CEN Sector Forum Gas JWG Pre-normative studies on H-gas quality parameter (SFGas GQS)

SFGas GQS TF1_N 210

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SFG-I and SFG-U joint report

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CEN SFGas GQS — Recommendations and considerations on Wobbe Index aspects related to H-gas — Final report

CEN SFGas GQS - Recommandations et considérations sur les aspects de l'indice de Wobbe liés au gaz H - Rapport final

CEN SFGas GQS – Empfehlungen und Überlegungen zu Wobbe Index Aspekten in Bezug auf H-Gas - Abschlussbericht

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Contents

Foreword

This document has been drafted by the joint WG of the CEN Sector Forum Gas infrastructure and Gas utilisation 'Pre-normative Study on H-gas quality parameters' in an intensive process started in May 2016 with very broad involvement of stakeholders and active support of EC Joint Research Center (JRC). The study started as a reply to the invitation of EC DG Energy to continue to work on the harmonisation of the Wobbe Index aspects to be included in the CEN standard EN 16726 'Gas infrastructure – Quality of gas – Group H'. Wobbe Index is one of the major gas quality parameters.

This document is subject to CEN BT approval to give it a formal status as CEN Sector Forum deliverable and to make it available on the CEN SFGas Websites for interested parties.

CEN Members are invited to acknowledge the character of this document, i.e. as the sectors' technical evaluations and compromises based on comprehensive and controversial experts' exchange and several surveys supporting the inclusion of Wobbe Index aspects in EN 16726 in the context of M/400 and the encouragement of the EC to support the standardisation with pre-normative study.

1 Introduction

This document summarises the outcome of the technical studies on Wobbe index aspects and discussions carried out in the CEN SFGas WG 'Pre-normative studies of H-gas quality parameters' (short CEN SFGas GQS). The studies and considerations resulted in a proposal for inclusion in the standard for H-gas EN 16726:

- a recommendation for an EU WI entry range and
- the requirement of a WI classification system at exit to the end-use applications made.

During the study work, it turned out that this CEN SFGas GQS proposal can only be approved in the standard and implemented in practice if it is embedded in a European legal/regulatory framework (see clause 6)

This report documents and identifies those aspects for which consensus is given and those for which no full consensus could be achieved with the respective reasoning.

This report is drafted according to SFGas GQS TF1/CAG Conclusion 28/2019 made on 2019-12-18, at the moment, when TF1/CAG has considered that further studies would not facilitate or lead to major further developments in the subject. The stakeholder consultation of the document and the related comments treatment contributed constructively to the study

This report is the final report of the current process. It is addressed to:

— CEN/TC 234 Gas infrastructure as basis of revision of EN 16726, according to M/400;

— EC DG Energy as documentation of the further development of the standardisation request under M/400 MANDATE TO CEN FOR STANDARDISATION IN THE FIELD OF GAS QUALITIES (2007-01-16) and as information for any further European legal/regulatory framework;

— any further interested parties.

The aim of this report is to document the Wobbe Index related matters as unambiguously as possible to avoid different interpretations and the repetition of discussions during the standard revision in CEN/TC 234 and/or elsewhere.

NOTE It is noted that almost all CEN/TC 234 WG 11 members have been directly involved in the SFGas GQS process.

2 Context of the CEN SFGas GQS study

Different H-gas quality specifications are given in the EU Member States, in form of national legislation and/or standards or national codes of practice. These could create barriers to trade gas on the internal EU market and could limit the development of renewable and decarbonised gases. At the same time, gas quality and gas quality variations can affect end-use applications in terms of safety, performance and emissions.

Several initiatives have been carried out, like:

— the EASEE-gas Common Business Practice on H-gas Quality at cross-border points of 2005 (CBP 2005-001/02);

— the mandate M/400 of 2007 asking CEN to elaborate a standard on H-gas quality specifications based on a pre-normative study (cf. Gasqual study) on the impact of gas quality on safety, efficiency and environmental performance of residential gas appliances;

— the European network code on Interoperability and Data Exchange (Commission Regulation (EU) 2015/703);

— the European standard EN 16726:2015+A1:2018 (ref. M/400);

— ENTSOG Impact analysis of a reference to the EN 16726:2015+A1:2018 in the European network code on Interoperability and Data Exchange.

EN 16726 was published in 2015 without specifications for Wobbe Index as no consensus could be found while the M/400 mandate clearly identified the Wobbe Index as one of the parameters to be specified.

NOTE 1 The Amendment A1:2018 is adding an A-Deviation to the standard requested by Denmark. An A-Deviation informs about a conflict with national legislation due to which the standard or parts of the standard cannot be applied in a country. It is specified in an informative annex to a European standard.

The Madrid Forum during its meeting of October 2016 encouraged CEN “to carry on the work on finding an agreement on a band for the Wobbe Index, elaborating on the possibility of regional bands, to be included in an updated CEN standard [EN 16726] [...] "

NOTE 2 Although the term 'band' is used in the Madrid Forum Conclusion, in this document term 'range' is used and defined (see 3.1.9).

As a result of a CEN/TC 234 workshop concerning further harmonization of gas quality, a WG was formed as joint WG of CEN Sector Fora Gas Infrastructure and Utilization (CEN SFGas GQS) to study – as a pre-normative task - the impact of identified values of H-gas quality parameters not yet or insufficiently established in EN 16726:2015 on the whole gas chain and on the basis of technical and fact based findings with the purpose of supplying information and recommendations on the parameters in question to CEN/TC 234 for the future revision of EN 16726:2015+A1:2018

The CEN SFGas GQS consists of the representative sector organizations of the different stakeholders along the whole gas chain including end-use and the national mirror committees (see list in Annex E).

The CEN SFGas GQS started its work on the 24th of May 2016. At first, the work was limited to the Wobbe Index of natural gas. It has been extended to the analysis of the impact of renewable and decarbonised gases on the Wobbe Index and the calorific value, complying with the Madrid Forum Conclusion of the 31st MF (October 2018).

In 2018 a dedicated task force Oxygen (TF 3) was formed reviewing the oxygen content specifications due to biomethane injection.

NOTE For several end-use applications (e.g. some industrial firing systems, gas engines or feedstock processes) other gas quality parameters are of similar relevance, e.g. calorific value (CV), methane number (already part of the EN 16726), gas composition, etc.

As far as Wobbe Index is concerned the group decided end of 2019 after a consultation of the involved stakeholder organisations and mirror committees (see Annex D) to document the WI recommendations in this report. The recommendation was developed further and adapted during the drafting of this report.

Finding a unanimous consensus turned out not to be possible, but the recommendations made in this report are supported by the majority of the represented sector organizations.

Ultimately, this work is the outcome of a lot of preceding work, efforts and meetings. All members are thanked for their efforts and valuable contributions. Furthermore, a special word of thanks to the EC's Joint Research Centre for the provision of data and analysis and their helpful advises.

3 Definitions, abbreviations and acronyms

3.1 Definitions

The definitions hereafter have, as only purpose, to allow common understanding of the content of this report.

3.1.1
reference conditions
Reference conditions are necessary to quantify the calorific properties (Wobbe Index, Calorific Value) of a fuel.

Note 1 to entry: Reference conditions: Unless stated otherwise all volumes are given for the real dry gas at ISO standard reference conditions of 15 °C (288,15 K) and 1013,25 mbar (101,325 kPa). Unless otherwise stated all pressures are absolute pressures. Whenever data on the volume, gross calorific value (GCV), energy and Wobbe Index are communicated, it shall be specified under which reference conditions these values were calculated.

Note 2 to entry: In the EU, two reference systems exist which are commonly used. EN ISO 13443 and 14532 defines the reference system with 15 °C as a combustion reference temperature and 15 °C for volume with 1.013,25 mbar as reference pressure, with energy contents given in MJ/m3, while many other documents and national and or European regulations use a reference system with 25 °C as a combustion reference temperature and 0 °C for volume (also with 1,01325 bar as reference pressure). Calorific properties, e. g. CV or WI, can be given as kWh/m^3 as well.
The use of the reference condition 15°C/15 °C is in line with the Mandate M/400. The values in 25 °C/0 °C (kWh) will be indicated in this document, where considered relevant for information (Annex C for conversion factors, based on EN ISO 13443).

Note 3 to entry: In this document, the reference conditions are indicated systematically, even if the agreed ISO reference conditions (15 °C/15 °C) are used.

3.1.1.1
combustion reference conditions
specified temperature T and pressure p at which a fuel is notionally burned

3.1.1.2
metering reference conditions
specified temperature T and pressure p at which an amount of fuel to be burned is notionally determined.

Note 1 to entry: There is no a priori reason for the metering reference conditions to be the same as the combustion reference conditions

[SOURCE: EN ISO 14532, 2.6.1]

3.1.2
shipper
individual or company that contracts with a gathering, transmission or distribution system for transportation of customer-owned natural gas.

[Source: Enbridge Glossary of Terms, modified]

3.1.3
system (gas infrastructure)
means any transmission networks, distribution networks, LNG facilities and/or storage facilities owned and/or operated by a natural gas undertaking, including line pack and its facilities supplying ancillary services and those of related undertakings necessary for providing access to transmission, distribution and LNG;

Note 1 to entry: the term system in this document refers to gas infrastructure, if not further specified (as e.g. for combustion system, control system, classification system)

[SOURCE: Directive 2003/55/EC on common rules for the internal market in natural gas and repealing Directive 98/30/EC Art. 2 (13)]

3.1.4
system operator
private or public organisation authorised to design, construct and/or operate and maintain a system

3.1.5
transmission
the transport of natural gas through a network, which mainly contains high-pressure pipelines, other than an upstream pipeline network and other than the part of high-pressure pipelines primarily used in the context of local distribution of natural gas, with a view to its delivery to customers, but not including supply

[SOURCE: Directive 2003/55/EC on common rules for the internal market in natural gas and repealing Directive 98/30/EC Art. 2 (3)]

3.1.6
transmission system operator'
a natural or legal person who carries out the function of transmission and is responsible for operating, ensuring the maintenance of, and, if necessary, developing the transmission system in a given area and,

where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transport of gas;

[SOURCE: Directive 2003/55/EC on common rules for the internal market in natural gas and repealing Directive 98/30/EC Art. 2 (4)]

3.1.7
distribution
the transport of natural gas through local or regional pipeline networks with a view to its delivery to customers, but not including supply

[SOURCE: Directive 2003/55/EC on common rules for the internal market in natural gas and repealing Directive 98/30/EC Art. 2 (5)]

3.1.8
distribution system operator

means a natural or legal person who carries out the function of distribution and is responsible for operating, ensuring the maintenance of, and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of gas;

[SOURCE: Directive 2003/55/EC on common rules for the internal market in natural gas and repealing Directive 98/30/EC Art. 2 (6)]

3.1.9
application
equipment that utilizes the transported and distributed gas

Note 1 to entry: Some examples of gas applications are: appliances (domestic or commercial), processes (chemical or industrial), power plants, power generation, vehicles, greenhouses etc.

[SOURCE: EN 16726:2015+A1:2018, 3.5]

3.1.10
appliances
'appliances' means appliances burning gaseous fuels used for cooking, refrigeration, air-conditioning, space heating, hot water production, lighting or washing, and also forced draught burners and heating bodies to be equipped with such burners;

[SOURCE: Regulation (EU) 2016/426 on appliances burning gaseous fuels (GAR), Art. 2, (1)]

3.1.11
energy from renewable sources or renewable energy
from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas;

[SOURCE: DIRECTIVE (EU) 2018/2001 on the promotion of the use of energy from renewable sources, Article 2 (1)]

3.1.12
gases from renewable sources or renewable gases
means gases from renewable non-fossil sources, according to 3.1.6.

[SOURCE: DIRECTIVE (EU) 2018/2001 on the promotion of the use of energy from renewable sources. Article 2 (1), modified]

3.1.13
decarbonised gases
no common definition is given. Terminology is subject to manifold initiatives at the moment and coming with the outstanding framework

EXAMPLE gases containing hydrogen and/or ammonia

Note 1 to entry: The term 'renewable and low-carbon gases' is used in the MF conclusion (2019) which addresses the inclusion of the matter in CEN standardisation. In the sense of this document the term low-carbon and decarbonised are considered interchangeable.

3.1.14
Wobbe Index
WI
ratio of the calorific value of a gas per unit volume and the square root of its relative density under the same reference conditions; the Wobbe Index is said to be gross or net according to whether the calorific value used is the gross or net calorific value

[SOURCE: EN 437:2018]

Note 1 to entry: Two fuel gases with the same Wobbe Index will release the same amount of heat in a combustion system, as long as the nozzle pressure and the nozzle diameter remain constant. The gas temperature is assumed to remain constant in this context. The Wobbe Index is the primary gas interchangeability criterion for residential and commercial appliances as well as for some large-scale combustion equipment in industry and power generation.

Note 2 to entry: The Gross Wobbe Index is used in this document.

3.1.15
rate of change (RoC) = speed of change
change of the value of a gas quality property at a location per unit of time.

Note 1 to entry: Nearly instantaneous change in local gas quality is often referred to as 'plug flow'.

3.1.16
range
values between maximum and minimum for a given gas quality property in absolute terms

3.1.17
bandwidth
difference between a maximum and a minimum of a range

3.1.18
entry (point)
point - except interconnection points – at which gas enters a gas transmission or distribution system.

[SOURCE: EN 16726:2015+A1:2018, 3.2]

Note 1 to entry: CEN SFGas GQS TF1 Conclusion 21/2019 foresees the use of definition as given in EN 16726:2015+A1:2018

3.1.19
exit (point)
point at which gas leaves the gas transmission or distribution system for end-use.

Note 1 to entry: A number of connected exit points with the same class in the same topological and geographic region are considered to be a WI exit area.

3.1.20
interconnection (point)
physical point connecting adjacent gas transmission and distribution systems and/or storage systems

[SOURCE: EN 16726:2015+A1:2018, 3.3 modified taken from Regulation (EU) No 984/2013 and modified for purpose]

3.1.21
validity duration
period of time (to be determined) during which the bandwidth and the lower and upper WI values [of the class] are staying the same.

3.1.22
affected user
an end-user whose installation experiences a switch of class.

Note 1 to entry: some affected users might be considered sensitive users, as well

[PMG SG 1-036-21]

3.1.23
adjustment
choosing the settings of a gas appliance or a gas application in such a way that the nominal operational process parameters (e.g. firing rate, air excess ratio, required process temperatures, emission values) and expected lifetime of the system , as prescribed by the manufacturer, are met.

Note 1 to entry: For residential and commercial appliances, this can be done with a reference gas like G20 (pure methane). For industrial and power generation equipment, the adjustment is usually part of the commissioning process and carried out with the locally available gas and the ambient conditions at the time of commissioning. This is called on-site adjustment.

[PMG SG 1-036-21, agreed on 2021-06-26, modified]

3.1.24
gas blending
a deliberate activity of mixing two or more separate gas streams for a specific purpose where a relevant fuel quality criterion (e.g. WI or GCV) of the resulting gas blend is specified. It takes place at specific locations in the network (e.g. a blending station)

[PMG SG 1-36-21]

3.1.25
mitigation measure
any measure in order to avoid, prevent or reduce, significant adverse effects of gas quality changes on the end-user.

