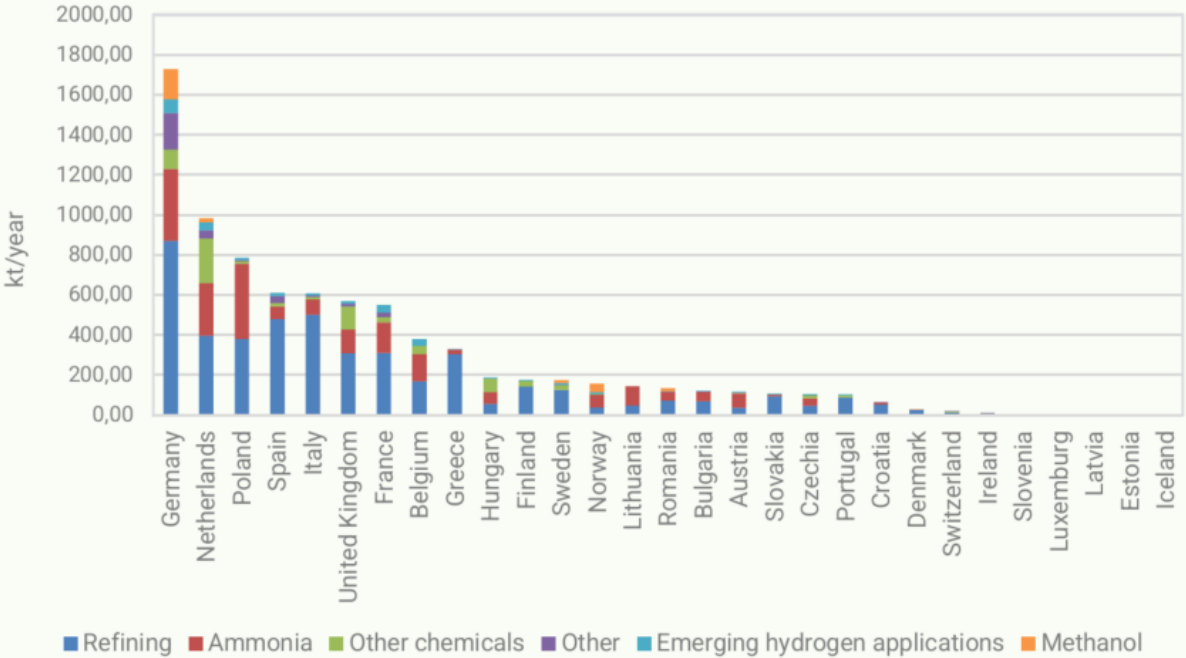


Figure 31. Conventional hydrogen demand by country and end-use

Source: Fuel Cells and Hydrogen Observatory

*Source: [Petrochemicals Europe](#)

Chemical Industry: Hydrogen Quality Needs

- The chemical industry is **the third largest consumer of hydrogen today**.
- **Feedstock use dominates the hydrogen consumption in our sector** – and is highly sensitive to even low concentrations of contaminants.
 - Chemical processes which consume hydrogen produce, amongst others, aniline, butanol, butanediol (BDO), hydrogen-peroxide, propylene-oxide and polyethylene, alcohols, solvents and ammonia....
 - We point in particular to catalyst poisons such as CO, O₂, total sulphur content and halogens, to which feedstock applications are sensitive.
- **The risk:** Mismatching hydrogen quality needs at end-user level with those standards set in the backbone necessitates on-site purification – the resulting costs and permitting implications may well deter consumers from connecting to the backbone.

Chemical Industry: Hydrogen Quality Needs

- **Another challenge:** how to move from localised hydrogen clusters to an integrated hydrogen backbone:
- We want to facilitate the competitive development of a hydrogen backbone, whilst safeguarding the specific needs met through existing, private hydrogen pipelines.
- **We propose:**
 - **Adopt a minimum hydrogen purity standard of ≥ 99.9 mol-%** (at the exit point) in the EU hydrogen backbone to facilitate the development of the EU hydrogen economy.
 - **Safeguard the hydrogen quality in existing networks.**

Table 1: Proposed Cefic hydrogen quality and process specification for European hydrogen transport networks at the exit point.

Parameter	Units	Cefic proposal	LBST-DBI-DNV-Trinomics 2025
Hydrogen	mol%	≥ 99.9	> 99.5
Inerts (N ₂ , Ar, He)	mol%	≤ 0.01	< 0.5
Hydrocarbons, including CH ₄	mol%	≤ 0.001	< 0.5
Water - dewpoint	molppm	≤ 5	-8 at 70 bar
Oxygen	molppm	≤ 0.1	≤ 10
Carbon Dioxide	molppm	≤ 0.1	≤ 20
Total S content (incl. H ₂ S)	molppm	Concentration below the detection limit (0)	≤ 3

Halogen compounds	molppb	Concentration below the detection limit (0)	≤ 50
Carbon Monoxide	molppm	≤ 0.1	≤ 20
Ammonia	molppm	≤ 1	≤ 10
Temperature (entry)	°C	5 - 40	
Temperature (exit)	°C	Ambient to 40	

Additional parameters, not featured in the work of DNV:

Mercury	wtpm	≤ 0.05	
MEA/DEA	wtpm	≤ 0.1	
Oil	wtpm	≤ 1	
Arsenic	molppm	Concentration below the detection limit (0)	
Phosphorus	molppm	Concentration below the detection limit (0)	

**Position available
[here.](#)**

Chemical Industry: Hydrogen Quality Needs

- **The purity standard the EU sets today ought to guide investments and avoid stranded assets.**
 - A successive upgrading of standards risks investments in stranded assets for purification that can be avoided by setting a single, high level of purity in the backbone.
- **Promote access to high purity hydrogen through public grids.**
 - The EU Gas Package puts limits on capacity and network extensions for existing private networks – possibly raising a barrier to accessing high purity hydrogen for consumers not already connected to a private network and unable to purify on-site.
- For setting a robust quality level, though, **we emphasise that a comprehensive mapping of current and future stakeholder needs is an indispensable precondition.**
 - While the overall quality level is clearly important, so are the thresholds for individual contaminants.

Thank you.

Contact:

Nicolai Romanowski
Senior Energy Manager
Cefic
nro@cefic.be



About Cefic

Cefic, the European Chemical Industry Council, founded in 1972, is the voice of large, medium and small chemical companies across Europe, which provide 1.1 million jobs and account for 15% of world chemicals production. Cefic members form one of the most active networks of the business community, complemented by partnerships with industry associations representing various sectors in the value chain. A full list of our members is available on the Cefic website. Cefic is an active member of the International Council of Chemical Associations (ICCA), which represents chemical manufacturers and producers all over the world and seeks to strengthen existing cooperation with global organisations such as UNEP and the OECD to improve chemicals management worldwide



H2 quality in dedicated infrastructure & standardisation

- ENNOH Workshop on H2 quality | 12.02.2026

Grzegorz Pawelec



- An important caveat to start with:

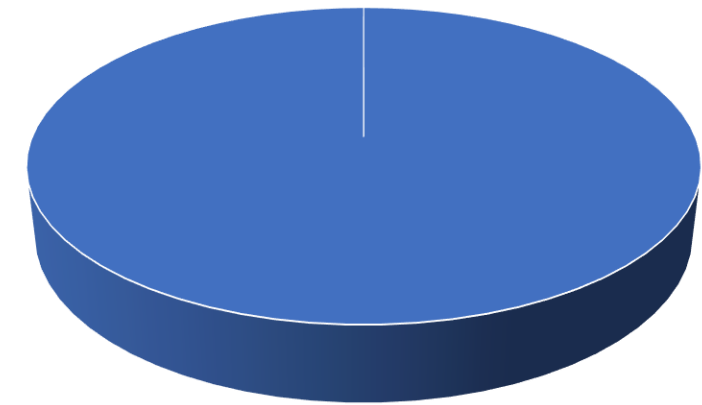
There is no approved
Hydrogen Europe position
yet on the topic of H₂ quality
in dedicated infrastructure &
standardisation

- There are strong arguments in favour of a 99.5% standard

Main arguments:

- Lowering costs for industrial offtakers
- Lower system costs in general
- Suitable for most uses (depending on what the other 0.5% is)
- Ensuring wide access to the H2 grid from a wide variety of users – including small scale consumers which could be locked out of the market otherwise

Results of a survey among members (Industrial Demand Working Group)



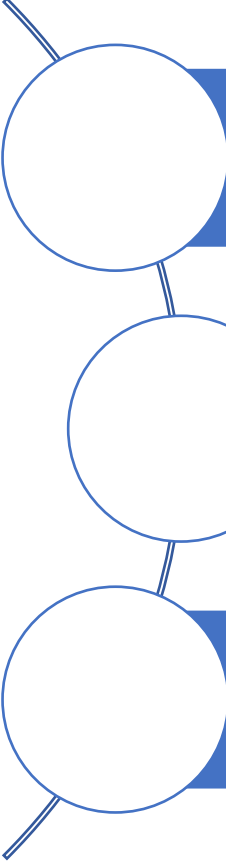
■ 99,50% ■ 98%

- More work is needed however...

Main reservations:

- Modelled costs mostly based on literature review and not nuanced well enough
- It is not only about costs but also feasibility
- Might limit the potential to repurpose existing infrastructure
- Could potentially exclude repurposed gas storage from the market ... storage is absolutely crucial
- Important differences between MS

- **Potential solutions for breaking the deadlock**
- Ideas to be discussed (not recommendations!)

A diagram consisting of three white circles arranged vertically, connected by thin blue lines. Each circle is partially overlapped by a blue rectangular box containing text.

Allowing MS to implement a standard that works for them with a pan-EU standard only enforced at interconnection points

Start with a lower (>98%) standard with a clear timeline of getting to a high purity one (>99.5%) within X years

Adopt a 99.5% standard with a derogation for underground storage sites allowing them H₂ injection with a lower purity – i.e. pushing purification downstream

Thank You



Avenue Marnix 23
1000, Brussels / Belgium

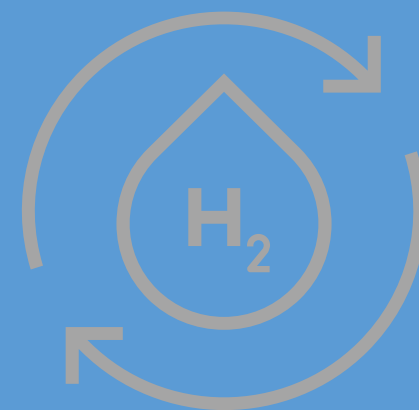
secretariat@hydrogeneurope.eu
hydrogeneurope.eu



Technical considerations, 1st measurement experience on repurposed infrastructure for an evidence-based approach

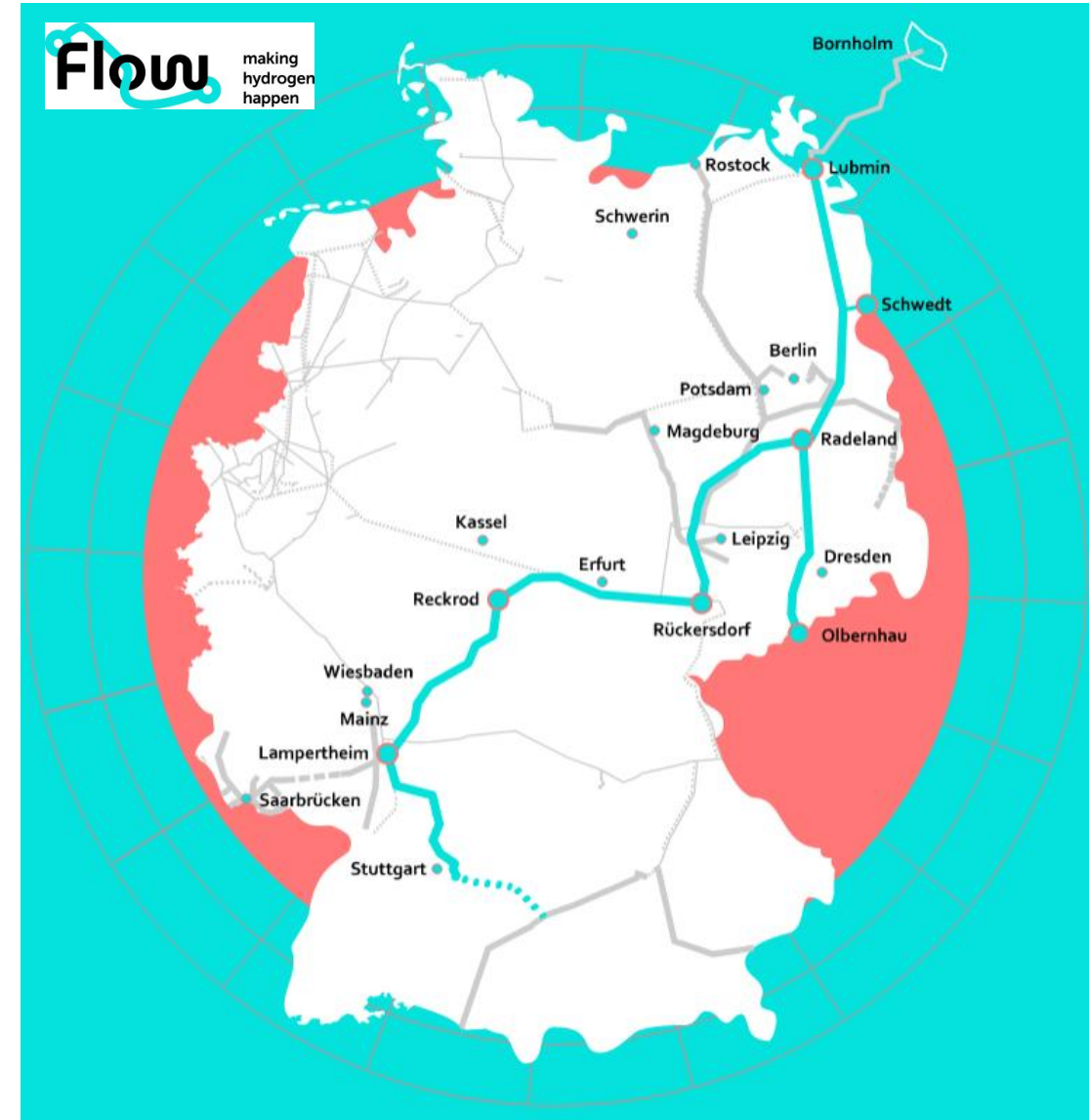
H₂ Quality in dedicated infrastructure & standardisation

ENNOH H₂ Quality Stakeholder Workshop
on 12th February 2026



FLOW – MAKING HYDROGEN HAPPEN

- transport of large volumes of hydrogen from the Baltic Sea coast through Germany
- use of existing infrastructure and interconnection with other H₂ projects
- planned connections to several EU Member States
- associated partners along the hydrogen value chain projekt from program partners GASCADE, ONTRAS und terranets bw



Quality monitoring of the project

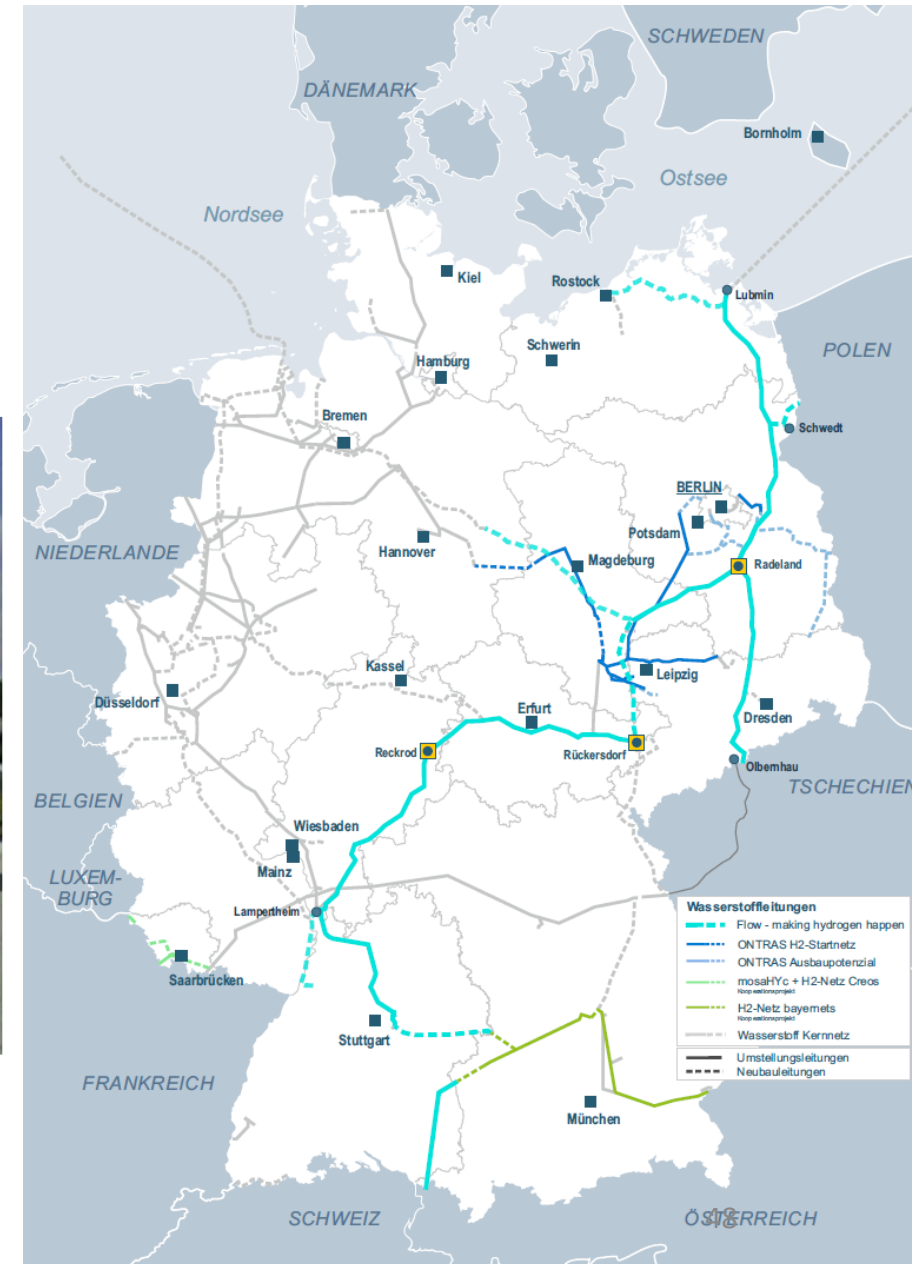
- 2024 examination of contaminants in Gas pipeline on object scale
- considerations on impurity-impact on material & components
- 2025 initial filling of first parts with industrially produced hydrogen by trailer supply
- Input Certificate by supplier monitored



Produkt/Produktspezifikation:
Product/ Product Specification:

GH2 für Brennstoffzellen gemäß DIN EN 17124:2019 und ISO14687:2019 TYP I Grad D
GH2 Fuel cell grade according to DIN EN 17124:2019 and ISO14687:2019 type I grade D

- Measurement campaign at the filling with independent laboratory



Approach to the hydrogen purity discourse

- 2023/24 internal assessment of existing published studies and campaigns EU-wide (limits, validation gaps)

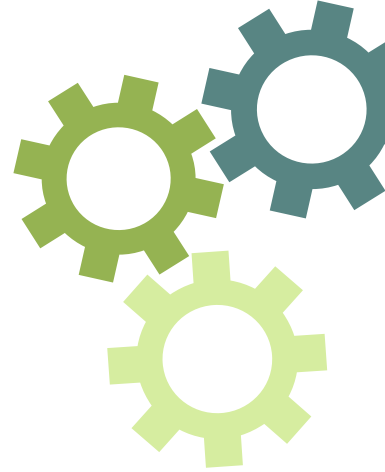
GASCADE

→ maintains neutrality in hydrogen purity discourse
→ focus on validated facts → **PUT INFORMATION FIRST**

- 2024 co-initiated and directly financed studies in cooperation with partners
- 2026 start estimation **measurement campaign** on own infrastructure – ongoing
 - with own designed and tailor-made equipment **Measuring Trailer** (MeterQ MGCmobile+)



- 1. **validation** of the measurement equipment
- 2. validation of the infrastructure



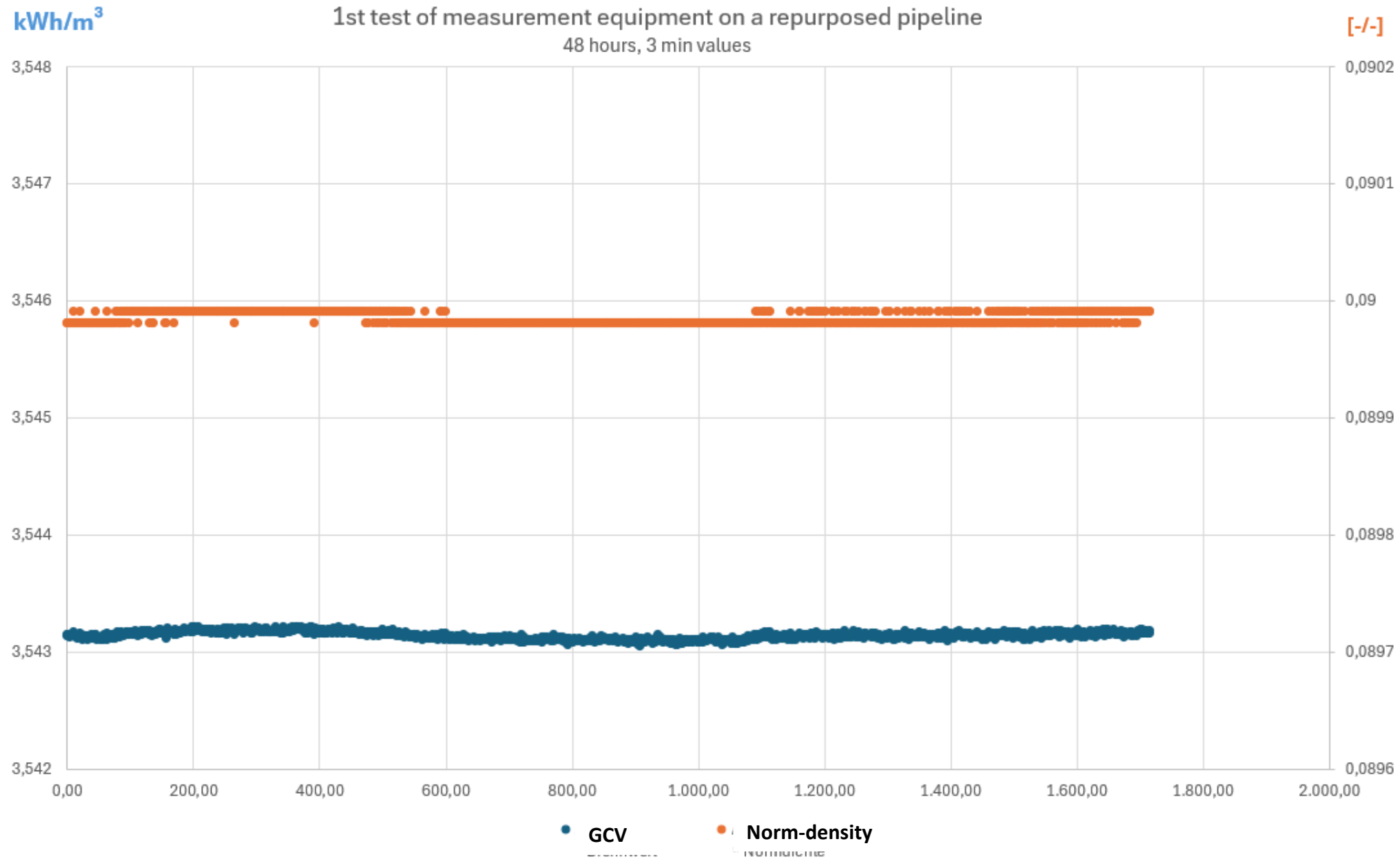
Measurement campaign - technical challenges

- Admission of the device/chromatograph not yet in Germany, verified by Dutch campaign
- German DVGW Info 33 (published after commissioning), proposed 3 different calibration gases and one test gas, were/are not available yet
- **GCV and density 1st measurement data** stable, although environment situation and condition not in operation phase
- validation ongoing for the measurement device
 - traceability remains today open issue
 - test/validation against existing equipment intended



Measurement campaign

GCV and density 1st measurement data

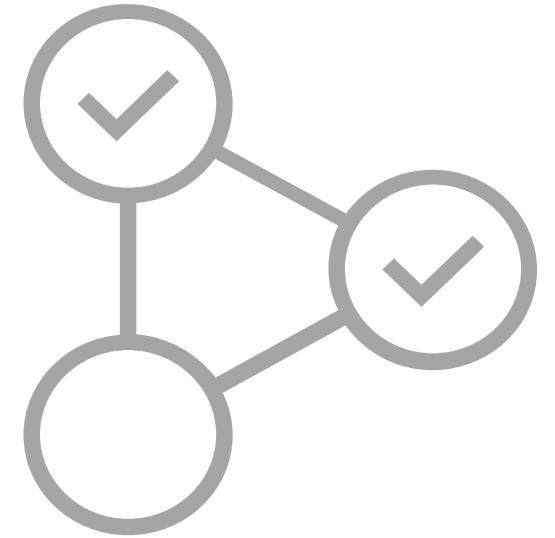


Path Forward

- Need for harmonized H₂ quality standards to facilitate save and reliable Cross-border transport
- Collaborative research
- outcomes from ongoing studies e.g. EASEE-gas study, DVGW- H2-Optimum and measurement campaigns

Conclusion

- **differentiate between correlation and causality**
- Neutrality in the purity discourse until robust data is available
- multi-million € decisions on validated evidence
- commitment to validated measurements



Infrastructure applicable to standards ↔ in emerging markets standards applicable to Infrastructure

GASCADE



WIR VERSORGEN DEUTSCHLAND.
UND VERBINDEN EUROPA.

Markus Hössel, M. Eng.

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MAIL: markus.hoessel@gascade.de

post:: GASCADE Gastransport GmbH,
Kölnische Str.108 - 112, 34119 Kassel

Panel Discussion

What to do about it?

