OVERVIEW OF AVAILABLE TEST RESULTS* AND REGULATORY LIMITS FOR HYDROGEN ADMISSION INTO EXISTING NATURAL GAS INFRASTRUCTURE AND END USE

*ACCORDING TO THE LIST OF REFERENCES

marcogaz
TECHNICAL ASSOCIATION
OF THE EUROPEAN NATURAL GAS INDUSTRY

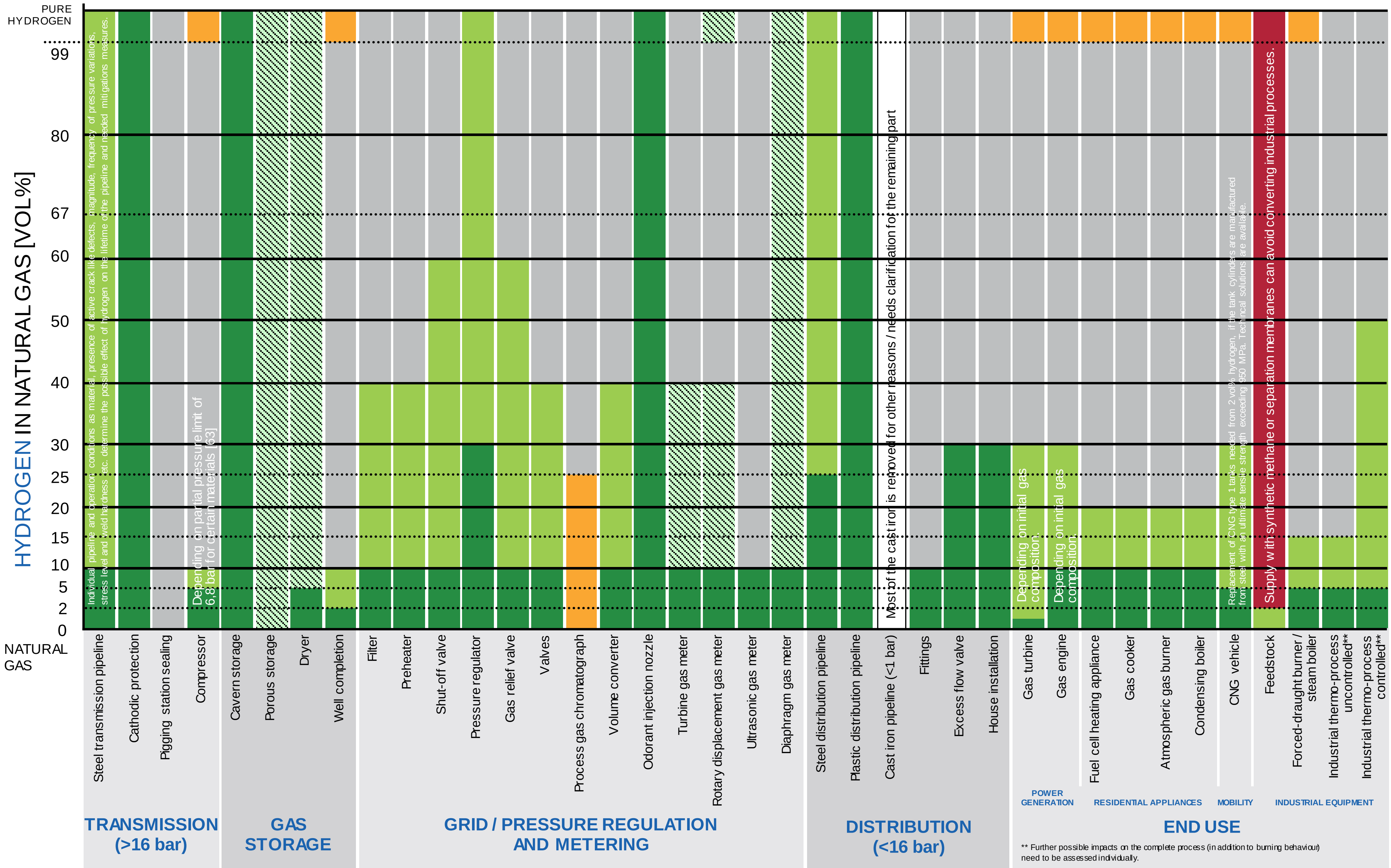
01-10-2019 - TF_H2-427

OVERVIEW OF AVAILABLE TEST RESULTS* AND REGULATORY LIMITS FOR HYDROGEN ADMISSION INTO THE EXISTING NATURAL GAS INFRASTRUCTURE AND END USE

