July 2021

Use of heaters and controls with hydrogen admixtures

Statement of the figawa project group on hydrogen

Introduction

If the climate protection strategy of the Federal Republic of Germany is followed, 85% of the primary energy currently used (i.e. 12,779 PJ - approx. 1,900 PJ or just under 15% of energy consumption was covered by renewable energies in 2020) must be substituted by climate-neutral energy or efficiency gains by 2050. A significant share of this substitution can be covered in perspective and in an economic way by hydrogen and other climate-neutral gases.

A successful heating transition is the most important prerequisite for the success of the energy transition. More than 50% of the energy used in Germany is used to heat and cool the buildings in which we live and work or as heat in trade and industry. Heating transition means a gradual reduction of heat demand and replacement by renewable energies while avoiding waste heat losses wherever possible. The transition from natural gas to renewable gases plays an important role in this.

The figawa member companies are meeting this challenge with their technological and scientific expertise along the entire value chain.

HYDROGEN ADMIXTURE OF 20% TO NATURAL GAS AND 100% HYDROGEN

Gas appliances and gas controls are currently approved in accordance with the Gas Appliances Regulation EU/2016/426, applying/considering the corresponding standards. These standards do not yet contain any requirements for use with hydrogen mixtures. Operation with hydrogen of the currently tested and certified devices and controls no longer leads to operation as intended.

Hydrogen admixtures (20% by volume) and 100% hydrogen are included in the future devel-

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opment of the corresponding product standards. In addition, the gas industry has experience from the past. For example, city gases or coke gases contained hydrogen contents of approx. 50-60 vol%.

Based on research projects and the published final reports as well as other publications, we can say that the majority of gas controls are suitable for the use of hydrogen admixtures to methane of 20 %. This statement also applies to various components in gas distribution and gas installation. We will also accompany and observe the projects starting in the future in order to make statements for higher hydrogen admixtures to natural gas. Based on research projects that have been started, we are currently working out whether the majority of installed gas heating equipment is suitable for use with hydrogen admixtures of 20 % to methane.

Attachment: Literature list

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figawa – Association of Companies for Gas and Water Technologies, Cologne, is the technical-scientific association of manufacturing and service companies in the gas, water and media supply industry. Its goals are to establish high standards of quality, safety and hygiene, to establish efficient testing and approval processes for these technologies, and to create legal certainty for manufacturers, installers, operators and consumers.
For more information, visit www.figawa.org.

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Literature list

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Seq.-Nr.	Title	Authors	Publisher	Topics	Year	Availability	Labeling	Source type	Link
1.	**Wasserstoff in Transport- und Verteilnetzen**	Henel, M.;Knorr, C.; Pischko, R.	Vulkan Verlag	Hydrogen, natural gas network, gas mixture, analysis system, plastic pipes	2020	not public (available for purchase)		Paper	https://www.vulkan-shop.de/wasserstoff-im-transport-und-verteilnetz
2.	**H2-Tauglichkeit des Ferngasnetzes der Open Grid Europe**	Blick, D. S.; Schmücker, A.	Vulkan Verlag	Status, required adjustments and roadmap for implementation	2020	not public (available for purchase)		Paper	https://www.gwf-gas.de/produkte/2009-gwf-gaserdgas-ausgabe-11-2009-1/
3.	**PAS 4444 - Hydrogen-fired gas appliances. Guide**		BSI	Hydrogen, Gas appliances, Safety, Performance, Construction	2020	not public (available for purchase)	ISBN 978 0 539 03457 8	Standard	https://shop.bsigroup.com/ProductDetail?pid=000000000030389165
4.	**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	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 H2NG. - Collect and assess the most up-to-date knowledge on the use of hydrogen and H2NG 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 H2NG 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	2019	public (freely available)	TF_H2-427	Infographic	https://www.marcogaz.org/publications-1/documents/