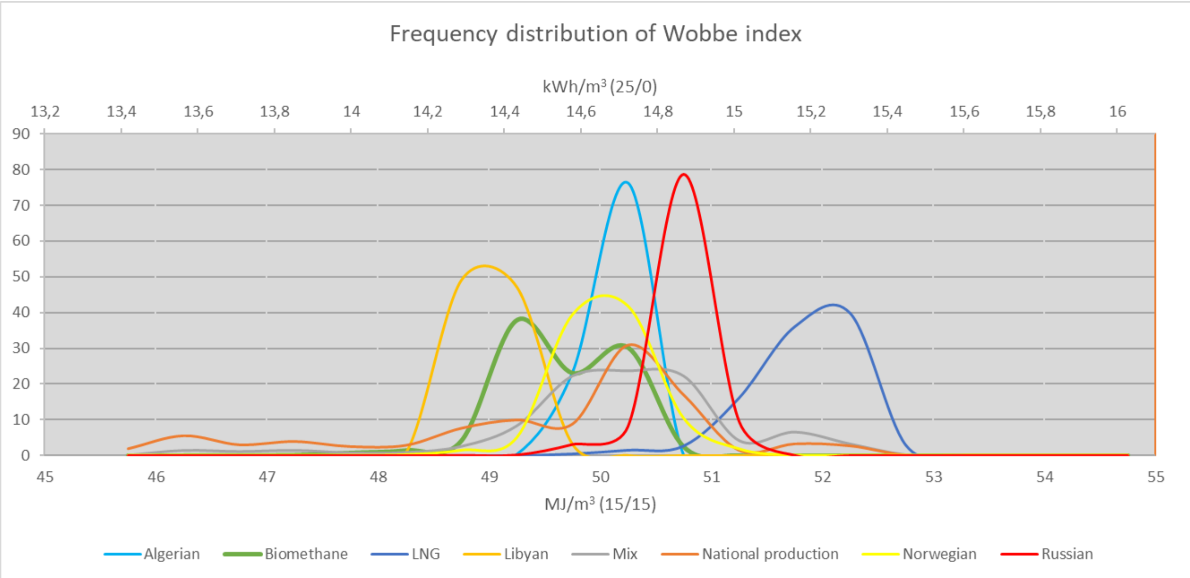
[PMG SG 1-36-21]

3.2 Abbreviations and acronyms

The abbreviations and acronyms used in this document are listed in Annex E (Involved parties) and Annex G.

4 CEN SFGas GQS proposal of Wobbe Index approach – Context and explanations

The WI variation of natural gas produced by one source is quite limited. By consequence, the WI variations at an entry point supplied with gas from a single source is in general quite limited, too. Gas entering the gas grid from gas fields can have a wide range because of several gas fields feeding in on the same pipeline. Figure 1 gives an insight in WI values of different gas sources.



NOTE 1 This figure is only an example for the gas distributed 2015-2016. If the exercise is made for another time period the curves, more specifically of biomethane and indigenous production, could deviate.

NOTE 2 More details on the data is available: https://www.entsog.eu/events/cen-entsog-workshop-on-wobbe-index-and-gross-calorific-value-in-the-european-gas-value-chain#downloads

NOTE 3 The graph does not express the volumes of supply to the European market.

Figure 1 —Frequency distribution of WI ranges of natural gases distributed in EU according to Survey 2 [Source: ENTSOG]

An explanation to this figure is the following:

- The WI of Russian (red line) and Algerian (light blue) gas are pretty stable.

- LNG (dark blue) tends to be more diverse WI-wise, that makes the blue curve flatter and wider.

- National production (orange curve) is extremely varied. Almost all types of gas can be found, though it is more noticeable on the lower end of the band.

The WI range experienced at an entry point depends on the sources it is supplied from (physically connected to). If it is connected to more than one source, the WI at a certain moment will be determined by the mix of gases of the different sources it is supplied from.

Sources can be e.g.: offshore/onshore fields, gas pipelines, LNG terminals, biomethane and hydrogen facilities, underground storage, etc. Underground storage can also experience a wide range in WI depending on the sources delivering gas to the storage.

NOTE The sources used in Figure 1 do not contain hydrogen.

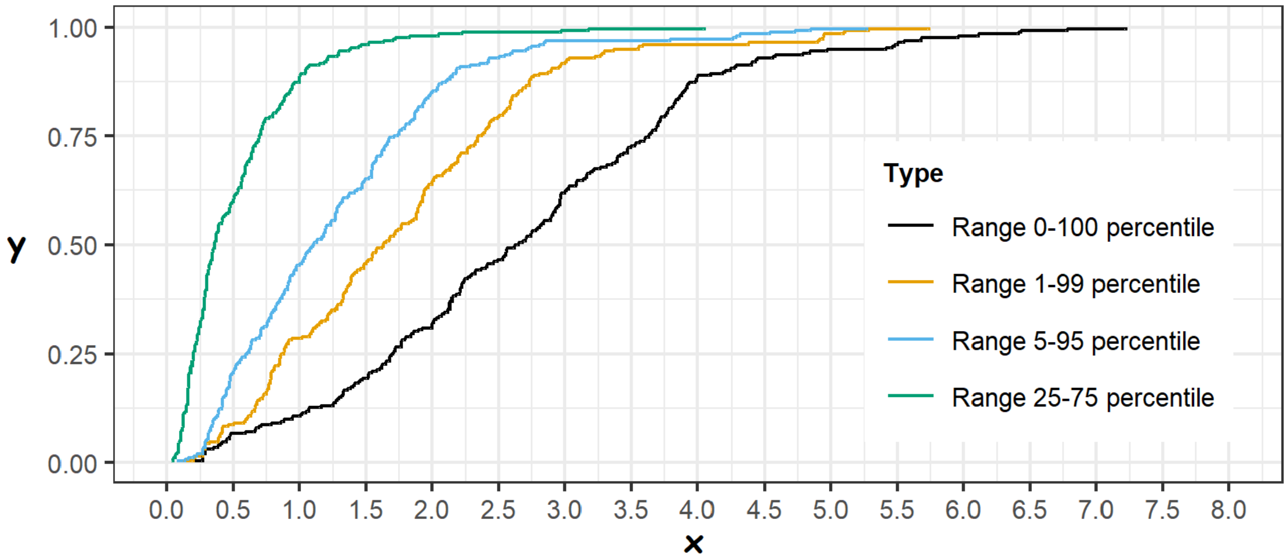
If several fields/sources feed into the same pipeline, the gas transported can experience a range in WI. Sources with e.g. high WI can be mixed with lower WI gases to reduce the WI and blending might even enable delivery of gas that originally is outside the specifications. In upstream transmission systems delivery and production is planned/agreed (months) in advance to maintain a steady gas quality. Quantities at the entry points are decided by the shippers and operated by system operators.

If gas quality from one gas source is off-spec, in some cases, it can be mixed with other sources to be compliant with the specifications (this is mostly done upstream of the transmission network and sometimes downstream).

Survey 2 examined the WI of gases supplied to exit points over the years 2015-2016. The results show that:

— the WI bandwidth experienced at exit points is most often significantly smaller than the bandwidth between the legal min. and max. value for Wobbe Index;

— the WI bandwidth and range is different for different exit points depending on the upstream grid configuration, gas supply sources and demand.



Key

X	Wobbe Index bandwidth (MJ/m^3)
Y	Percentage/10 of the grid points (%/10)

[Source: JRC on Survey 2 data)

Figure 2 — Empirical cumulative distribution function of the Wobbe Index bandwidth for different percentiles for the 252 data sets over 2015-2016 from Survey 2 (see 9.3.1)

Figure 2 shows the Wobbe Index bandwidth for different percentiles indicated by the WI values observed in the time series of 252 grid points. The *Range* indicates the fractions as percentage of the extreme values disregarded:

- For *Range 25-75* the lowest 25% and the highest 25% of the data are disregarded. This means that 50% of the time the measured WI of the gas is within this bandwidth.
- For *Range 5-95* the lowest 5% and the highest 5% of the data are disregarded. This means that 90% of the time the measured WI of the gas is within this bandwidth.
- For *Range 1-99* the lowest 1% and the highest 1% of the data are disregarded. This means that 98% of the time the measured WI of the gas is within this bandwidth.
- For *Range 0-100* no data are disregarded. This the measured WI of the gas is always within this bandwidth.

Considering the *Range 1-99* Figure 3 indicates that 98% of the time the bandwidth of measured Wobbe Index is for

- 60% of the investigated grid points below 1,93 MJ/m^3
- 80% of the investigated grid points below 2,55 MJ/m^3
- 90% of the investigated grid points below 2,90 MJ/m^3
- 95% of the investigated grid points below 3,60 MJ/m^3

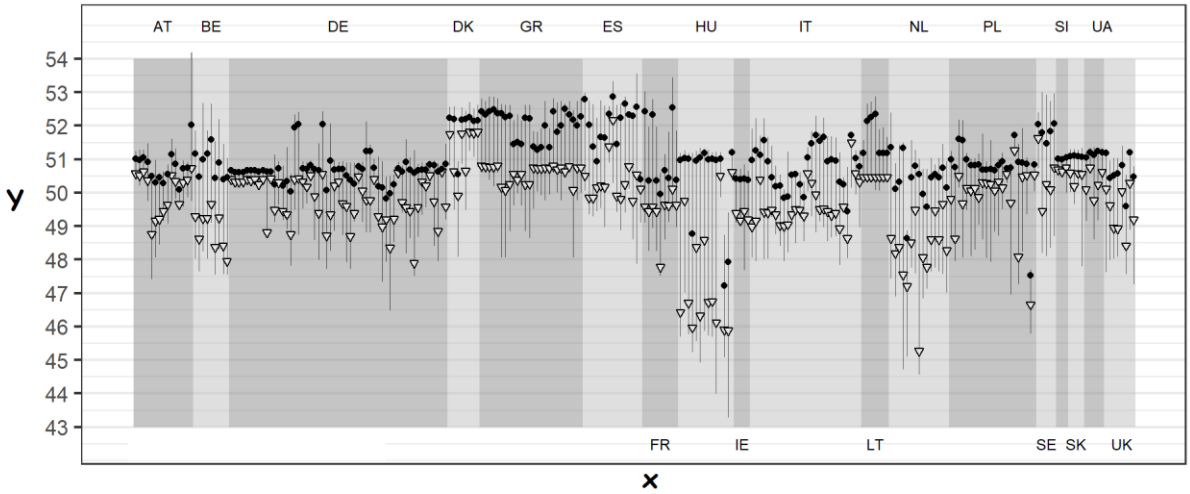
- 98% of the investigated grid points below 5,00 MJ/m³

So for only 5 % of the grid points (that is 10 out of the 252 grid points observed) the measured Wobbe Index is not 98% of the time within a bandwidth of 3,6 MJ/m³. For only 2 % of the grid points (that is 4 out of the 252 grid points observed) the measured Wobbe Index is not 98% of the time within a bandwidth of 5,00 MJ/m³.

NOTE 1 The data refers to a number of (chosen) exit points, and not to percentages of the gas delivered in one country. It was provided during a CEN SFGas GQS survey 2 by ENTSOG members and other market partners on a voluntary basis covering different types of gases and network points with a special focus on transmission system exit points. Both points, with high variability and low variability of gas quality, as reasonably determined by the TSO and other CEN SFGas GQS members have been included.

NOTE 2 Since the collection of data (2015 and 2016) more injection points for biomethane and LNG terminal are built. This development leads to a changing supply situation (biomethane injection / LNG imports) which is expected to widen the local WI bandwidths for some exit points.

In 'Figure 3, the Wobbe Index bandwidth and the 5th to 95th percentile for each of the 252 data sets from survey 2 is given as line chart and by Country (see 9.3.1)



Key

X	Country
Y	Wobbe Index (MJ/m³)
∇	5th percentile
●	95th percentile

[Source: JRC on Survey 2 data)

Figure 3 — Line chart of the Wobbe Index bandwidth and 5th - 95th percentile for each of the 252 data sets from survey 2 by Country

This situation of smaller bandwidths at exit points has been existing for decades but the bandwidth might widen due to diversification of sources (see Figure 4) and the increasing need for interconnection that are driven by

— security of supply and competitiveness and

— injection of renewable and decarbonised gases in the natural gas system in the framework of decarbonisation

Also in case of declining production of indigenous gases in Europe the Wobbe Index bandwidth at exit point can be impacted.

Natural gas as a "natural product" has some innate variation of composition; also gases from different sources will differ in their compositions. At the same time, end users generally prefer or even require stable composition and gas quality for optimum performance.

It is possible that wider bandwidths at the exit points affect the performance of end-use applications.

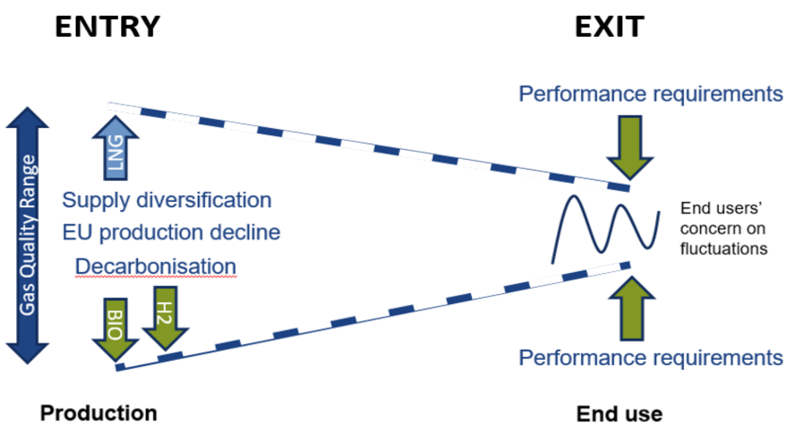


Figure 4 — Illustration of competing requirements on the Wobbe Index range for the gas entering and exiting the system

The WI range at an exit point can vary from the lowest WI to the highest WI of the gases of entry points, the exit point is connected to, if no gas mixing or blending takes place. The frequency distribution over this WI range can obviously be very different from one exit point to the other.

For a better understanding of the consequences of a variable value and width of the range of the Wobbe Index, it is needed to know how and what gas is used for (see Figure 5):

a) as fuel to burn it and to convert it to thermal or mechanical energy with the purpose of producing heat, moving an object or producing electricity;

b) as raw material/feedstock

1) to process it with the purpose to produce a product/consumable (e.g. production of hydrogen, methanol, ammonia).

2) to convert it to chemical energy with the purpose of producing electricity by fuel cells;

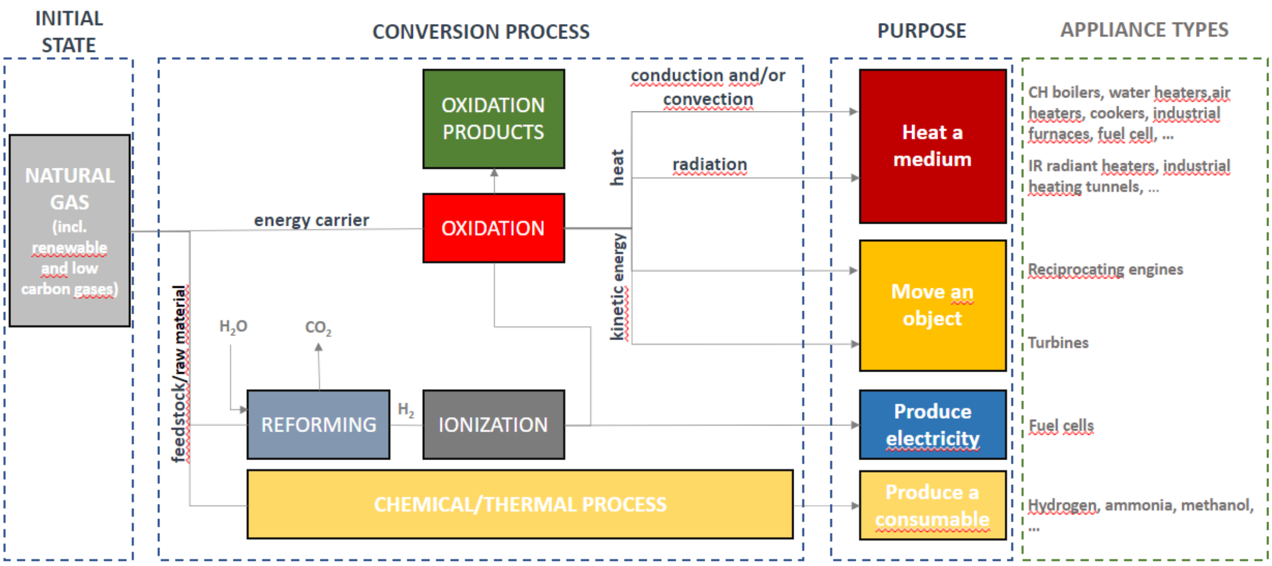


Figure 5 — Schematic view of different types of gas end-use

End-use applications have to be:

— safe;

— fit for purpose;

— efficient;

— reliable and robust;

— satisfying the end-use emission requirements, if applicable.