- No significant issues in available studies*.
- Mostly positive results from available studies*. Modifications/ other measures may be needed.
- Technically feasible, signifcant modifications/ other measures or replacement expected.
- Currently not technically feasible.
- Insufficient information on impact of hydrogen, R&D required.
- Conflicting references were found, R&D/ clarification required.

This assessment is based on information from R&D projects, codes & standards, manufacturers and MARCOGAZ members expertise.
The assessment applies to segments in isolation. Any decision to inject hydrogen into a gas infrastructure is subject to case by case investigation and local regulatory approval.

*According to the list of references.



Purpose of infographic

- The properties of Hydrogen (H_2) are different to those of natural gas. Mixtures of hydrogen and natural gas (H_2NG) have different properties than the two individual gases. This raises the question of the suitability of the existing natural gas infrastructure and end uses equipment for utilizing such mixtures.

This infographic aims to:

- Provide an overview of the technical readiness of the gas infrastructure and end uses equipment to handle hydrogen-natural gas mixtures at each stage of the gas chain. The infographic currently focuses on material aspects and functional principles It does not consider the effect of increasing levels of hydrogen on performance, efficiency and output.

- Identify gaps in knowledge and areas where R&D is required to remove barriers that limit hydrogen uptake in the supply chain and enabling new applications for hydrogen and H_2NG.

- Collect and assess the most up-to-date knowledge on the use of hydrogen and H_2NG based on evidence and experience from gas network & storage operators and end use experts.

- Collect and appraise the current state of knowledge of transmission, storage, distribution and use of H_2NG and hydrogen, drawing on the wide expertise and experience of network operators, storage operators and end use experts.

- Assist with the investigation into the opportunities with the existing gas infrastructure to achieve the best benefits and contribute to reaching climate goals.

Summary

- MARCOGAZ members with experience in operating gas infrastructure or involved in pertinent research have reviewed more than 60 references on the hydrogen tolerance of the existing gas infrastructure and end use applications.

Natural gas infrastructure and residential appliances:

- Major elements of the gas transmission, storage and distribution infrastructure and residential gas appliances are expected to be able to accept 10 vol.-% H_2 without modification.

- Some networks and residential appliances are already being operated with 20 vol.-% of hydrogen [62].

- Major elements of the infrastructure and residential appliances are expected to be able to accept 20 vol.-% H_2 with modification*.

- Higher concentrations (> 20 vol.-% H_2) can be reached through R&D by further measures or replacement.

Industrial processes:

- Many industrial processes (except feedstock) are expected to be able to accept 5 vol.-% H_2 without modification.

- Current power plant gas turbines, industries using natural gas as feedstock and also CNG steel tanks are assessed to be sensitive to even small quantities of hydrogen and need further R&D/mitigation measures when planning to convey higher hydrogen concentrations.

- Thermoprocessing equipment (such as furnaces and burners) are expected to be able to accept 15 vol.-% H_2 with modifications*.

- Higher concentrations (> 15 vol.-% H_2) can be tolerated through R&D, further measures or replacement.

* According to the studies listed in the references.

Next steps

- To enable hydrogen concentrations in the range of 5 to 10 vol.% H_2, R&D is recommended to understand the effect on underground gas storage, gas turbines, process equipment in the chemical industry using natural gas feedstock and steel tanks for CNG vehicles.

- To exceed hydrogen concentrations of 10 vol.-% H_2 in addition to the topics mentioned before, special R&D focus is required on gas transmission issues including pipelines and compressors. Underground gas storages (including well completion and the suitability of porous rock structures) should also be investigated. In addition, metering devices and industrial gas use need to be addressed.