1) Cooperation and coordination:

- between economic operators, network operators, regulators and legislators at both – the national and EU level

yes/ no/ how?

2) Regulation:

- splitting or no-splitting of hydrogen quality responsibilities at a regional/ national level by regulators (centralised/ decentralised purification)
- purification cost sharing at system level (production – pipelines – storages) – at national/ regional level

yes/ no/ how?

3) Standardisation:

- real-life data collection and knowledge sharing beyond regulation
- specific measures to ensure active involvement of all stakeholder groups along the supply and demand chain – at all stages of standardisation

yes/ no/ how?

- gradual increase of quality over time in the standard?

yes/ no/ how?

- specific boundaries/ additional specifications (entry and exit points/ pipelines and storages/ pipeline networks and storages)

yes/ no/ how?

Join at
slido.com
#1226 085



 Passcode: **hydrogenforgood**



Lunch break

We will be back at 13:00



Optimum Hydrogen Purity in Europe

Michael Sostmann – Chair of EASEE-gas Board of Directors

Peter van Wesenbeeck – Chair of EASEE-gas Gas Quality Harmonization Working Group

ENNOH Hydrogen Quality Workshop – 12 February 2026



Introduction

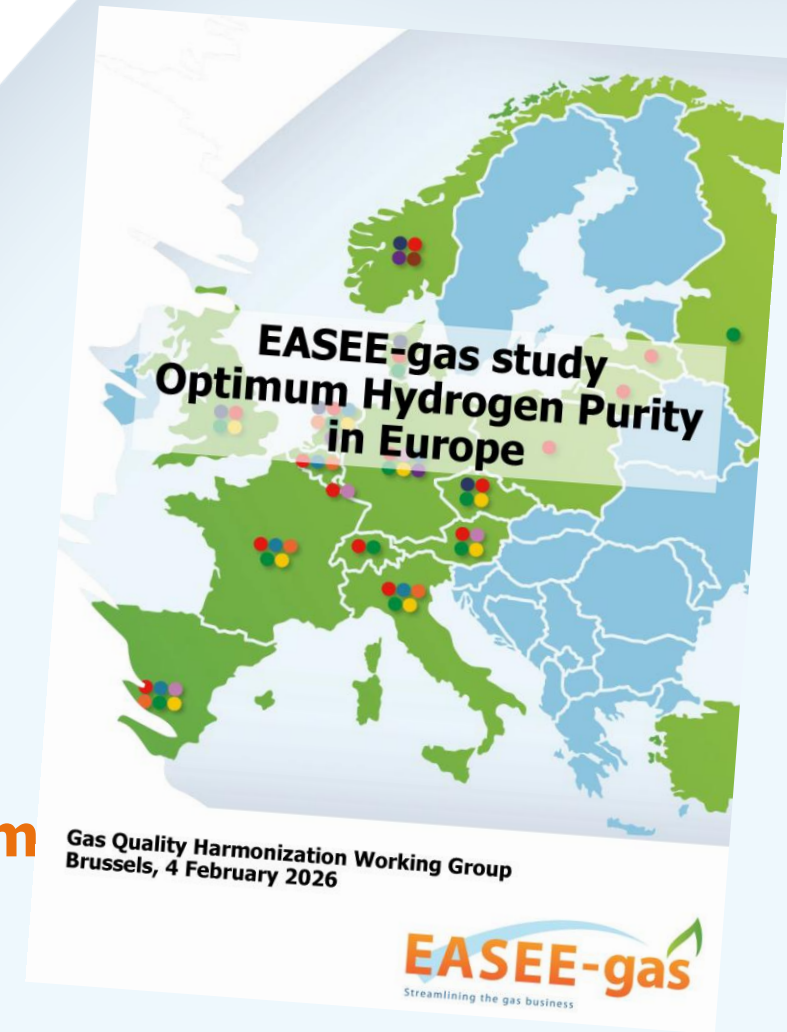
EASEE-gas

- A short **overview** of the organisation

Study “Optimum Hydrogen Purity in Europe”

- The **Background** of this study
- **Methodology** and **scope** of the study
- Entry- and exit **scenarios** and hydrogen **purity requirements**
- **Overview** of the model including examples
- **Results**
- Overview of the main **limitations** of the study
- **Conclusions & Recommendations**

Future activities of the Gas Quality Harmonization Working Group



Streamlining the gas business

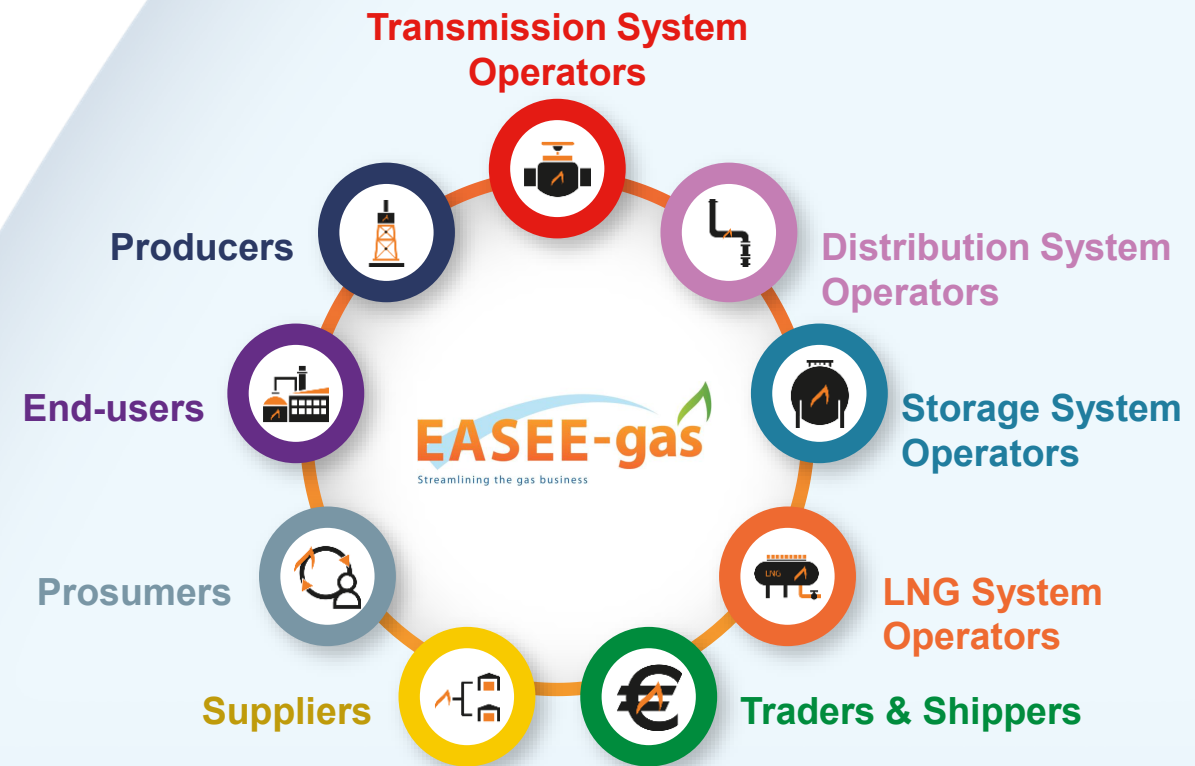
EASEE-gas enables a **sustainable** and **optimal** functioning of the energy value chain

EASEE-gas delivers **efficient and harmonized solutions** that reinforce business processes within and across the **gas value chains in Europe**

- Edig@s
- Gas Role Model
- Security Certificates
- Common Business Practices (CBP's)

Three working groups

- Technology Standards
- Message & Workflow Design
- Gas Quality Harmonisation



Study “Optimum Hydrogen Purity in Europe”

Background

Need for a harmonised European hydrogen specification

- **Harmonization is key** for security of supply, market integration, and competition and to develop an integrated European hydrogen network
- Variability in production, storage, and end-user specs drives **differing purity requirements** and cost impacts

Objectives

- Determining the hydrogen purity level that **minimizes total system costs** along the **whole value chain** (CAPEX/OPEX)
- Covering the full value chain: production, transport, storage and end use
- Supporting EU-wide standardization and market integration



European Hydrogen Backbone map (© EHB)
(<https://www.h2inframap.eu/#map>)

Study "Optimum Hydrogen Purity in Europe"

Set-up

Methodology used:

- Techno-economic model based on DNV KIWA study carried out in the Netherlands (2023)
- Adapted for the European situation
- Model is **only** focussing on hydrogen purity **not** on the other (trace)components

Scope Expansion:

- Europe wide study: includes all EU member states, cross-border flows
- Storage: considers repurposed natural gas storages (salt caverns, aquifers, depleted fields)

Hydrogen Value Chain consists of

- **Production** - SMR, SMR+CCS, electrolysis, ammonia cracking, imports
- **Transport** - new and repurposed pipelines
- **Storage** - impact of storage type on hydrogen purity (contaminants, withdrawal effects)
- **End use** - industry (feedstock, heat), mobility (fuel cells), power generation, e-fuels



Study "Optimum Hydrogen Purity in Europe"

Input data

Scenarios (TYNDP 2024)

- Demand and supply projections for 2040 and 2050 for the various production and end-use segments
 - **Distributed Energy** - decentralized production, regional self-sufficiency
 - **Global Ambition** - large-scale, cross-border hydrogen trade

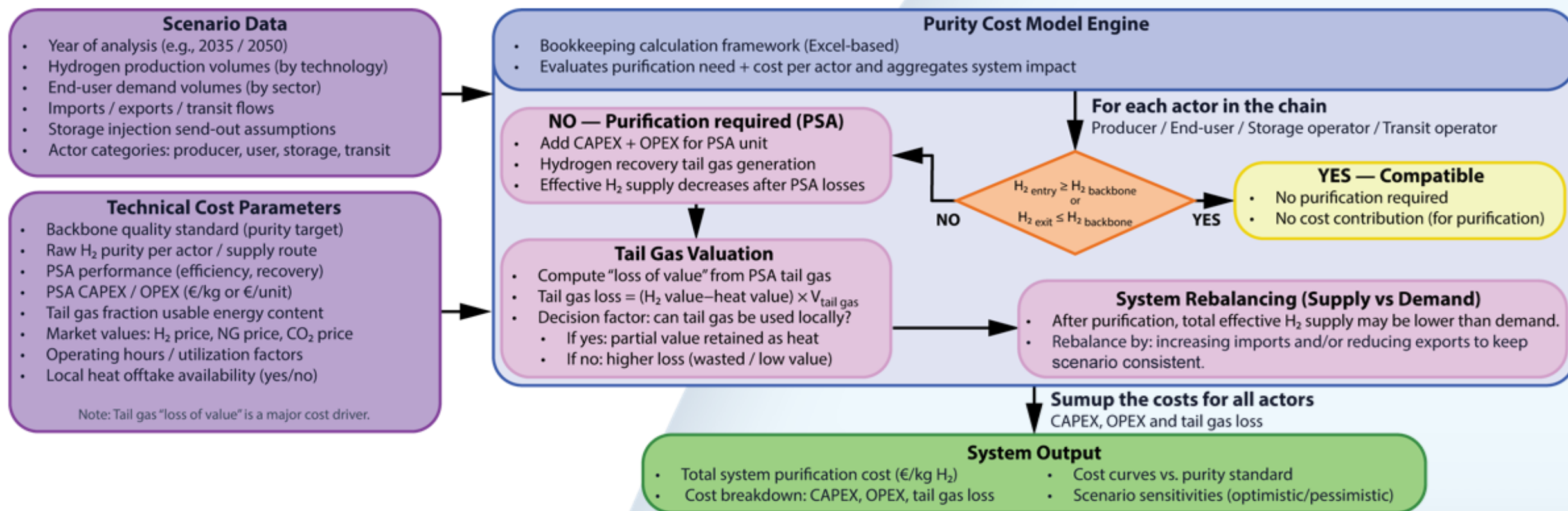
Hydrogen purity requirements (mol% H₂)

- **E-fuels** - (TYNDP 2024 assumes netto-zero in 2050): 99.5 – 99.9
- **Heating & power plants** - usually 98
- **Industrial feedstock** - usually 98 – 99.5
- **Mobility** (fuel cells) - 99.97+
- **Storage withdrawal** - usually 98 (repurposed) / 99.5 (newly built)
- **Pipeline system** - 99.5 (repurposed) / 99.97+ (newly built)



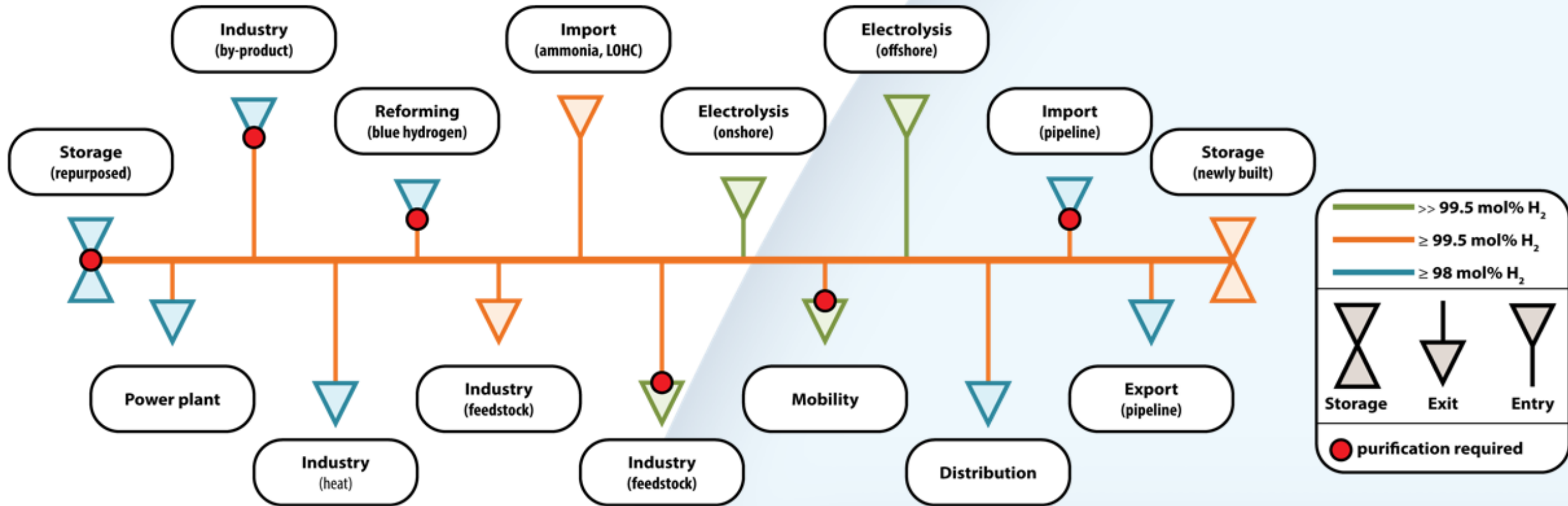
Study "Optimum Hydrogen Purity in Europe"

Overview of hydrogen purity cost model



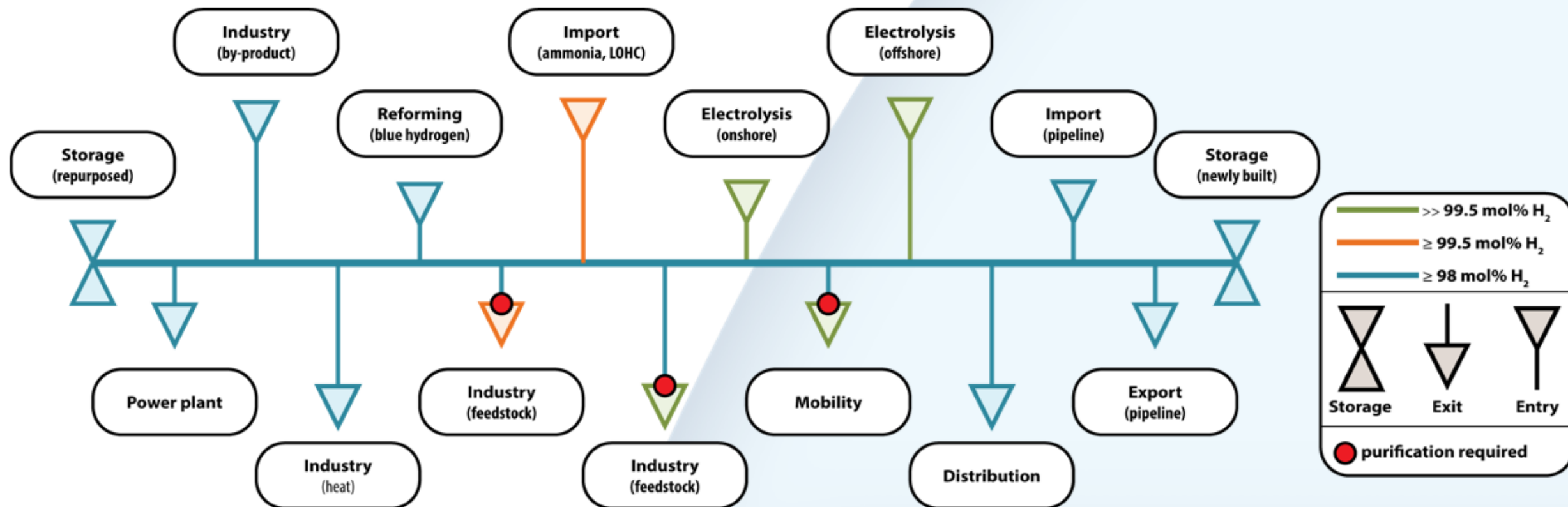
Study "Optimum Hydrogen Purity in Europe"

Situation based on a high purity hydrogen backbone

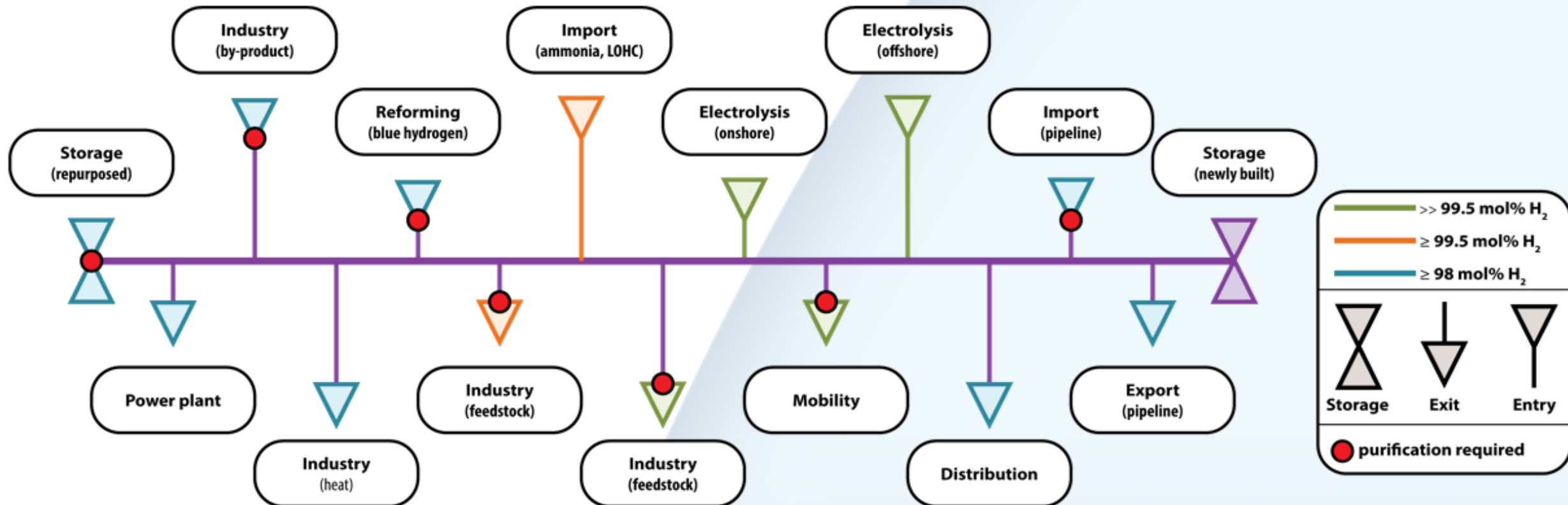


Study “Optimum Hydrogen Purity in Europe”

Situation based on a low purity hydrogen backbone



Study “Optimum Hydrogen Purity in Europe” Situation be on a mid purity hydrogen backbone



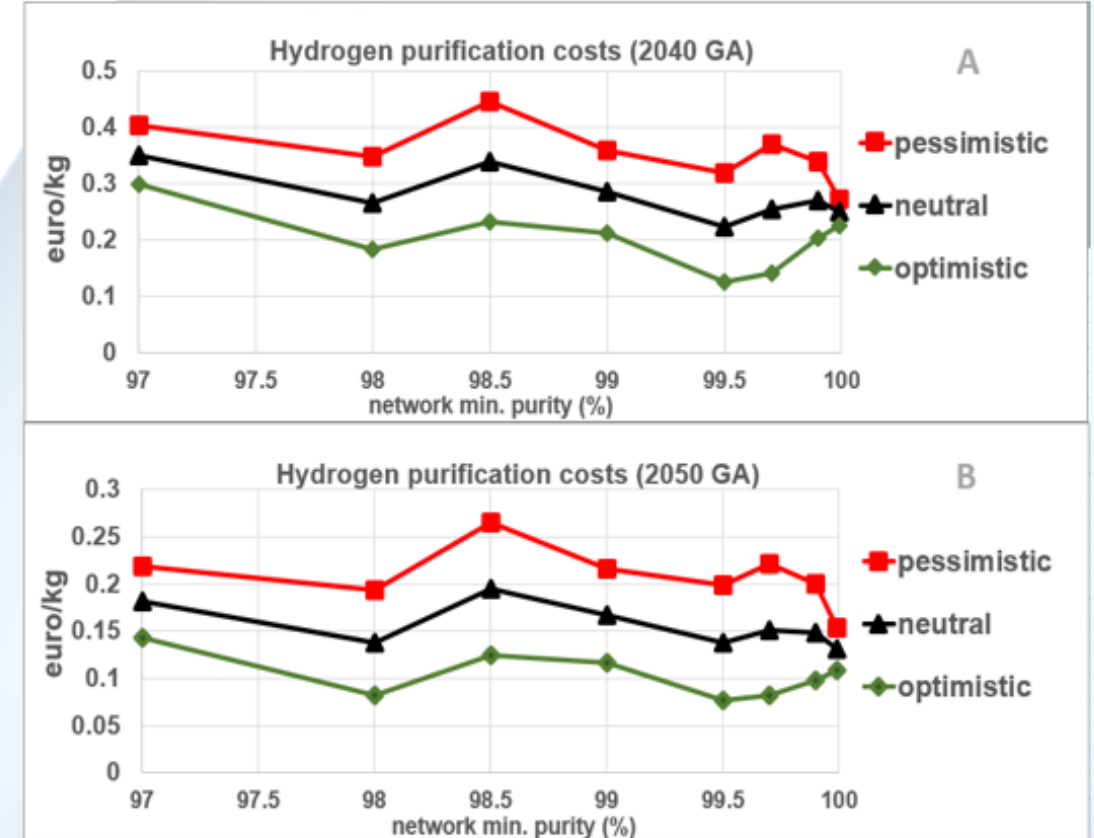
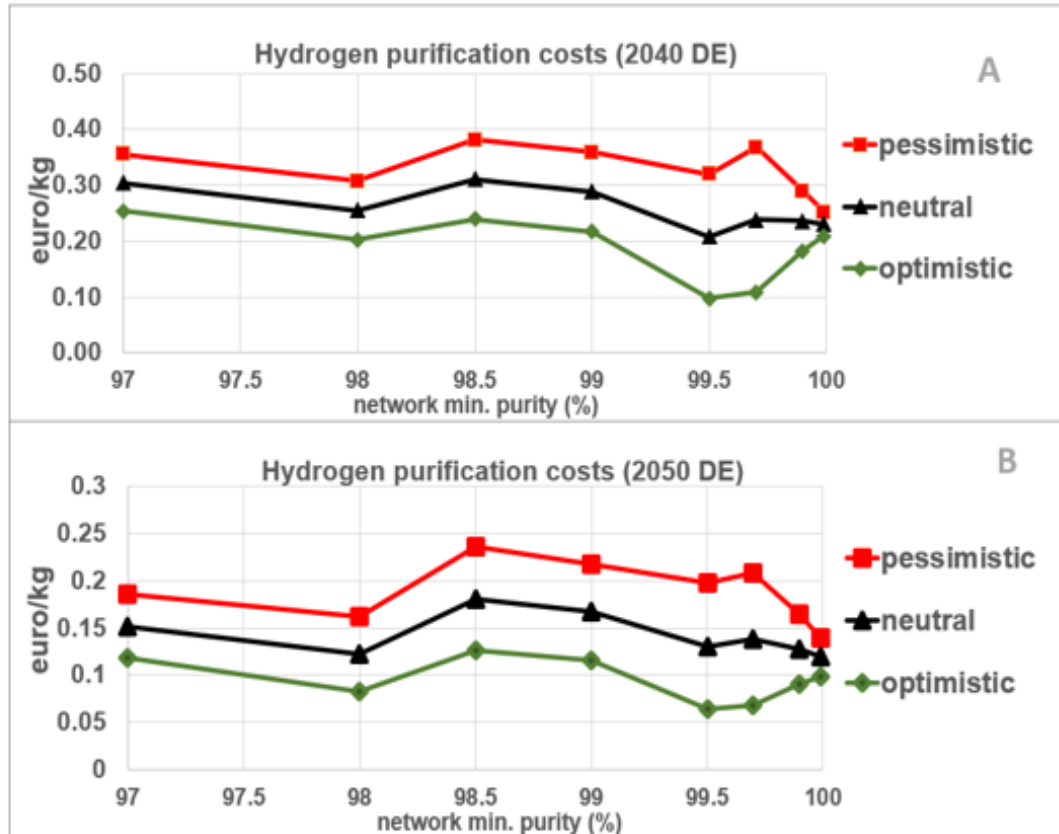
Study “Optimum Hydrogen Purity in Europe”