The end-use applications have been designed and optimized to answer all those requirements.

Gas quality property change over a wider range can compromise the performance. To mitigate this, end-use applications can be equipped with an appropriate auto-adaptive combustion control. Although their market share is increasing (e.g. in case of condensing boiler), only a limited number of end-use applications is equipped with such controls today. Some current applications have physical limitations that cannot be mitigated by a combustion control system. There is also a limit to the range that combustion controls can handle.

Applications – not equipped of combustion controls – that are optimised for having the highest efficiency possible, will typically be more sensitive to gas quality variations and will not be able to cope with wide range of Wobbe Index.

For feedstock applications, engines and some other end-use equipment the actual gas composition is the dominant factor.

Due to environmental concerns, legal requirements and efficiency, wide variations of local gas qualities pose a challenge to fulfil the operational requirements of a gas application, which is why end users require a limited gas quality range on a local level. (see also Figure 2).

Given the wide diversity of end-use technologies across all sectors, the operational requirements of these technologies to gas as a fuel or feedstock are very different. At the same time, there often are no harmonized EU regulations for application performance, emissions or safety, even for comparable technologies (some harmonisation is given for emissions).

There are harmonized EU regulations for putting residential and commercial appliances on the market and into service, but there are no harmonized EU regulations for operating and using appliances after they have been put into service. Regional or national requirements on efficiency or emissions (CO, NOx) will typically also lead to highest sensitivity to gas quality variations. This is the reason why the same technology may be seen as very sensitive to gas quality change in one country and less in another country.

The (legal) gas specification limits are applicable on country level, and – as described earlier – values of the gases distributed locally fulfil the legal requirements, however the actual local bandwidth is today generally narrower than the legally allowed range. Adjusting and/or adapting of end-use application (residential, commercial and industrial) to this local situation is a widespread practice (see DVGW-Hauptstudie, [20]), mainly for optimizing performance. By consequence, applications, that are adjusted and/or adapted to the local situation, can require an intervention by a service provider if the local gas quality changes significantly. Technological solutions do exist to make many end-use applications more resilient to gas quality changes, but they can be expensive and often have to be tailored to a specific application.

Currently, this on-site adjustment and/or adaptation is done without knowing the real-time measurement value of the WI (or other gas quality criteria) in most cases, meaning that the new settings are appropriate for the current WI value, but not necessarily for the local WI range. Inappropriate adjustment can lead to issues (see Annex B). In the future with the setting up of smart grids and the installation of sensors and other measurement equipment and tracking system through the DSO more data will be available to the market.

All the above has led to an approach (Figure 4) recommending for differentiation between entry and exit points as follows:

— at entry points:

  - a single WI range;

— at exit points:

  - a locally defined WI range that is equal to or narrower than the WI entry range and stable for as long as possible and acceptable for the majority of the local end-users;

  - a higher level of information on the WI range to be expected;

  - a WI bandwidth limit beyond which an assessment for sensitive end-use application is required and for which appropriate measures are necessary (related procedures to be defined by a regulatory framework). In case of change of the current local WI bandwidth an assessment is necessary.

The Rate of Change of Wobbe Index is also identified as significant but is not part of the current proposal. For the explanation see 5.2.3 and Annex A.

This document focuses specifically on Wobbe Index aspects, even if many statements also apply, in broader terms, for other gas properties.

NOTE Finally, it is important to keep in mind that for several end-use applications gas quality impact is not only a matter of WI, but also of calorific value (GCV), methane number, gas composition, etc.

The findings are based on broad preparatory work carried out by SFGas GQS TF2 'National situations' convened by EC JRC:

— CEN SFGas GQS Survey 1a: National situations regarding the regulatory framework on Wobbe Index

— CEN SFGas GQS Survey 1b: National situations regarding the regulatory framework on environmental in-use requirements for gas application and maintenance practices (not published)

— CEN SFGas GQS Survey 2: Wobbe Index data on entry and exit points of distributed gases in 2015-2016

As further basis CEN SFG GQS TF1/CAG carried out a survey on pre-defined WI scenarios:

— CEN SFGas GQS Simple Scenario Assessment – Part 1: Compilation of replies to SSAS survey, (CEN SFGas GQS SSAS Part 1)

— CEN SFGas GQS Simple Scenario Assessment – Part 2: Evaluation of the replies to SSAS survey (CEN SFGas GQS SSAS Part 2)

For a description of these surveys see Clause 9.

To get also a picture of the impact of renewables and decarbonised gases on the WI and GVC, an AhG analysed the Simple Scenarios for this purpose:

— CEN SFGas Simple Scenario Assessment: Impact of renewable and decarbonised gases on Wobbe Index (WI) and Gross Calorific Value (GCV) in blends with natural gas (CEN SFGas GQS SSAS, Part 3)

For a description of this analysis see Clause 7.

5 Wobbe Index recommendations

5.1 Entry point WI recommendation

CEN SFGas GQS considers the following aspects:

a) the EC's M/400 mandate asking for 'gas quality parameters that are the broadest possible within reasonable costs' (see Clause 2);

b) the EASEE-gas Common Business Practice on Harmonization of Natural Gas Quality (CBP 2005-001/02);

c) the EU legislation on gas appliances, initially directive 90/396/EEC (GAD), currently regulation (EU) 2016/426 (GAR). This legislation sets out requirements for putting on the market and into service non-industrial gas appliances. And more specifically the appliance categories I_{2H}, I_{2E} and I_{2E+} as defined in the standard EN 437 containing harmonized parts related to EEC mandate M89/6 supporting the essential requirements of the EU Directive 2009/142/EC (GAD) are considered;

d) the outcome of CEN SFGas GQS surveys 1A and B;

e) a broad range of supply sources (e.g. natural gas, LNG, renewable and decarbonized gases) injected at TSO and DSO level and allowing a reasonable diversity;

f) taking note of the broad acceptance of CEN SFGas GQS TF1/CAG (Conclusion 27/2019) of the differentiated approach for a wide entry and a narrower WI bandwidth at exit including a classification system (see Figure 4 and Table 2);

g) the replies to the SFGas GQS TF1/CAG consultation addressed to the European sector organisations and national mirror committees in November 2019 (see Annex D);

h) enabling a cost-efficient decarbonisation of the entire gas chain.

Based on these considerations, CEN SFGas GQS proposes to integrate the following **recommendation**, for the Wobbe Index of H-gas at entry points written in blue italics and phrased according to the CEN/CENELEC rules:

The WI entry range should be within 46,44 and 54,00 MJ/m³ [15°C/15°C] (see Table 1)*.*

Table 1 —Wobbe Index entry range

minimum WI ***[MJ/m³, 15 °C/15 °C at 1.013,25 mbar]*** *(grey values kWh/m³, 25 °C/0 °C at 1.013,25 mbar)*	***maximum WI*** ***[MJ/m³, 15 °C/15 °C at 1.013,25 mbar]*** *(grey values kWh/m³, 25 °C/0°C at 1.013,25 mbar)*
46,44 MJ/m³ *(13,59 kWh/m³)*	*54,00 MJ/m³* *(15,81 kWh/m³)*

NOTE This proposal corresponds to the WI range of the EASEE-gas Common Business Practice on Harmonization of Natural Gas Quality (CBP 2005-001/02).

The following notes are made related to the WI entry proposal above:

a) Standards (e.g. CEN Standards) give the commonly recognised codes of practice.

b) They are not legally binding as long as they are not enforced in legislation. However, they are an acknowledged part (or integral part) of the technical framework of the sector.

c) SFGas GQS could not agree on a binding identical WI range for all Member States due to different national legal situations (considering any national production and the currently installed base of appliances being different) and the overall bandwidth of the proposed WI entry range.

d) The recommendation for a European WI entry range instead of a requirement leaves the stipulation of the national WI entry range in the competence of the EU Member States (corresponding to the current legal situation); the European harmonisation of the WI at entry seems currently not possible. However, this allows EU Member States with deviating national WI range limits to adapt to the European WI range at medium or long term. This proposal avoids A-deviations from these countries when voting on the future CEN standard.

Also with the national WI ranges, the management of cross-border restrictions due to gas quality differences is being ensured with reference to INT NC Art 15. According to this, TSOs need to work together on how to mitigate incl. cost-benefit-analysis, public consultation and involvement of national authorities. The ENTSOG implementation monitoring report proofs good results with these provisions by now.

It gives the cross-border entry range given in the EASEE-gas CBP and implemented by many TSOs the formal status of a European standard.

e) Euromot considers the recommended WI entry range as too wide and puts forward a harmonised European WI range from 49,0 up to 52,7 MJ/m^3 based on following arguments:

   1) the majority of currently distributed gases in the EU has a WI within this range;

   2) a fixed WI bandwidth of 3,7 MJ/m^3 is acceptable for all represented end-use application sectors;

   3) it would have several advantages, such as facilitating proper adjustment of end-use application settings.

   NOTE This has also been supported by representatives of some other organisations.

f) Although 54,00 MJ/m^3 as upper limit for the entry range was concluded on during the TF1/CAG meeting of 18/12/2019, it was contested at the meeting and after the meeting by a number of manufacturers and end-use representatives stating that it is not acceptable at the exit level

   1) for reasons of safety, emissions and performance (see CEN SFGas SSAS Survey 3);

   2) due to possible interlinkage with other gas quality parameters determining the combustion process (e.g. MN);

   NOTE The impact of other gas quality parameters is beyond the scope of CEN SFGas GQS work and this report.

   3) as hardly any of the gases at entry points currently reach 54,00 MJ/m^3.

5.2 Exit point WI recommendation

5.2.1 Establishment of a classification system for WI exit points

CEN SFGas GQS considers the following aspects:

a) the broad acceptance of CEN SFGas GQS TF1/CAG (Conclusion 27/2019) of the differentiated approach for a wide WI bandwidth at the entry and a narrower WI bandwidth at the exit including a classification system (see Figure 4);

b) renewable and decarbonised gases injected closer to the exit points and therefore possibly leading to more variation than in the past;

c) the discrepancy between WI values of today's locally distributed gases (at exit points) and the legal WI limits (see Survey 1A and Figure 10 below);

d) the fact that for most gas end-use applications the absolute values of the local WI matter less than the bandwidth (i.e. relative values);

e) at the same time, the fact that the position of this relative WI range within the entry range is to be maintained for a reasonable amount of time (to be defined in the framework process, see Clause 6).

f) the added value (or even need) of adjustment of end-use application settings to the local WI range to optimize performance and minimise emissions;

g) the WI bandwidth of 3,7 MJ/m^3 accepted as a compromise by the represented end-use application sector organisations; it should be noted that even with a limited local WI range of 3,7 MJ/m^3, not all types of end-use equipment will be able to fulfil all safety, operational and legal requirements today. (Reference to existing studies.)

NOTE It should be noted that even with agreed limited local WI bandwidth of 3,7 MJ/m^3, not all types of end-use equipment will be able to fulfil all safety, operational and legal requirements without significant technical measures. It is recommended that all future end-use equipment can accept this bandwidth.

h) in case of change of the current local WI bandwidth an assessment can be necessary depending on the new class;

i) experience from several European countries showing that sharing data about delivered gas qualities and prognosis of future gas qualities has value for the end-users.

Based on these considerations, CEN SFGas GQS proposes the **requirement** of a classification system for WI of H-gas at exit points based on the local WI bandwidth consisting of two classes: a so called 'specified' and an 'extended' class:

- the 'specified' class has a maximum bandwidth of 3,7 MJ/m^3 (15°C,15°C) within the WI range of 46,44 to 53,00 MJ/m^3 (15°C/15°C);
- the 'extended' class covers any other situation of WI bandwidth and/or of the WI range;

In both cases the upper and lower WI values need to be indicated.

The CEN SFGas GQS recommendation, written in blue italics and phrased according to CEN/CENELEC rules is as follows:

The distributed gases at an exit point (or a cluster of exit points) shall be classified according to Table 2:

Table 2 —Wobbe Index exit classification

Class	***Indicated WI range*** *[MJ/m³, 15 °C/15°C at 1.013,25 mbar]* (grey values kWh/m³, 25 °C/0 °C at 1.013,25 mbar)	***Bandwidth of WI of distributed gases at the exit point*** *[MJ/m³, 15 °C/ 15°C at 1.013,25 mbar]* (grey values kWh/m³, 25°C/0°C at 1.013,25 mbar)	***Acceptable deviation [%]***

Class ***specified***	***Lower and upper limit values defined per exit point with an interval of 3,7 MJ/m³*** *[1,08 kWh/m³] based on the distributed gas, within the WI range.*	***The WI of the distributed gases is ≤ 3,7 MJ/m³*** *[1,08 kWh/m³] within the WI range of* ***46,44 MJ/m³ to 53,00 MJ/m³*** *[13,59 kWh/ m³ to 15,51 kWh/m³]* *The WI of the distributed gas is never outside the national legal entry range.*	*The WI of the distributed gas can fall* ***below*** *the lower WI limit value of the range for a maximum of* ***1%*** *of the duration of the class specification and* ***above*** *the upper WI limit value of the range for another* ***1%*** *of the duration of the class specification.* *Clarification of the extent/intensity of deviation and the time distribution of the '1 % deviation' in the framework discussion is required.*
Class ***extended***	***Lower and upper limit values defined per exit point, based on the distributed gas, within the WI range.*** *Note: This class requires an assessment (due diligence principle) of the presence of sensitive users downstream of the concerned exit point and, if any, the implementation of appropriate mitigating measures.*	***Any other situation of WI bandwidth and/or of the WI range.*** ***Continuous experienced situations in class extended*** *could be considered similar to a class specified (e.g. after an initial assessment) and should be part of the framework discussion* *The WI of the distributed gas is never outside the national legal entry range.*	*The WI of the distributed gas can fall* ***below*** *the lower WI limit value of the range for a maximum of* ***1%*** *of the duration of the class specification and* ***above*** *the upper WI limit value of the range for another* ***1%*** *of the duration of the class specification.* *Clarification of the extent/intensity of deviation and the time distribution of the '1 % deviation' in the framework discussion is required.*

Regarding the acceptable deviation, all parties in the gas supply chain shall strive to minimize the time and extent of exceedance of the limit values of the given classification. It is recommended that mitigation measures will be considered. (See for further recommendations chapter 6.)

NOTE 1 It is acknowledged that more clarification of the extent, intensity and time distribution of the deviation is needed (e.g. a max of x days per year and, possibly including a distinction between normal and extremes and cost-benefit aspects). This seems to be only possible in alignment with the outstanding framework discussions. During the CEN SFGas GQS process, end-users request a reasonable maximum deviation beyond the specified/extended class to ensure safety and reliability of installed equipment but also to meet the emission and efficiency requirements. With the current framework, this is not possible.

In case of emergency creating an extreme situation, the end-users needs to be informed as soon as possible and, where applicable, in line with the national provisions.

NOTE 1 EUROMOT cannot agree on the phrasing of the deviation without specification of the time distribution, frequency, duration and extent of deviation.

NOTE 2 ENTSOG supports the concept above (Tables 1 + 2), subject to the development of an appropriate regulatory framework. The approval of the technical standard should only proceed with clear definitions of the regulatory framework and related procedures, responsibilities, and liabilities for the classification system for exit points.

The requirement of a classification system gives good certainty to the end-users, especially with view to the increased diversification of gases including renewable and decarbonised gases in future. The clearly defined WI range for the 'class specified' reflects the presumably most current situation of distributed gases in Europe (looking backwards) and builds a solid basis also for future situations. The 'class extended' safeguards the needs of the end-users also in all other situations than those of the class specified. It also replies to the experiences with steady situations on the higher or lower WI bands.

The aspects described in Clause 6, subject to the European framework, are decisive for the proper implementation of the described WI provisions. The immediate start of work under the umbrella of the EU Prime Mover Group is appreciated and supported.