- R&D for residential appliances is especially recommended for hydrogen concentrations above 20 vol.% H_2 as well as to understand the impact of varying hydrogen concentrations in general. A few cases are expected where R&D will be recommended for hydrogen concentrations above 10 vol.% H_2.

- Further focus should be put on the development of retrofit solutions for existing installed appliances to allow them to handle hydrogen / natural gas mixtures.

- Mitigation technologies, such as membranes and methanation, used to reduce hydrogen concentration in gas grids exist. They are considered to be very important to protect sensitive equipment and processes and can be installed beforehand Further R&D is recommended in such cases.

- Further R&D does not mean that the equipment is not suitable for use with hydrogen / natural gas mixtures or that no modification measures are currently available. Rather, it reflects the need for innovation to develop new opportunities with the aim of obtaining the maximum benefit from the existing infrastructure.

Additional Explanation

- Equipment in the gas infrastructure, underground gas storages and end use are diverse and have different life/usage times. Nevertheless, all equipment needs to be renewed at the end of its useful economic life.
  This is a continuous process that naturally offers the opportunity to install optimised and more future-proof equipment. Hence renewal cycles should be used to increase the tolerance of the gas infrastructure and end uses to higher hydrogen concentrations.

- For many current installed end-use applications, the presence of hydrogen in natural gas is a relatively new topic. Given the wide variety of end-uses across all sectors (residential, commercial, industry, power generation and mobility), R&D activities are required to investigate the impact of higher levels of hydrogen and to develop technology solutions for “hydrogen readiness”. The aim is to maintain highest levels of performance in terms of efficiency, fitness for purpose, flexibility and low-pollutant emissions that these appliances and applications have achieved over the last decades.

- Sensitive end use equipment could require the use of digital reproduction systems, local gas quality measurement and appropriate control technology.

References

The assessment is based on public and non-public information R&D projects, Codes & Standards as well as manufacturer and MARCOGAZ member expertise. Due to the large number of references, these are summarised in a list below.

Contact

MARCOGAZ
Rue Belliard, 40
1040 Brussels
Belgium

phone: +32 2 786 30 74
www.marcogaz.org

marcogaz
TECHNICAL ASSOCIATION
OF THE EUROPEAN NATURAL GAS INDUSTRY

List of references

	Reference	Accessibility	Source Type	
[1]	Feedback from valve manufacturer.	Non-public	Communication	DE
[2]	Bütler, T. et al: Vehicle investigation on Hydrogen/Compressed Natural Gas mixtures (HCNG, 2 Vol.% H2). Empa, Automotive Powertrain Technologies Laboratory, 2015.	Public (Free available)	Paper	EN
[3]	Nony, F. ; Mazabraud, P. ; Foulc, M.P.; Thomas, C.; Pocachard, J.; Morel, B.; D. Alincant, D. (CEA): Report on the effect of H2 on polymers - Effect on the ageing of PE discs. NATURALHY, 2008.	Non-public	Report	EN
[4]	Nony, F. (CEA): Study of hydrogen ageing of ductile PVC pipes. NATURALHY, Januar 2010.	Non-public	Report	EN
[5]	CeH4 technologies GmbH: Persönliche Kommunikation, September 2017.	Non-public	Communication	DE
[6]	Feedback CEOCOR.	Information by MARCOGAZ partners	Communication	EN
[7]	Chen, Y. et al: Emissions of automobiles fueled with alternative fuels based on engine technology: A review. School of Automobile, Changán University China, 2018.	Public (Free available)	Paper	EN
[8]	ckd-dichtungstechnik. [Online] 12. 09 2018. http://www.ckd-dichtungstechnik.de/download/medienbestaendigkeit.pdf.	Public (Free available)		DE
[9]	Müller-Syring, G.; Henel, M. (DBI GUT); Köppel, W. (EBI); Mlaker, H. (E.ON); Sterner, M. (IWES); Höcher, T. (VNG): Entwicklung von modularen Konzepten zur Erzeugung, Speicherung und Einspeisung von Wasserstoff und Methan ins Erdgasnetz. DVGW, Bonn, 2012.	Public (Free available)	Report	DE
[10]	Müller-Syring, G.; Henel, M. (DBI GUT): Wasserstofftoleranz der Erdgasinfrastruktur inklusive aller assoziierten Anlagen. DVGW, Bonn, Februar 2014.	Public (Free available)	Report	DE
[11]	Krause, H.; Werschy, M.; Franke, S. (DBI); Giese, A.; Benthin, J. (GWI); Dörr, H. (EBI): Untersuchung der Auswirkungen von Gasbeschaffenheitsänderungen auf industrielle und gewerbliche Anwendungen. DVGW, Bonn, April 2014.	Public (Free available)	Report	DE
[12]	Krause, H. (DBI GUT); Giese, A. (GWI); Dörr, H. (EBI); Brückner, H.J. (INNOFACT): Hauptstudie zur Analyse der volkswirtschaftlichen Auswirkungen von Gasbeschaffenheitsschwankungen au die Sektoren des Gasverbrauchs und deren Kompensation. DVGW, Bonn, November 2016.	Public (Free available)	Report	DE
[13]	DBI expert knowledge from unpublished industry projects	Non-public	Expertise	DE
[14]	Iskov, H: Field test of hydrogen in the natural gas grid. Dansk Gasteknisk Center (DGC), Hørsholm, 2010.	Public (Free available)	Report	EN
[15]	DGC input component overview	Information by MARCOGAZ partners		EN