Calculation results

Cluster	Optimistic Bias	Pessimistic Bias
End-users	Lower purity needs (e-fuels 99.5%); higher tail-gas <u>utilisation</u>	Higher purity needs (e-fuels 99.9%); low tail-gas utilization
Storage	Send-out 99.5–99.7%; 50% tail-gas use	Send-out ~98%; 10% tail-gas use
PSA	Higher recovery (≤ 0.97), lower tail-gas	Lower recovery (0.85–0.88), high tail-gas
Producers	High purity (electrolysis 99.99%)	Lower purity (ATR/SMR 95–97%)

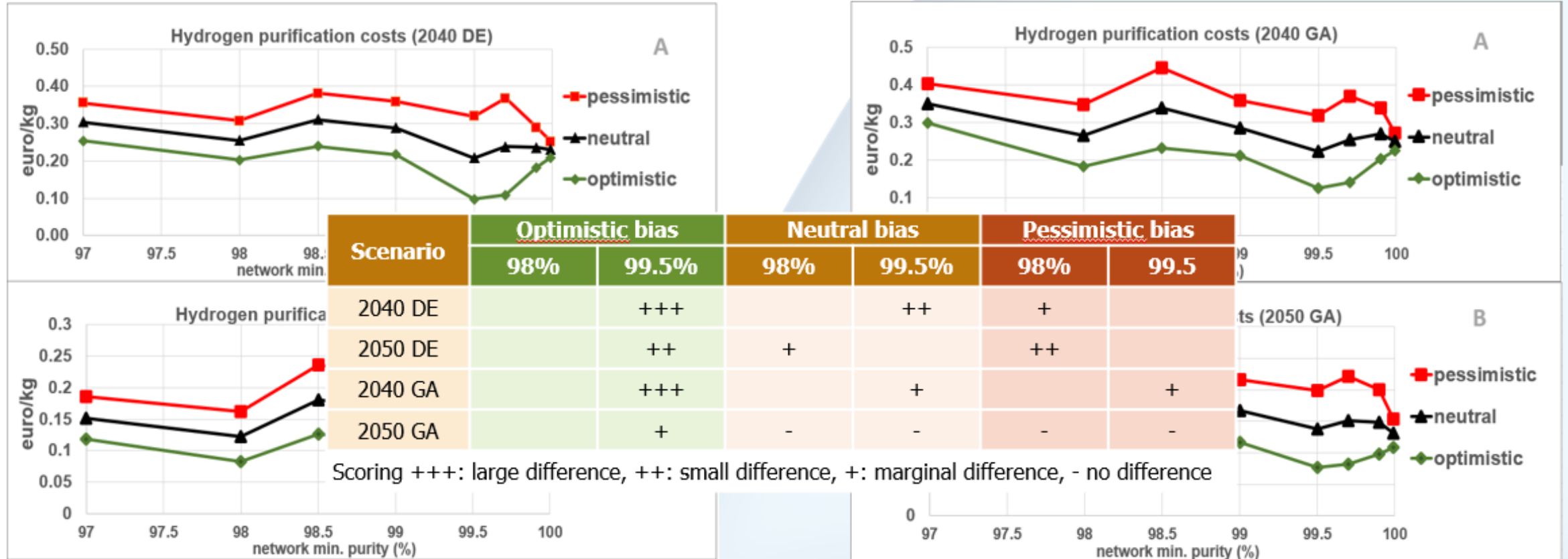
Study "Optimum Hydrogen Purity in Europe"

Calculation results



Study "Optimum Hydrogen Purity in Europe"

Calculation results



Study "Optimum Hydrogen Purity in Europe"

Calculation results – various variants (DE-scenarios)

Scenario	Variant	Optimistic bias		Neutral bias		Pessimistic bias	
		98%	99.5%	98%	99.5%	98%	99.5%
2040 DE	default		+++		++	+	
2050 DE	default		++	+		++	
2040 DE	Double prices		+++		++		+
2050 DE	Double prices		++	+		++	
2040 DE	Extra storage CAPEX				+		
2050 DE	Extra storage CAPEX			+			
2040 DE	2 stage PSA		+++		++	+	
2050 DE	2 stage PSA		++			++	
2040 DE	Alt 1 stage PSA		+++		+	+	
2050 DE	Alt 1 stage PSA		++	+		++	
2040 DE	higher tailgas valorisation storages		+++		++	-	-
2050 DE	higher tailgas valorisation storages		++		+	+	

Scoring +++: large difference, ++: small difference, +: marginal difference, - no difference

Study “Optimum Hydrogen Purity in Europe”

Limitations

Purification

- **Only Pressure Swing Adsorption (PSA)** is considered; alternative technologies (e.g. TSA) are not assessed.
- Study does not address **mandatory removal of corrosive impurities** (e.g. H_2S , H_2O).
- **Simplified cost modelling** may not reflect real-world complexity (CAPEX/OPEX, tail gas handling).
- **Spatial, permitting, and infrastructure constraints** for PSA (specifically at storage sites) are not taken into account.

Scenario Sensitivity

- The **distribution of end-user applications** (quality requirements) **significantly** affect the model's outcomes.



Pressure swing adsorption plant (PSA) (© Linde)

Study “Optimum Hydrogen Purity in Europe”

Key insights

Conclusions

- First EU-wide **cost-benefit analysis** for complete **hydrogen value chain**
- Identified **“Sweet spots”** are 98% or 99.5% **depending** on the **scenario** and **assumptions** used
- Study provides **input** for **future standardization** and **policy development**

Recommendations

- This study has inherent **scope limitations** that warrant **further examination**
- Alongside the overall costs, **technical, infrastructural, end-user and regulatory factors** play also role
- Conduct **complementary studies** on the 98–99.5 mol% purity range:
 - to compare purification options (incl. non-PSA),
 - assess costs and scalability, and
 - align specifications with real-world end-user demand.

Gas Quality Harmonization Working Group Outlook

Current focus is on minimum hydrogen purity:

- Most discussions emphasize **minimum purity levels** (e.g., 98% or 99.5% H₂)
- However, trace contaminants are crucial for safety, equipment protection, and product quality.

Need for a CBP on hydrogen trace components:

- There is **consensus** on **acceptable** trace impurity limits.
- This can support current hydrogen trade and infrastructure development.
- It could be used as an input in a future CEN hydrogen standard.

Which components covered?

- **"Real trace components"** based on **current specifications**
- **Minor components** in the CBP – Inerts & Higher hydrocarbons
- Components **not** covered in the CBP – Hydrogen & Methane



Construction H₂ pipeline (© Gasunie)

Thank you for your attention





- **SSO-view on Hydrogen Quality**
- **EASEE-gas study „Optimum Hydrogen Purity in Europe“**

- *Sebastian Cichowski, RWE Gas Storage West GmbH*
- 12.02.2026

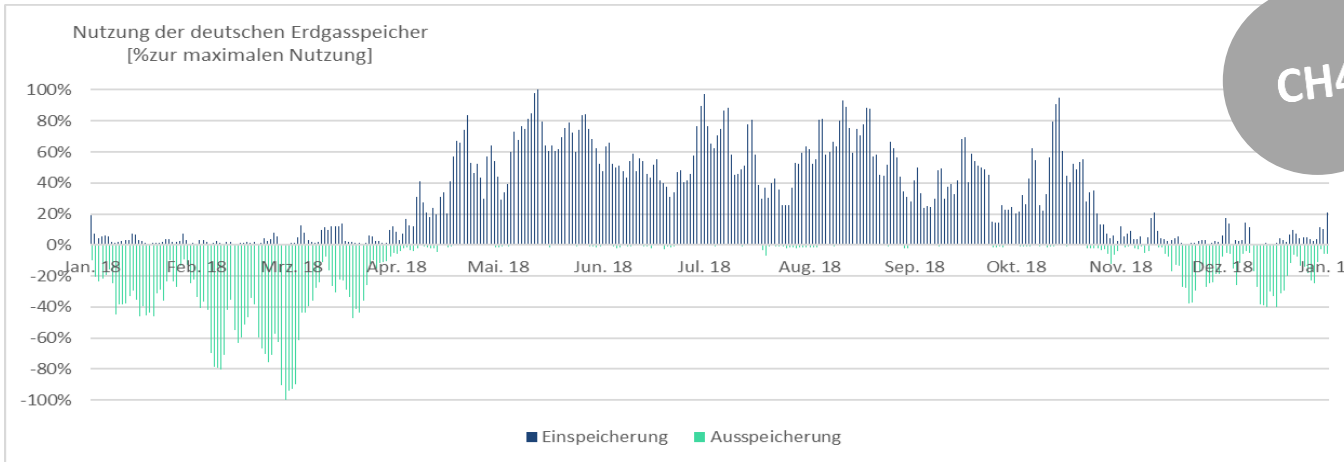
Results

EASEE-gas study „Optimum hydrogen purity in Europe“

- scenario-based calculations
 - direct input from different TYNDP 2024 scenarios (demand/supply)
 - purity-demands have been added based on general knowledge
 - storage-demands taken from Guidehouse-study
 - focus on commercial view
 - restricted view on technical limits
 - optimistic/pessimistic approach
- first European-wide view on the value chain
 - important for upcoming standardisation
 - emphasising the important role of large-scale underground storages
- limitations pointed out by EASEE-gas
 - study integrated in an accompanying document

underground storages relevant for hydrogen infrastructure

structuring the needs of supply and end-users

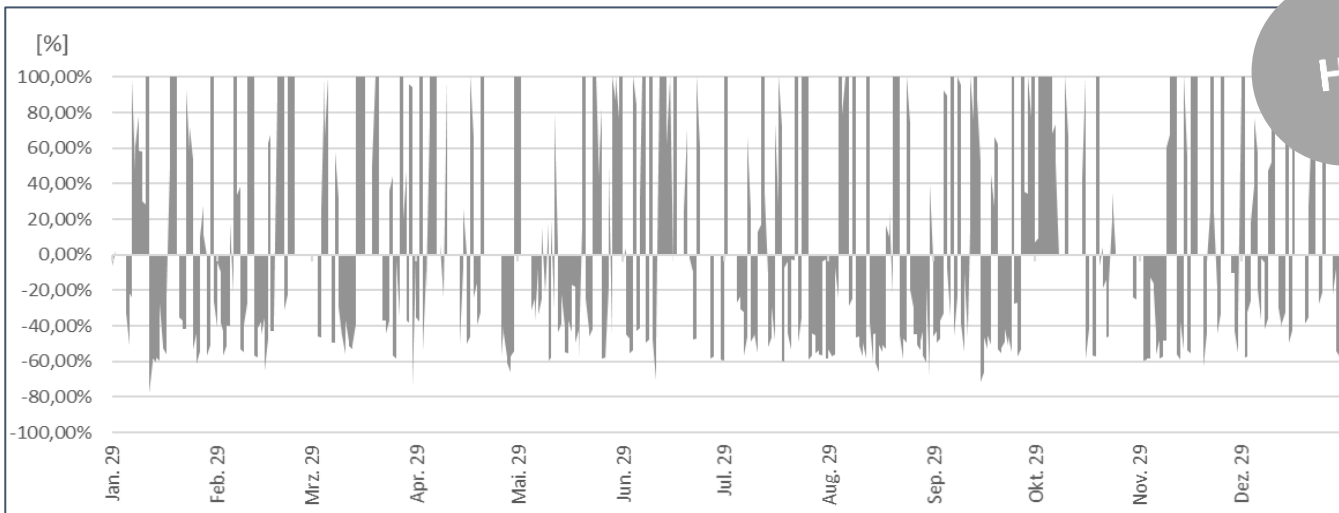


source: GIE; AGSI+; RWE GSW

CH₄

- volatile production
 - based on green supply
- restricted line-pack
- continuous demand
 - industrial offtakers
 - peaks for power-plants

H₂

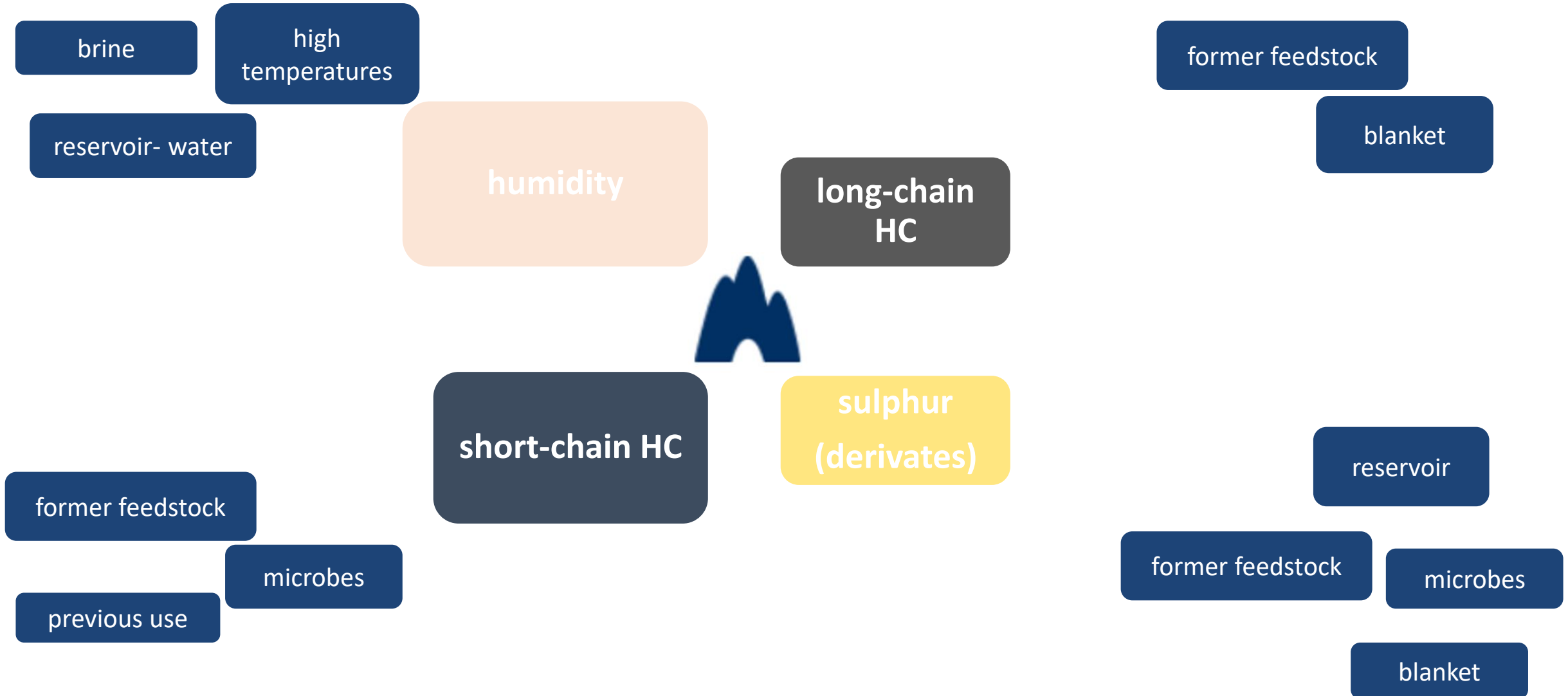


source: GetH2 IPCEI

- high injection/withdrawal-rates
- switching direction on short-notice

contamination of hydrogen

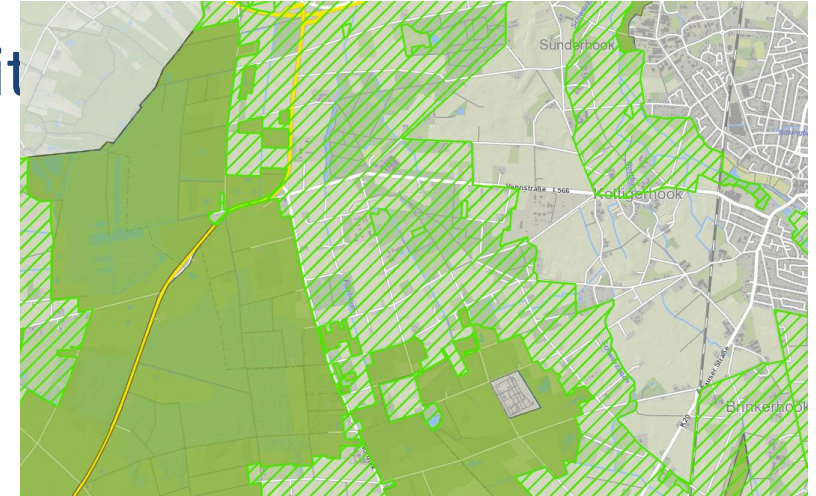
cavern-storages – porous-rock storages – aquifer based storages



focus on PSA-technology

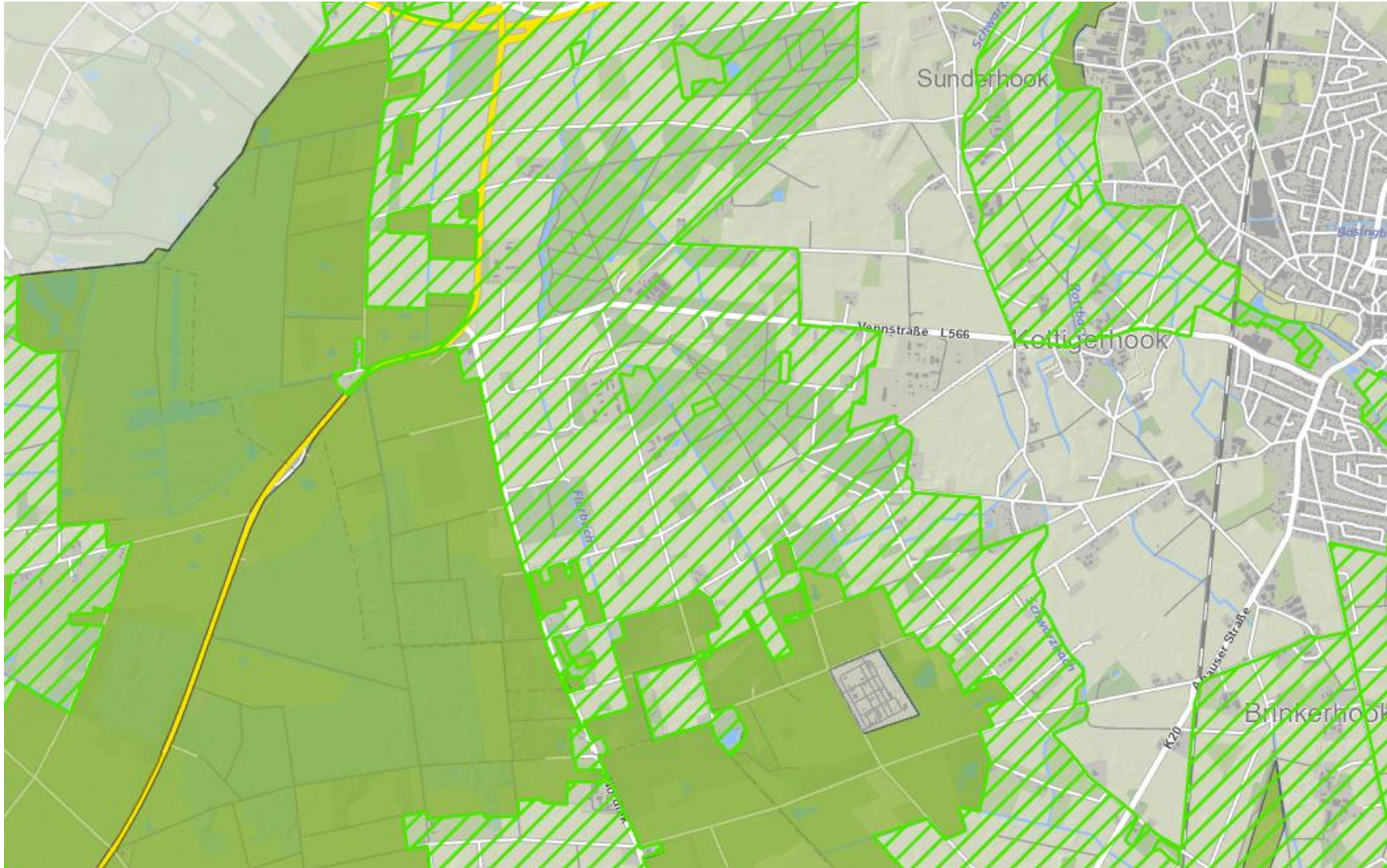
neglecting other purification-methods

- tail-gas without commercial value at storage-sites
 - major share of storage-sites located in rural areas
 - no/low industrial need for fuel-gas
 - often protected-areas next to storage-sites
 - transport to industrial-sites problematic
 - additional pipelines
 - off-spec gas transported in pipelines
- PSA operation leads to noise
 - affecting on protected areas
 - residential neighbours next to storage-sites
- other purification-methods with restriction
 - no effect on short-chain hydrocarbons



focus on PSA-technology

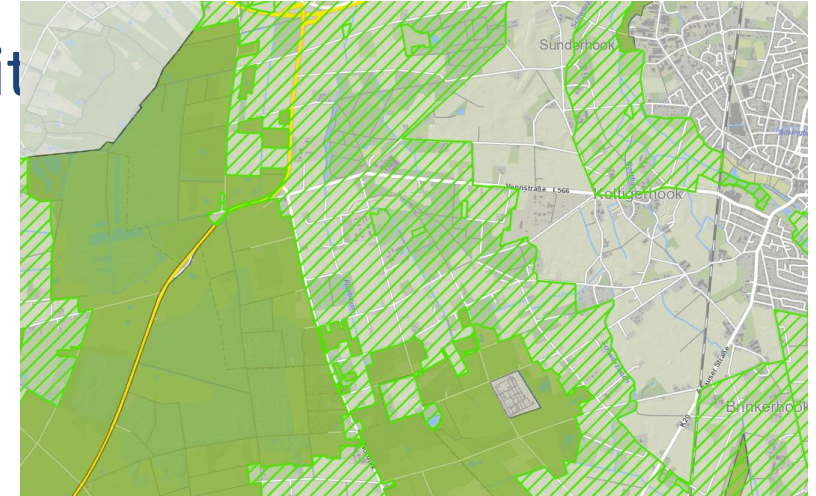
storage-sites located in rural-areas (example)



focus on PSA-technology

neglecting other purification-methods

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focus on PSA-technology

storage-sites located in residential-areas (example)



focus on PSA-technology

neglecting other purification-methods

- tail-gas without commercial value at storage-sites

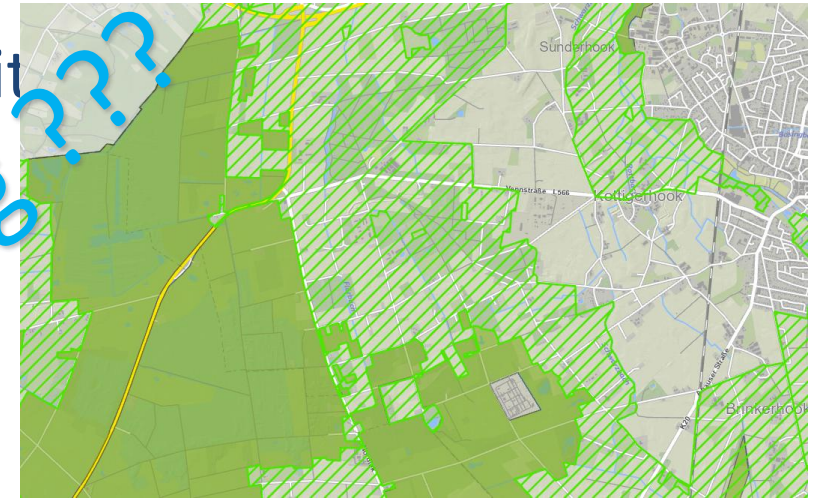
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- PSA operation leads to noise

- affecting on protected areas
- residential neighbours next to storage-sites

- other purification-methods with restriction

- no effect on short-chain hydrocarbons



restrictions partly unconsidered

technical limitations and availability

- high-purity restrains existing storages
 - transformation of storages relevant for the scale-up
 - „new“ storages have long development period
 - limited availability of new (cavern) sites
- existing storages restricted to existing terrain
 - attached to certain places due to geology
 - complex overground facilities for hydrogen-purification
- focus on hydrogen-content
 - no differentiation of trace-components
 - effect of different traces on infrastructure/offtakers unconsidered



98% vs. 99,5%

restrictions partly unconsidered

restricted land-use



Outlook

further investigations and standardisation

- focus on trace-components
 - effects on offtakers
 - effects on infrastructure
 - technical restrictions
- creating technical-standards on short-notice
 - incorporating all parts of the value-chain
 - important base for the ramp-up of the H2-infrastructure
- consider limitations
 - theoretical-approach → real-world

~~98% vs. 99,5%~~
H₂O, H₂S, N₂, CO₂, CO...





Thank you!