5.2.2 Definition of classes

5.2.2.1 General criteria for a class

A class describes an exit point with a defined WI range:

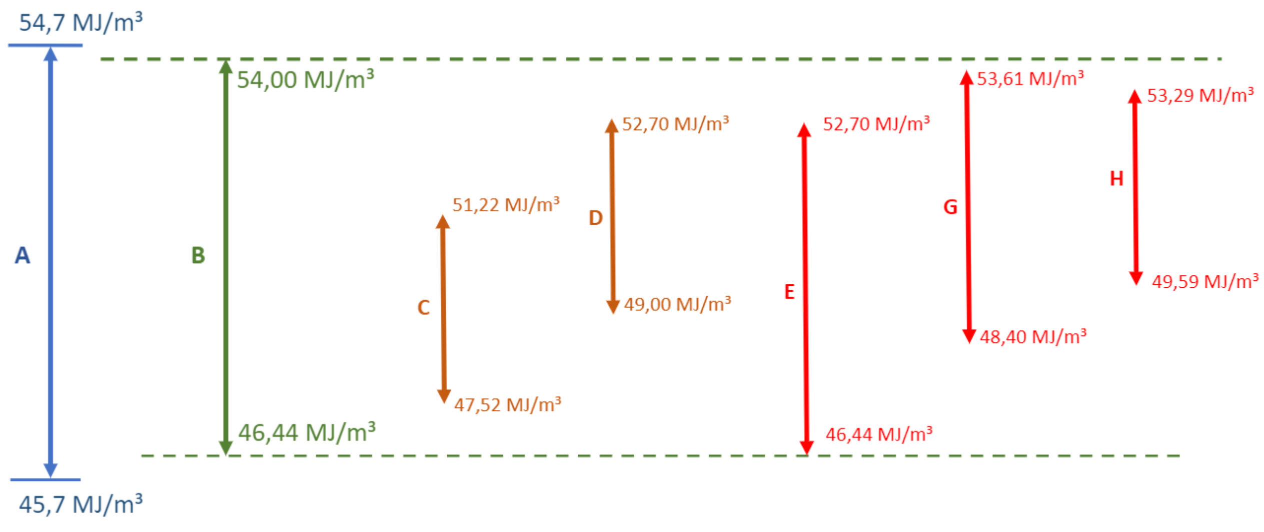
a) In the classification scheme, a class is assigned to an exit point (or a cluster of exit points), based on a forecast of local Wobbe Indices at this point for a period of time (to be determined in the WI framework discussion). For the communication associated to the classes see 5.2.2.2 and 5.2.2.3. The minimum and the maximum of the WI range are defined and valid for a certain time period on basis of the gases that are reasonably foreseeable to be supplied to the concerned exit point within that time period;

b) the minimum and the maximum of the range are within the limits of the WI entry range;

— the type of class determines whether an assessment is required or not for the presence of sensitive users downstream of the concerned exit point.

c) The class has to be maintained for a reasonable duration of time (to be determined, see Clause 6).

A graphic example is given in Figure 6.



Key:

A	EN 437, H-gas	E	Exit 3 (Class extended)

B	WI range at entry point proposed by CEN SFGas GQS (and as given in EASEEgas CBP)	F	Exit 4 (Class extended)
C	Exit 1 (Class specified)	G	Exit 5 (Class extended)
D	Exit 2 (Class specified)		

Figure 6 — Example of assigned WI classes – specified and extended - to some exit points

Procedures are needed to specify classes (incl. at least the switch to a new class, time scales, liabilities and responsibilities) and to enable an implementation of the classification system. Considerations during the CEN SFGas GQS work are documented in Clauses 6 and 7.

These procedures shall be subject to another (parallel) process on elaboration of the legal framework with European and national authorities.

The proposal to allow classification of exit points up to the upper respectively lower WI value of the defined WI entry range (54,00 MJ/m^3, 46,44 MJ/m^3) as defined in Table 1 can conflict with the safety margins intended in EN 437. For appliances in the scope of EN 437 and also other applications and processes which can be adjusted to local gas quality, this is no problem; for appliances, applications and processes which cannot or are not allowed to be adjusted, the related standards and certification schemes would need revision, in case the upper limit of 54,00 MJ/m^3 is kept.

NOTE An adaptation of the existing standards and regulations would not be a solution to the current and very large stock of existing appliances in Europe.

NOTE For the situation of a constant high WI range, appliances and processes are specifically adjusted.

On-site adjustment at the time being is generally done without knowing the local gas quality at the time of adjustment. In order to find an appropriate set point for an appliance within the proposed class system, information on both, the current local gas quality and an appropriate gas quality for the appliance to be adjusted for, is necessary. (See Annex B)

5.2.2.2 Class 'specified'

Class specified is allocated to exit points or cluster of exit points for which the bandwidth of the distributed gases' WI range is smaller than or equal to 3,7 MJ/m^3. The lower and upper limit values need to be defined per exit point or cluster of exit points with an interval of 3,7 MJ/m^3 within the WI entry range. The WI exit limits of 46,44 to 53,00 MJ/m^3 are probabilistic respecting acceptable deviations (see Table 2,); in case of deviation, the WI shall never be outside the national legal WI range.

This class does not require further steps by the system operator (or another designated party) besides the allocation of the class to the exit point.

NOTE It should be noted that even with agreed limited local WI bandwidth of 3,7 MJ/m^3, not all types of end-use equipment will be able to fulfil all safety, operational and legal requirements without significant technical measures (e.g. CEN SFGas GQS SSAS; German Hauptstudie). It is recommended that all future end-use equipment can accept this bandwidth.

EXAMPLE Example for class specified:

Potential situation for the system operator:

— the actual distributed gases in exit point A have a WI bandwidth of 2,5 MJ/m^3;

— the gas quality data over a certain period of time (to be determined) obtained for exit point A show WI values comprised within 49,2 MJ/m^3 and 51,7 MJ/m^3 (corresponding to the 2,5 MJ/m^3 WI bandwidth);

— class specified has a fixed bandwidth of 3,7 MJ/m^3, whereas the actual distributed gases in an exit point in a class specified might have a WI range below or equal to 3,7MJ/m^3. This to ensure that the class limits given for this exit point stay true for as long as technically possible (same class, same lower and upper WI values);

→ according to the classification system, exit point A is in a Class Specified.

Potential information to the end-users connected to exit point A (communicating party to be determined, see Clause 6):

— classification: the customers' gas application receives gas from an exit point in a Class Specified;

— indication of the foreseen lower WI value of 48,0 MJ/m^3 and the foreseen upper WI of 51,7 MJ/m^3, i.e. a WI bandwidth of 3,7 MJ/m^3;

— indication of the period of time (to be determined) during which the range defined by the lower and upper WI values is staying the same.

NOTE 1 The indicated range (48,00 MJ/m^3 and 51,70 MJ/m^3) depends on the individual forecast for the distributed gases at that specific exit point. Therefore, the range can be defined differently for another period of time.

NOTE 2 The described example presumes that a procedure for classification and communication is set in the European legislative framework, reflections occurring during the CEN SFGas GQS process on this are given in Clause 6.

5.2.2.3 Class 'extended'

Class extended is allocated to exit points of distributed gases for which the bandwidth of the WI range exceeds 3,7 MJ/m^3 or the upper WI limit exceeds 53,00 MJ/m^3. The lower and upper WI limit values need to be defined per exit point within the WI entry range.

These WI exit limits are probabilistic, respecting acceptable deviations (see Table 2); the WI shall never be outside the national legal WI range.

This class requires unbiased assessment (due diligence principle) of the presence of sensitive users at the concerned exit point or cluster of exit points and, if any, the implementation of appropriate mitigating measures in cooperation with all parties involved (see Clause 6).

The majority of applications (including residential and commercial) are not able to accept the whole proposed range of the entry (46,44 to 54,00 MJ/m^3) covering a bandwidth of 7,56 MJ/m^3. Furthermore, it is not compatible with on-site adjustment of end-use settings to the local gas quality (see Clause 8 and Annex B).

EXAMPLE Example for Class extended

Potential situation for the system operator:

— the actual distributed gases in exit point B have a WI bandwidth of 4,5 MJ/m^3;

— the gas quality data over a certain period of time (to be determined) obtained for exit point B show WI values comprised between 48,0 and 52,5 MJ/m^3 (corresponding to the 4,5 MJ/m^3 WI bandwidth);

→ in the classification system exit point B is in a class Extended.

Potential information to the end-users connected to exit point B (communicating party to be determined, see Clause 6):

- classification: the customers' gas application receives gas from an exit point in a Class Extended;
- indication of the foreseen lower WI limit value of 48,0 and the foreseen upper limit value of 52,5 MJ/m^3, i.e. a WI bandwidth of 4,5 MJ/m^3;
- indication of the period of time (to be determined) during which the range defined by the lower and upper WI values is staying the same,
- indication of a warning remark that if the end-use application is sensitive to WI aspects:

  i) the wider range might have an impact,

  ii) an impact analysis in cooperation with the TSO/DSO will be carried out to identify which mitigation measures, if needed, are the most reasonable. Inclusion of the equipment manufacturer in the process might be needed.

5.2.3 Rate of change

Besides the WI range and bandwidth, a high rate of change of the WI is also identified as being detrimental for proper functioning of a number of end-use applications such as feedstock processes, gas engines and gas turbines. Its relevance is increasing with larger WI bandwidths at exit level. Based on the diverse origin of gas quality changes and the distributed responsibility along the gas value chain, no common threshold value could be determined in the CEN SFGas GQS process as sufficient data on rates of change are not available. Research is needed to define the critical rate of change for the sensitive technologies. For more information see Annex A.

6 Recommendation for the framework enabling the implementation

6.1 With view to the regulation of the gas market, the process-related aspects are not in the competency of CEN but they are indispensable for the finalisation and implementation of the described recommendations for WI entry and exit (5.1 and 5.2) and the approval of any related technical CEN standard. The clarification and stipulation of process-related aspects such as classification procedures, responsibilities and liabilities shall be subject to a process on the legal/regulatory framework with European and national authorities (EC, ACER, NRA, Ministries, etc.) involving all stakeholders groups.

NOTE CEN SFGas GQS TF1/CAG participants emphasize that an agreement on the involvement of all stakeholder groups would be requested, in case the Network Code process is used for this purpose.

Although the competency of CEN is clearly technical in this matter, CEN SFGas GQS collected the framework/process-related issues raised during the discussions in order to document and forward them to EC together with the result of the CEN SFGas GQS process results (CEN SFGas GQS TF 1 Conclusion 20/2019).

CEN SFGas GQS recommends launching the required process as soon as possible and to take the following aspects into account:

6.2 Transparent methodology rules and procedures for a reliable implementation of the proposed classification system, including at least:

1) the assessment of the presence of sensitive users downstream of the exit point;

2) assignation of classes;

3) validity duration of classification including potential re-evaluation due to unforeseen circumstances;

4) procedures of switching classes from

   i) class specified to another class specified;

   ii) class specified to class extended;

   iii) class extended to another class extended;

   iv) class extended to class specified;

5) handling of continuous experienced situations in class extended similarly to a class specified (e.g. after an initial assessment);

6) a procedure for reassessing the classification range for an exit area taking into account the future developments of the changes in supply sources driven by the energy transition which might provide gases with lower WIs;

7) identification and implementation of appropriate mitigating measures (including CBA) and the related responsibilities and liabilities;

8) information provision before and after the assignment of classes between the grid operators, the injectors and the end-users (incl. how to communicate and what to communicate).

9) definition of procedure for 'forecast of local WI' (analysis of historical data and reasonably foreseeable changes to the gas supply)

6.3 The concept of classification needs a clear definition of responsibilities in the European framework. The classification described in 5.2 is based on the idea that:

1) for specified classes, the initiative for action is in the responsibility of the user, if this user has special requirements for the local gas quality that cannot be fulfilled by the specified class specifications. There is no obligation for the system operator to respond to this initiative.

   NOTE This does not exclude co-operation between end-user and system operator.

2) for extended class, the initiative for action lies with the system operator by informing the end-users about:

   i) their classification as extended class,

   ii) the related specifications and

iii) their rights for assessment and support (in reference with 6.2 (1), (5) to (7)).

6.4 In case of the classification methodology (see 6.2) and in case of an extended class (see 6.3 (2)), the framework needs to regulate the cooperation between the affected end-users, gas grid injectors, and system operators, involving NRAs, on the identification and the analysis of potential mitigation measures (cost benefit analysis and the criteria/needs it is based on).

NOTE: It is recommended to evaluate the process and experience of the L/H conversion in Belgium, France and Germany.

6.5 A legal framework for enforcing the implementation of the classification proposal and more specifically roles and responsibilities is to be elaborated by the European and national authorities (ministries & regulators) in close collaboration with all stakeholders.

6.6 European alignment of safety and environmental requirements for comparable end-use applications for the residential and commercial sector, as the existing situation leads to different acceptable WI bandwidths in different Member States or even different regions in one Member State, whereas:

— safety requirements: CO concentration in combustion products;

— environmental requirements, like NOx emissions and/or

— efficiency (related to environmental and economic aspects).

6.7 The current Regulation (EU) 2016/426 on gas appliances requires residential and commercial appliances to satisfy the essential requirements for the gases distributed on the territory in the country of destination. To limit the variety of installed residential and commercial gas appliances ready for the classification scheme of the two classes, it is recommended to study the possibility of replacing the current national WI specifications published in the Official Journal of the European Union (OJEU) by harmonized WI specifications based on the classification system.

Additionally, the following findings related to the rules, procedures and a legal framework have been identified during the study work:

6.8 In case of presence of sensitive users, a range of mitigating measures shall be considered locally and on a case-by-case basis (reference to item 6.3) with close cooperation between the stakeholders:

— end-use adaptation and mitigation;

— gas quality measurements (DSO, TSO) and data sharing;

— grid management measures;

— gas treatment;

— optimised communication of system operators to end-users, also in the context of rate of change;

— others

6.9 The existing regulation should be evaluated for:

— the feasibility of using it for future implementation of the recommendations for WI at entry and/or exit points;

— communication between the different grid levels (producer, TSO, DSO, end-user, etc.) and between gas system operators and end-users;

— default situations;

— others.

The existing network code on Interoperability and Data Exchange (Regulation (EU) 2015/703) can be a starting point, referring to:

— art. 15 on managing cross-border trade restrictions due to gas quality differences;

— art. 16 and 17 on short-term gas quality variation monitoring, data publication and further information provision.

6.10 The regulatory framework probably needs to foresee a step-by-step implementation to allow for solving different national issues (due to current legislation, stock of existing installed applications not coping with wider WI bandwidths, etc.).

7 Impact of renewable and decarbonised gases on the Wobbe Index in blends with natural gas

7.1 General

The impact of renewable and low carbon gases on the Wobbe Index (WI) in blends with natural gas was studied by a taskforce composed by a limited number of CEN SFGas GQS experts. The renewable and low carbon gases taken into account are biomethane, biogas, synthetic methane and hydrogen. This study focusses on the effect of blending of renewable and decarbonized gases on the WI proposal of CEN SFGas GQS (see Clause 5). In addition to WI the injection of renewable and decarbonized gases also has an impact on other gas quality criteria, such as calorific value, relative density or methane number, which also have to be considered.

Hydrogen and often also biomethane will reduce the WI of the natural gas they are injected in. Depending on the WI limits of the class assigned to the concerned exit points such injection could lead to WI values below the lower limit Such situations would require limiting the injection of hydrogen or biomethane to respect the class' lower WI limit during at least 99% of the duration of the class specification (cf. percentiles defined for deviation from the class' limits). To overcome or at least reduce limiting the injection of renewable or low-carbon gases, assign a new WI class to the concerned exit points can be considered according to the rules defined for changing a class.

The resulting WI will obviously always have to be within the applied WI entry range.

The outcome of the study is available as CEN SFGas GQS SSAS Report Part 3.