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5.	**Approval requirement 214 - Fitness for admixtures up to and including 100% hydrogen gas (GASTEC QA approval requirement)**		Kiwa Nederland B.V.	Valves, Regulators, Maximum flow rate safety valves, gas stopper materials: PE80, PE100, PCV-A, PVC-CPE, NBR, POM, Nodular cast iron, Copper/ copper alloys, Carbonsteel (St 37/235, ASTM A106 gr B, API 5L gr B), Stainless steel (AISI 316 sorts), Aluminium alloys, Methacrylate Ester adhesive	2019	public (freely available)	AR 214	Technical Report	https://www.kiwa.com/nl/en/products/hydrogen-has-the-future-new-approval-requirement-ar-214/ke-214-_2019_en.pdf
6.	**Gasdruckregelung für Wasserstoff bis 16bar**	Zander, D.	Medenus Gas-Druckregeltechnik mbH	Aluminum alloys in gas pressure control up to 16 bar	2019	public (freely available)		Paper	https://www.medenus.de/files/upload/downloads/wasserstoff/medenus-wasserstoff-gasdruckreglung-de.pdf
7.	**Mögliche Beeinflussung von Bauteilen der Gasinstallation durch Wasserstoffanteile im Erdgas unter Berücksichtigung der TRGI**	Scholten, K. F.; Dörr, H.; Wersch, M.	DVGW Deutscher Verein des Gas- und Wasserfaches e. V Technisch-wissenschaftlicher Verein	Gas installation in the building, components of the gas infrastructure	2018	not public (available for purchase)	DVGW G 201615	Final report	https://www.dvgw-regelwerk.de/plus/?desktop=1#technische-regel/dvgw-abschlussbericht-g-201615/640d56
8.	**Hydrogen in Natural Gas : How does it affect industrial endusers?**	Leicher, J.; Nowakowski, T.; Giese, A.; Görner, K.;	World Gas Conference 2018, Washington DC	Impact of hydrogen admixture on industrial combustion processes	2018	public (freely available)	Session: RD&I: 6. (TIC) What's hot in gas research – utilization technologies and environmental footprint	Conference Paper	https://www.researchgate.net/publication/326199589_Hydrogen_in_natural_gas_how_does_it_affect_industrial_end_users
9.	**Appraisal of Domestic Hydrogen Appliances**	Frazer-Nash Consultancy	Department of Business, Energy, & Industrial Strategy	Technical review of domestic gas appliances - Description of domestic gas appliances - Impact of appliances of converting hydrogen - Technology readiness - R&D Gaps Appliances' development options Market Development	2018	public (freely available)	FNC 55089/46433RIssue 1	Report	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/699685/Hydrogen_Appliances-For_Publication-14-02-2018-PDF.pdf

10.	**Toekomstbestendige gasdistributienetten**	Hermkens, R.; Jansma, S.; van der Laan, M.; de Laat, H.; Pilzer, B.; Pulles, K.	Netbeheer Nederland	Use of Hydrogen, Distribution of Hydrogen (e.g. Materials); Effects of and measures for introducing hydrogen into existing gas networks Annexes: Main materials present in the gas distribution network; Composition of hydrogen; Influence of hydrogen on the distribution network; Compositions of sustainable gases in the future-proof gas network; Influence of biomethane on the distribution network; Permeation; Calculation of maximum acceptable concentration	2018	public (freely available)	004P00090 9	Technical Report	https://www.netbeheernederland.nl/_upload/Files/Toekomstbestendige_gasdistributienetten_133.pdf
11.	**Einfluss von Wasserstoffanteilen im Erdgas auf Bauteile der DIN EN 746-2**	Pietsch, P.; Wiersig, M.; Werschy, M.;	DBI - Gastechnologisches Institut gGmbH Freiberg	Fuel line systems in flow direction starting with the main shut-off valve	2018	not public (access to be clarified with DBI?)		Final report	-
12.	**Einfluss von Wasserstoffanteilen im Erdgas auf die Bauteile der Gasinstallation**	Werschy, M.; Pietsch, P.	DBI - Gastechnologisches Institut gGmbH Freiberg	The following connection techniques and sealing materials were tested with a leakage test gas: - Press connections according to DVGW G 5614 (DBI) - Detachable smooth pipe connections according to DIN 3387-1 (DBI) - Teflon sealing tape - Thread adhesive - Sealing materials FKM, FPM, HNBR	2017	not public (access to be clarified with DBI?)		Final report	-
13.	**Untersuchungen zur Einspeisung von Wasserstoff in ein Erdgasnetz - Auswirkungen auf den Betrieb von Anwendungen im Bestand, auf Gas-Plus-Technologien und auf Verbrennungsregelungs strategie**	Dörr, H., Kröger, P., Nitschke-Kowsky, P., Senner, J., Tali, E., Feldpausch-Jägers, S.	DVGW Deutscher Verein des Gas- und Wasserfaches e. V Technisch-wissenschaftlicher Verein	practical laboratory tests - Experiments on basic types of flames, on combustion control systems, commercial gas appliances and gas-plus technologies with up to 30% hydrogen by volume content in natural gas as well as a field test in the grown existing area of Klanxbüll / Neukirchen for hydrogen feed-in - A total of 171 gas appliances of various types at 164 customers were measured. The appliance field mainly consisted of condensing boilers and circulating water heaters. In addition to stoves, forced draught burners and low-temp appliances, a gas engine micro CHP unit was also found.	2016	not public (available for purchase)	DVGW G 201205	Final report	https://www.dvgw-regelwerk.de/plus/#technische-regel/dvgw-Final report-g-201205/0de1ea
14.	**Sicherheitstechnische Eigenschaften von Erdgas-Wasserstoff-Gemischen**	Schröder, V.; Askar, E.; Tashqin, T.; Habib, A.K.	BAM Bundesanstalt für Materialforschung und -prüfung	Effects of hydrogen additives to natural gas on the required explosion protection - Safety characteristics of hydrogen-natural gas mixtures according to the standards in force in Europe and - safety assessment of deviations of H2/CH4 mixtures from natural gas	2016	public (freely available)	Forschungsvorhaben 2539	Final report	https://www.bgetem.de/redaktion/arbeitssicherheit-gesundheitsschutz/dokumente-und-dateien/brancheninformationen/energie-und-wasserwirtschaft/gasversorgung/Final report-zum-forschungsvorhaben-2539-sicherheitstechnische-eigenschaften-von-erdgas-wasserstoff-gemischen