RWE Gas Storage West GmbH
Sebastian Cichowski
Head of UGS Epe-L
s.cichowski@rwe.com



EUROPEAN INDUSTRIAL
GASES ASSOCIATION

INDUSTRIAL HYDROGEN PURIFICATION TECHNOLOGIES & H₂-USEABILITY

Presented by:
Wolfgang Ott

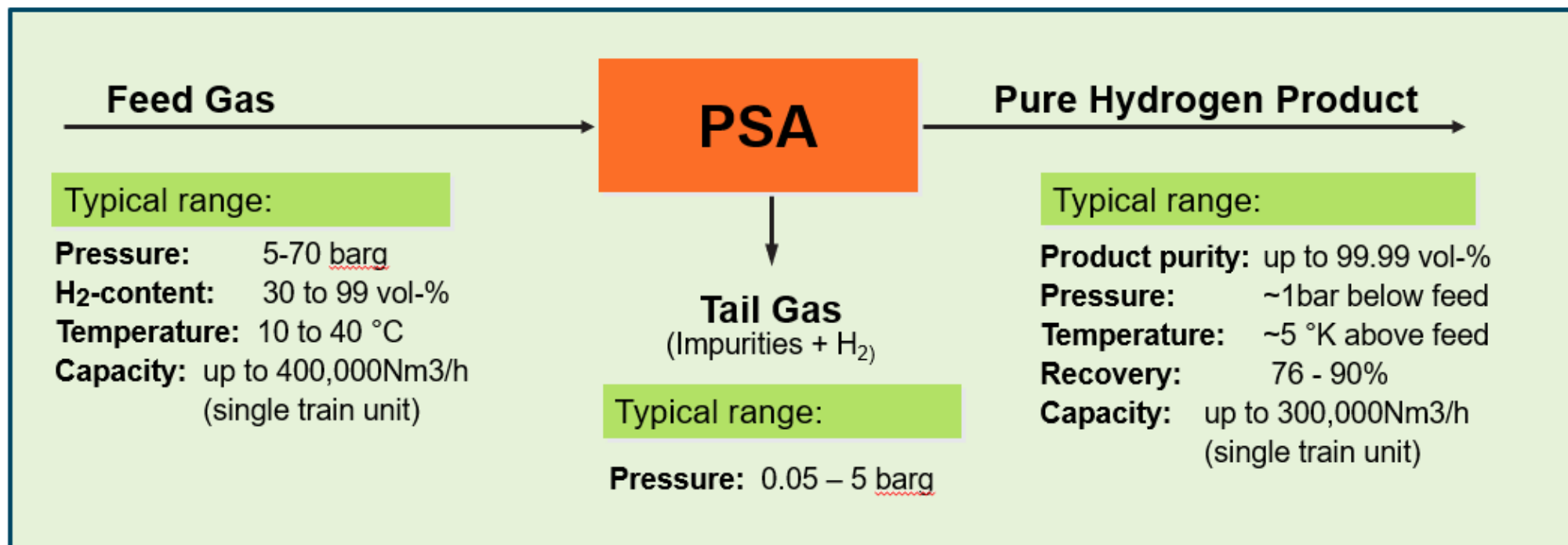
21/03/2022



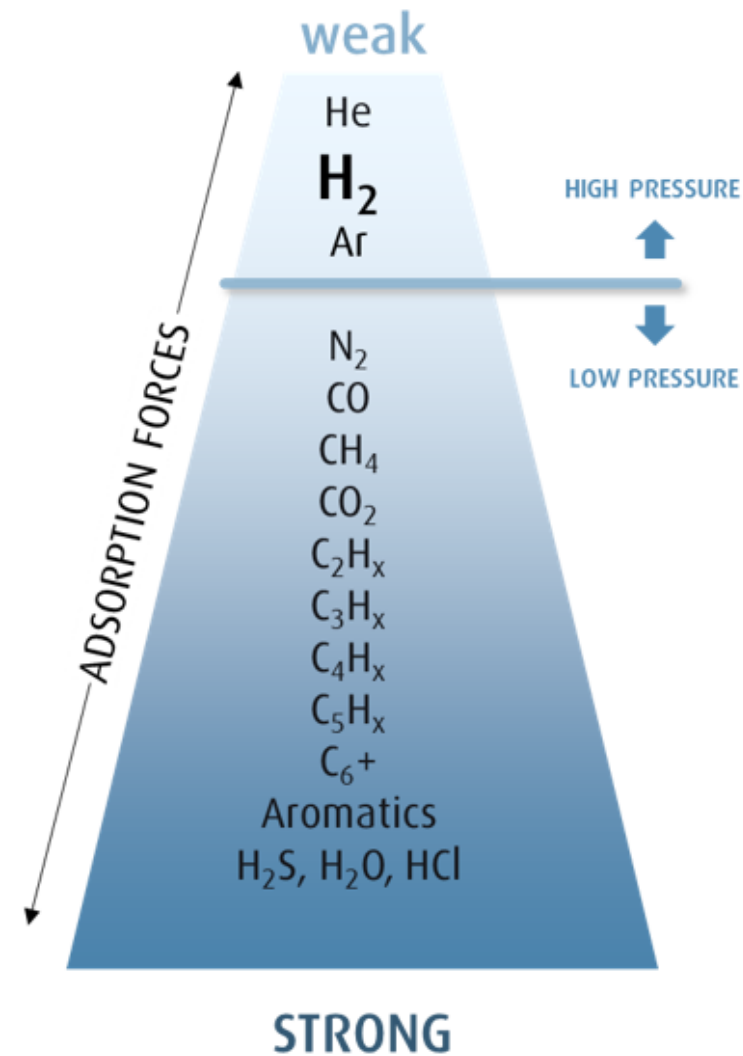
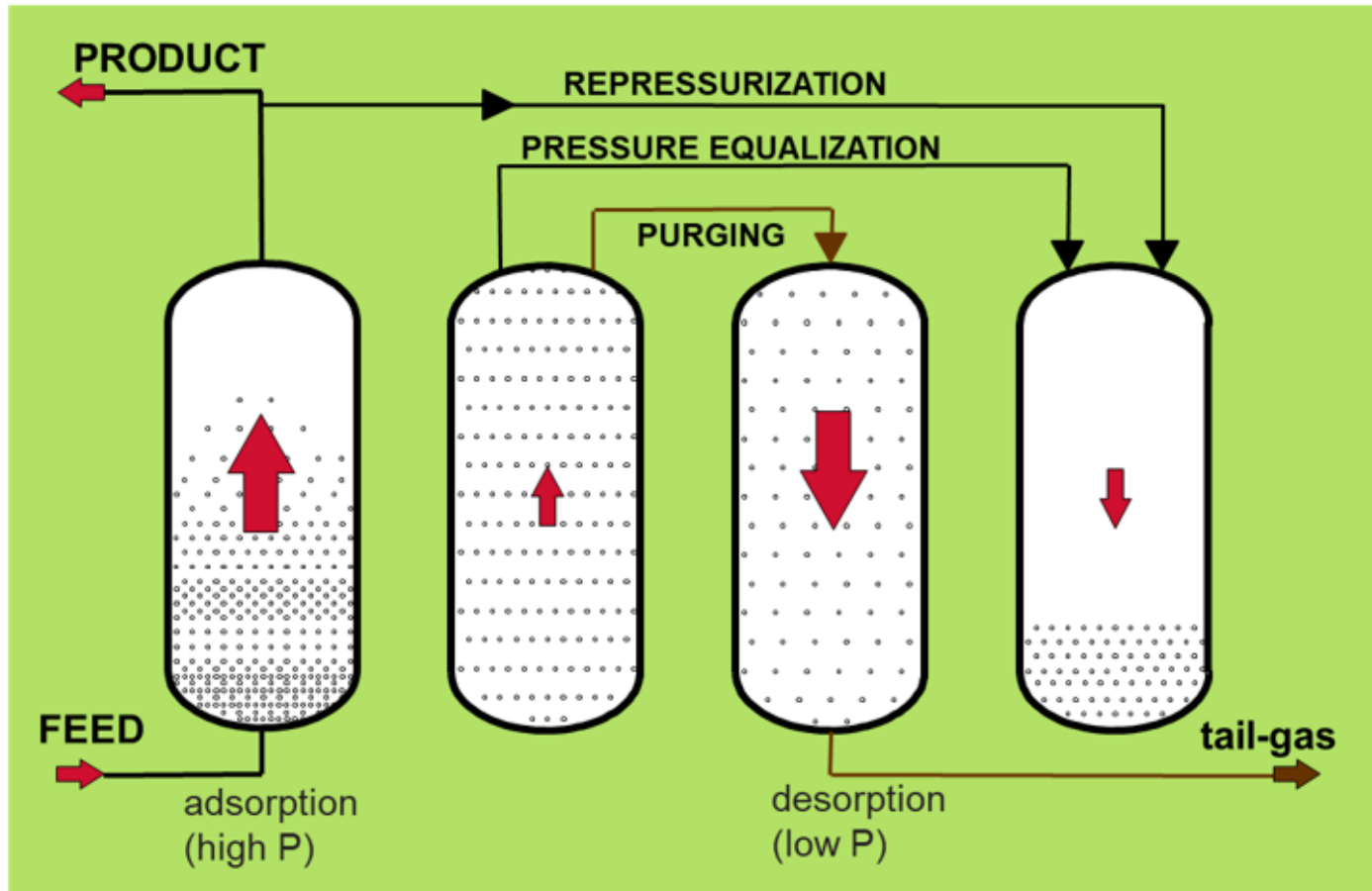
- 1. Pressure Swing Adsorption (PSA)**
- 2. Membrane Units**
- 3. Temperature Swing Adsorption (TSA, dryer unit)**
- 4. Ultrapurifier (Cryogenic Adsorption, Vppb level)**

1. PSA (Pressure Swing Adsorption)

- Multiple adsorbent filled pressure vessels in cyclic pressure operation
- Adsorption of impurities at high pressure and typically 30-40°C
- H₂ recovery depends various factors, e.g. system pressures, no. of vessels, sequence steps, impurity levels, etc.
- Impurities desorb at low pressure, typically as low as 0.3 bara
- Desorption in vacuum is in principle the same process but called VPSA (vacuum PSA)



1. PSA



1. PSA (Pressure Swing Adsorption)

Valve Skid

Adsorber
Vessels

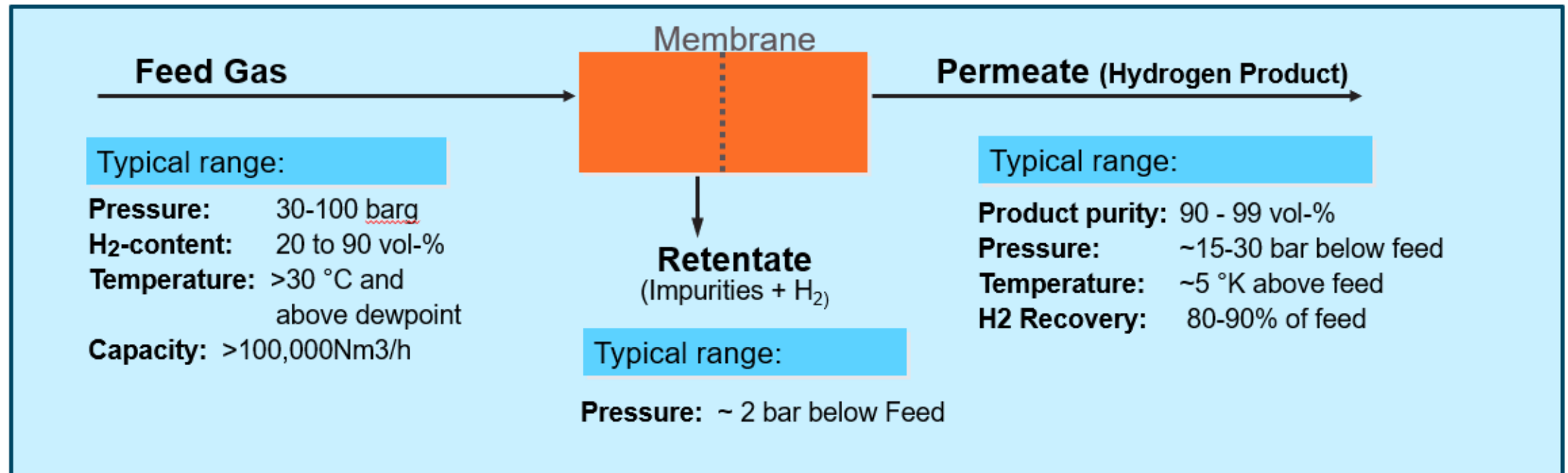
Tail Gas Buffer



Source: LINDE

2. Membrane Units

- Semi-permeable membrane materials used to separate gas molecules ("gas permeation")
- Only in the gas phase; liquid phase (water) disturbs the gas permeation
→ upstream demister to remove droplets and preheater to ensure operation above dew point
- Membrane materials usually sensitive to solvents (e.g. alcohols, ethers, hydrocarbons etc.)
→ requires pre-purification e.g. water washed demister
- Selectivity and purity are usually less compared to H₂ PSA
→ typically used to "enrich" H₂ (or enrich impurities like CO in the retentate), rather than producing high purity
- High temperature syngas membranes are a special/different technology with limited proven large-scale applications



2. Membrane Units



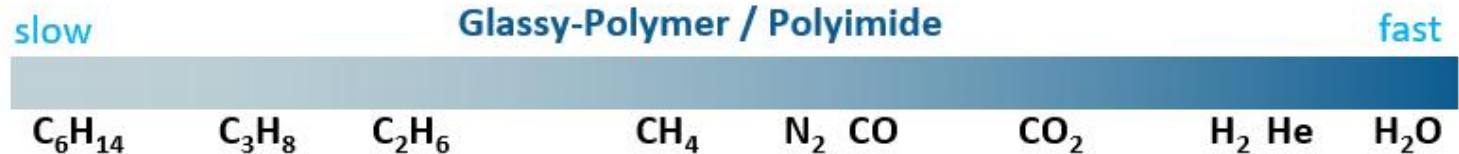
Feed demister
with wash section
(optional)

Membrane modules.
Banks of modules
can be arranged in
multiple stages

Water wash
circulation pumps
(optional)

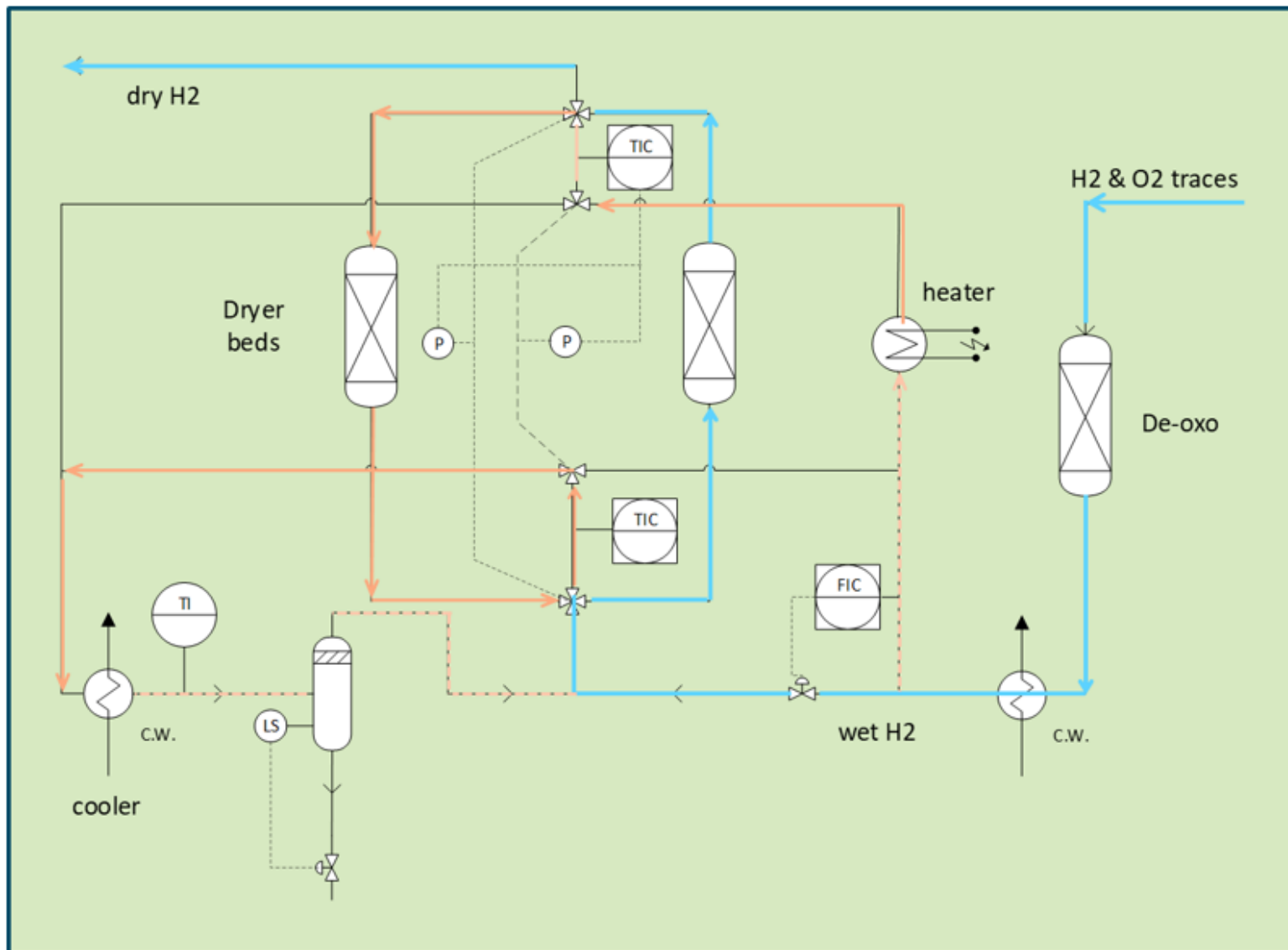
Source: LINDE

Typical permeation behaviour:



3. TSA - dryer unit (with optional catalytic recombiner)

- If only drying (removal of water) is required for H₂ purification, then a TSA (Temperature Swing Adsorption) is used for drying.
- Water is adsorbed at lower temperatures and higher pressure. Desorption (regeneration) is done with same feedgas but at low pressure and elevated temperatures
- When oxygen traces in hydrogen are the main impurity, then a catalytic recombiner (de-oxo reactor) will remove the oxygen by forming water (H₂O). The formed water is removed in the downstream dryer (TSA) station.
- Potential other impurities may require additional cleaning steps upstream the dryer (e.g. dichlorination, hydrocarbon removal, etc.)



H2 Useability per Industry/Sector

FORECAST Hydrogen Demand 2045 ^{a), b)}					Useability per Quality ^{c), d), e)}		
Sector	use	unit	demand	% of total	H2 Quality DVGW G260		
		total	514		Group A ≥ 98%	Group D ≥ 99.97%	Medium ≥ 99%
Buildings	energetic	TWh	78	15%	(✓)	✓	(✓)
Energy	energetic	TWh	128	25%	(✓ *1)	✓	(✓ *1)
Traffic	mobility	TWh	59	11%	(✓ *2)	✓	(✓ *2)
PtX	catalytic	TWh	58	11%	x	✓ *2)	(✓ *2)
Industry		total	191	37%			
* Construction (stone&soil)	energetic	TWh	11	2%	✓	✓	✓
* others	energetic	TWh	14	3%		✓	✓
* Paper	energetic	TWh	2	0%	✓	✓	✓
* Non ferrous metals	energetic	TWh	4	1%	✓	✓	✓
* Glas & Ceramic	energetic	TWh	2	0%	(✓ *1)	✓	(✓ *1)
* Iron & Steel	material	TWh	43	8%	(✓ *2)	✓	(✓ *2)
* Iron & Steel	energetic	TWh	32	6%	✓	✓	✓
* Petro-/Chemical	catalytic	TWh	59	11%	x	✓ *2)	x *2)
* Petro-/Chemical	energetic	TWh	24	5%	(✓ *1)	✓	(✓ *1)
H2 demand high purity (>99.97%)				23%			

Note:
brackets () indicate that suitability depends on type of use or specific contaminant / trace component

*1) dependent on stability of Wobbe Index over time

*2) Dependent on the composition of trace components

Sources:

a) Source: Adapted based on DBI GUT & Frontier (2022)2. Low- and high-quality specifications referring to DVGW G260, Group A & D.

b) Frontier Economics, based on Statista (2022). Future Gas (2022) and data attachment (Results) of dena study assessor report (EWI Cologne, 2021)

c) DVGW study 06-2022: symbols in brackets indicate that in such case a dependency exists between type of impurity/component in the hydrogen and the user application

d) Study on hydrogen quality in dedicated infrastructure and standardization, Final Report, 31-03-2025 for European Commission

e) based on c), d) adjusted as per experiences from industrial gases industry (EIGA)



EUROPEAN INDUSTRIAL
GASES ASSOCIATION

THANK YOU!





Knowledge grows

Hydrogen specification for Ammonia Synthesis

Geir Thorson Solvi,

Yara International ASA



Yara at a glance

- Founded in **1905** to extract nitrogen from air using hydropower
- Today Europe's **leading** fertilizers & industrial nitrogen company
- ~**7%** of the total H₂ production in EU (>20% of the ammonia production)

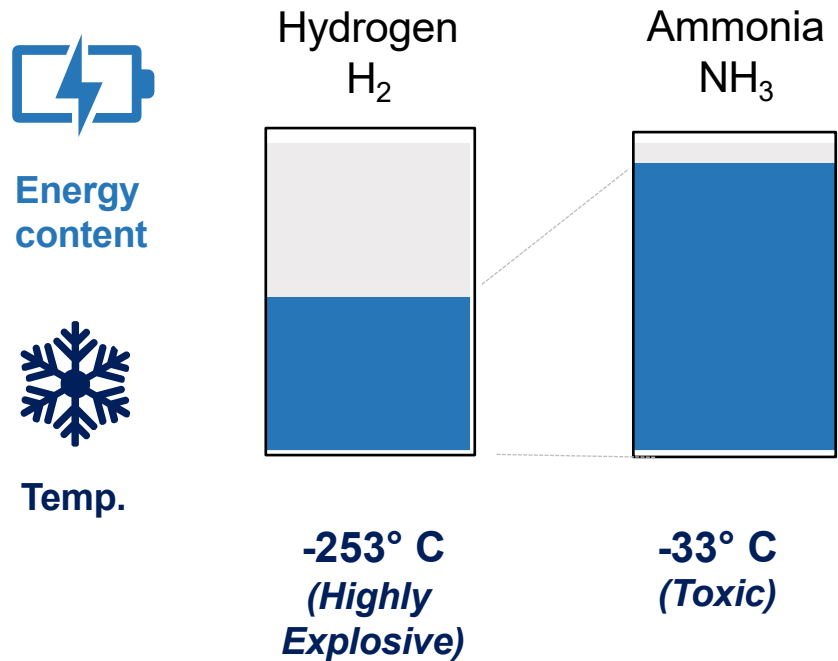


- Largest ammonia trader globally (**20%**)
- Ammonia **import terminals** in the EU and globally + own shipping **fleet**



Ammonia is an effective hydrogen carrier with multiple application areas

Attractive storage & transport properties



Potential uses for low carbon intensity ammonia



Carbon-free fertilizer and food



Industrial applications in chemistry, automotive and construction



Power generation (co-combustion)



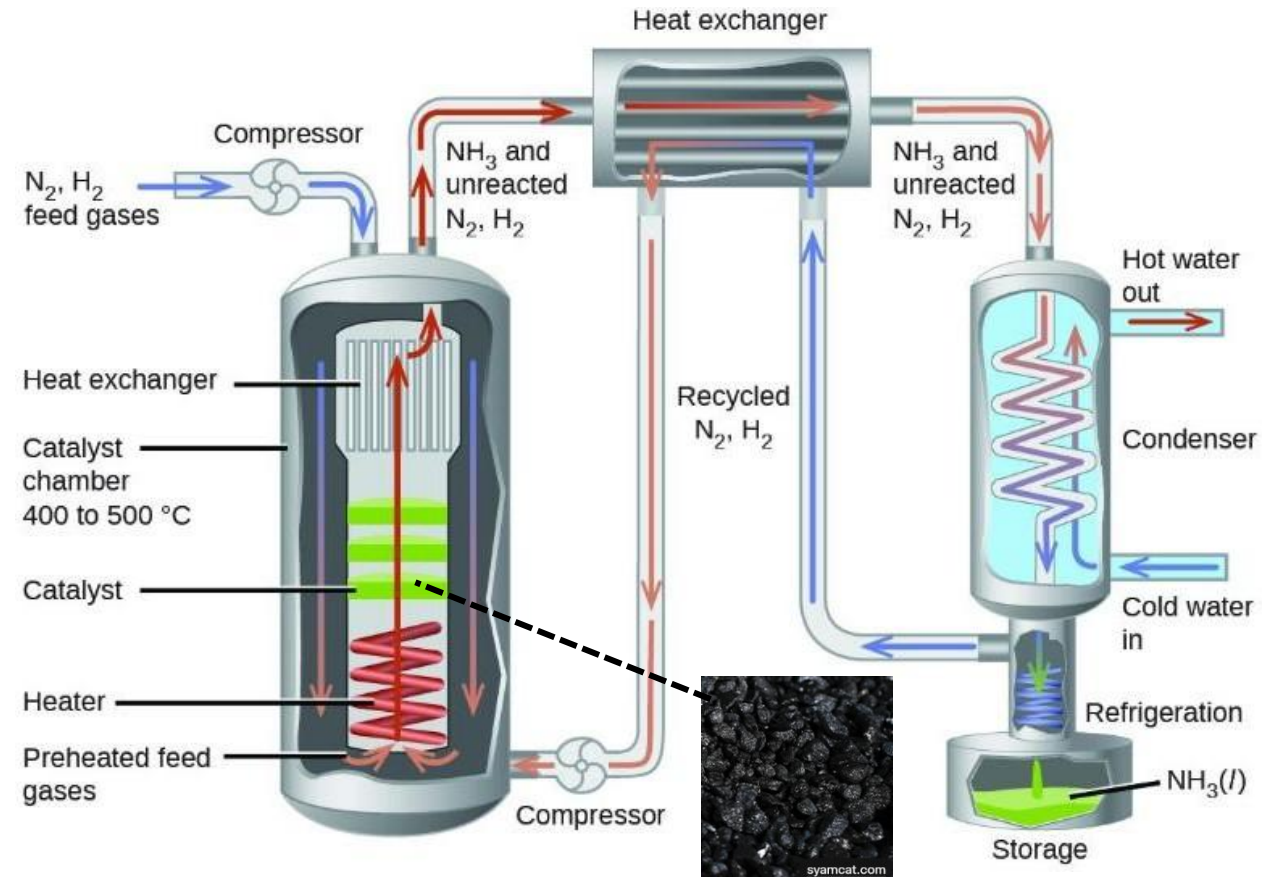
Zero-carbon fuel for long-distance shipping



Best-suited long-distance hydrogen carrier

Ammonia production

- Ammonia is produced by reacting Hydrogen and Nitrogen under high pressure and temperature
- The chemical reaction occurs by introducing the hydrogen and nitrogen into a vessel filled with a catalyst
- Certain polluting elements will, depending on concentration pollute the catalyst, either permanently or temporary.
- Catalyst pollution may lead to plant trip and can lead to need for catalyst change