marcogaz
TECHNICAL ASSOCIATION OF THE EUROPEAN NATURAL GAS INDUSTRY

	Reference	Accessibility	Source Type	
[16]	European Committee for Standardization (CEN): Gas-fired heating boilers - Part 1: General requirements and tests. EN 15502-1:2015-06, June 2015.	Public (Purchasable)	Technical standard	EN
[17]	European Committee for Standardization (CEN): Gas-fired heating boilers - Part 2-1: Specific standard for type C appliances and type B2, B3 and B5 appliances of a nominal heat input not exceeding 1 000 kW. EN 15502-2-1+A1:2016-12, December 2016.	Public (Purchasable)	Technical standard	EN
[18]	Deutscher Verein des Gas- und Wasserfaches (DVGW): Gasbeschaffenheit. Technische Regel - Arbeitsblatt G 260, Januar 2000.	Public (Purchasable)	Technical standard	DE
[19]	Schley, P.; Wolf, D. (E.ON Technologies); Henel, M.; Schreck, H.; Müller-Syring, G. (DBI GUT); Fiebig, C.; Span, R. (RUB): Einfluss von Wasserstoff auf die Energiemessung und Abrechnung. DVGW-Forschungsprojekt G 3-02-12, 2014.	Public (Free available)	Report	DE
[20]	European Industrial Gases Association (EIGA): Hydrogen Pipeline Systems. IGC Doc 121/14, 2014.	Public (Free available)	Report	EN
[21]	Eßbach, R.; Müller-Syring, G.: Effect of H2 on the materials for inner grids (task 3.4), NaturalHy, January 2009	Non-public	Report	EN
[22]	Eustream_ component_overview_181017_vs_1	Information by MARCOGAZ partners		EN
[23]	Gestock Entrepose: Stockage souterrain de gaz naturel de Wuustwezel (Loenhout); April 2019	Information by MARCOGAZ partners	Report	FR
[24]	FRAZER-NASH Consultancy: Appraisal of Domestic Hydrogen Appliances, Februar 2018	Public (Free available)	Report	EN
[25]	Gasunie: VA-180558-rev1-position-paper-H2-pipelines	Information by MARCOGAZ partners		EN
[26]	Leicher, J., Nowakowski, T, Giese, A., Görner, K.: Hydrogen in natural gas: how does it affect industrial end users?, World Gas Conférence2018, June 2018	Public (Free available)	Report	EN
[27]	Scholten, K. (GWI), Dörr, H. (EBI) und Werschy, M. (DBI): Mögliche Beeinflussung von Bauteilen der Gasinstallation durch Wasserstoffanteile im Erdgas unter Berücksichtigung der TRGI. DVGW, Bonn, Februar 2018.	Public (Purchasable)	Report	DE
[28]	Hermkens, R. J. M.; Colmer, H.; Ophoff, H.A.: Modern PE Pipe Enable the Transport of Hydrogen, Proceedings of the 19th Plastic Pipe Conference, September 2018	Public (Free available)	Paper	EN
[29]	van den Noort, A.; Joeroen Dirven, G.; Müller-Syring, G.: Engineering guidelines - For the preparation of natural gas systems for hydrogen/NG mixtures, HyReady, Juli 2018	Non-public	Paper	EN
[30]	Joos, F.: Technische Verbrennung - Verbrennungstechnik, Verbrennungsmodellierung, Emissionen. Springer-Verlag, Berlin, 2007.	Public (Purchasable)	Book	DE