15.	**CEN - CENELEC Sector Forum Energy Management / Working Group Hydrogen**	Weidner, E.; Honselaar, M.; Ortiz Cebolla, R.; Gindroz, B.; de Jong, F.	CEN / CENELEC; European Commission; Netherlands Standardization Institute	Need for Standardization and Pre-normative Research for - Task Force 1 Electricity grid connection - Task Force 2 Electrolysers - Task Force 3 Natural Gas system and usage (H2NG) [Gas system (Gas infrastructure equipment and devices; Gas infrastructure installations and other components) Grid integrity; Grid operation; Separation, H2NG End-users (Residential appliances, gas turbines, Industry) - Task Force 4 Hydrogen System and usage - Task Force 5 Cross cutting issues	2016	public (freely available)	EUR 27641EN;10.2790/66386	Final report	https://publications.jrc.ec.europa.eu/repository/bitstream/JRC99525/sfem%20wg%20hydrogen_final%20report%20%28online%29.pdf
16.	**Wasserstofftoleranz der Erdgasinfrastruktur inklusive aller assoziierter Anlagen**	Müller-Syring, G.; Henel, M.	DVGW Deutscher Verein des Gas- und Wasserfaches e. V Technisch-wissenschaftlicher Verein	Investigations of: Long-distance gas pipelines, gas turbines, compressor stations, cavern storage tanks / pore storage tanks, completion techniques / above-ground systems, spherical, tubular storage tanks and tanks, gas meters, volume correctors, process gas chromatographs, gas pressure control systems, pipelines for gas distribution made of steel, pipelines for gas distribution made of plastic, seals, membranes / connections, gas flow monitors / fittings / domestic installations, natural gas filling stations, natural gas vehicles: CNG1 tanks, natural gas vehicles: engines, cogeneration units, atmospheric burners, forced draught burners / large burners / condensing boilers, gas stoves, fuel cells, Stirling engines	2014	public (freely available)	DVGW G10212	Final report	https://www.dvgw.de/medien/dvgw/forschung/berichte/g1_02_12.pdf
17.	**Hydrogen Pipeline Systems**		EIGA European Industrial Gases Association AISBL	Materials: Copper based alloys, Nickel base alloys, Stainless steel alloys, Cobalt alloys, Non-ferrous alloys, Ferrous alloys, Microalloyed steels, ... Topics: Design philosophy; Piping, valves and equipment; Cleaning, Construction; Design and construction of stations; Operation and Monitoring; General protective measures	2014	public (freely available)	IGC Doc 121/14	Technical publication	https://www.eiga.eu/index.php?eID=dumpFile&t=f&f=2532&token=17b3cf7479e0b3ebf9a602a522c7be5b25aa5f22
18.	**Entwicklung von modularen Konzepten zur Erzeugung, Speicherung und Einspeisung von Wasserstoff und Methan ins Erdgasnetz**	Müller-Syring, G.; Henel, M.; Köppel, W.; Mlaker, H.;Sterner, M.; Höcher, T.	DVGW Deutscher Verein des Gas- und Wasserfaches e. V Technisch-wissenschaftlicher Verein	Feeding hydrogen into the natural gas grid - state of the art and need for research	2013	public (freely available)	DVGW 10710	Management Summary and Final report	https://www.dvgw.de/medien/dvgw/forschung/berichte/g1_07_10.pdf
19.	**Admissible hydrogen concentration in natural gassystems**	Altfeld, K.; Pinchbeck, D.	DIV Deutscher Industrieverlag GmbH	Admixtures of 10% H2 in natural gas systems - Study topics - Combustion of different gases (Wobbe Index, Methane number, laminar flame speed) - Noncritical aspects - Sensitive components (e.g. specific gas burners in the domestic sector; leak detection, ...)	2013	public (freely available)	gas for energy 03/2013 ISSN 2192-158X	Paper	https://www.gerg.eu/wp-content/uploads/2019/10/HIPS_Final-Report.pdf