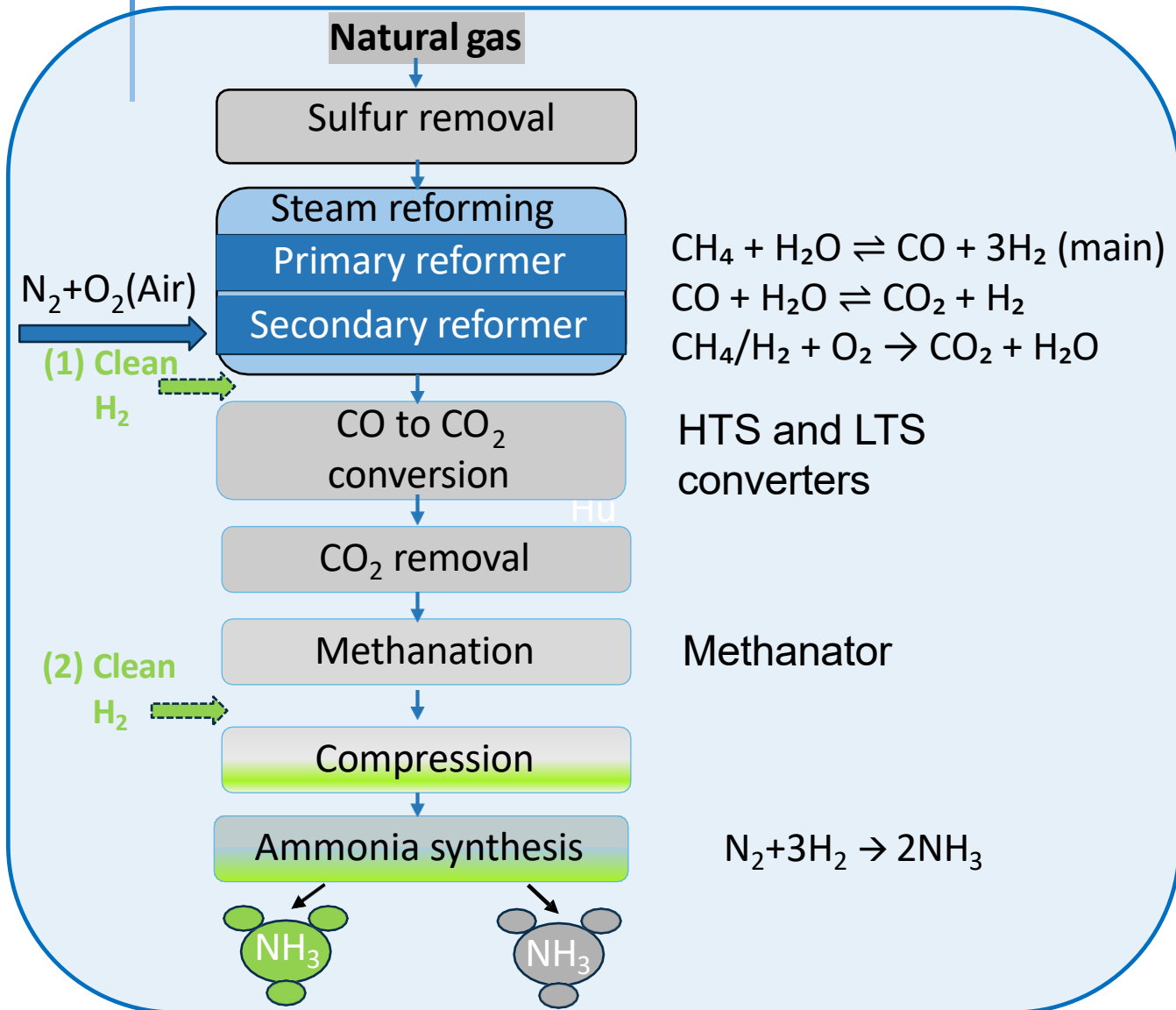
Source: <https://courses.lumenlearning.com/>

A catalyst is a substance that increases the reaction rate of a chemical reaction without being consumed

Yara's position on Hydrogen Quality

- Hydrogen is expensive. Too weak specification on quality can add additional economical burdens to end potential end users, example:
 - Electricity generation in PEM fuel cells
 - Ammonia synthesis
 - Methanol Synthesis
 - Fischer-Tropsch Synthesis (example: power-to-liquids (PtL) for synthetic fuels/diesel/waxes)
 - Semiconductor and Microelectronics Manufacturing
 - Pharmaceutical and Fine Chemical Hydrogenation
- We support Cefic's proposal to have a strict specification, including a high concentration of the hydrogen in the grid (99.9 mol% H₂) → Minimize the end user's purification treatment costs.
- **HOWEVER**, 99.9% mol% H₂ require a strict specification of max. concentration of components that may poison our ammonia catalysts. Even 0.1% pollutants = 1000 ppm are way above the max. allowable concentration for some components.

Hybridization of an ammonia plant – Example



- No need to significantly change the ammonia process
- Nitrogen comes from adding air to the secondary reformer or by utilizing an ASU
- Clean Hydrogen can be added in the front end (1) or prior to compression of the synthesis gas (2)
- Still some uncertainty of the long-term effect of any “new” impurities, e.g. fluorine components from the PEM electrolysis process
- Typically around 10% of the fossil hydrogen can be replaced without large modifications of our existing plants by adding to position (1). Adding to position (2) typically allow for replacing even more of the fossil fuel H₂.

H2 Specification – Injection upstream NH3 converter

- For full replacement of fossil H₂ in existing ammonia plants, Hydrogen from the grid should ideally contain 99.999 mol% H₂, but at least 99.9 mol% with a max. concentration of non-hydrogen components specified

Parameter	Units	Specification (min/max)	Rationale/comments
Hydrogen	mol%	≥ 99.9	Ensures high partial pressure of H ₂ in the synthesis reactor for optimal equilibrium and rate. Limits inerts, purge losses, and ensure efficiency. Should target high purity for maximum productivity.
Inerts (N ₂ , Ar, He)	mol%	≤ 0.1	Inerts reduce partial pressures of the reactants, hence lowering conversion per pass.
Hydrocarbons, including CH ₄	mol%	≤ 0.1	Inert in the ammonia synthesis, but reduce partial pressures of the reactants, hence lowering conversion per pass.
Oxygen species	molppm	≤1	Reversible catalyst poisons. 2*PPM O ₂ + 2*PPM CO ₂ + 1*PPM CO + 1*PPM H ₂ O<1 PPM
Water - dewpoint	molppm	Covered under Oxygen species	Non-permanent poison: Poisoning is reversible but reduces rate.
Carbon Dioxide	molppm	Covered under Oxygen species	Reversible catalyst poison
Carbon Monoxide	molppm	Covered under Oxygen species	Reversible catalyst poison
Total S content (incl. H ₂ S)	molppm	0*	Permanent catalyst poisoning
Halogen compounds	molppm	0*	Permanent poison.
Ammonia	molppm	≤ 1	Ensure optimum energy efficiency
Mercury	wtpm	≤ 0.01	Toxic component. Uncertain effect on ammonia synthesis catalyst.
N- components (MEA/DEA etc.)	wtpm	≤ 0.1	Not a considered to be an ammonia catalyst poison, however if they decompose, they may form components that may poison the ammonia synthesis catalyst.
Oil	wtpm	≤ 0.1 (not detectable)	Oil can contain sulfur which is an irreversible catalyst poison. Oil can also lead to deposits on the catalyst.
Arsenic	molppm	0*	Catalyst poison - irreversible
Phosphorus	molppm	0*	Catalyst poison - irreversible

* Below the detection Limit

H2 Specification - Injection upstream HTS/LTS converters

- Injection of Hydrogen upstream the HTS/LTS allow for higher concentration of O₂, CO and CO₂ in the injected gas, but require more investments than injection upstream the NH₃-converter.

Parameter	Units	Specification (min/max)	Rationale/comments
Hydrogen	mol%	≥ 99%	Ensures high partial pressure of H ₂ in the synthesis reactor for optimal equilibrium and rate. Limits inerts, purge losses, and ensure efficiency. Should target high purity for maximum productivity.
Inerts (N ₂ , Ar, He)	mol%	≤ 1	Inerts reduce partial pressures of the reactants, hence lowering conversion per pass.
Hydrocarbons, including CH ₄	mol%	≤ 1	Inert in the ammonia synthesis, but reduce partial pressures of the reactants, hence lowering conversion per pass.
Water	molppm	< 10	Water must be removed prior to the Ammonia converter
Oxygen species	molppm	<5	If added upstream the HTS, the oxygen will likely react with H ₂ to produce water
Carbon Dioxide	molppm	<100	Reversible catalyst poison vs. Ammonia synthesis catalyst. Can be removed in the CO ₂ removal unit followed by methanation.
Carbon Monoxide	molppm	<10000	Reversible catalyst poison vs. Ammonia synthesis catalyst. Can be removed in the HTS and LTS units
Sulfur	molppm	0*	Catalyst poison
Halogen compounds	molppm	0*	Catalyst poison
Arsenic	molppm	0*	Catalyst poison
Phosphorus	molppm	0*	Catalyst poison
N- components (MEA/DEA etc.)	wtppm	≤ 0.1	Potential poisoning of LTS and Methanator catalyst
Oil	wtppm	≤ 0.1 (not detectable)	Oil carryover from compressors can potentially poison all downstream catalysts (LTS Cu, methanator Ni, NH ₃ synthesis Fe).
* Below the detection Limit			



Knowledge grows

Thank you for your attention!

GIE Position Paper on Hydrogen Quality Specifications

Moneos Nikolas
GIE H₂ Purity TF Chair

ENNOH Workshop on Hydrogen Quality

12 February 2026

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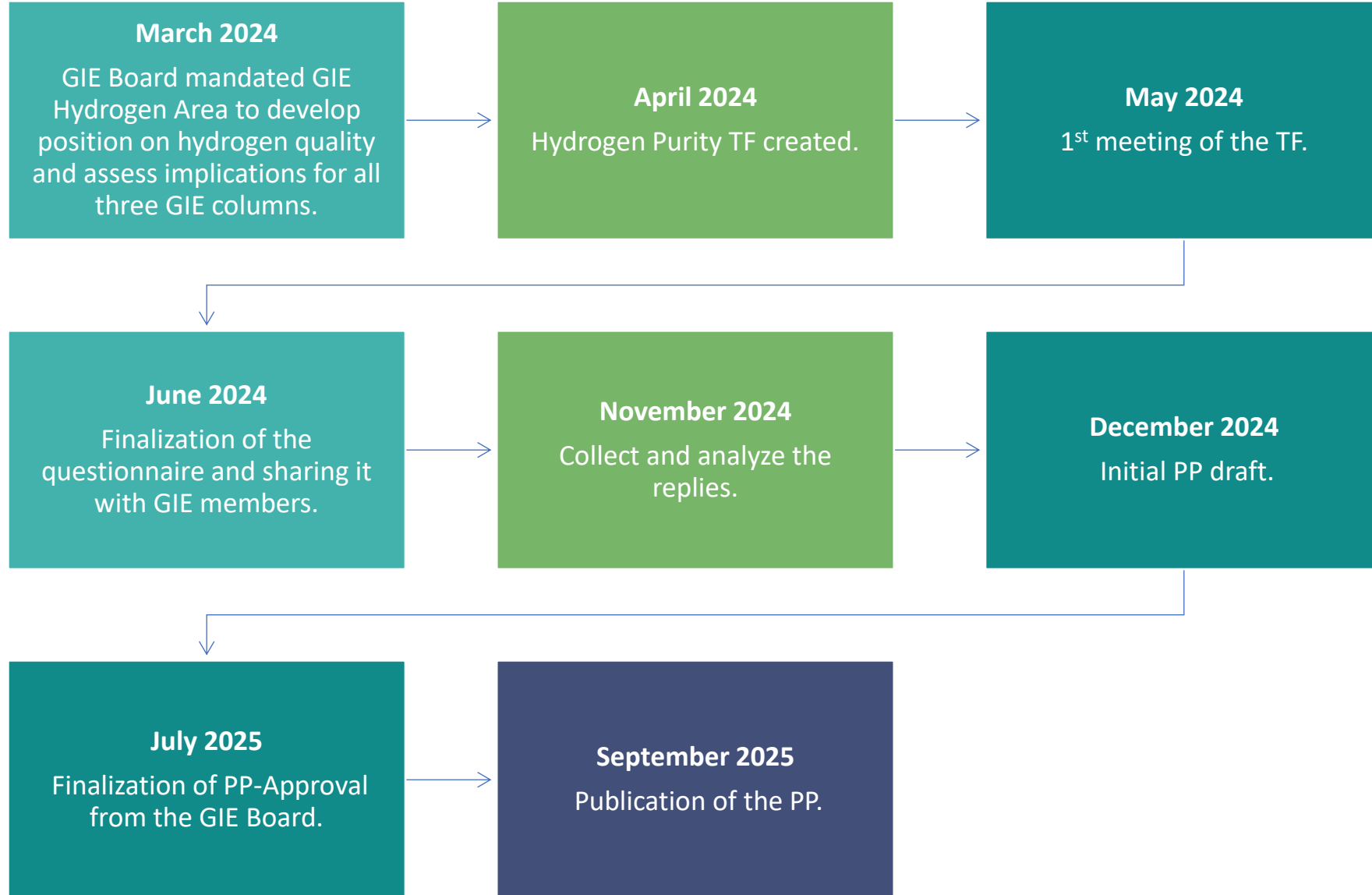
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n.moneos@desfa.gr

LinkedIn: [Nikolas Moneos](#)



Position Paper timeline



H₂ purity publications



	ISO 14687:2019 <i>Type I / Grade A</i>	BSI PAS 4444:2020	DVGW G260:2021 <i>5th Family / Group A</i>	EASEE-gas 2022/001/01	CEN/TS 17977:2023	KIWA / DNV 2023 study
H ₂	≥ 98 mol%	≥ 98 mol%	≥ 98 mol%	≥ 98 mol%	≥ 98 mol%	≥ 99.5 mol%
Inerts (N ₂ , Ar, He)	-	≤2 mol%	-	≤2.0 mol%	≤2 mol%	≤0.5 mol%
Hydrocarbon	≤100 μmol/mol	-	-	≤1.5 mol%	≤2 mol%	≤0.5 mol%
H ₂ O+O ₂ +N ₂ +Ar	≤1.9 mol%	-	-	-	-	-
CO ₂ +CH ₄ +C _x H _y	-	≤1 mol%	-	-	-	-
H ₂ O	-	< -10 °C @ 85 bar	≤200 mg/m ³ (n) (MOP≤ 10 bar) ≤50 mg/m ³ (n) (MOP> 10 bar)	< -8 °C @ 70 bar(a)	≤250 μmol/mol (MOP≤ 10 bar) ≤60 μmol/mol (MOP> 10 bar)	< -8 °C @ 70 bar(g)
HC Dewpoint	-	< -2 °C @ 1 – 85 bar	< -2 °C @ 1 – 70 bar	< -2 °C @ 1 – 70 bar(a)	< -2 °C @ 1 – 70 bar	< -2 °C @ 1 – 70 bar(a)
O ₂	-	≤0.2 mol %	≤0.001 mol% (24h avg) ≤1 mol %	≤0.001 mol% (24h avg) ≤0.1 mol %	≤10 μmol/mol (24h avg) ≤0.1 mol%	≤10 μmol/mol
CO	≤1 μmol/mol	≤20 μmol/mol	0.1 mol%	≤20 ppm	≤20 μmol/mol	≤20 μmol/mol
CO ₂	-	-	-	≤20 ppm	≤20 μmol/mol	≤20 μmol/mol
Total S	≤2.0 μmol/mol	≤50 mg/m ³ ≤35 μmol/mol	≤6 mg/m ³ (n)	≤21 mg S/m ³ (n)	≤7 μmol/mol	≤3 μmol/mol
NH ₃	-	-	≤10 mg/m ³ (s)	-	≤13 μmol/mol	≤10 μmol/mol
Halogenated	-	-	≤0.05 μmol/mol	≤0.05 μmol/mol	≤0.05 μmol/mol	≤0.05 μmol/mol
Wobbe Index	-	42.0 – 46.0 MJ/m ³ (s)	-	-	42.0 – 46.0 MJ/m ³ (s)	45.99 – 48.35 MJ/m ³ (n)

Questionnaire



2 Hydrogen Quality

2.1 What would be the minimum concentration of hydrogen that can be handled in your infrastructure/process?

- a. 98% - mol
- b. 99.5% - mol
- c. Other (please specify)

2.1.1 Is the minimum hydrogen concentration determined by the hydrogen content alone, or is it set to limit the total amount of other components that might be present in the hydrogen?

Comment:

2.2 Does this value originate from any internal study for your infrastructure/process?

- a. Yes
- b. No

2.2.1 If no, please specify the reasoning behind your answer?

Comment:

2.3 Total Inerts (Ar, He, N₂)- What is the maximum value that can be handled by your infrastructure/process?

- a. 0.5 mol-%
- b. 2 mol-%
- c. Other (please specify)

Aim of Questionnaire:

- Collect GIE members' input on H2 quality-related questions
- Develop a GIE Position Paper on H2 purity

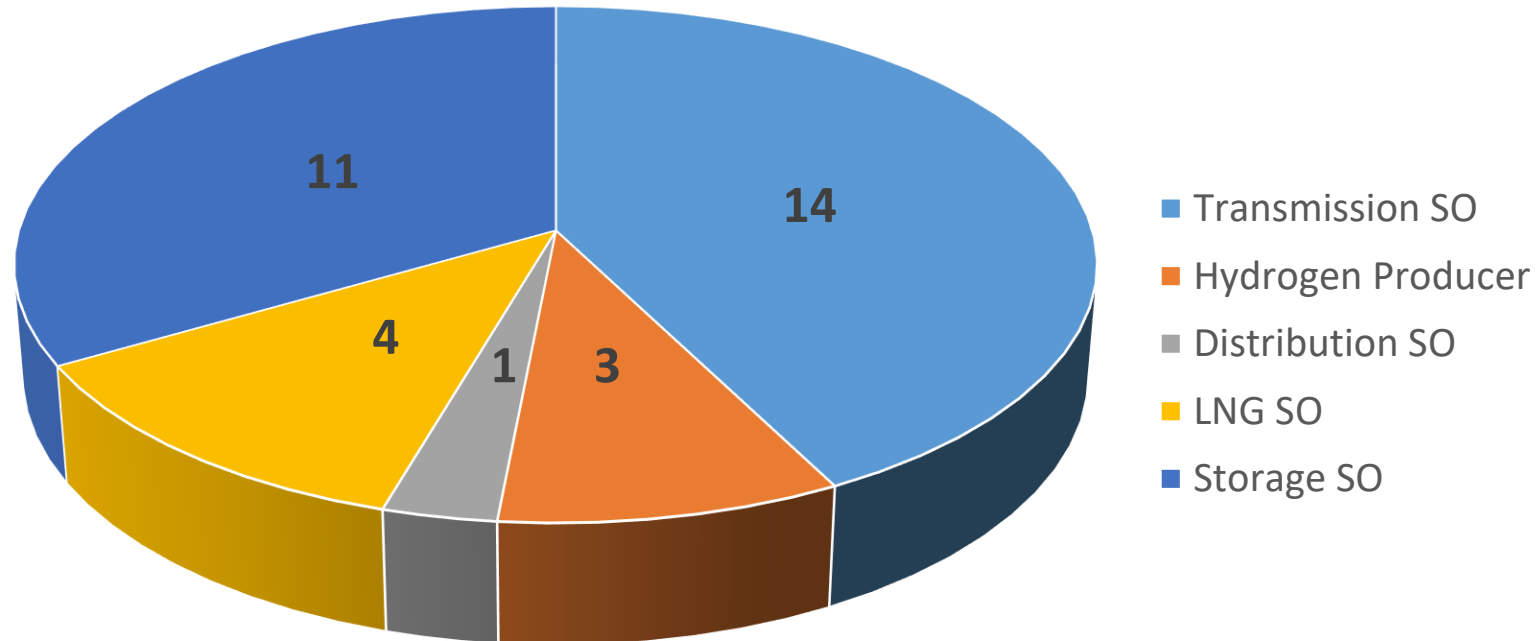
Format of Questionnaire:

- > 70 questions
- Sub-chapters:
 1. General Information
 2. Hydrogen Quality
 3. Pilot projects / internal studies

Process of Questionnaire:

- All GIE members got the chance to fill-in the questionnaire over summer via Microsoft Forms

Type of responders



The questionnaire was answered by 23 GIE members (out of 70 members, as July 2024). Out of these members, 14 are members of Gas Transmission Europe (GTE), 11 are members of Gas Storage Europe (GSE), and 4 are members of Gas LNG Europe (GLE). A member may belong to more than one of these groups. Also, responses were collected between July and October 2024.

What would be the minimum concentration of hydrogen that can be handled in your infrastructure/process?



H ₂ % - mol	Count of Sector
85% - mol	1
Storage System Operator;H2 Producer	1
95% - mol	1
Storage System Operator	1
98% - mol	14
Storage System Operator	4
Storage System Operator;H2 Producer	1
Transmission System Operator	6
Transmission System Operator;LNG System Operator	1
Transmission System Operator;Storage System Operator;LNG System Operator	2
99.5% - mol	5
Transmission System Operator	4
Transmission System Operator;Distribution System Operator;Storage System Operator;	1
99.9% - mol	1
LNG System Operator;H2 Producer ;	1
Grand Total	22

Majority results of GIE members through the questionnaire

Below, you can find the table which shows the hydrogen quality parameters that were indicated by the majority of GIE members through the questionnaire. It should be noted that the values shown represent the majority view and do not constitute a formal proposal for a hydrogen specification.

Quality parameters	Limits
H ₂	≥ 98 mol%
Inerts (N ₂ , Ar, He)	≤2 mol%
Hydrocarbons	≤2 mol%
H ₂ O	< -8 °C @ 70 bar(a)
HC Dewpoint	< -2 °C @ 1 – 70 bar
O ₂	≤0.1 mol% <u>or</u> ≤10 µmol/mol (24h avg) for sensitive users
CO	≤20 µmol/mol
CO ₂	≤20 µmol/mol
Total S	≤7 µmol/mol ⁽¹⁾
NH ₃	≤13 µmol/mol
Halogenated	≤0.05 µmol/mol
Wobbe Index	42.0 – 46.0 MJ/m ³ (s) ^(2,3)

^[1] 7 µmol/mol ≈ 10 mg/m³ (n)

^[2] Wobbe Index is not relevant for the majority of GIE members' infrastructure/process.

^[3] Wobbe Index determines the concentration of non-hydrogen gases.

Advantages of 98 mol% hydrogen



🔌 **Operational Feasibility & Faster Deployment:**

Easily integrated into existing infrastructure with minimal technical modification. It facilitates more rapid rollout of hydrogen systems and projects. Furthermore, the 98 mol% hydrogen minimum concentration reduces operational and transformation challenges for both existing pipelines and storages, given that the majority of the infrastructure has to be repurposed. Also, there is an impossibility to apply required purification plants at some storage sites due to infrastructure/land-use limitations.

🔌 **Cost Efficiency:**

98 mol% hydrogen minimum concentration reduces capital expenditure on purification systems and infrastructure retrofits for infrastructure operators, avoiding required investments in advanced purification, and adaptation of storage, and transport infrastructure as well as import sources.

🔌 **Impact on the Market:**

Although the hydrogen market development is not clear yet, a significant share of the (industrial) demand might not need higher purification with the effect of reducing commodity prices for a majority of end users. Purification is required irrespective of initial quality when intended for high-purity applications (e.g. fuel cells, electronics, hydrogen mobility etc.). Hence, the mass market is not forced to bear the premium for high purity.

🔌 **Wider Compatibility:**

Suitable for current storage and some transmission systems across member states.

Advantages of 99.5 mol% hydrogen



🔗 Meets Requirements of some strict end-users:

Mainly applicable for the chemical feedstock market and some industrial processes due to the limited quality variation. It also might provide cost-reduction benefits for further individual purification for high-purity hydrogen applications and sensitive end-users with high-purity demand such as fuel cells, electronics, and hydrogen mobility.

🔗 Potential Ramping-up of hydrogen market:

Although the hydrogen market development is not clear yet, raising the baseline hydrogen purity from 98 mol% to 99.5 mol% might accelerate the hydrogen economy by increasing market compatibility and reducing downstream processing needs.

🔗 Reduces Risk of Quality Variability:

Setting a minimum hydrogen purity of 99.5 mol% helps reduce quality variability (mainly gross calorific value, Wobbe Index, inerts concentration and hydrocarbons concentration) across the supply chain. This is an advantage particularly relevant for end-users with sensitive applications and processes.

Policy Recommendations



1. Adopt Practical and Flexible Purity Standards:

- Advocate for a hydrogen purity that balances operational feasibility and cost-effectiveness for most infrastructure operators, while being aligned and acceptable to all stakeholders along the value chain.
- Strive for a uniform hydrogen purity standard across the EU to guarantee interoperability.

2. Align with Standards:

- Ensure harmonisation with current and future standards to maintain compatibility across the European hydrogen system.

3. Empower Storage Operators:

- Recognize the crucial role of storage operators across the hydrogen system and provide targeted support to address their specific issues.

4. Encourage Research and Development:

- Continue to support pilot projects and studies that explore innovative solutions for hydrogen storage and quality management.

5. Clarify Investment and Operational Costs:

- Encourage the whole hydrogen value chain (from production to end-use) to conduct detailed cost analyses for infrastructure adaptation regarding hydrogen purity, providing stakeholders with transparency and clarity for decision-making.

Read and share the PP documents and posts



- ✓ Position Paper → [here](#)
- ✓ Press Release → [here](#)
- ✓ LinkedIn post → [here](#)
- ✓ X post → [here](#)



Press Release

Hydrogen purity: balancing technical feasibility and market needs

Brussels, 02 Septembre 2025

As hydrogen plays an increasingly pivotal role in Europe's decarbonised energy future, defining clear and harmonised purity specifications is crucial to ensure infrastructure compatibility, operational efficiency, and smooth market integration. Gas Infrastructure Europe (GIE), the European association representing gas and hydrogen transmission, storage and terminal operators, explores the vital role of hydrogen purity from an infrastructure perspective. The position paper delves into the implications of hydrogen quality specifications on the operation of infrastructure systems.