	Reference	Accessibility	Source Type	
[31]	Korb, B. et al.: Influence of hydrogen addition on the operating range, emissions and efficiency in lean burn natural gas engines at high specific loads. Tokyo : s.n., 2015.	Public (Purchasable)	Paper	EN
[32]	Linke, G.: Hydrogen integration in natural gas grids, Brussels 2018.	Public (Free available)	Presentation	EN
[33]	Jentzsch, M. F.; Büttner, S.: Dezentrale Umsetzung der Energie- und Verkehrswende mit Wasserstoffsystemen auf Kläranlagen, gwf-gas 6/2019, 2019	Public (Free available)	Paper	DE
[34]	MARCOGAZ: 18-03-28 MARCOGAZ- injection of H2 EASEE-gas GMOM Budapest 2018	Public (EASEE-gas website)		EN
[35]	MARCOGAZ: WG_STO-160-Hydrogen - WG Storage input for TF Hydrogen	Information by MARCOGAZ partners		EN
[36]	MARCOGAZ: UTIL-GQ-17-29-Impact of hydrogen in natural gas on end-use applications	Public (Free available)	Paper	EN
[37]	MARCOGAZ: WG_DIS-135-Renewable gases_WG distribution	Information by MARCOGAZ experts		EN
[38]	MARCOGAZ: WG_GM-126-GI-GM-17-43_working document_non conventional gases	Public (EC website)		EN
[39]	MARCOGAZ: WG_TP-147-Preliminary report on H2 - Transmission	Information by MARCOGAZ experts		EN
[40]	MARCOGAZ: WG-STO-16-08-Injection of hydrogen/natural gas admixtures in Underground Gas Storage (UGS)	Public (Free available)	Paper	EN
[41]	MARCOGAZ: TF_H2-341-GASUNIE-Memo on Hydrogen and pig trap installations---VA-190168-H2-pig	Information by MARCOGAZ partners	Communication	EN
[42]	MEDENUS Gas-Druckregeltechnik GmbH: Persönliche Kommunikation, September 2017.	Non-public	Communication	DE
[43]	Mischner, J.: Netzplanerische Aspekte der Wasserstoffeinspeisung in Erdgasnetze. Präsentation, DVGW-Jahrestagung, 2013.	Public (Purchasable)	Presentation	DE
[44]	Mischner, J.; Fasold, H.-G.; Heymer, J.: gas2energy.net - Systemplanerische Grundlagen der Gasversorgung. Deutscher Industrieverlag GmbH, 2015.	Public (Purchasable)	Book	DE
[45]	EU Project NATURALHY, Reliability of domestic gas meters, 2009.	Non-public	Report	EN
[46]	Nitzsche, J.: Auswirkungen von Wasserstoff auf die Emissionen von Erdgas-BHKW vor dem Hintergrund der TA-Luft Novellierung. Freiberg, DBI Gastechnologisches Institut gGmbH, Freiberg, 2017.	Public (Free available)	Report	DE
[47]	Pasini, S.: Fusina: Achieving low NOx from hydrogen combined-cycle power, POWER ENGINEERING INTERNATIONAL, Januar 2010	Public (Free available)	Paper	EN
[48]	Pietro Fiorentini S.p.a.: Persönliche Kommunikation, September 2017.	Non-public	Communication	DE