20.	**Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues**	Melaina, M. W.; Antonia, O.; Penev, M.	NREL - National Renewable Energy Laboratory, a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.	Benefits of blending, Extent of the U.S. Natural Gas Pipeline Network, Impact on End-Use Systems, Safety, Material Durability and Integrity Management, Leakage, Downstream Extraction	2013	public (freely available)	NREL/TP-5600-51995	Technical Report	https://www.energy.gov/sites/prod/files/2014/03/f11/blending_h2_nat_gas_pipeline.pdf
21.	**Technical Reference for Hydrogen Compatibility of Materials**	San Marchi, C.; Somerday, B.P.	Sandia National Laborities	Materials: Plain Carbon Ferritic Steels, Low-Alloy Ferritic Steels, High-Alloy Ferritic Steels, Austenitic Steels, Aluminum Alloys, Copper Alloys, Nickel Alloys, Nonmetals (Polymers)	2012	Public (freely available) - Unlimited Release	SAND2012-7321	Report	https://www.sandia.gov/matlsTechRef/
22.	**Field Test of Hydrogen in the Natural Gas Grid**	Iskov, H.; Backmann, M.; Nielsen, H.P.	18th World Hydrogen Energy Conference 2010 - WHEC 2010	Test and analysis from former pipelines - polymer pipe (Distribution) - steel gas transmission pipeline (Transmission) - determination of compatibility problems between polyethylene pipes and hydrogen under long term exposure - dynamic testing and analysis of the steel pipes from the gas transmission grid	2010	public (freely available)	Parallel Sessions Book 1: Fuel Cell Basics / Fuel Infrastructures	Conference Paper	http://juser.fz-juelich.de/record/135367/files/HI1_pp_Isk_Iskov_rev0426.pdf
23.	**Review of Hydrogen Use in Natural Gas Distribution Systems**	Zhou, Z.; Ersoy, D.	NREL - National Renewable Energy Laboratory, a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.	Overview - Natural Gas Distribution Network in US; Life Cycle Assessment; safety; Leakage Assessment; Durability; Integrity; End-Use Hydrogen Separation; Impacts (Environmental and Macroeconomic Benefits)	2010	public (freely available)	GTI PROJECT NUMBER21029 Apendix A to Technical Report "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues"	Technical Report	https://www.energy.gov/sites/prod/files/2014/03/f11/blending_h2_nat_gas_pipeline.pdf

24.	**Existing Natural Gas Pipeline Materials and Associated Operational Characteristics**	Schmura, E.; Klingenberg, M.	U.S. Department of Energy - DOE Hydrogen Program	Analyze natural-gas infrastructure in the United States Parameters that will influence the feasibility of co-transporting hydrogen and natural gas	2005	public (freely available)	FY 2005	Report	https://www.hydrogen.energy.gov/pdfs/progress05/v_g_1_schmura.pdf
25.	**Safety Standard for Hydrogen and Hydrogen Systems, Guidelines for Hydrogen System Design, Material Selection, Operations, Storage and Transportation**	NASA National Aeronautiv and Space Association	NASA National Aeronautiv and Space Association	- BASIC HYDROGEN SAFETY GUIDELINES - PROPERTIES AND HAZARDS OF HYDROGEN - MATERIALS FOR HYDROGEN SERVICE - HYDROGEN FACILITIES	1997		NSS 1740.16	Report	https://www.energy.gov/sites/prod/files/2014/03/f11/871916.pdf