Based on insights gathered from a comprehensive questionnaire, many GIE members consider 98 mol% hydrogen purity a practical and cost-effective threshold for infrastructure operations, while some members and countries see advantages in setting the level at 99.5 mol% to better serve more demanding end-use sectors. Both options come with benefits

Introduction



GIE Position Paper on Hydrogen Quality Specifications

This position paper, based on responses to a comprehensive questionnaire distributed to Gas Infrastructure Europe (GIE) members and further insights from the Hydrogen Purity Task Force (TF)¹, represents the collective perspective of GIE members – representing transmission, storage and terminal operators – on a hydrogen quality specification. As hydrogen becomes integral to Europe's decarbonised energy system, establishing clear and practical hydrogen quality specifications is critical to ensure infrastructure compatibility, operational efficiency, and market integration. This paper looks at the implications of hydrogen quality specifications on the operation of infrastructure systems.

Hydrogen Quality Specifications

Results from the GIE Questionnaire

The information below reflects the collective input of GIE members gathered through the Hydrogen Purity TF questionnaire².

GIE members indicate a preference for a hydrogen purity that is both operationally feasible and cost-effective. There are different positions among the GIE members regarding an optimal purity level. The majority of members advocate for a hydrogen minimum content of **98 mol%**, recognising it as a threshold that balances technical requirements and economic considerations. Higher purity levels, while technically

A low-angle, wide shot looking up at a large, leafy tree with a person standing at its base, framed by a stone archway. The image has a blue tint and serves as the background for the text.

Thank you for your attention

www.gie.eu | Avenue de Cortenbergh, 100 - 1000 Brussels – Belgium
gie_brussels_ | @GIEBrussels | gas-infrastructure-europe-gie



Panel Discussion

Join at
slido.com
#1226 085

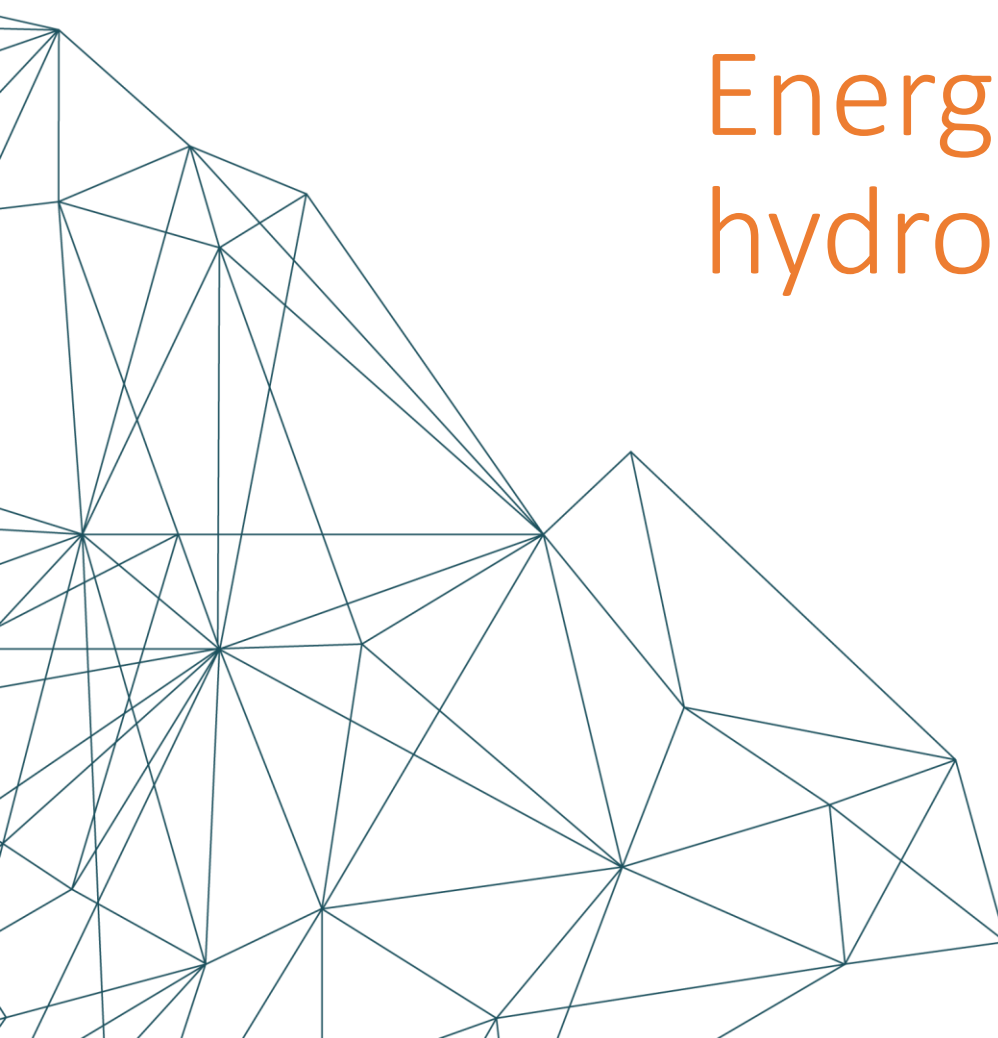


 Passcode: **hydrogenforgood**



Coffee break

We will be back at 15:00



Energinets preliminary hydrogen specification

ENNOH Workshop
12th of February 2026

*Christina Würtz Bjerre
Gas Quality Specialist*

WE OPERATE AND OWN THE DANISH ENERGY BACKBONE



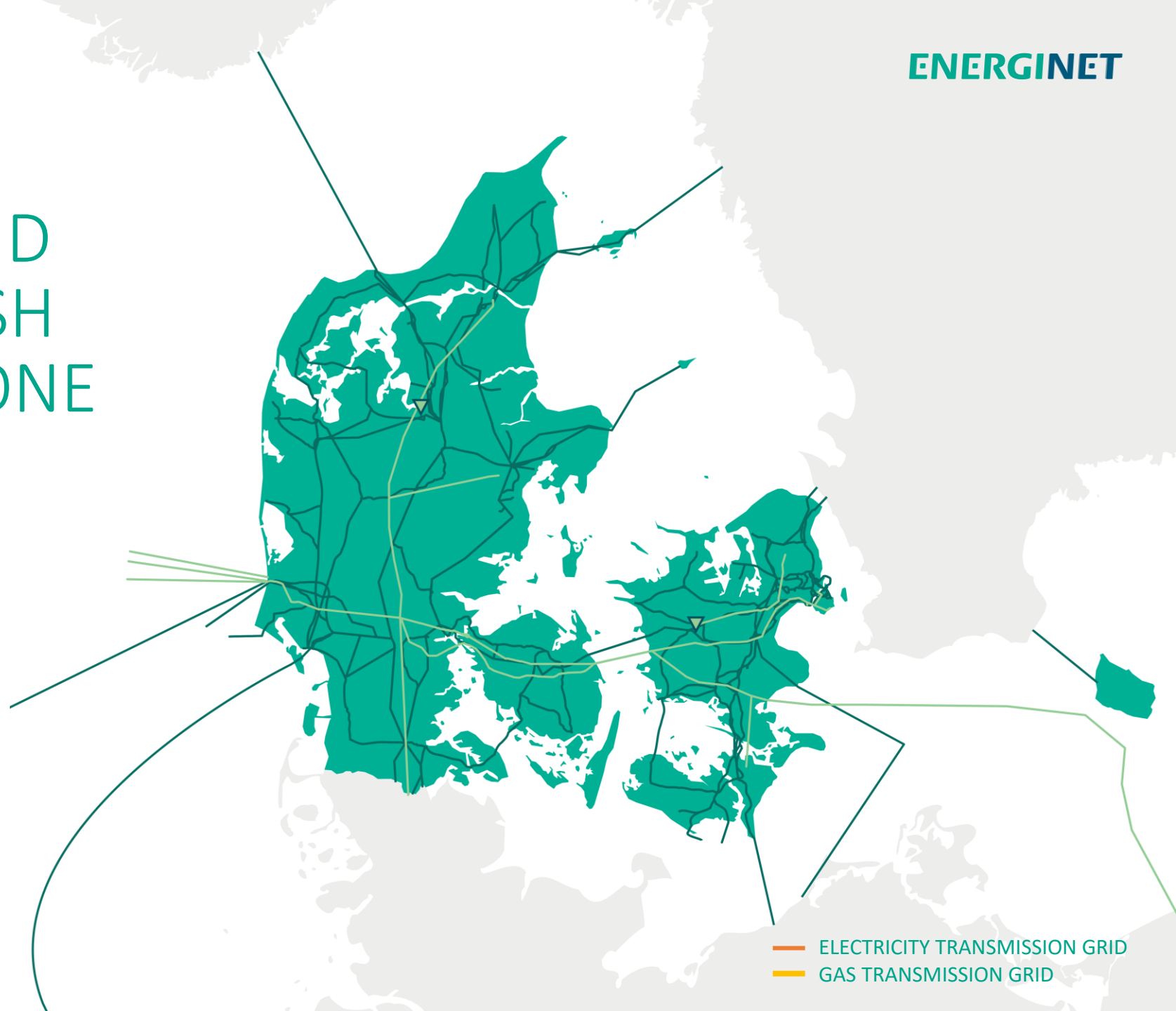
9,445

km electricity grid



1,250

km gas grid



— ELECTRICITY TRANSMISSION GRID
— GAS TRANSMISSION GRID

DANISH HYDROGEN BACKBONE (DHB)



The hydrogen pipeline is underground. The flow is monitored from Energinet's control centre.

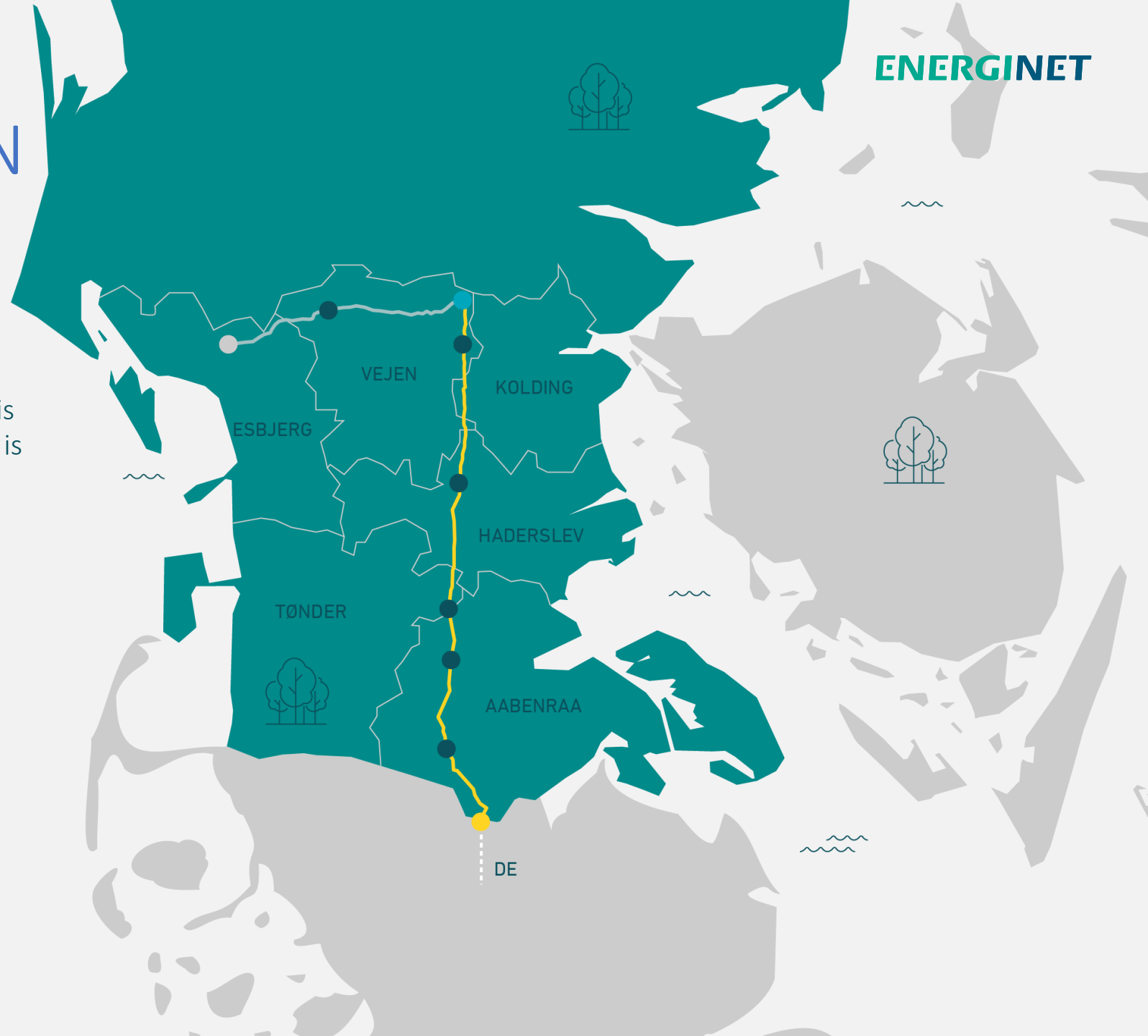
ESBJERG - VEERST

45 km of new 36" hydrogen pipeline (914 mm) with a design pressure of 100 bar.

VEERST - FRØSLEV

89 km of converted 30" natural gas pipeline (762 mm) with a design pressure of 80 bar.

APPROX. 134 KM TOTAL LENGTH.



PRELIMINARY SPECIFICATION FOR HYDROGEN

- ❖ First published in 2023
- ❖ Based on, CEN/TS 17977, international conversations and ASME B31.12
- ❖ National departures

Origin	Name	Abbreviation	unit	Limits
H ₂ Generation	Hydrogen	H ₂	mol-%	≥ 99,5
	Σ inerts	I _{tot}	mol-%	≤ 0,5
	Carbon monoxide	CO	ppm	≤ 20
	Carbon dioxide	CO ₂	ppm	≤ 20
	Ammonia	NH ₃	ppm	≤ 13
	Halogenated compounds	R-Cl/F/Br	ppm	≤ 0,05
	Water	H ₂ O	ppm	20
	Oxygen	O ₂	ppm ppm	(≤ 1000) ≤ 10
NG Infrastructure	Hydrocarbons	C _x H _y	mol-%	≤ 0,5
	Hydrocarbon DP	HCDP	°C	- 2 (@1-70 bara)
	Total sulphur	-	ppm	≤ 7
	Particles	-	mg/kg	Technically free
	Wobbe index	WI	MJ/m ³	43,6-46,0 (15/15)

- See information package 3, chapter 3 p. 11-13
<https://en.energinet.dk/hydrogen/hydrogen-news/information-package-3/>

PRELIMINARY SPECIFICATION FOR HYDROGEN

Based on CEN TS 17977, ASME B31.12

- ❖ Departures from **CEN TS 17977**
 - ❖ Hydrogen, inerts, hydrocarbons
- ❖ **ASME B31.12**
 - ❖ Water
- ❖ Oxygen?
 - ❖ Are two limits sustainable?
- ❖ Subject to change
- ❖ Harmonization across system borders
 - ❖ On-going standardization work

Origin	Name	Abbreviation	unit	Limits
H ₂ Generation	Hydrogen	H ₂	mol-%	≥ 99,5
	∑ inerts	I _{tot}	mol-%	≤ 0,5
	Carbon monoxide	CO	ppm	≤ 20
	Carbon dioxide	CO ₂	ppm	≤ 20
	Ammonia	NH ₃	ppm	≤ 13
	Halogenated compounds	R-Cl/F/Br	ppm	≤ 0,05
	Water	H ₂ O	ppm	20
	Oxygen	O ₂	ppm ppm	(≤ 1000) ≤ 10
NG Infrastructure	Hydrocarbons	C _x H _y	mol-%	≤ 0,5
	Hydrocarbon DP	HCDP	°C	- 2 (@1-70 bara)
	Total sulphur	-	ppm	≤ 7
	Particles	-	mg/kg	Technically free
	Wobbe index	WI	MJ/m ³	43,6-46,0 (15/15)

Main takeaways

PRELIMINARY QUALITY SPECIFICATION

- Subject to change
- Except for water

INTEROPERABILITY

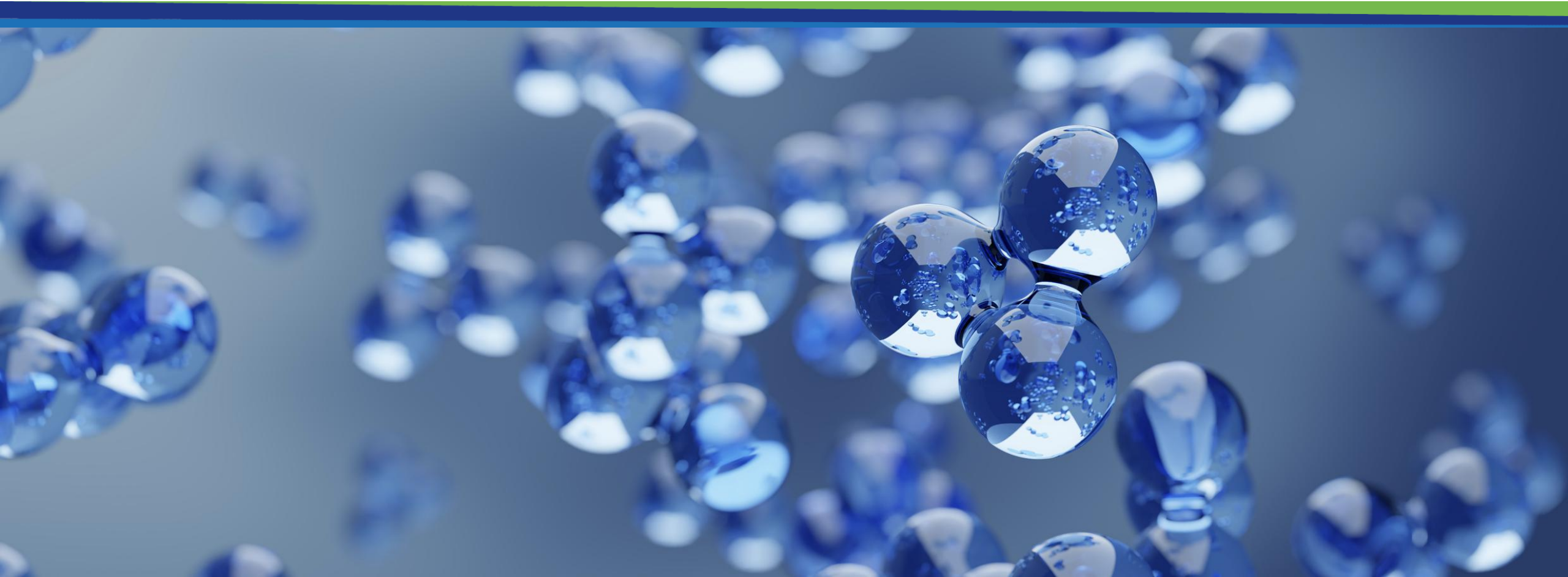
- Entire value change
 - Harmonization

- EU STANDARD WAS NEEDED YESTERDAY

GERG Hydrogen Activities

from knowledge building to standards

February 12th 2026, ENNOH Hydrogen Quality Workshop
Robert Judd, Secretary General GERG



The European Gas Research Group



Our members



Associate members



- **Collaborative** R&D group for gas with strong industry focus
- Over 30 members - gas companies, research centres and universities
- Young Researchers Event – Awards supporting the best students
- Links to Brussels Institutions and External Organisations



EC-funded Projects

DEO • CONRAD • DIGBUILD • VOGUE • MICROMAP • PRESENSE • LABNET • GIGA • COMBO • NATURALHY • ORFEUS • INTEG-RISK • GASQUAL • LNG DENSITOMETER • ELEGANCY • THYGA • Biomethane Barriers (BioStar2C) • H2PNR • Met4H2 • MetCCUS • BiometCAP • OPTHYCS • THOTH2 • MetHyTrucks • SHIMMER • CANDHy • PilgrHYm • NHyRA • COREu • H2FlowTrace • MaritimeMET • SmartGasNet • CryoMet • MetNH3Energy • HyQualNet

Snapshot of GERG Hydrogen Activities

- 1) The Hydrogen Working Group
- 2) European Projects Overview
- 3) Key Takeaways



GERG Hydrogen Working Group and Roadmap

Supply Vectors

Electrolysis
CCUS, Natural
hydrogen Energy
Carriers eg
Ammonia, LOHC

Transport & Distribution

System
Integration,
Impact on
infrastructure
and
components

Hydrogen Storage

Underground,
Above ground,
mobility

End Use

Industrial
Domestic
Commercial

Cross Cutting Issues

Gas Quality and Gas Properties
Flow Metering and Measurement
Purification Technologie
Odourisation
Safety and Emissions
Skills and Social Impacts

GERG Hydrogen Working Group

- 130 experts from industry, academia and research
- ~37 participating organisations across Europe

Hydrogen Research Roadmap

- 1st Edition published in 2021
- Summary available via the GERG website

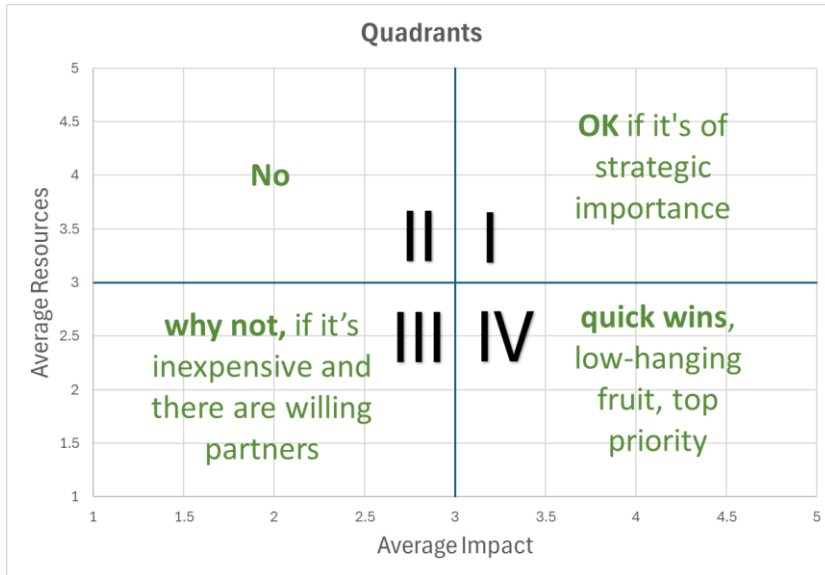
2024 Roadmap Update (All Working Groups)

- Strategic refresh across Hydrogen, Biomethane, CCUS, Methane Emissions Management

Update Process

- Review and refinement of previous roadmap structure
- Member feedback and workshops
- Questionnaires and topic validation
- Prioritisation discussions and written feedback

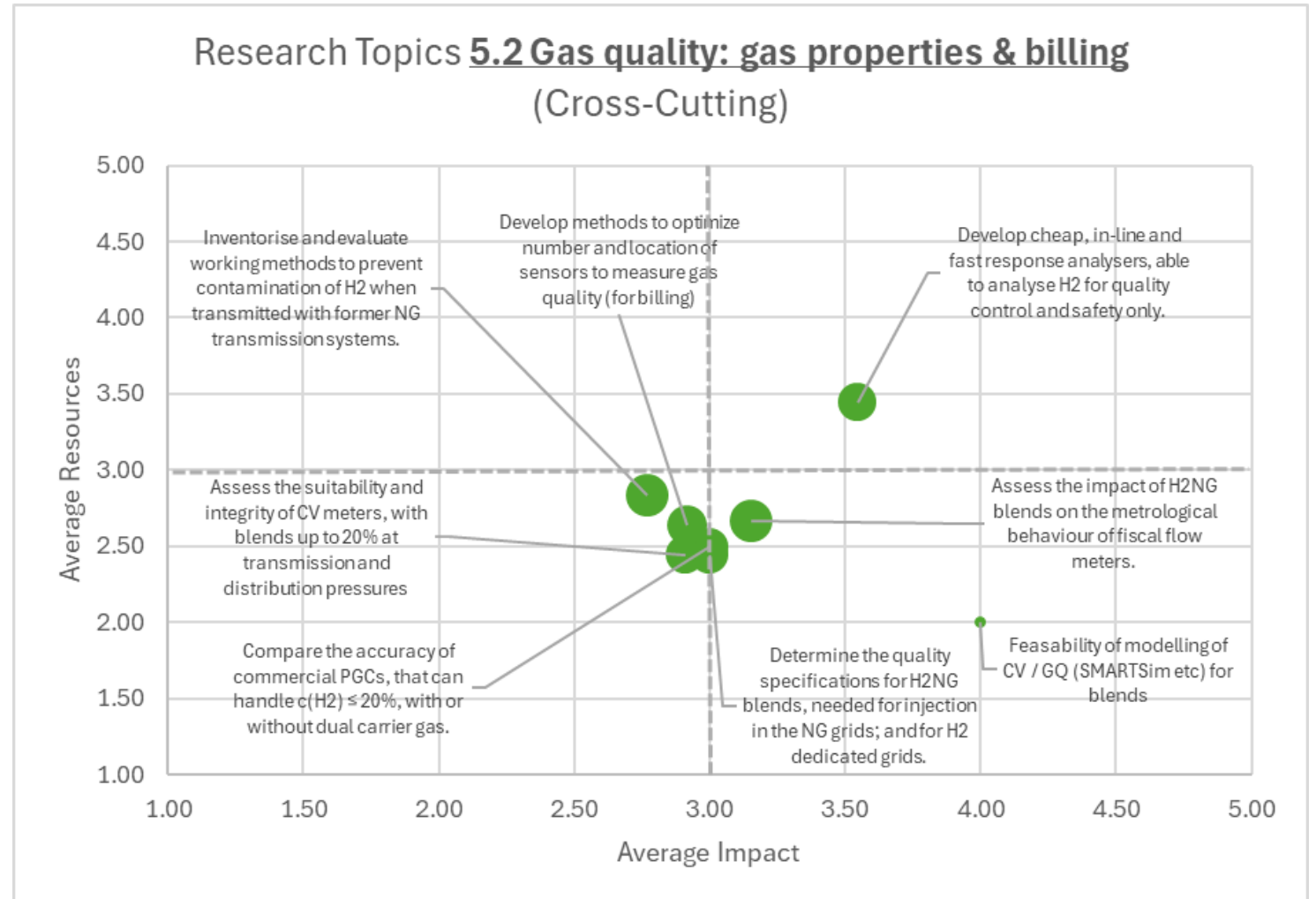
Impact versus Resources Analysis - example