	Reference	Accessibility	Source Type	
[49]	Pietsch, P.: Einfluss von Wasserstoffanteilen im Erdgas auf Bauteile der Gasinstallation. DBI-Gastechnologisches Institut gGmbH, Freiberg, 2017.	Public (Free available)	Report	DE
[50]	Underground Sun.Storage: Publizierter Endbericht, Oktober 2017.	Public (Free available)	Report	DE
[51]	Schütz, S.; König, J.; Glandien, J. (DBI); Weßing, W.; Gollanek, S. (E.ON): Permeationsuntersuchungen an Kunststoffrohren. gwf Gas+Energie 9/2017	Public (Purchasable)	Paper	DE
[52]	SNAM: Gas Turbine World Marzo Aprile 2018 - Gas Turbines runs on 30 per cent hydrogen	Information by MARCOGAZ experts	Paper	EN
[53]	SNAM: component_overview_181017 REV Snam	Information by MARCOGAZ experts		EN
[54]		Information by MARCOGAZ partners	Communication	EN
[55]	Staffell, I.; Scamman, D.; Velazquez Abad, A.; Balcombe, P.; Dodds, P. E.; Ekins, P.; Shah, N.; Ward, K.R.: The role of hydrogen and fuel cells in the global energy system, The Royal Society of Chemistry Energy & Environmental Science, 2019	Public (Free available)	Report	EN
[56]	Steiner, K.; Wolf, D.; Mozgovoy, A.; Vieth, D.: Einfluss von Wasserstoff auf die Hochdruckfehlerkurve von Erdgaszählern. gwf-Gas, Mai 2013.	Public (Purchasable)	Paper	DE
[57]	Wortel, H. v.; Gomes, M.; Demofonti, G.; Capelle, J.; Alliat, I.; Chatzidouros, E.: Durability of Steels for Transmission Pipes with Hydrogen, NATURALHY report, WP-3, report No. R0096 WP3-C-0, deliverable D32, 2009.	Non-public	Report	EN
[58]	Eichhorn, A.; Rehmer, K.-P.: Roadmapstudie Wasserstoffkaverne - Lokation Bad Lauchstädt, UGS GmbH, Dezember 2014.	Non-public	Report	DE
[59]	de Vries, H. Mokhov, A.; Levinsky, H.: The impact of natural gas/hydrogen mixtures on the performance of end-use equipment: Interchangeability analysis for domestic appliances. V 208, 2017, Bd. Applied Energy, 2017.	Public (Purchasable)	Paper	EN
[60]	H. Krause, M. Werschy, A. Giese, J. Leicher, H. Dörr: „Untersuchungen der Auswirkungen von Gasbeschaffenheitsänderungen auf industrielle und gewerbliche Anwendungen“, Phase II, 14.12.2018, DVGW-Förderkennzeichen G2/01606	Public (Purchasable)	Presentation	DE
[61]	European Committee for Standardization (CEN/TC): Domestic cooking appliances burning gas. Safety. General, EN 30-1-1:2008+A3:2013-06, June 2013	Public (Purchasable)	Technical Standard	EN
[62]	Boivnet, Xavier: A Dunkerque, GRHYD injecte 20% d'hydrogène dans le réseau de gaz naturel, 12.06.2019, Industries et Technologies	Public (Free available)	Paper	FR

marcogaz
TECHNICAL ASSOCIATION
OF THE EUROPEAN NATURAL GAS INDUSTRY

	Reference	Accessibility	Source Type	
[63]	American Petroleum Institute (API): API Standard 617 - Axial and Centrifugal Compressors and Expander-compressors, September 2014	Public (Purchasable)	Technical Standard	EN
[64]	European Committee for Standardization CEN/TC 234: Gas Infrastructure - Consequences of hydrogen in natural gas infrastructure - (TC Roadmap), September 2019	Non-public	Working document	EN