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Hydrogen quality for blending with natural gas

Technical recommendations

June 2022

Contact

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ABOUT MARCOGAZ

Founded in 1968, MARCOGAZ represents 28 member organisations from 20 countries. Its mission encompasses monitoring and policy advisory activities related to European technical regulation, standardisation and certification with respect to safety and integrity of gas systems and equipment, rational use of energy as well as environment, health and safety issues. It is registered in Brussels under number BE0877 785 464.

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1. Executive summary

Hydrogen is seen as a key enabler in the EU decarbonisation strategy for reaching the proposed 2050 targets. Hydrogen, as minimum, should allow for storage of intermittent renewable energy and can be used as a fuel for applications that are hard to electrify.

For doing this, the European gas industry is mobilized in:

- retrofitting the natural gas infrastructures for blending of hydrogen in natural gas as an intermediate solution, and
- repurposing existing natural gas pipelines into dedicated hydrogen networks and/or new pipelines for the transport of pure hydrogen, when needed.

MARCOGAZ is supporting these efforts.

Currently (at the time of writing this document), there is no known standard defining the hydrogen quality needed for blending with natural gas or biomethane.

It should be noted that, in the current European framework, main combustion properties (calorific value, Wobbe index, …) and other parameters of the resulting mixture of natural gas and hydrogen should fulfil national regulation/specification for natural gas. This will determine the actual amount of hydrogen to be blended with natural gas.

Anyhow, related to the previous point, it is important to mention that, regarding hydrogen/natural gas blend, the recently published draft *Gas Regulation* (part of the so-called *Gas Package*[1]) released by the European Commission on 15th December 2021, states in its Article 20.1 that *"Transmission system operators shall accept gas flows with a hydrogen content of up to 5% by volume at interconnection points between Union Member States in the natural gas system from 1 October 2025, subject to the procedure described in Article 19 of this Regulation."*

Following a review of the current standards and other national specifications for natural gas, biomethane and pure hydrogen quality, MARCOGAZ proposes technical recommendations on the quality of hydrogen to be blended with natural gas or biomethane.

It is proposed that the *minimum hydrogen content before injection will be 98 mol%,* which is in line with the existing standards and other works in progress on hydrogen quality. The rest of the parameters are similar to the requirement currently in place for natural gas or biomethane. Indeed, the resulting hydrogen/natural gas blend should fulfil the national pipeline natural gas specifications/requirements and any minor/trace components added to the natural gas in conjunction with the hydrogen should respect this.

MARCOGAZ initial recommendation on hydrogen quality for blending proposal could evolve in the future once the hydrogen economy is developed and the market requirements will be clearer and more defined than today.

[1] EU Hydrogen and Gas Market Decarbonisation Package

2. Introduction

Hydrogen is seen as a key enabler in the EU decarbonisation strategy for reaching the proposed 2050 targets. Hydrogen, as minimum, should allow to store intermittent renewable power and to be used as the fuel of application hard to electrify.

At this moment, it is not clear how the hydrogen market/industry will evolve in the short/midterm, being on the table many proposals for distributed or centralized production (from renewable power or other energy sources) as well as hydrogen applications, from back-up power generation to renewable power for utilisation in parallel/instead of natural gas. The same uncertainty applies to the type of transportation/distribution infrastructure needed. It is expected that in parallel with the evolution of the hydrogen economy, many requirements (of any type) will be more defined than today.

The European natural gas industry is mobilized to inject hydrogen into the natural gas system (*blending)*, or to repurpose a part of the infrastructure asset into dedicated hydrogen networks, and MARCOGAZ is supporting this position. In this regard, MARCOGAZ believes that supporting the blending of hydrogen with natural gas (or biomethane) will allow:

- Capitalizing the production of hydrogen from excess of renewable power, that otherwise would be wasted, giving a market exit to this production.
- Reducing electrical grid congestion and curtailment of renewable power by using the excess in hydrogen production.
- In case of minor surplus of hydrogen, avoiding long-distance transportation of it using pressurized containers (tube-trailers).

For doing this, retrofitting of natural gas infrastructures for blending is an intermediate solution and it goes in parallel with repurposing (which represents a fast and cost-effective solution and thereby avoiding stranded assets) and/or building new pipelines for the transport of pure hydrogen when needed.

Currently (at the time of writing this document) there is no known standard defining the hydrogen quality needed for blending with natural gas or biomethane. Several standards related to **pure**[2] hydrogen quality have already been published or are in preparation.

Another point to take into account is that the resulting hydrogen/natural gas blend should fulfil the national pipeline natural gas specifications/requirements and any minor/trace components added to the natural gas in conjunction with the hydrogen should respect this.

Finally, it is important to mention that natural gas quality specification/requirement is defined at national level by EU Member States. Anyhow, regarding hydrogen/natural gas blend, the recently published draft *Gas Regulation* (part of the so-called *Gas Package*[3]) published by the EC [1], states in its Article 20.1 that *"Transmission system operators shall accept gas flows with a hydrogen content of up to 5% by volume at interconnection points between Union Member States in the natural*

[2] Pure hydrogen is not referred to 100% hydrogen but to a high % of it, normally, more than 98%.
[3] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_6682 (at January 2021).

gas system from 1 October 2025, subject to the procedure described in Article 19 of this Regulation."