Use of Impact versus resources matrix to determine:

- Potential quick wins (High impact/ low resources)
- Strategically important themes

Approach will lead to prioritisation of projects with the GERG roadmap and allows alignment with other initiatives



European Commission Supported Projects: overview

Horizon Europe

BIOSTAR2c

- Phase 2c of the project 'Removing the technical barriers to uses of biomethane in gas networks'

COREU

[LinkedIn](#)

- CO2 Routes Across Europe

THYGA

- Testing Hydrogen Admixture for Gas Applications



OPHYCS

[LinkedIn](#)
[Website](#)

- Optic Fibre-based hydrogen leak control systems

THOTH2

[LinkedIn](#)
[Website](#)

- Novel methods of testing for measurement of natural gas and hydrogen mixtures

CANDHy

[LinkedIn](#)
[Website](#)

- Compatibility Assessment of Non-steel metallic distribution gas grid materials with Hydrogen

SHIMMER

[LinkedIn](#)
[Website](#)

- Safe Hydrogen Injection Modelling and Management for European gas network Resilience

PilgrHym

[LinkedIn](#)
[Website](#)

- Pre-normative Research On Integrity Assessment Protocols Of Gas Pipes Repurposed To Hydrogen And Mitigation Guidelines

NHyRA

[LinkedIn](#)
[Website](#)

- pre-Normative Research on Hydrogen Releases Assessment

Clean Hydrogen Partnership

European Partnership for Metrology

Met4H2

[LinkedIn](#)
[Website](#)

- Metrology for the hydrogen supply chain



MetCCUS

[LinkedIn](#)
[Website](#)

- Metrology Support for Carbon Capture Utilisation and Storage



BiometCAP

[Zenodo](#)

- Biomethane conformity assessment protocol



MetHyTrucks

[LinkedIn](#)

- Metrology for hydrogen fuel sampling for heavy duty transport

H2FlowTrace

[LinkedIn](#)
[Website](#)

- Flow measurement traceability for hydrogen in gas networks

MaritimeMet

[LinkedIn](#)
[Website](#)

- Metrology for green maritime shipping

MetNH3Energy

[LinkedIn](#)
[Website](#)

- Metrology to Support Ammonia Use in Emerging Applications

NEW

CryoMet

[LinkedIn](#)
[Website](#)

- Metrology for reliable liquefied energy gases measurement

NEW

SmartGasNet

[LinkedIn](#)

- Metrology for smart metering in gas networks

NEW

Active GERG EU-funded Hydrogen projects 2022-2027

Ongoing EU-funded hydrogen projects with GERG participation:

Clean Hydrogen Partnership



OPHYCS

• [LinkedIn](#) / [Website](#)



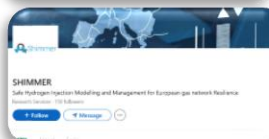
THOTH2

• [LinkedIn](#) / [Website](#)



CANDHy

• [LinkedIn](#) / [Website](#)



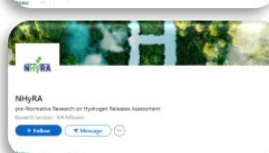
SHIMMER

• [LinkedIn](#) / [Website](#)



PilgrHym

• [LinkedIn](#) / [Website](#)



NHyRA

• [LinkedIn](#) / [Website](#)

Euramet



Met4H2

• [LinkedIn](#) / [Website](#)



MetHy
Trucks

• [LinkedIn](#)



H2Flow
Trace

• [LinkedIn](#) / [Website](#)



SmartGas
Net

• [LinkedIn](#) / [Website](#)



CryoMet

• [LinkedIn](#) / [Website](#)



MetNH3E
nergy

• [LinkedIn](#) / [Website](#)

Linkage to Standardisation



CEN H2 PNR project – 2021-2023

- To perform **detailed knowledge surveys** on the priorities
- To develop a **detailed understanding of the state of the art** relating to hydrogen injection in the gas networks based on international information sources
- To understand **gaps in knowledge** and develop proposed plans for mitigation
- To develop **recommendations** which include planned PNR activities to lower or remove barriers and enable update of standards or development of new ones
- To understand the **benefits of these actions versus business as usual** and to establish **costs of future PNR to remove barriers** wherever possible

	Priority / topic area	Lead
1	Safety	DNV
2	Gas Quality	GRT Gaz
3	Underground storage	DBI
4	Power Generation and Engines	DNV
5	Industry	Engie
6	Steel Pipes	GRT Gaz
7	Network Equipment	DBI
8	End use commercial and domestic	DGC
9	<i>Gas Quality Requirements for industrial users*</i>	<i>GRT Gaz</i>
	Project administration on behalf of CEN	DIN
	Coordination, interfaces and transverse subject management	GERG

** A state of the art survey*

EISMEA HyQualNet project – 2025-2026

- EISMEA call SMP-STAND-2024-ESOS-01-IBA Topic 10 Hydrogen quality in dedicated gaseous grids, May 2024/approved July 2024
- Project timeline: 01-01-2025 – 30-08-2026 (20 months)
- Workshop context: Preparing for CEN-CENELEC standardisation on hydrogen
- WP1: overall project coordination
- WP2 (DS): knowledge analysis and assessment
- WP3 (DIN): standardisation landscape and needs: draft scoping and technical provisions
- GERG is a partner of WP2
- GERG supports with knowledge-sharing (e.g. CEN H2 PNR results)



	Priority / topic area in WP2	Lead
1	Leak Detection	DVGW EBI
2	Leakage Monitoring	NaTran R&I
3	Odorants without sulfur	DBI
4	Safety Protocols	Kiwa
5	Purification	DBI
6	Hydrogen Quality Parameters	Evida

Knowledge Creation to Standards - Met4H2 project



Metrology for Hydrogen Supply Chain (October 2022-September 2025)

Main objective: to provide outputs that support development of new and improved standards for safe hydrogen application, flow measurement, hydrogen quality assessment, and custody transfer.

Results available:

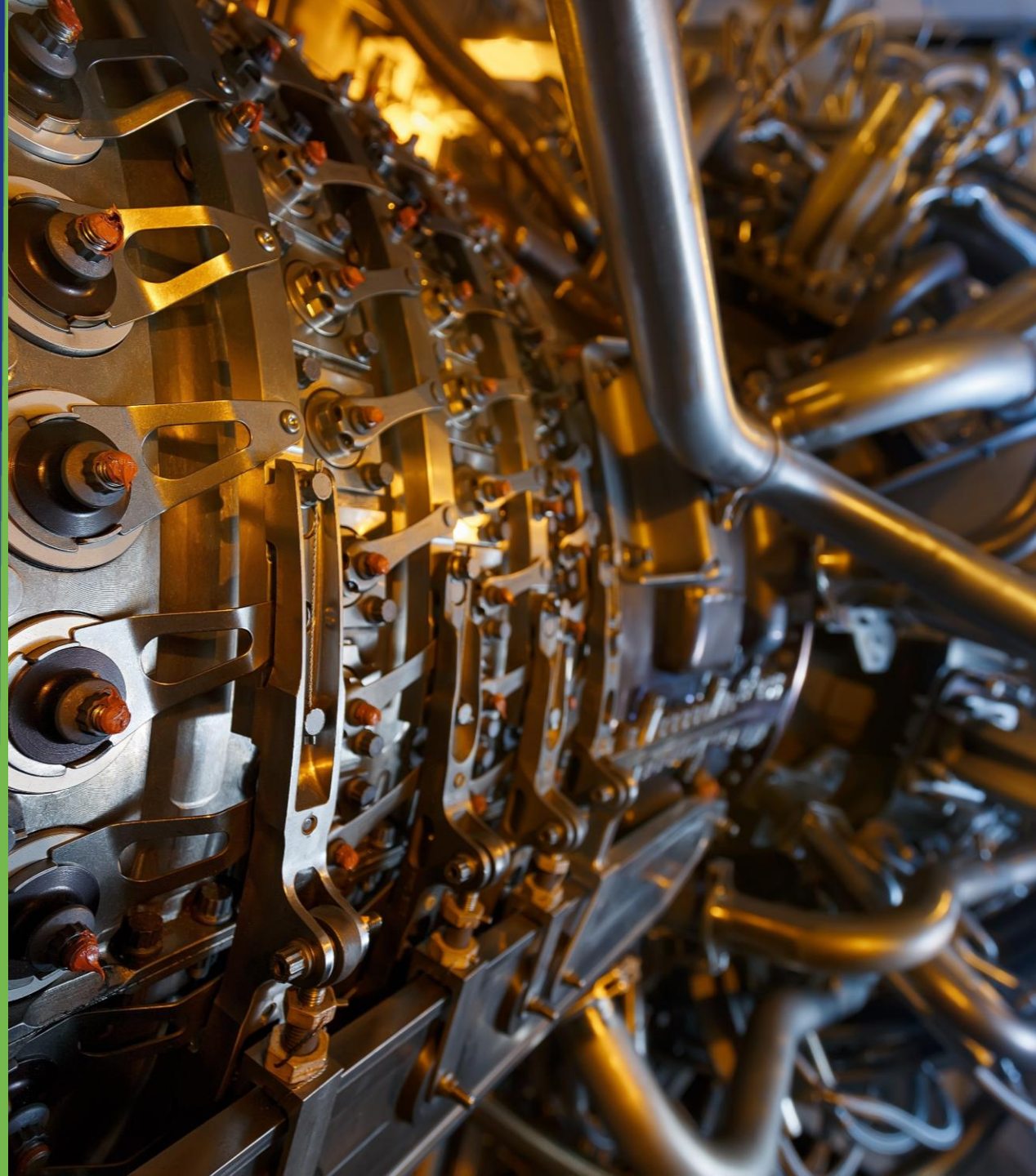
<https://met4h2.eu/about-the-project/>

[ZENODO](#)

- [framework for uncertainty calculations](#)
- [A procedure for evaluating uncertainty associated with averaging or totalisation calculations on time-sampled data in gas energy measurements](#)
- [Metrological guidelines for the validation, calibration and verification of hydrogen sensors used within the hydrogen supply chain for quality control](#)
- [On the autocorrelation of measurement results for gas volume and calorific value in fiscal metering in gas grids](#)
- [Evaluation of uncertainty associated with totalisation of time-sampled data in gas quantity and energy measurements](#)
- [Measurement Uncertainty in the Totalisation of Quantity and Energy Measurement in Gas Grids](#)
- [Evaluation of existing gas models for gas flow suitable of hydrogen](#)
- [A2.1.4 Technical Report on the current status and future plans within the European gas distribution grid, models for hydrogen flow, and liquid hydrogen supply chains - Met4h2](#)
- [A1.3.4: Test of the protocol developed in A1.3.2 using the rig developed in A1.3.3 for two different sensors - Met4h2](#)
- [A 3.1.2 REVIEW OF SAMPLING STRATEGY AND REQUIREMENTS FOR HYDROGEN QUALITY ANALYSIS - Met4h2](#)

Key Takeaways

- **Hydrogen gas quality is a fundamental enabler of Europe's hydrogen value chain**
Reliable understanding of composition, impurities and their impacts is essential for safe infrastructure operation, local and cross-border transport, and clear specifications for end-users
- **Consistent, evidence-based knowledge is critical for building confidence**
Robust research, shared data and validated measurement methods reduce uncertainty, support design decisions, and enable safe, predictable system behaviour.
- **Linking research to pre-normative activities is essential**
Coordinated R&I provides the technical foundation for harmonised standards and helps avoid fragmented national approaches.
- **Harmonised standards are key to scaling the hydrogen economy**
Common European rules for metering, quality, sampling, purification, and odorisation are necessary to unlock interoperability, lower costs and support cross-border hydrogen flows.
- **GERG plays a central role in connecting industry needs with standards development**
By structuring knowledge, consolidating results across EU-funded projects, and supporting CEN–CENELEC processes, GERG helps accelerate the transition from research to practical, implementable standards



Thank you for your attention!

secretariat@gerg.eu





ENNOH Workshop

H2 Quality for PEM fuel cells

12 February 2026



DECARBONIZING THE POWER, HEAVY MOBILITY & INDUSTRIAL SECTORS WITH CUTTING-EDGE H₂ SOLUTIONS

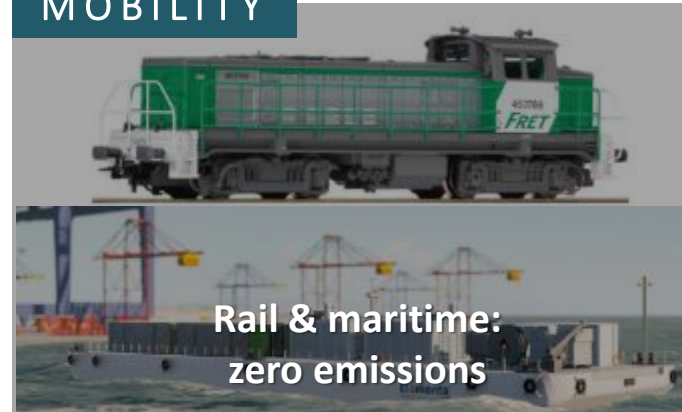


THE HYDROGEN REVOLUTION IS SPREADING
OVER MAJOR SECTORS IN TODAY'S ECONOMY

INDUSTRIES



MOBILITY



POWER

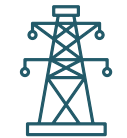


HDF ENERGY, A GLOBAL PURE PLAYER IN HYDROGEN

H2 PLANTS



Development, operation & ownership of large-scale hydrogen plants



Electricity production



Green hydrogen production

MULTI-MW FUEL CELL TECHNOLOGY



Design and production of high-power fuel cells



Power supply



Maritime



Rail

RENEWSTABLE®, OUR FLAGSHIP SOLUTION FOR NON-INTERMITTENT RENEWABLE ENERGY

MULTI-MW HYDROGEN POWER PLANT
DELIVERING BASELOAD ELECTRICITY, DAY & NIGHT,
AND ESSENTIAL GRID SERVICES

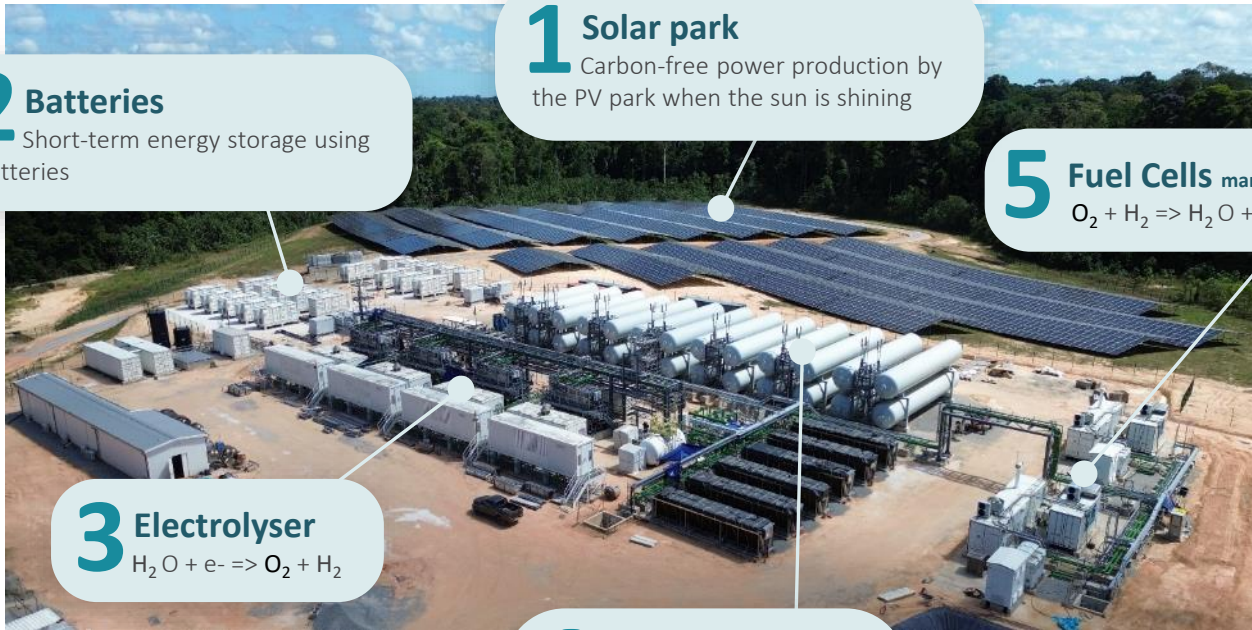
2 Batteries
Short-term energy storage using
batteries

1 Solar park
Carbon-free power production by
the PV park when the sun is shining

5 Fuel Cells manufactured by HDF
 $O_2 + H_2 \Rightarrow H_2O + e^-$

3 Electrolyser
 $H_2O + e^- \Rightarrow O_2 + H_2$

4 Hydrogen Storage
Long-term H_2 based mass
energy storage



KEY BENEFITS

ENSURE BASELOAD PROFILE

- Power profile guaranteed

DELIVER KEY GRID SERVICES

- Sustain grid stability
- Avoid costs of grid expansion

BUILD ENERGY INDEPENDENCE

- Locally produce electricity that is consumed locally
- Reduce dependence on fossil fuel imports

ENSURE COST STABILITY

- Benefit from a stable and competitive set price for 20+ years

BOOST THE LOCAL HYDROGEN ECONOMY

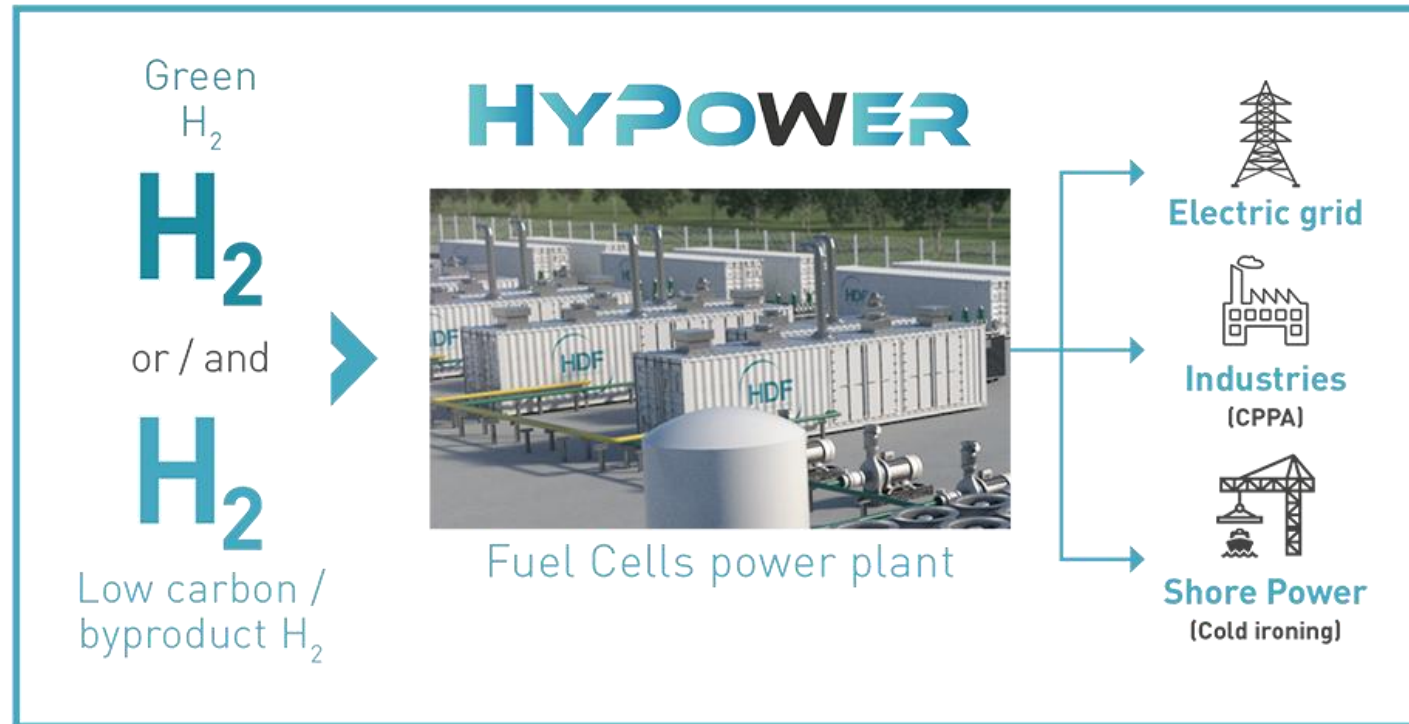
- Create local jobs and develop hydrogen skills

OTHER INFRASTRUCTURE MODEL

HYDROGEN-to-power solutions

ON-DEMAND 24/7 PRODUCTION OF LOW-CARBON POWER

H₂ TO POWER



OUR FACTORY IN FRANCE: THE WORLD'S FIRST PRODUCTION PLANT FOR MULTI-MW PEM FUEL CELLS



**Annual production
capacity**
1 GW by 2030



Employees
+500 by 2030



Location
Bordeaux, France



Factory size
7 000 m²
(phase 1)



**Environmental
certification**

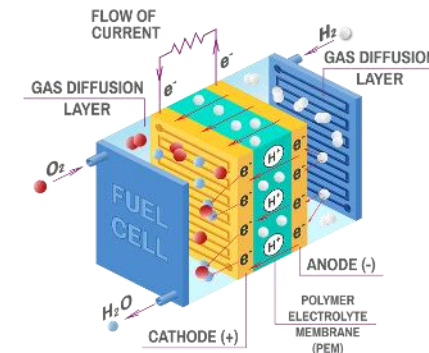
THE WORLD'S LARGEST FUEL CELL SYSTEM DESIGNED FOR ENERGY INTENSIVE APPLICATIONS

HDF ENERGY'S FUEL CELL SYSTEM



- ✓ 1 to 10 MW unit capacity
- ✓ Modular design
- ✓ Emission free
- ✓ Minimal noise pollution
- ✓ 25+ years lifetime
- ✓ Quick start-up and immediate response to fluctuations in power demand
- ✓ Easy maintenance
- ✓ Low operating costs
- ✓ Safety and CE certified

PEM* TECHNOLOGY



- ✓ High power density
- ✓ Mature technology
- ✓ High efficiency (> 50%)
- ✓ Long durability (> 30 000h)

* Proton Exchange Membrane

KEY MILESTONES – FUEL CELL DEVELOPMENT



THE CRITICAL ROLE OF HYDROGEN QUALITY IN LOW-TEMPERATURE PEM FUEL CELLS

Low-temperature PEM fuel cells are **highly sensitive** to **impurities**.

**Hydrogen purity of 99.97% is mandatory
for PEM applications**

Even ppm-level contaminants can permanently damage catalysts and membranes, leading to **irreversible performance loss**.

Impurity	Effect
CO	Causes poisoning of the catalyst (partially reversible if detected earlier)
SOx	Irreversible poisoning of the Pt catalyst
NH3, NOx	Irreversible damage to the membrane's conductivity : stops proton transport in the membrane deactivates it.
Helium, Nitrogen (inert gases)	Reduces performance (mainly H2 partial pressure) but do not cause permanent damage. Just less power production.

Existing norms and standards for hydrogen in PEM fuel cells



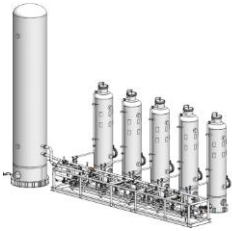
SAE J2719 : Automotive standard, requires maximum purity for mobility applications

ISO 14687 : Defines the minimum quality requirements for hydrogen for use in a wide range of applications and production modes

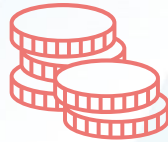
HDF ENERGY'S APPROACH TO ENSURING H2 QUALITY



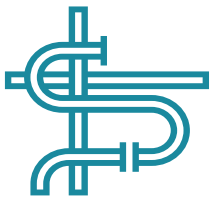
Electrolytic hydrogen – as in HDF Energy's Renewstable projects.



Use of PSA, Pressure Swing Adsorption before introducing hydrogen into HDF Energy's PEM fuel cells.



PSA increases the cost of hydrogen of 2€/kg and leads to an increase in the cost of electricity



Call for the **purest hydrogen possible** in pipelines (99.97%)

Call not to mix different types of hydrogen



Harmonisation of standards :

- Take into consideration the requirements and standards for the different applications
- Recognize that there is **no one-size-fits-all solution**: different applications require different levels of hydrogen purity.