Renewable and decarbonised gases in the context of the CEN SFGas GQS work can be differentiated as follows:

— gases that comply with the WI entry specification (such as biomethane and synthetic methane), which can substitute natural gas as far as WI is concerned; and

— gases that do not comply with the WI entry specification (such as biogas and hydrogen), which need to be blended need to be blended in the gas grid before reaching any exit.

NOTE In this analysis only the effect of WI and GCV is taken into account. It is clear that the blend also needs to be checked against other limit values such as oxygen (EN 16726), CO2 (EN 16726), relative density (EN 16726), methane number (EN 16726) and siloxanes (EN 16723-1). A dedicated CEN SFGas GQS Task Force Oxygen (TF 3) is currently studying the oxygen content specifications due to biomethane injection.

7.2 Synthetic methane

Synthetic methane with a WI close to 50,72 MJ/m^3 is considered fully compatible with the proposed WI entry specification (Table 1) and has characteristics comparable to the H-gas distributed in Europe. Determination of the impact of trace components is in detailed examination at the time being.

7.3 Biomethane

Biomethane with a WI ranging from 46,65 MJ/m^3 (15 °C/15 °C) to 50,37 MJ/m^3 (15 °C/15 °C) is fully compatible with the proposed WI entry specification (Table 1).

The spread in the WI values is mainly caused by the remaining CO_2 content in the biomethane. Today solutions are available to produce biomethane with WI of 49 MJ/m^3 and higher.

7.4 Biogas

Biogas has a WI lower than 46,44 MJ/m^3 and is by consequence not compatible with the proposed WI entry specification and nor with the EN 16726 and EN 16723-1 requirements.

In exceptional cases, the option of injecting biogas (CH_4+CO_2, clean of any harmful trace component as siloxanes, chlorines, etc.) or a low grade/poor biomethane (high CO_2 content) directly could be considered due to, for instance, local natural gas network considerations of any kind.

As far as WI is concerned injection of biogas into natural gas should only be allowed if the resulting blend meets the WI specification at the exit.

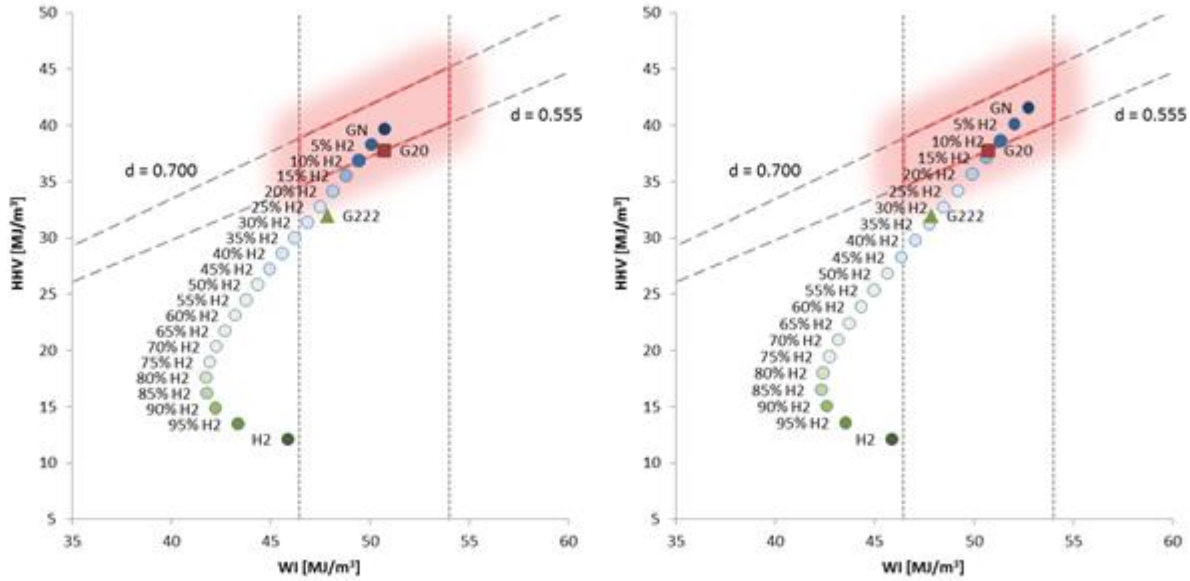
7.5 Hydrogen

Admixing hydrogen in natural gas alters the properties much stronger. Depending on the concentration, hydrogen injection in natural gas may impact the safety and proper functioning of applications even if the WI value stays within the WI limits of the class. This is due to the fact that hydrogen has a number of properties like e.g. molecular size, relative density, flame speed and flammability limits that are significantly different from those of methane, the main component of natural gas.

NOTE 1 EU and national projects are in process to examine the specific impact on applications, e.g. THyGA, and to enable applications to accept (more) hydrogen.

The WI of hydrogen (45,88 MJ/m^3 at 15°C/15°C) does not comply with the WI entry specification in Table 1. Therefore, it can only be accommodated in a complying blend with natural gas. Injecting hydrogen always lowers the WI of natural gas of group H. By consequence the maximum allowable hydrogen concentration is defined by the lower WI limit of the class assigned to the impacted exit points and the actual WI value of the gas it is injected in.

The impact of hydrogen injection on WI (and gross calorific value) on an example of pipeline gas and of LNG is shown in Figure 7.



Key:

Shaded area:	WI entry range/EASEEgas CBP (for reference only)

Figure 7 —Impact of H2 injection in resp. an example of pipeline gas and of LNG on WI (and GCV) with the addition of hydrogen. Source: Enagás/Marcogaz

The theoretical maximum concentration of H_2 related to the WI proposal in this document is defined by a gas with a WI value equal to the upper limit of 54,00 MJ/m^3 (15°C/15°C) and the concentration of H_2 that lowers the WI of the admixture to the lower limit of 46,44 MJ/m^3 (15°C/15°C). Such gas would allow the injection of up to 49 vol% of H_2. The impact of injecting hydrogen on other gas quality and combustion parameters needs to be taken into account.

NOTE 1 The limits of other gas quality parameters are likely to be exceeded before the limits of the WI. For example, the above theoretical maximum concentration disregards the relative density and methane number criteria given in EN 16726:2015+A1:2018.

NOTE 2 End-user applications may not be able to cope with this amount of hydrogen although the Wobbe Index is still within the allowed WI range.

For the purposes of analysing how the injection of hydrogen could affect the class of an exit point, a Monte-Carlo simulation has been carried out under the following premises:

a) The simulated exit point is originally of the *specified class*, used as example, before injecting any hydrogen. This is statistically characterized by:

   1) Percentile 1 being equal to 49 MJ/m3

   2) Percentile 99 being equal to 52.7 MJ/m3

   3) Normal distribution centred in the *specified class* range

b) Hydrogen is added in any random fraction between 0 and the injection limit. Several injection limits are simulated: 2, 5, 10 and 20%.

c) 5000 samples of the original gas quality are randomly generated within the said statistical parameters.

d) For each of the samples, a random quantity of hydrogen is simulated and “injected”. The resulting Wobbe index is calculated by assuming a linear reduction of Wobbe Index of 0,25% per 1% hydrogen concentration.

Figure 8 presents the frequency distribution diagrams of the different simulations.

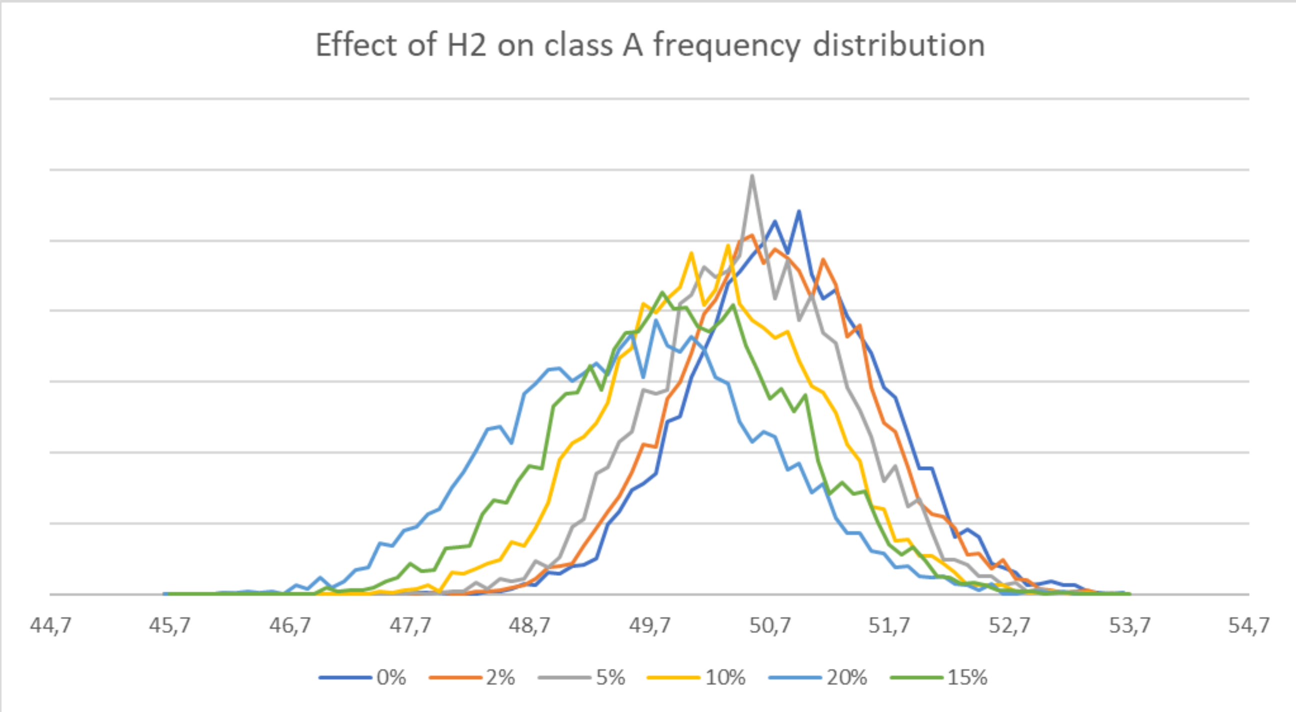
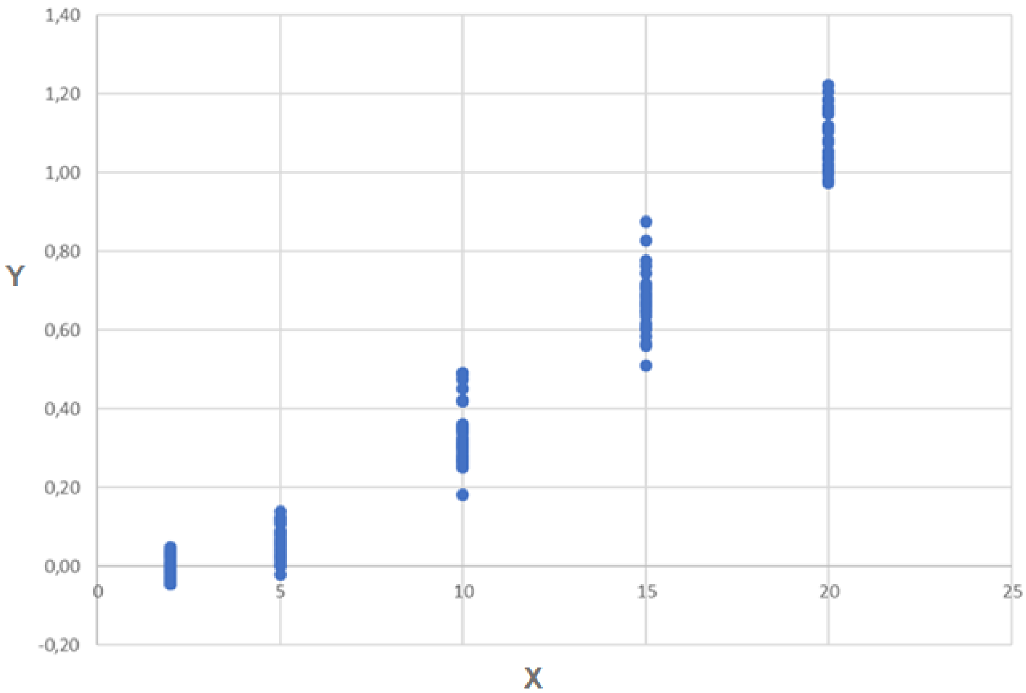


Figure 8 —Effect of hydrogen injection on the Wobbe Index exit point frequency distribution of a specified class with 49,00 MJ/m³ to 52,70 MJ/m³ – used as example [Source: ENTSOG, [26]]

It is also interesting to study how the bandwidth may be increased by an intermittent (random) injection of hydrogen. For this purpose, the simulations above have been iterated 30 times. Figure 9 represents the effect on the exit point’s bandwidth.



Key:

X	Hydrogen concentration (%)
Y	Wobbe index bandwidth increase (MJ/m^3)

Figure 9 **—Increase of Wobbe index bandwidth for an originally *specified class* exit point (49,00 MJ/m³ to 52,70 MJ/m³)**[Source: ENTSOG]

Table 3 presents the average bandwidth increment in the table (second column). The third column represents the effect of adding the said quantity of hydrogen to a gas at the lower limit of the class. Finally, the fourth column shows the percentile 1 of the simulated distribution.

NOTE Percentile 1 means that 1 % of the simulated results is lower than the value in column 4 of Table 3.

Table 3 — Change in *specified class*, used as an example, in width a lower limit of Wobbe index band [Source: ENTSOG]

Hydrogen fraction(%)	Average bandwidth increase (MJ/m^3)	Theoretical minimum [MJ/m^3]	New percentile 1 [MJ/m^3]
2	0,00	48,76	48,85
5	0,06	48,39	48,62
10	0,33	47,78	48,21
15	0,67	47,16	47,71
20	1,09	46,55	47,19

The overall conclusion taken from this exercise is as follows:

e) For a fraction of 2% a *specified class* is likely to remain as the original *specified class (effect about minus 0,2 MJ/m³)*. It could shift to a new *specified class*, with lower Wobbe Index, depending on the original WI values.

f) For 5% the effects on variability (about minus 0,6 MJ/m^3) and classification are only slightly more noticeable than for 2%.

g) For 10% the effect is more visible (about minus 1,2 MJ/m^3) shifting the point to a new *specified class*, with lower Wobbe Index and possibly to an *extended class*, depending on the original

h) A 20% variable fraction (effect about minus 2,5 MJ/m^3) will certainly lead to an *extended class*.

8 Open issues and considerations for CEN or elsewhere

8.1 For the following items, CEN SFGas GQS has identified the need for further considerations in CEN and/or in other organisations which are indicated in the following clauses.

8.2 **Gas appliances in the scope of GAR** (mostly residential and commercial appliances) need to be provided with an appliance category marking. This marking is composed of different elements (cf. EN 437) of which one is the gas group the appliance is designed for. Two gas groups H and E cover the H-gas WI range as defined again by EN 437. Appliances developed for a group E generally can cope with a wider WI bandwidth than those of category H. Further confirmation and information of the abilities of these appliances would be useful for a stepwise implementation of the above WI recommendations for entry and exit points.

8.3 In support of decarbonisation and security of supply, **further development of technologies** is needed to make applications robust for the present Wobbe Index proposals and the use of the various renewables and decarbonised gases as well as LNG, without compromising the safety, the environmental performance and the efficiency of the end-use equipment.

8.4 As far as **auto-adaptive controls of gas application** settings are concerned further work is needed

— to evaluate the ability of existing auto-adaptive controls to cope with gas quality variations;

— to evaluate the possibility of retrofitting existing gas applications with such controls; This is particularly relevant for larger applications;

— to improve auto-adaptive controls and more in particular sensors and feed-forward systems.

— ...

8.5 **On-site adjustment:** Experience from several countries in EU show that on-site adjustment of residential appliances is a widespread practice. This adjustment is almost never based on knowledge of the actual gas quality on-site at the time of adjustment, but purely based on measurement of flue gas components (e.g. oxygen in flue gas). This practice can optimise the performance of the appliance in terms of efficiency and level of emissions if the gas quality at the time of adjustment is typical and the supplied gas quality remains stable over a longer period, but this may in the same time increase the risk of malfunctioning or poor combustion if the gas quality changes. Reference is made to Annex B.