If the Gas Regulation is finally adopted as proposed in the draft, this will constitute an important support for the hydrogen blending into natural gas systems.

3. Literature review

As mentioned before, there is currently no available standard or specification for hydrogen to be injected into natural gas (or biomethane) networks. However, several (national or international) standards and specifications related to the quality of natural gas or hydrogen exist and can be used as a reference.

Assuming that the hydrogen/natural gas blend should be compatible with the current natural gas network, there are standards stating some quality parameters of natural gas or biomethane that could be a reference regarding the parameters to be fulfilled by the hydrogen. The most important are:

- EN 16726:2015, Gas infrastructure - Quality of gas - Group H [6].
- EN 16723-1:2016, Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network - Part 1: Specifications for biomethane for injection in the natural gas network [7].
- EASEE-gas CBP 2005-001/02, Harmonisation of Natural Gas Quality [5].

On the other hand, several standards and national specifications defining the quality of hydrogen for transportation in repurposed or new built pipelines are already available or in preparation:

- EASEE-gas CBP 2022-001/01, Hydrogen quality specification [8].
- BSI PAS4444:2020, Hydrogen-fired gas appliances. Guide [9].
- DVGW G260, Gas Quality [10].
- CEN TC234 N1362, prTS_WI 00234096 (E) Gas infrastructure — Quality of gas — Hydrogen used in converted/rededicated gas systems [11].
    - New CEN Technical Specification (TS) in preparation by CEN TC234/WG11.

Moreover, it is worth to consider an ISO standard defining the quality of hydrogen as fuel:

- ISO 14687:2019, Hydrogen fuel quality — Product specification [12].

4. Main impact of hydrogen on natural gas quality parameters

Although hydrogen is as fuel gas as natural gas is, there are some significant differences between these two gases. Table 1 shows several properties of hydrogen and methane (as main component of natural gas), highlighting some differences between the two gases.

Parameter	Methane	Hydrogen
Relative density (air = 1)	0.55	0.07
Flammability limits (Mol.-%)	4.4-17	4-77
Ignition energy (mJ)	0.26	0.017
Calorific Value (MJ/m^3)	Gross: 37.8 Net: 34.0	Gross: 12.1 Net: 10.2
Wobbe index (MJ/m^3)	Upper: 54 Lower: 48	Upper: 48 Lower: 41
Molecular mass (g/mol)	16	2
Molecular size (pm)	220	75
Diffusion coefficient in air (10^{-4} m^2/s)	0.61	0.20
Joule-Thomson coefficient (K/bar)	0.4	-0.03
Adiabatic stoichiometric combustion temperature (ºC)	1950	2100
Laminar combustion velocity (cm/s)	38	209
Sound velocity (m/s)	388	1203
Note 1: Calorific Value and Wobbe index are set for the real dry gas at ISO reference conditions of 15°C (combustion) and 15 °C and 101,325 kPa (metering).		

Table 1 – Comparison of some properties of hydrogen and methane (Source: CEN/TC234 [2] & THyGA [3])

Energy

Hydrogen has a volumetric Gross/Net Calorific Value (GCV/NCV) roughly 1/3 of the one of natural gas. For this reason, any volumetric unit of hydrogen/natural gas blend will have a minor energy content than the same volume of pure natural gas. The same occurs with relative density and methane number. As an example, Figure 1 shows the trend in Wobbe index (WI) and GCV (refered in the figure as High Heating Velue, HHV) of mixing different amount of hydrogen (in volumetric base) with a typical natural gas distributed in Europe.