CONTACT

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AND PUBLIC AFFAIRS**

clara.furlan@hdf-energy.com

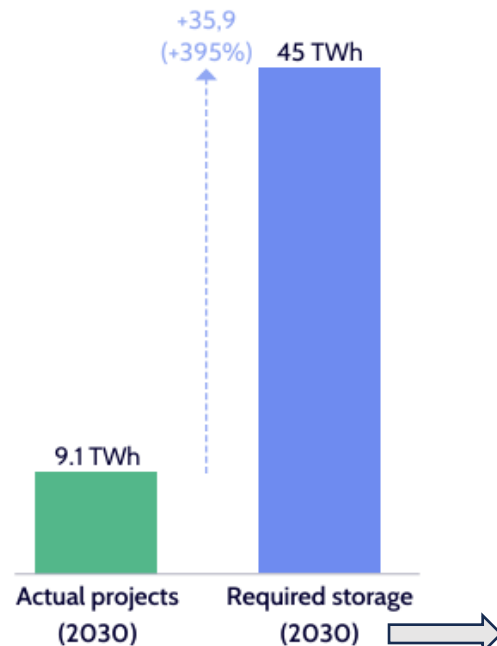
SSOs' perspective on H₂ Quality

Dr. Ulrich Duda, Brussels, February 12th, 2026

Underground Hydrogen Storage in Europe – Expected Demand is Huge

Required H2 storage capacity: Europe > 2030 and beyond

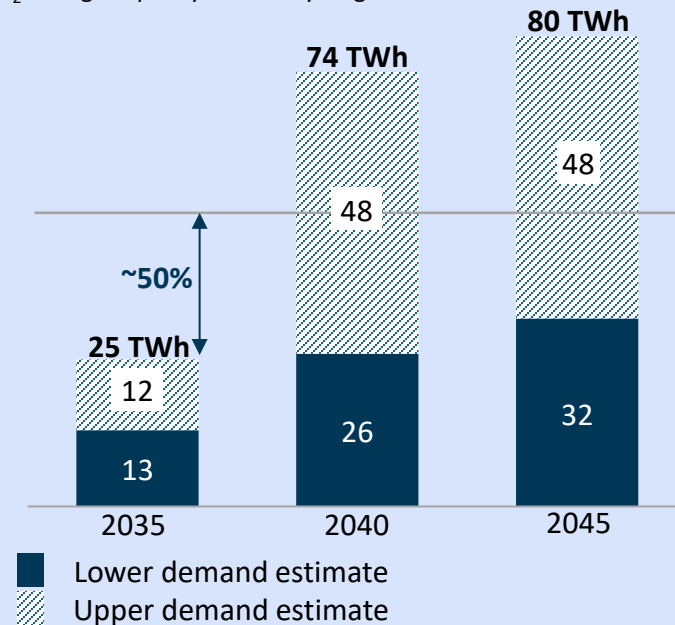
Actual project developments and required UHS storage volume in 2030



Source: Guidehouse / H2heart for Europe

Required H2 storage capacity: Focus Germany

H₂ storage capacity in TWh hydrogen



Existing methane gas storages sites:

- **Porous Rock Facilities:**
92 TWh
➔ 18 TWh H₂ potential
- **Cavern Storage Sites:**
168 TWh
➔ 33 TWh potential

~50 TWh H₂ storage potential in today's gas storages with **full use** for H₂¹

~5 TWh gas storage = 1 TWh H₂ storage

1. Including full use of existing porous storage capacity
Source: BMWK (Weißbuch Wasserstoffspeicher), Nationaler Wasserstoffrat, EWI, INES

Underground Storage in Europe are essential to successfully ramp up H₂-Infrastructure across Europe!

Underground Hydrogen Storage in Europe – Availability is Limited

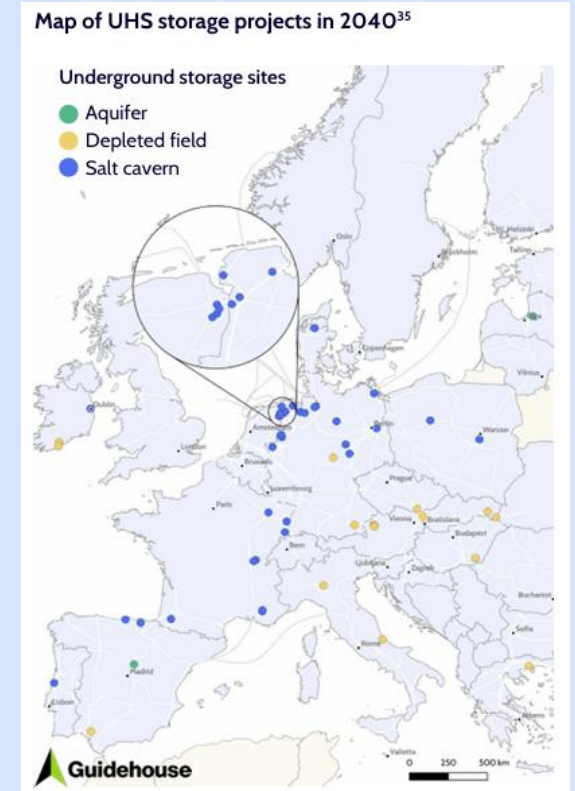
New built or repurposing?

- **Salt cavern storage** locations are mainly concentrated in northern Europe; newbuilt is limited
- **Porous rock facilities** additionally will be needed across Europe
- Conversion and extension of existing sites will drive H2 infrastructure developments along the European core network
- **Repurposed facilities will provide the majority of H2-storage capacities**

H2 storage projects essentially depend on availability of both salt cavern and porous rock facilities across Europe

Repurposing of existing gas storages are primarily for H2 storage development.

- **2035:** ~ 50% of storage capacity needed for H2.
- **From the 2040s:** Required H2 storage capacity likely higher than can be provided by converting the entire gas capacity.



Source: Guidehouse / H2heart for Europe

Challenges of Underground Hydrogen Storage – Implication on Purification Needs

Operational Parameter

Compared to grid operation:

- Higher **pressure range** in surface facilities from ~50 up to >200 bar leads to increased impurities from compressor operations
- Large mass flows/delivery rates to the grid: very **high short term delivery rates** implies design of purification plants
- **Increased hydrocarbon impurities** depending on individual history, cycling and delivery rates
- Pressure/temperature conditions and exposure time increase **chemical reaction with impurities** in subsurface installations

Challenges / Implications

Costs rise with higher purification requirements:

- **Operational parameter require additional purification steps and challenge PSA purification requirements**
- Huge **hydrogen losses** in the form of remaining tail gas
- On site tail gas usage is limited, **transport of remaining tail gas required**
- Purification is required regardless of individual end-user specifications, amplifying **system-wide cost implications**

Limitations:

- **Limited available space and environmental legislation drop out several existing sites to apply PSA purification**

Clear regulatory conditions needed to facilitate the ramp up of UHS

1

Set Realistic & Harmonised Hydrogen Quality Standards:

- Establish purity thresholds that are **technically and economically feasible for SSOs** – especially taking into account **repurposed** storage facilities.
- Promote **EU-wide harmonisation** of hydrogen purity to ensure full system interoperability.

2

Strengthen the Role of SSOs as Key Enablers:

- Recognise SSOs as **central actors** in hydrogen system integration and provide targeted support for their specific constraints (space limitations, environmental conditions, purification requirements).
- Ensure that policy and regulatory frameworks actively **address storage-related challenges**.

3

Enable Transparency & Innovation for Storage Infrastructure:

- Encourage full value-chain **CAPEX/OPEX assessments** to give SSOs reliable inputs for investment decisions.
- Support R&D and pilot activities advancing **innovative storage, purification, and quality-management solutions** relevant for SSOs.

Summary

Role of SSOs in H₂ Quality & Infrastructure

- ✦ SSOs are crucial enablers of **large-volume H₂ storage & system-wide balancing**
- They play a **central role in ensuring consistent H₂ quality** across the entire system while having **specific operational needs** related to purity thresholds and required infrastructure adaptations
- Many storage sites face constraints due to:
 - **Limited available space**
 - **Strict environmental requirements**
 - Locations often in agricultural or protected landscapes
- Additional **purification increases cost** and may be **infeasible** due to missing authorisation and/or space limitations
- Further assessments needed: disproportionately high hydrogen quality standards might lead to system wide cost-increases borne by everyone

Source: GIE Position Paper on Hydrogen Quality Specifications

For more information visit us: <https://www.h2eart.eu/>





ENNOH H₂ Quality Hybrid Workshop

CEN TC 234 / WG 11 “Gas Quality”

Recent activities on hydrogen standardisation

Tobias van Almsick, Convenor WG 11

Hiltrud Schülken, Secretary CEN TC 234

Fenja Severing, Secretary WG 11



Hydrogen standardisation for Europe



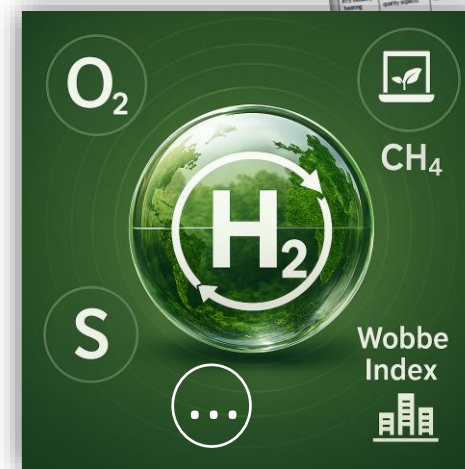
- About 60 CEN and CENELEC Technical Committees involved in hydrogen standardisation along the value chain
- **CEN-CENELEC Coordination Group ,Hydrogen‘ with involvement of European Commission;** Roadmap of European Clean Hydrogen Alliance (ECH2A) gives a basis.

- ***Hydrogen quality is key topic for the whole value chain***
- *The responsible CEN and CENELEC Technical Committee(s) ensure appropriate involvement of all stakeholders*
- *EC Standardisation Request to CEN is awaited*

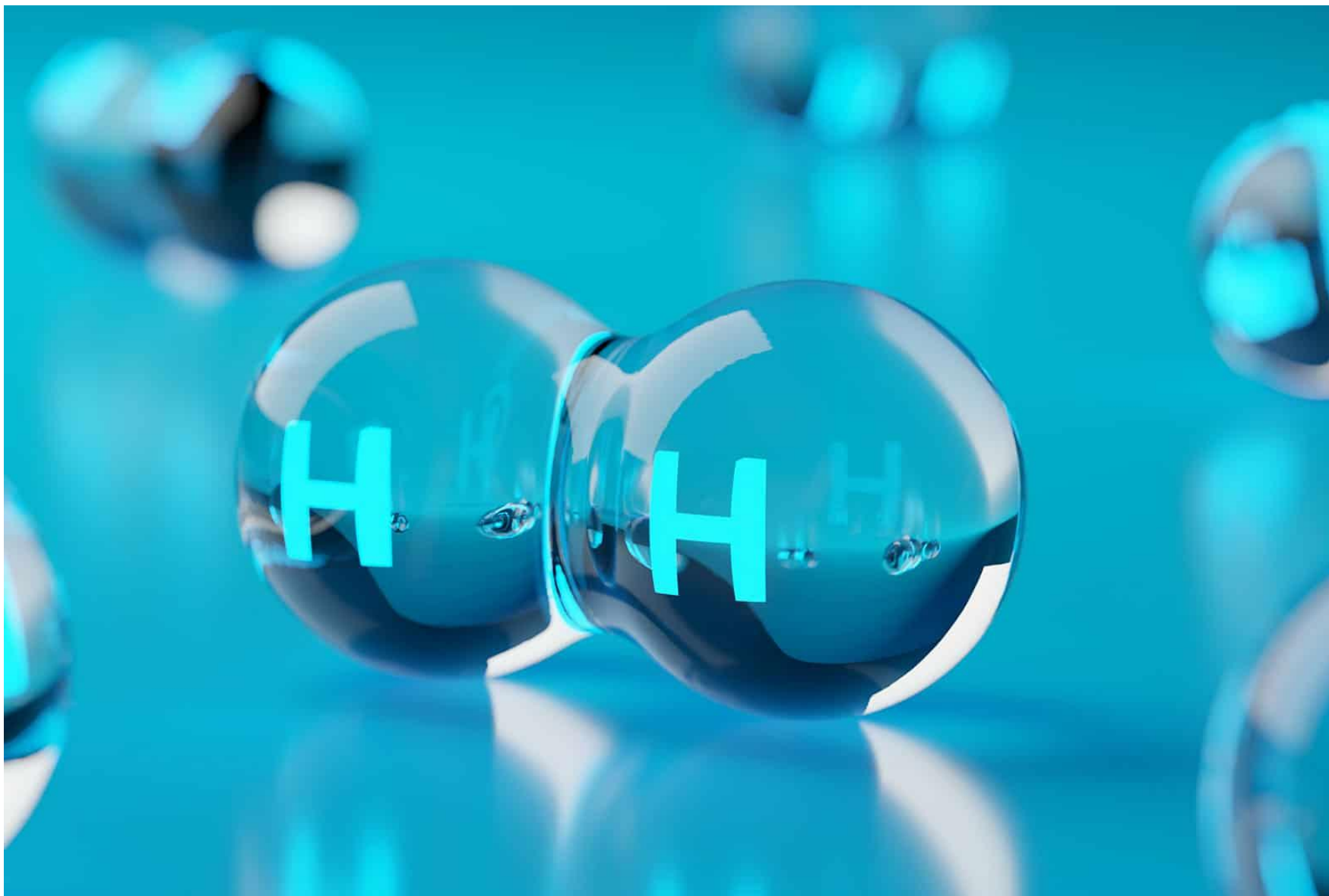


Table A2.1 – Standardisation topics identified by the WU on Standardisation and CEN-CENELEC

Standardisation topic	Standardisation topic details / description	Specific	Actions	Standards	Status of standardisation	Related to	Related to
Hydrogen safety	Hydrogen safety aspects	+	+	to be identified	to be identified	+	+
Hydrogen quality	Hydrogen quality aspects	+	+	to be identified	to be identified	+	+
Hydrogen infrastructure	Hydrogen infrastructure	+	+	to be identified	to be identified	+	+
Hydrogen storage	Hydrogen storage	+	+	to be identified	to be identified	+	+
Hydrogen transport	Hydrogen transport	+	+	to be identified	to be identified	+	+
Hydrogen distribution	Hydrogen distribution	+	+	to be identified	to be identified	+	+
Hydrogen use	Hydrogen use	+	+	to be identified	to be identified	+	+



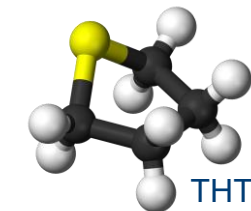
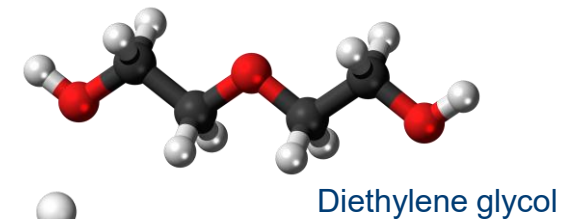
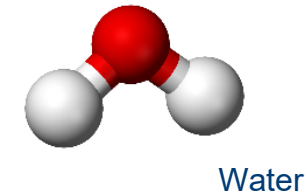
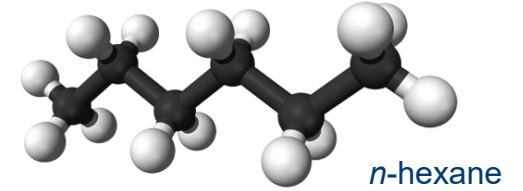
5th Gas Family / Hydrogen



HYDROGEN IS NOT EXCLUSIVELY H₂

- Hydrogen is usually characterized by its **purity level** (concentration of H₂) but it also contains other components
- These **impurities** can find their origin from, amongst other :

Origin		Possible impurities
Production	Electrolysis	Water, oxygen, argon
	Steam reformation + pressure swing adsorption (PSA)	Methane, CO, argon, nitrogen
	Biogenic processes + membrane processes	Water, CO ₂ , methane, sulphur / chlorine / nitrogen compounds
Transmission	Converted natural gas pipelines	Typical associated gas components, condensate components
	Operations and maintenance	Nitrogen
Storage		Water, higher hydrocarbons, glycol



- For many end users, the type of impurities present in the hydrogen matters more than the purity level

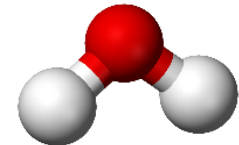
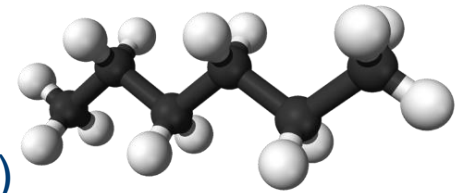
Hydrogen Quality / trace impurities

- Impurities due to gas infrastructure



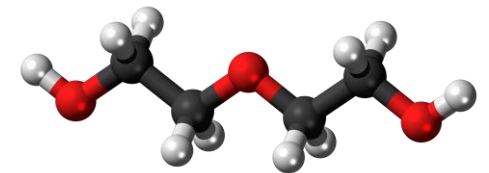
Liquid dropouts

- **Natural gas condensate ($C_5 - C_{13}$)** → originated in natural gas
- **Diesel fraction ($C_{13} - C_{25}$)** → operational (e.g. storages)
- **Lubrication oil** → operational (e.g. compressors)
- **Water** → ubiquitary
- **Glycoles / Amines** → Gas treatment / drying facilities



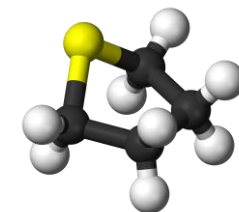
Solid deposits

- **Black Powder** → comprised of iron-oxides / -sulfides
- **Dust, sand** → ubiquitary



Odorization

- **Mercaptanes and THT**
- **Sulfur-free odorization**



National and international codes

	 DVGW- Arbeitsblatt G260 Gruppe A	 Hydrogen network Netherlands SEP22-5	 EASEE-Gas CBP 2022-001/01	 BSI PAS 4444 (UK)
Hydrogen	≥ 98 mol-%	≥ 98 mol-%	≥ 98 mol-%	≥ 98 mol-%
Water	≤ 50 mg/m ³	-8°C from 1 to 70 bar	-8°C from 1 to 70 bar	-10°C from 1 to 70 bar
Oxygen	≤ 1 mol-% ≤ 0,001 mol-%	≤ 0,001 mol-%	≤ 0,001 mol-%	≤ 0,2 mol-%
CO	≤ 0,1 mol-%	≤ 0,002 mol-%	≤ 0,002 mol-%	≤ 0,002 mol-%
CO ₂	-	≤ 0,002 mol-%	≤ 0,002 mol-%	≤ 1 mol-%
Sulfur	≤ 6 mg/m ³	≤ 3 μmol/mol	≤ 21 mg/m ³	≤ 50 mg/m ³

Subject matter experts in Europe have a similar view on gas quality issues:

- 98% purity is seen as the starting point, which is further developed to higher purities
- Outlook is recorded in writing in CEN TS 17977:2023

CEN TS 17977:2023 Gas infrastructure — Quality of gas — Hydrogen used in rededicated gas systems

Table 1 – Quality requirements for hydrogen in rededicated gas networks

Parameter	unit	value	Reference standards for test methods (informative)
Hydrogen	mol-%	≥ 98	DIN 51894
Wobbe Index	MJ/m ³ (15 °C/15 °C)	42,0 – 46,0	EN ISO 6976
The content and composition of the further quality parameter (e.g., sum of inerts) shall satisfy the Wobbe Index value above.			
Water	μmol/mol	≤ 250 ≤ 60 ^a	ISO 21087
Hydrocarbon dew point (HCDP) ^d	°C	< -2 °C at 1 < p < 70 bar	ISO 21087
Sum of inerts (N ₂ , He, Ar)	mol-%	≤ 2	ISO 21087
Gaseous hydrocarbons ^d	mol-%	≤ 2	ISO 21087
Oxygen (O ₂) ^e	mol-% μmol/mol	≤ 0,1 ^b ≤ 10	ISO 21087
Carbon monoxide	μmol/mol	≤ 20	ISO 21087
Carbon dioxide	μmol/mol	≤ 20	ISO 21087

Total sulfur ^d	μmol/mol	≤ 7 ^c	ISO 21087
Ammonia	μmol/mol	≤ 13	ISO 21087
Halogenated compounds	μmol/mol	≤ 0,05	ISO 21087
max. particulate concentration ^d	mg/kg	technically free	ISO 21087
Contaminants	The gas shall not contain constituents other than listed in this table at levels that prevent its transportation, storage and/or utilization without quality adjustment of treatment.		ISO 21087

^a 250 μmol/mol at MOP less or equal to 10 bar, 60 μmol/mol at MOP over 10 bar

^b max. 0,1 Mol-% in grids with no exit point to UGS or to sensitive customers, otherwise max. 10 μmol/mol

^c non odorised hydrogen

^d these components most likely have their source in the previous use of the pipework

^e rolling 24 h average

In addition to the contaminants featured in Table 1, the hydrogen shall not contain any constituents that can impede safety or the integrity of the infrastructure and/or of gas appliances and operations of end-users. Appropriate measures shall be taken.

NOTE 2 Applications are sensitive towards variation of the gas quality depending on the type of application and the degree of variation.

- Conservative approach – due to lack of practical knowledge
- Transition phase – will be subject to revision in future times
- Quite likely to be more strict with the parameters in future times

Shift from rededicated infrastructure => dedicated infrastructure

Controversy over the correct H₂ Quality

- Different stakeholders along the hydrogen value chain are in favour of different quality options.
- Two different approaches are currently being discussed:

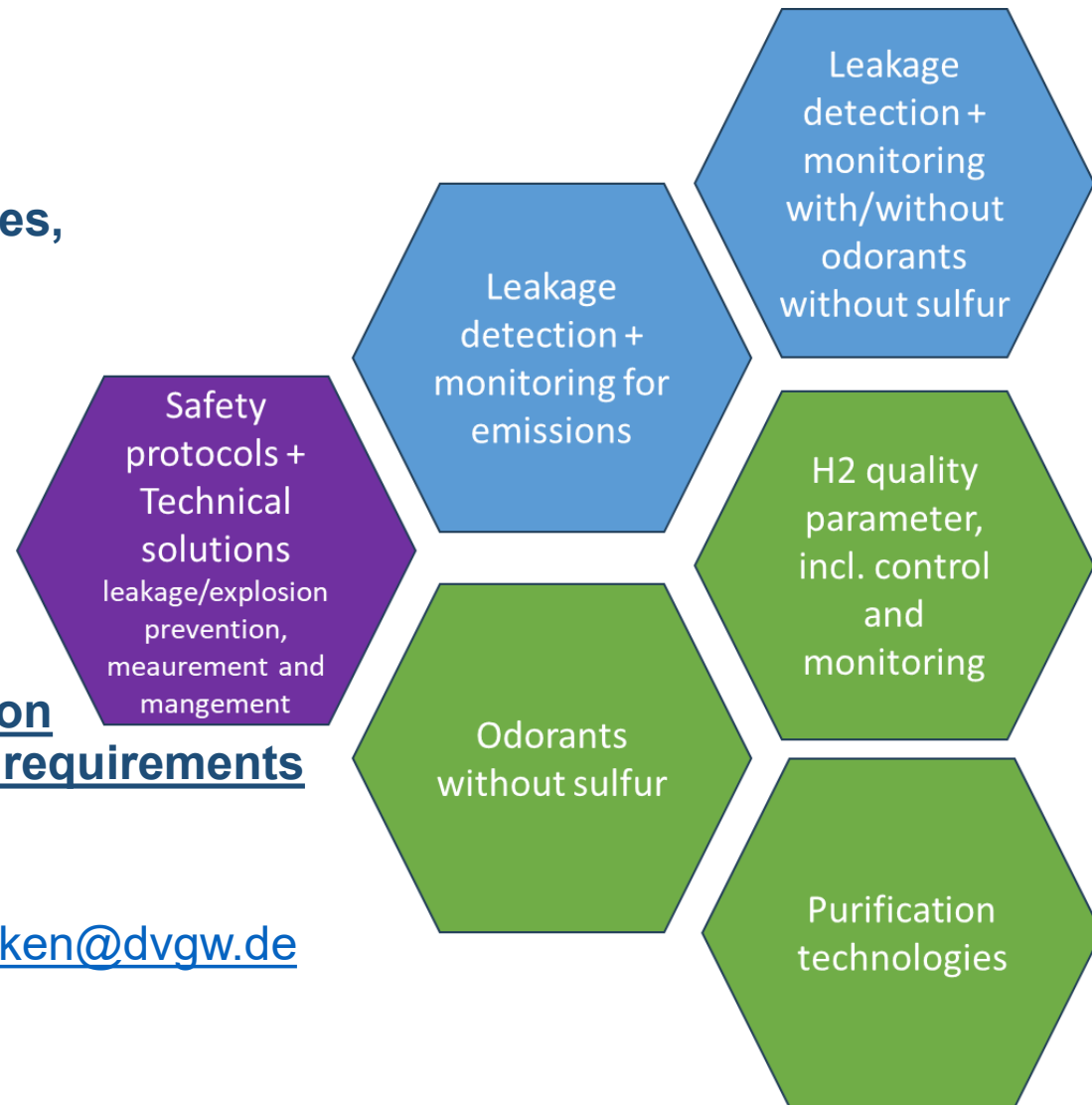
Hydrogen Quality: 98,0%	Hydrogen Quality: 99,5%
• Promoted esp. by storage operators due to several reasons • Sufficient for non sensitive users • Most cost efficient for infrastructure operators	• Promoted by end users and majority of infrastructure operators • Meets requirements of stricter end users • Facilitates market ramp-up.

- **Discussions about the overall economic optimum began. Plenty of stakeholders contributed...**
 - DG ENER report “Study on Hydrogen Quality, Dedicated Infrastructure and Standardisation”
 - EASEE-gas: Optimal hydrogen purity for the European market
 - GIE position paper on “Hydrogen Quality Specifications”
 - Article of 5 TSO with respect to hydrogen quality
 - ...

EISMEA HyQual Net – Hydrogen quality in dedicated gaseous grids – Content and aiming

Expected results:

- **Bundling of technical knowledge** from technical studies, laboratory test and real projects in technical report as input for the project and further CEN-CENELEC standardisation
- **Mapping of existing standardisation** (⇒ Deliverable D3.1 in consultation)
- **Identification of further standardisation needs**
- **Writing of concrete proposal of potential standardisation documents per topic, including scopes and technical requirements** as input for CEN-CENELEC standardisation
- Interest to contribute or to get more information – please contact ines.weller@dvgw.de and/or hiltrud.schuelken@dvgw.de



Timeline: 2025-01-01 to 2026-08-31

EASEE-Gas CBP on Hydrogen Quality

Common Business Practice Hydrogen impurities Components covered



“Real” trace components based on

- Current specifications

Minor components in the CBP

- Inerts
- Higher hydrocarbons

Components not covered in the CBP

- Hydrogen
- Methane



NWIP on Hydrogen Quality

- DG ENER report suggests a plurality of standardization items
- **WG 11 takes the initiative to prepare a NWIP:**

Gas infrastructure – Quality of gas – Hydrogen

- Definition of Wobbe-Index and trace components
 - EASEE-GAS CBP on H₂ Trace Components serves a basis
 - *Not covering: hydrogen purity*

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