For large-scale end users in industry and power generation, on-site adjustment is usually necessary to meet the application's requirement in terms of fitness of purpose, efficiency, safety and/or pollutant emissions, both during the design and commission phase, but also after maintenance or repairs.

Industrial furnaces in thermal processing industries, feedstock processes in the chemical industry or power generation equipment are technologically very different and will require tailor-made solutions to handle gas quality/composition variations. Examples could be customised advanced measurement and control technologies or on-site fuel gas conditioning. However, there are physical limits to what some of these end-use applications can accept in terms of gas quality.

Detailed data about local gas qualities at the site of the installation as well as forecast information as part of the exit-point classification approach are an added benefit in this regard, as additional information can help find optimal solutions for specific applications. With the future implementation of smart grids and the availability of better and cheaper sensors, measurement and tracking systems more and faster information will be available in the future, also at the DSO level.

8.6 Rate of change (see 5.2.3 and Annex A): Further research work on the WI rate of change is needed to identify the limits, effects and mitigation measures. Clear recommendations and involvement of all relevant stakeholders (gas suppliers, OEMs and end users) are needed.

9 Preparatory work

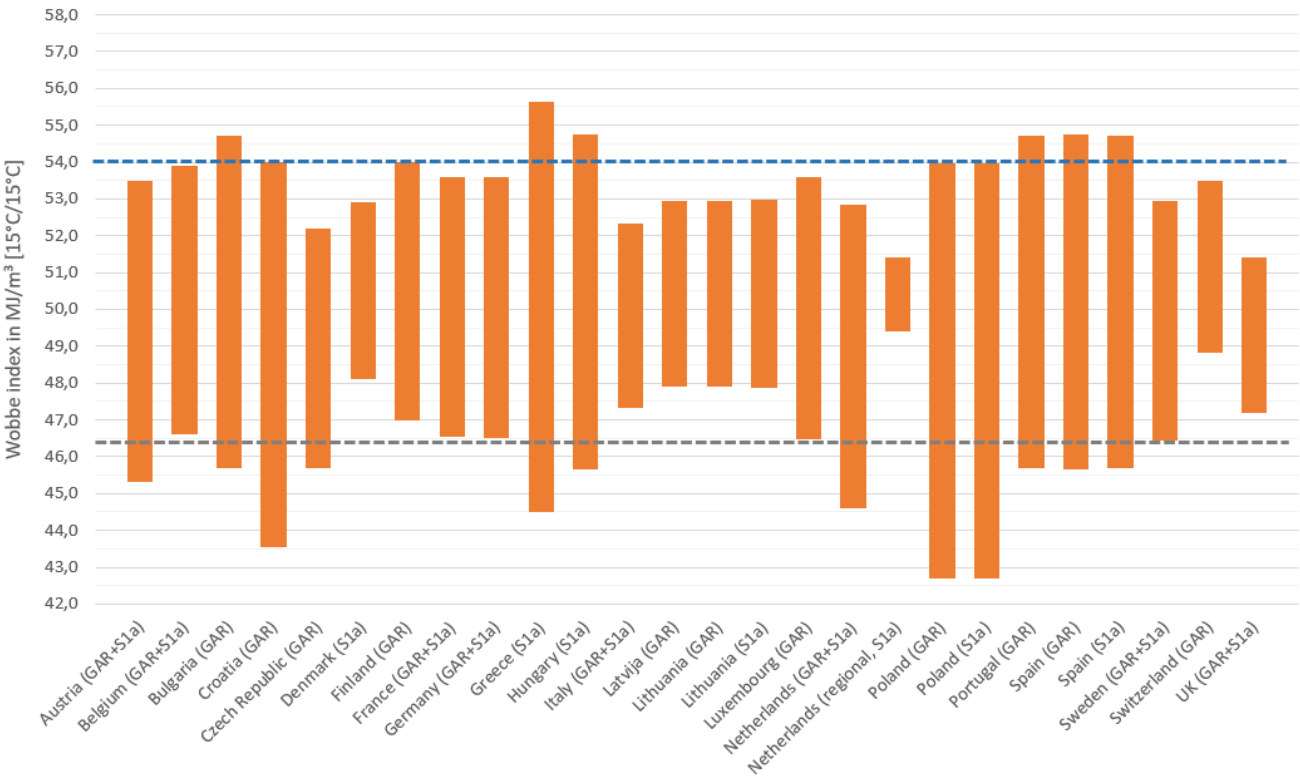
9.1 Survey 1A – National situations regarding the regulatory framework on WI

The goal of Survey 1 - Part A: Legal and technical framework of gas quality was to probe the jurisdictive national frameworks on gas quality in order to provide an overview of the different legislative and technical national frameworks, encompassing actors, legislative instruments employed and binding technical parameters. The survey ran from 25/05/2017 until 15/07/2017, it was addressed to the heads of national delegations within the CEN SFGas GQS and identified relevant representative for EU and Energy Community members not yet involved in this study. In total, 14 countries submitted answers[1]. The outcome of the survey revealed significant differences in national regulatory frameworks from country to country. Some countries have very strict and specific limits, while others leave more space to technical specifications from TSO.

A report has been made available to the working group on the outcome of Survey 1A. This supported the CEN SFGas GQS in being aware of specific national legislative structures and possible bottlenecks or conflicts. This knowledge was meant to help in furthering the discussions of the CEN SFGas GQS and in identifying further action needs, enabling gas quality harmonisation.

The Survey 1A also made differences clear between reported legal limits and the ranges the Member States communicated to the Commission and the other Member States on the types of gas and corresponding supply pressures of gaseous fuels used on their territory, according to art 4 of the GAR (EU regulation 2016/426) (see Figure 10).

[1] Austria, Belgium, Denmark, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Poland, Spain, Sweden, United Kingdom



Key:

orange bar	WI range
dotted blue line	Upper WI limit of WI entry range proposed by CEN SFGas GQS in this document
dotted grey line	Lower WI limit of WI entry range proposed by CEN SFGas GQS in this document
S1a	Wobbe Index values as reported to JRC in the context of Survey 1a
GAR	Wobbe Index values as published in The Official Journal of the European Union based on the report of EU countries to the Commission and the other EU countries according to art 4 (1) of the GAR; converted into the reference conditions here below, where other reference conditions are applied
Reference conditions	(MJ/Nm^3 - 15°C/15°C/101.325 kPa)

Figure 10 — WI range (MJ/Nm^3 - 15°C/15°C/101.325 kPa) in the European countries as reported in the Tables of Survey 1A and as published in the OJEU based on the report of EU countries to the Commission and the other EU countries according to art 4.(1) of the GAR

The Netherlands use H-gas only for industrial users and large-scale power plants and there are specific regional limits.

9.2 Survey 1B – national situations regarding the regulatory framework on environmental in-use requirements for gas application and maintenance practices

Performance parameters: Legal framework and current practice in end-use application of natural gas aimed at providing an overview of relevant legislation for Emission, Efficiency, Safety and Maintenance of different applications using natural gas in different European regions or member states. Within the EU there are different approaches for the specification of performance parameters associated directly or indirectly with natural gas quality requirements. As only five member states submitted answers to the survey, which moreover were difficult to analyse as the complex questions were interpreted differently, no further analysis took place. The answers were circulated with the Chair Advisory Group (CAG) of the CEN SFGas GQS.

9.3 Survey 2 – WI data on entry and exit points

9.3.1 Aim, content and outcome of Survey 2

CEN SFGas GQS launched a survey in 2017 in order to map the status quo on relevant gas quality parameters within European countries, as a basis for developing technical scenarios. A survey was to provide the necessary data to map and analyse national and sectorial situations and experiences in the European Union. This survey aimed at collecting gas quality information from a variety of representative end use and transmission points, in different European regions. The overall aim of the data collection was:

— to produce maps at national and regional level to summarise and describe main statistical properties of aggregated and anonymised data for the Superior Wobbe Index and Superior Calorific Value;

— to further elaborate the data to provide aggregated and anonymised descriptive statistical values covering the average behaviour and the rate of change by category of end-user.

The data was collected through two parallel exercises – ENTSOG collected data from its transmission system operator members, whereas JRC conducted a survey directed at distribution system operators and end user level. The participants contributed data sets corresponding to different types of points (distribution, residential, industrial, …) and time granularities. The time period covered is from 01/01/2015 until 31/12/2016. The data requested for the time series were Superior Wobbe Index (WI) and Superior Calorific Values (GCV).

Survey 2 collected 121 time series for different types of end user off-take points. From the ENTSOG survey data set at the level of TSOs a total of 136 time series were used. Overall, 257 time series of GCV data and 252 time series with WI data were analysed, consisting of hourly and 15 minutes data. Results were made available to the WG through a report summarising the findings. The report contains a chapter for each Member State for which at least 3 data sets have been provided. A common set of tables and figures is presented for each member state. An overview of findings at European level are also provided.

Table 4 provides details on the number of series by type and group. The “end user” group accounts for 70% of the points, with 54% points labelled as “City Gate”.

Table 4 — Summary of the WI number of time series used in the report by type of point and group

Type of point	Group	Acronym	Number of time series
City Gate	End user	C	140
Industry		I	11
Industry - combustion		Ic	7
Industry - non combustion		In	5
Power generation		Po	13
Biomethane injection point	Other	B	9
Interconnection point		Ip	35
Domestic Production point		P	6
LNG terminal		L	6
Underground Storage Facility		U	3
Transit		T	10
EU import point		Im	7
		Total	**252**

[Source: JRC on ENTSOG and CEN SFGas GQS Survey 2 data.]

Seventeen Member States provided data (Table 5) which is complemented by data for the interconnection points between Ukraine and Poland, Slovakia, Hungary and Romania. Germany, Italy and Greece have the highest number of observations, while other Member States were under-represented – in particular for end user points – such as France and the United Kingdom (Table 5).

Table 5 — Summary of the number of WI time series used in the report by Member State and participating country

Member State	Number of points
Austria	15
Belgium	9
Denmark	8
France	9
Germany	55
Greece	26

Member State	Number of points
Hungary	14
Ireland	4
Italy	28
Lithuania	7
the Netherlands	15
Poland	22
Slovakia	4
Slovenia	3
Spain	15
Sweden	5
United Kingdom	8
Other Countries	
Ukraine	5
Total	**252**

[Source: JRC on CEN SFGas GQS Survey 2 data]

Considerable effort has been put into data processing and analysis. Due to concerns with data reliability and the identification of outliers, a methodology was agreed in CEN SFGas GQS. This was deemed necessary as the results of the data analysis may be affected by errors and noise in the data sets (e.g., chromatograph calibration points). The aim of any data treatment was to remove any data points which may falsify or bias the analysis results. Data handling, management and processing has been carried out using R, an open-source programming language and software environment for statistical computing and graphics. All data sets contributing to the survey were analysed with the same data analysis methodology, with the aim to provide a summary of the most relevant statistical parameters on WI and GCV in support of the study. The type of data analysis performed and the visualisation of the data has been discussed and agreed with CEN SFGas GQS.

Though Survey 2 is based on an extensive and validated data set, it may suffer from possible limitations in providing an EU wide view of the extent and variability of the WI values and GCV. Nine Member States did not support the survey, creating some gaps particularly along some supply corridors starting from the Russian Federation. Furthermore, for some of the participating Member States the number of contributed data sets might not be enough to describe the variability within the country, especially when multiple supply corridors are available. It should be noted that flow rate information was not available and no weighting of the data has been performed. So figures for points other than end users are indicative of the final gas mixture of the country. Finally, the time series collected do not allow for an extrapolation or forecasting of future gas quality developments and. The number of biomethane injections is not representative for the future.

9.3.2 Key findings

The analysis of WI data at the regional level demonstrates the presence of potentially quite consistent 'gas quality areas' in Europe.

For a given Member States, all time series were screened and the minimum, average and maximum median calculated under different conditions.

Table 6 provides an overview of such summary statistics for WI bandwidth values observed per country for all data in each series, or by sub-sets defined by the 1st-99th percentile of each series, the 5th-95th percentile and the 25th-75th percentile. Figure 12 provides an overview of the average median value per Country and the sets considered. When looking at Europe as a region – as covered by the survey – the average bandwidth of WI varies between 0.67 and 4.93 MJ/m^3.

Even considering the full data range, Austria, Germany, Denmark, Slovakia and Slovenia show a particularly narrow bandwidth (0.54 – 1.25 MJ/m^3 average bandwidth for the range of 1st-99th percentile). Hungary is on the contrary highly variable due to the characteristics of the national production. The higher WI bandwidth values, as observed from Table 6, are quite similar across the EU (around 4 MJ/m^3 on average for the full data range, or between 2.80 and 3.73 MJ/m3 for the range of 1st-99th percentile), and they are linked to MS where national production plays still an important role in the period of time under consideration. France, Belgium, and Spain share similar values (between 3.17 and 3.81 MJ/m^3 for the full data range or between 2.29 and 2.75 MJ/m3 for the range of 1st-99th percentile) potentially linked to the variety of supply corridors they use. The average WI bandwidth for the 1st-99th percentile range is below 3 MJ/m^3 for all considered countries, with the exception of Hungary. Slovenia is always the less variable Country due to the stability of its supply corridors, and for the period considered the absence of supply sources other than pipelines.

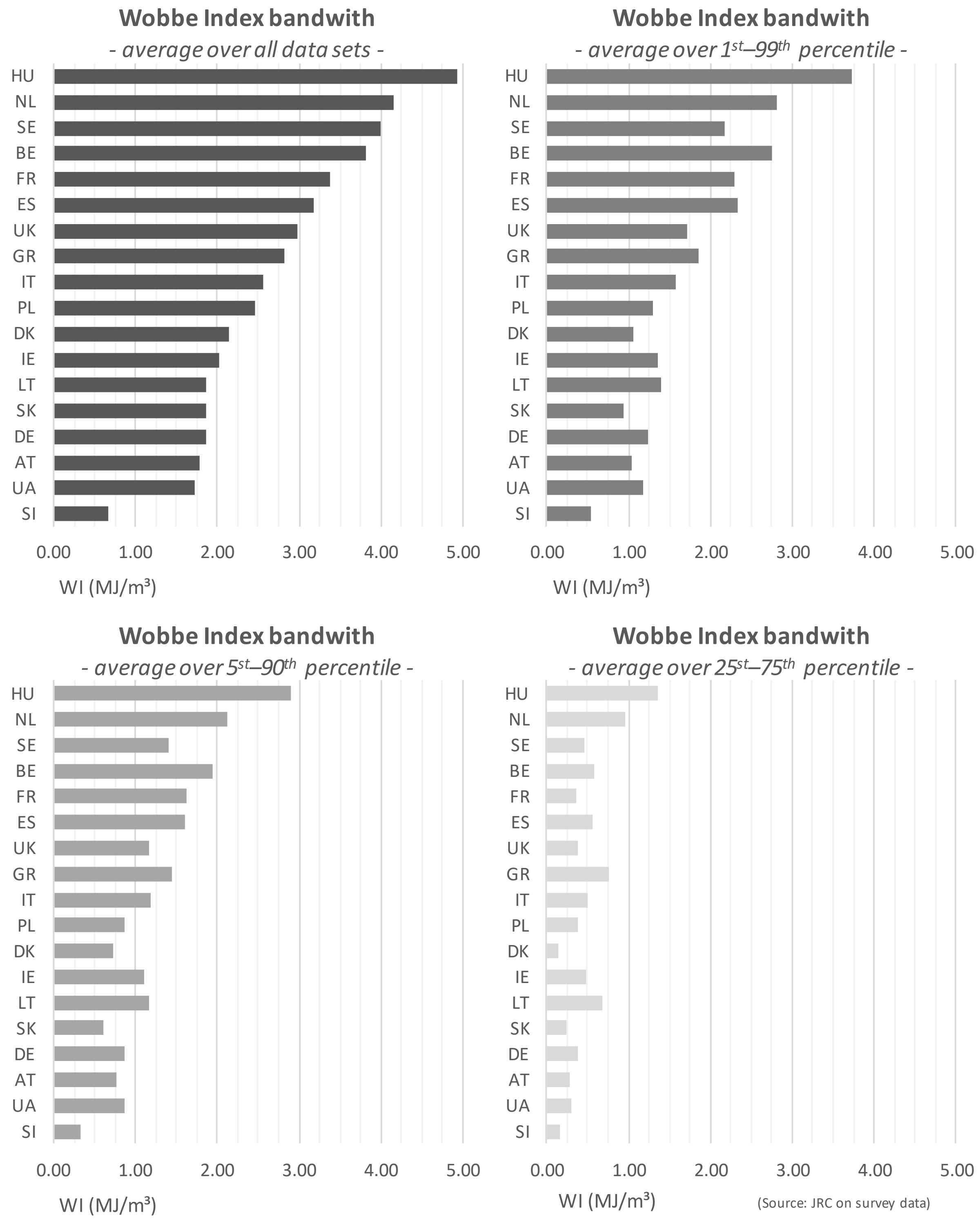
Figure 11 shows the values in Table 6 as bar charts. These charts show the Wobbe Index bandwidth by Country in MJ/m^3 for values calculated over all values of the 252 data sets of Survey 2. The range of considered values is progressively reduced moving from all figures to the interval set by the 1st and 99th percentile for each data set, up to the interval defined by the 25th and 75th percentile. The graphs show that for the 1st-99th percentile, six countries have bandwidths above 2 MJ/m^3, Hungary, Netherlands, Sweden, Belgium, France and Spain.