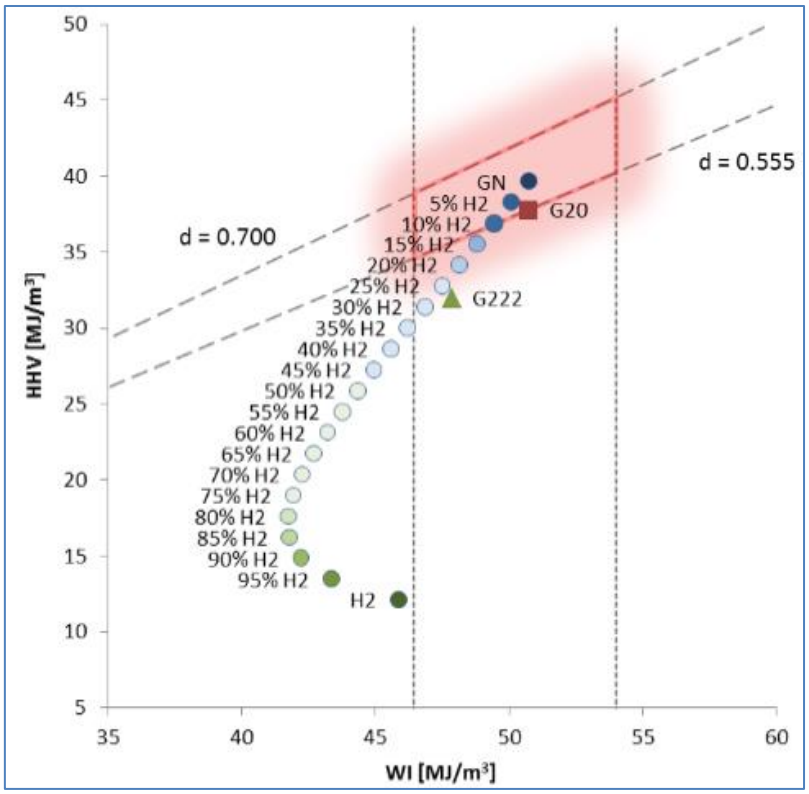

Figure 1 – Effect of hydrogen concentration on Wobbe index (WI) and gross calorific value (HHV) in natural gas (Source: Enagás).

Figure 1 also indicate the WI/HHV of test gases G20 and G222 [4] for reference. Shadow area corresponds to WI range defined in EASEE-gas CBP [5], for reference. GN: Natural gas / HHV = GCV.

Combustion

There are also some combustion properties of hydrogen that are different from those of natural gas and that should be taken into account in the utilisation of the hydrogen/natural gas blend. Without being extensive, it is worth to mention:

- Flame speed: hydrogen flame speed is one order of magnitude higher than the one of natural gas.
- Combustion air requirement: hydrogen needs much less air than natural gas.
- Adiabatic flame temperature at constant air excess ratio. This temperature is higher for 100% hydrogen and for hydrogen blended with natural gas (Figure 2) than for natural gas. This could impact the NOx production in combustion processes if no appropriate mitigation measures are taken.

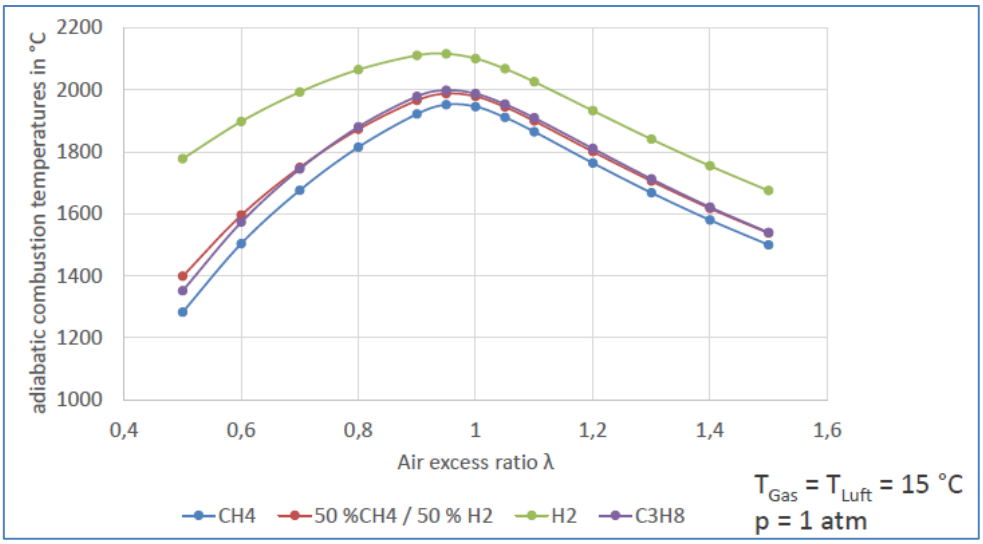

Figure 2 – Effect of air excess ratio in adiabatic flame temperature for different fuels (Source: GWi).

5. Hydrogen quality parameters

In defining the hydrogen quality parameters, the following considerations are taken:

1. The hydrogen quality defined in this document is only for blending with natural gas or bio-methane. A high purity of hydrogen (i.e., as the one needed in fuel cell utilisation) is therefore not needed.
2. Although a high purity is not needed, a minimum purity is recommended in line with current proposals.
3. Main combustion properties (calorific value, Wobbe index, …) and other parameters of the resulting mixture of natural gas and hydrogen should fulfil national regulation/specification for natural gas. This will determine the actual amount of hydrogen to be blended[4] with the natural gas.

Therefore, regarding the specification for hydrogen to be blended with natural gas or biomethane, **MARCOGAZ recommends**:

- A minimum hydrogen concentration of 98 mol% before its injection.
  This hydrogen purity is the same purity as the one of Type I, Grade A quality defined in ISO 14687. It is in line with the proposals made in BSI PAS4444, DVGW G260, EASEE-gas CBP for hydrogen, and the working draft for the CEN TS.

- Regarding to trace component, the hydrogen injected into the natural gas grid must fulfil the values/limits specified in the existing European standards (EN 16726 & EN 16723-1) or national specifications/standards on gas quality (except for GCV, WI, relative density, and methane number).

[4] With the exception of the cross border points between EU Member States if finally new Gas Regulation is approved as proposed in the current draft.

6. Bibliography

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