Table 6 —Wobbe Index bandwidth statistics by Country for different ways of setting the range of considered values .

	Wobbe Index bandwidth												Wobbe Index Median of single data set (MJ/m^3)			
	All data			*1st – 99th percentile*			*5th – 95th percentile*			*25th – 75th percentile*						
Country	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	diff(Max - Min)
AT	1,78	4,44	0,59	1,04	2,26	0,59	0,76	1,74	0,35	0,28	0,70	0,07	50,51	51,21	49,89	1,31
BE	3,81	4,43	3,43	2,75	2,96	2,50	1,95	2,50	1,64	0,59	0,83	0,33	50,11	50,31	49,87	0,44
DE	1,86	4,00	0,20	1,25	3,26	0,11	0,87	2,70	0,08	0,37	1,46	0,04	50,30	51,29	49,31	1,98
DK	2,14	3,09	1,44	1,06	2,14	0,63	0,73	1,58	0,34	0,15	0,20	0,08	51,74	51,99	50,26	1,73
ES	3,17	5,68	1,52	2,33	3,29	0,75	1,61	2,54	0,29	0,57	1,07	0,10	51,25	52,58	50,27	2,31
FR	3,37	3,92	2,55	2,29	3,27	1,54	1,63	2,85	0,75	0,36	0,52	0,18	49,99	52,20	48,09	4,10
GR	2,82	4,58	1,79	1,85	2,90	0,72	1,44	2,20	0,56	0,76	1,44	0,27	51,02	51,34	50,80	0,54
HU	4,93	7,22	0,95	3,73	5,28	0,76	2,91	4,85	0,51	1,37	3,17	0,19	49,14	50,93	46,26	4,67
IE	2,02	3,16	1,60	1,35	1,38	1,33	1,10	1,23	0,96	0,48	0,77	0,28	49,77	49,90	49,54	0,36
IT	2,55	4,27	1,02	1,58	3,00	0,32	1,18	2,15	0,22	0,50	1,00	0,09	50,24	51,61	49,00	2,61
LT	1,87	2,79	1,16	1,40	2,09	0,88	1,17	1,88	0,71	0,68	1,21	0,30	51,03	51,71	50,71	1,00
NL	4,16	6,78	3,08	2,80	5,74	1,63	2,12	5,27	1,08	0,97	4,05	0,27	49,52	50,35	47,51	2,84
PL	2,47	4,18	0,45	1,30	3,36	0,21	0,87	2,84	0,16	0,38	1,72	0,11	50,39	51,57	47,24	4,33

SE	4,00	4,84	1,68	2,17	3,58	0,78	1,41	2,35	0,42	0,45	0,92	0,13	51,00	51,82	50,38	1,44
SI	0,67	1,07	0,45	0,54	0,77	0,42	0,34	0,37	0,32	0,16	0,17	0,15	50,83	50,89	50,77	0,12
SK	1,86	3,53	1,01	0,93	1,39	0,75	0,61	0,92	0,50	0,25	0,30	0,22	50,78	50,79	50,77	0,02
UA	1,72	2,74	0,69	1,19	1,90	0,58	0,88	1,36	0,47	0,30	0,48	0,19	50,86	50,96	50,72	0,24
UK	2,98	3,68	2,40	1,72	2,34	1,13	1,16	1,65	0,79	0,38	0,64	0,12	50,18	51,07	49,15	1,91
All Countries	2,67	7,22	0,20	1,74	5,74	0,11	1,27	5,27	0,08	0,53	4,05	0,04	50,41	52,58	46,26	1,78

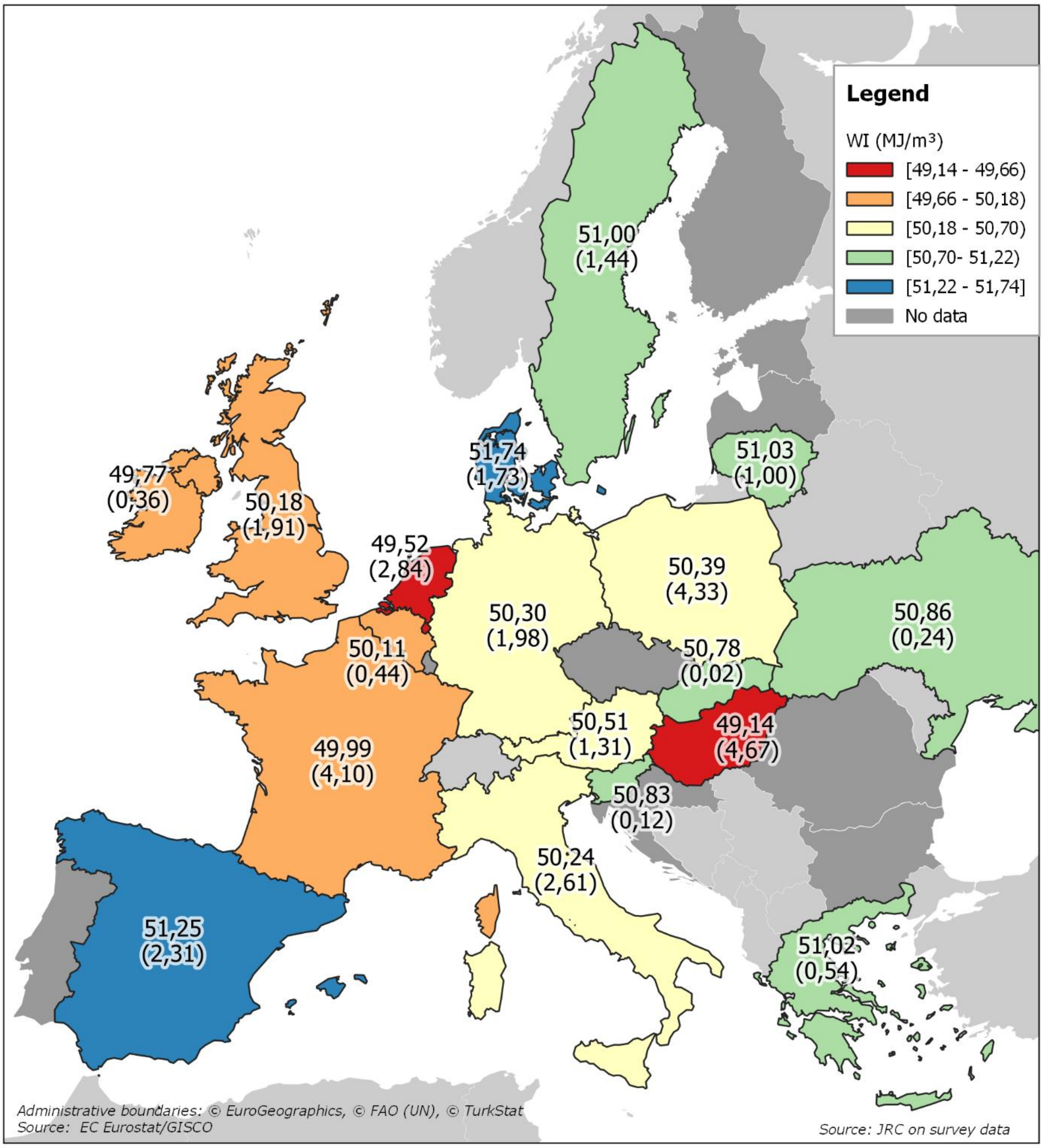
The range is estimated for each of 252 data sets of survey 2 by considering all values (after removal of calibration figures), the interval set by the 1st and 99th percentile, the interval set by the 5th and 95th percentile or the interval set by the 25th and 75th percentile. Furthermore, average, minimum and maximum value of the median of each of the series for the 252 data sets of Survey 2 are provided, along with the difference between the maximum and minimum as indication of spread. The Wobbe Index is expressed in MJ/m^3.



NOTE The range of considered values is progressively reduced moving from all figures to the interval set by the 1st and 99th percentile for each data set, up to the interval defined by the 25th and 75th percentile. The same data are available in Table 6.

Figure 11 —Bar charts of the Wobbe Index bandwidth by Country in MJ/m³ in decreasing order for figures calculated over all values of the 252 data sets of Survey 2.

Figure 12 combines the average of the median values of the WI data sets per country and difference between the maximum and minimum median value (DMM, in brackets) as an indicator of intra-country variability. Colours represent steps of 0.52 MJ/m^3. The map roughly helps to identify possible clusters or "quality regions" for the observed variable. Such regions could be associated to main supply corridors or to specific local situations (e.g., role of domestic production in Hungary or the Netherlands). When looking at DMM, The Figure 12 shows that overall the majority of MS experiencing a range of median WI values below 2 MJ/m^3. Member States, when DMM is higher than 2 MJ/m^3, have a mixture of supply sources where LNG, domestic production or the use of UGS play a relevant role.



NOTE In brackets the difference between the highest and lowest median value in the country. Wobbe Index values are expressed in MJ/m^3. See Table 6 for details.

Figure 12 — Geographic distribution of the Wobbe Index average of the median values for the national data sets of CEN SFGas GQS Survey 2.

9.4 Survey 3 – CEN SFGas GQS Wobbe Index Simple Scenarios Assessment (CEN SFGas GQS SSAS Report)

9.4.1 Aiming and content of the survey

Aiming of the survey was to get a better view and better understanding of the issues with WI over the whole natural gas value chain. As a basis for this survey, a set of what was called 'simple WI scenarios' has been elaborated.

A 'simple WI scenario' is defined as a fixed WI range that is imaginarily to be applied to the whole of the EU and to the whole of the gas value chain from entry into the transport and distribution system to exit for and including end use.

All stakeholder groups/sector organisations from production to end use were asked to assess for the absolute values of the limits and the width of the defined Wobbe Index scenarios

- the affected assets
- the impacts of a change in the Wobbe Index range or rate of change on the assets, indicating:
  - the relevance of the potential impact/effect;
  - the likelihood or probability of the effects;
  - a short description of the effects(problematic situations/issues, occurring effects);
  - facts and figures supporting the statements;
  - relevant references for the facts & figures, if any;
  - possible technical mitigating measures.
- the relevance of the following criteria:
  - security of supply;
  - markets (CEN territory);
  - fitness for purpose/reliability;
  - safety/integrity;
  - maintenance;
  - efficiency;
  - environmental impact/ sustainability;

— contractual/legal and technical framework;

— rate of change;

— any other issues.

The national mirror committees were asked to contribute to their findings to the sector organisations during the survey and to question their replies after closure of the survey.

The defined simple WI scenarios for the survey are given in Table 7:

Table 7 — Simple scenario

Scenario number	WI range [MJ/m^3] (ref. conditions 15°C/15°C)	WI bandwidth [MJ/m^3]	Justification of choice
Scenario 0	current situation	current situation	The current legal and contractual situations different from country to country representing the base case.
Scenario 1	44,46 – 54,0	7,54	The widest considered WI range based on the EASEE-gas Common Business Practice 2005-001/02 on gas quality harmonization to streamline interoperability at cross-border points.
Scenario 2	47,4 – 52,7	5,3	WI range limited
Scenario 3	47,4 – 51,4	4,0	WI range limited to the lower values and by consequence offering easier compliance for renewable and low-carbon gases, but rendering compliance more complicated for LNG.
Scenario 4	49,0 – 53,0	4,0	WI range limited to the higher values and by consequence offering easier compliance for LNG, but rendering compliance more complicated for renewable and low-carbon gases.
Scenario 5	49,24 – 51,15	1,91	The narrowest considered WI range based on the existing common WI range in the EU based on the member states' publications in the OJEU in the framework of the Gas Appliances Regulation.

9.4.2 Replies to the survey and their documentation

28 responses from European sector organisations have been received referring to the following stakeholder groups:

- production

- transmission
- distribution
- end use – industrial
- end use – power generation
- end use – residential & commercial

The replies to the survey are compiled for readability a written text (CEN SFGas GQS SSAS Report Part 1) and evaluated (CEN SFGas GQS SSAS Report Part 2). The replies to the survey were analysed per scenario and per part of the gas chain.

NOTE The survey was meant to provide a comprehensive fact-based overview of the proposed scenarios' possible consequences and mitigation measures for each part of the gas value chain. Although not all figures put forward are supported by scientific or fact-based evidence, they are considered sufficiently solid to be taken into account as they are put forward by an organization considered representative for the concerned sector except if any evidence to the contrary has been provided.

Thus, CEN SFGas GQS SSAS Report summarises the replies and their evaluation:

— Part 1: Compilation of replies to SSAS survey
— Part 2: Evaluation of the replies to SSAS survey

In parallel to the SSAS, the impact of renewable and decarbonised gases on Wobbe Index and Gross Calorific Value in blends with natural gas (see Clause 7) was studied in a dedicated Adhoc Group:

— Part 3: 3 Influence of renewable and low carbon gases on Wobbe Index and Gross Calorific Value of natural gas group H

9.4.3 Main outcome of the survey

The main outcome of the survey was that none of the scenarios completely satisfies the needs of all parts of the gas chain. Whilst producer and system operators need flexibility and wide WI ranges, end users need stability and narrower WI ranges.

The evaluation of the survey input resulted in differentiated approach for a wide entry and a narrower WI bandwidth at exit (see Figure 2) including the classification system, as described in Clause 5.

The detailed outcome of the survey can be found in the CEN SFGas GQS SSAS Report. The report includes, furthermore, considerations of the relevance of GCV and the gas composition versus gas quality and an excurses on theoretical considerations on efficiency, CO and NO_x emissions in relation to gas quality.

Annex A
(informative)

Rate of change of Wobbe Index

A.1 General

In addition to the change of the values of gas properties (e. g. Wobbe Index or GCV), the rate) of change with which this change of the property occurs at a given location is of importance as well for many end-use application.

NOTE Remind the definition of RoC = : speed of change: Change of the value of a gas quality property at a location per unit of time. Note 1 to entry: Nearly instantaneous change in local gas quality is often referred to as 'plug flow'.

Nearly instantaneous change in gas quality can be due to a number of causes, including:

— lack of mixing in the main flow direction of different gas qualities

— bidirectional flows of gasses with different gas qualities

— further causes e.g. by intermittent consumption.

The listed causes are described in A.2.

There are a number of potential issues with instantaneous gas quality change for existing installed technologies; those are described in A.3. Technical mitigation solutions do exist and are discussed in section A.4.

A.2 Examples of nearly instantaneous changes in gas quality

A.2.1 General

Gas transmission systems operators have several entry points from gas producers like gas from local fields, off-shore, import from Norway, Russia and also LNG from a lot of different sources. For instance, in the Netherlands there are almost 40 different entries of different gas qualities in the H-gas grid. Distribution grids have as entry points the interconnection to TSO, other DSO or local production of biomethane, SNG and hydrogen. In the near future, more biomethane will be injected and possible also hydrogen which has a much lower density compared to methane. All these gases will mostly enter at different places into the gas grid. Mostly depending on the local situation, the end-user receives the gas from the gas grid with a different impact on gas quality.

Three possible situations are described:

— Lack of mixing in the main flow direction of different gas qualities (see A.2.2)

— Bidirectional flows of gasses with different gas qualities (see A.2.3

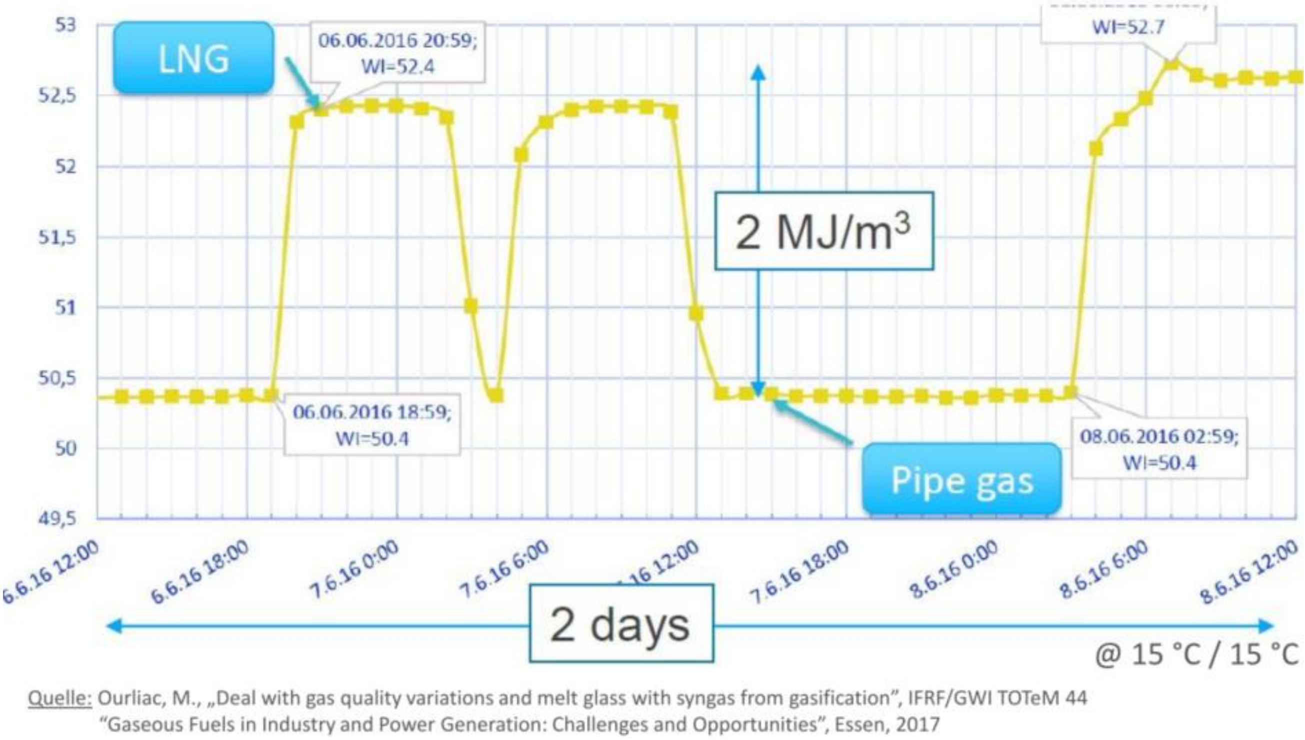
— Intermittent consumption (see A.2.4)

A.2.2 Lack of mixing in the main flow direction of different gas qualities

Figure A.1 shows the situation with the entry of two or more gas sources at one side of the gas grid. If one of the gas sources changes in gas quality (gas fields have mostly different gas wells and therefore different gas qualities) or in case of emergency stops producing gas, the entry gas quality is also going to change.

If gas from two sources is subsequently fed into one entry there is hardly any mixing in the gas pipeline. The maximum gas quality change occurs when there is a switch from one source to another (see

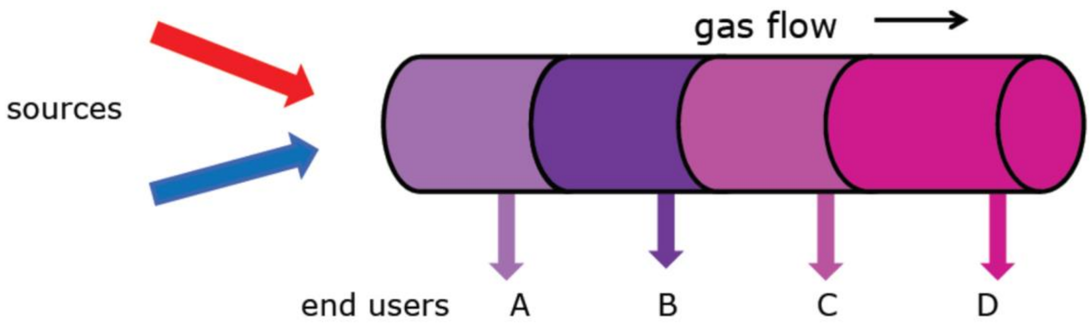
Figure A.1 shows an example of variation observed at an industrial end user in France.



NOTE This figure gives an example and does not mean that it is the same situation for all end-users.

Figure A.1 — Example of gas quality variation in front of an industrial customer in France

Figure A2 explains what happens in a pipeline when the ratio of gases of different qualities are supplied at different times.



Key:

Red arrow: a source of gas

Blue arrow: a source of gas

A, B, C, D End users connected to the grid and receiving the gas from the sources.

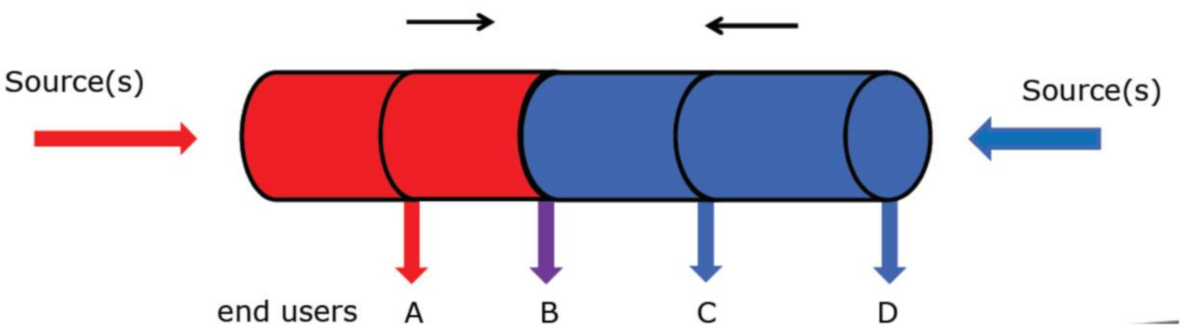
NOTE The ratio of the red and blue sources can vary; the grades of purple describe potential levels of mixing of the gases in the grid.

Figure A.2 —Example on single direction section

Variations as shown in figure A.2 can also occur if a supply point or compressor in the system is operated intermittently.

A.2.3 Bidirectional flows of gasses with different gas qualities

Figure A.3 shows the situation where gas enters from two or more different gas sources on both sides of different end-users and the gas flow also comes from both sides. In this situation you have a so called "zero flow point" where you have a rather quick transition between the two different gas qualities. In figure A.3 the "zero flow point" is located at end-user "B". The "zero flow point" will move to the left or right depending on which source changed or because of changes in entry or exit flow. This is typical due to change the off-take from the grid that varies with consumption.



Key:

Red arrow: source(s) of gas

Blue arrow: source(s) of gas

A, B, C, D end users connected to the grid and receiving the gas from the sources.

NOTE The ratio of the red and blue sources can vary; the grades of purple describe potential levels of mixing of the gases in the grid.

Figure A.3 — Example of frontal flow

It can be concluded that changes in quality will differ per location of the user and the impact of quality changes will be different for different end-users in the same region.

A.2.4 Intermittent consumption

A third case of change in gas quality at the end-user is where the end-user has not used any gas for a period of time and then starts the gas application, while the gas quality in the grid have changed in between and is therefore different from the one in the dedicated supply line for the end-user (Figure A.4). Then the gas quality shift is seen after consuming the stored gas in the connection line between the main pipe and the appliance (application).

This case has been experienced in Denmark.

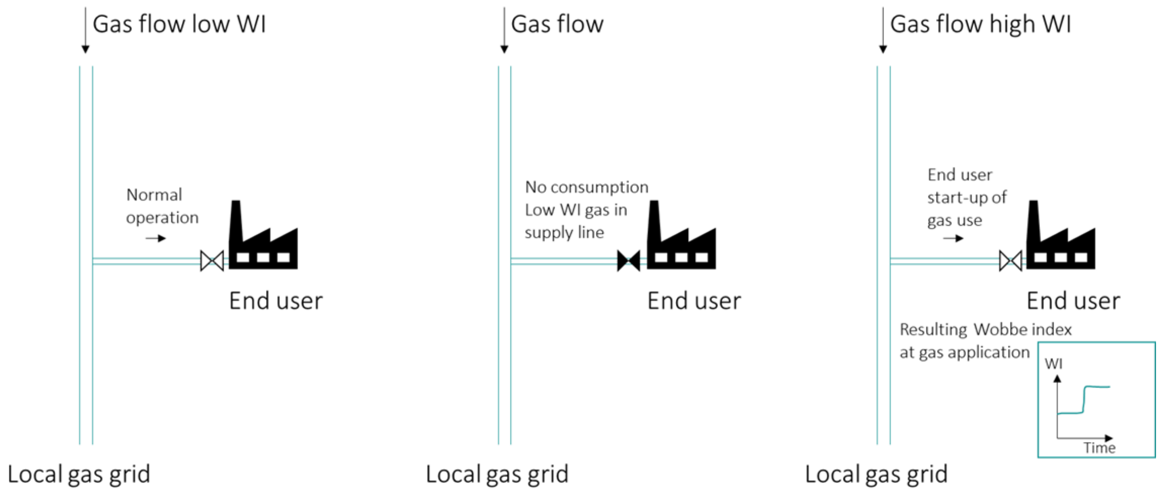


Figure A.4 — Example of gas quality change due to end-use start-up

If the dedicated supply line to the customer contains sufficient 'old' gas to facilitate the start-up process, the installation will experience plug flow as soon as the 'old' gas has been consumed. If the dedicated supply contains just very little gas, the gas using installation will experience a change in gas quality during the start-up process which might result in a failed start.

A.3 Impact of a changing WI on sensitive gas applications

In many combustion systems, for burners for heating purposes, for gas turbines and for gas engines, the energy flow is linearly proportional with the Wobbe Index value. At the same time, changes in Wobbe

Index (or gas composition in general) can also affect the air excess ratio of a combustion process, with consequences for flame temperatures and shapes, efficiency and pollutant emissions.

For natural gas as a feedstock, there is relationship between the Wobbe Index and the composition of the gas which is of consequence for the production. Therefore, changes in Wobbe Index value can affect the energy output of systems as well as the process efficiency, the emissions, the product quality and safety.

Most domestic heating appliances are not sensitive to moderate Wobbe Index value changes.

However, many commercial and industrial applications (e.g. turbines, reciprocating gas engines, some premixed industrial burners, ammonia) can only handle disturbances in a limited range where the change is gradual in time. A too spontaneous and too large stepwise change (plug flow) of the Wobbe Index (or the gas quality in general), will negatively affect the product quality and the safety. For turbines and reciprocating gas engines, an instantaneous change in Wobbe Index will result in undesirable power output fluctuations. The air-to-fuel ratio can be affected in such a way that flash-back of the flame occurs or even flame out with consequently a detrimental trip, i.e. a sudden shut-down. At the same time change of gas quality can affect start up procedures for large-scale equipment. Also, the product quality, reliability and safety in e.g. the industrial sector and in many thermal processing industries will suffer from rapid wide variation in Wobbe Index value. The impact of the rate of change on the application will be smaller, if the local WI bandwidth is restricted.

For many industrial applications and for power plants, (based on an internal survey of power sector)

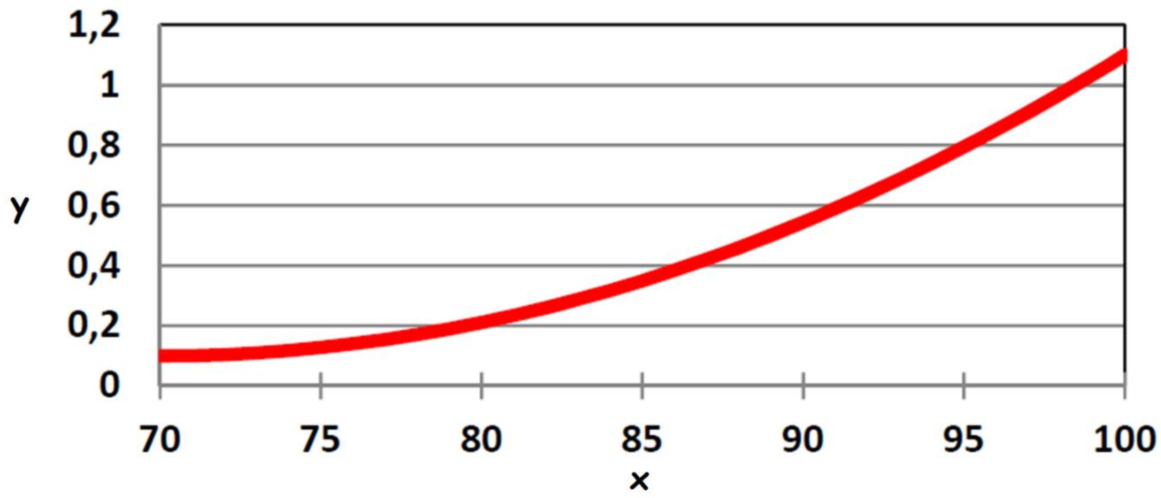
- the maximum acceptable ‘instantaneous’ change in Wobbe Index value is +/- 0,5 MJ/m^3.
- for a larger change in Wobbe Index value, within a maximum bandwidth of 3,7 MJ/m^3, the maximum ramp rate is 0,5 % of the WI value/min (even with control systems), roughly equals 0,25 MJ/m^3 per minute.

NOTE This value (+/- 0,5 MJ/m^3) is experienced for gas turbines and engines can be extrapolated for other industrial applications.

In general, the plug flow issue is more relevant if there is a larger permissible range at the exit level.

For natural gases, there is often a tendency that high WI imply low MN.

The acceptable downward swing in MN depends however on the initial value of the methane number (figure A.5).



Key

x	Actual methane number
y	Max. decrease rate in MN (points/min)

Figure A.5 — Example of a maximum acceptable downward rate of change in the Methane Number (contributed by the power sector)

A.4 Measures to mitigate the effect of gas variations, plug flow and a high rate of change

Examples of possible technical measures of mitigation gas variations, plug flow and a high rate of change:

— gas treatment (e.g gas component stripper) and gas blending before and at the entry level into the gas system

— use of gas blending and mixing facilities in the network (example for a mixing facility in Figure A.6)

— facilitate a gradual change of gas quality on entry points by operational and/or commercial measures;

— flow controls in the grid at DSO level

— gas component, WI, GCV measurement (e.g. by sensors) and data communication at higher frequency to relevant and interested party

— optimisation of the process of appliances and applications adapting to gas quality information

— feed forward process control and local gas quality measurement at the end user

— fuel gas conditioning on site of the end-user (Figure A.3)

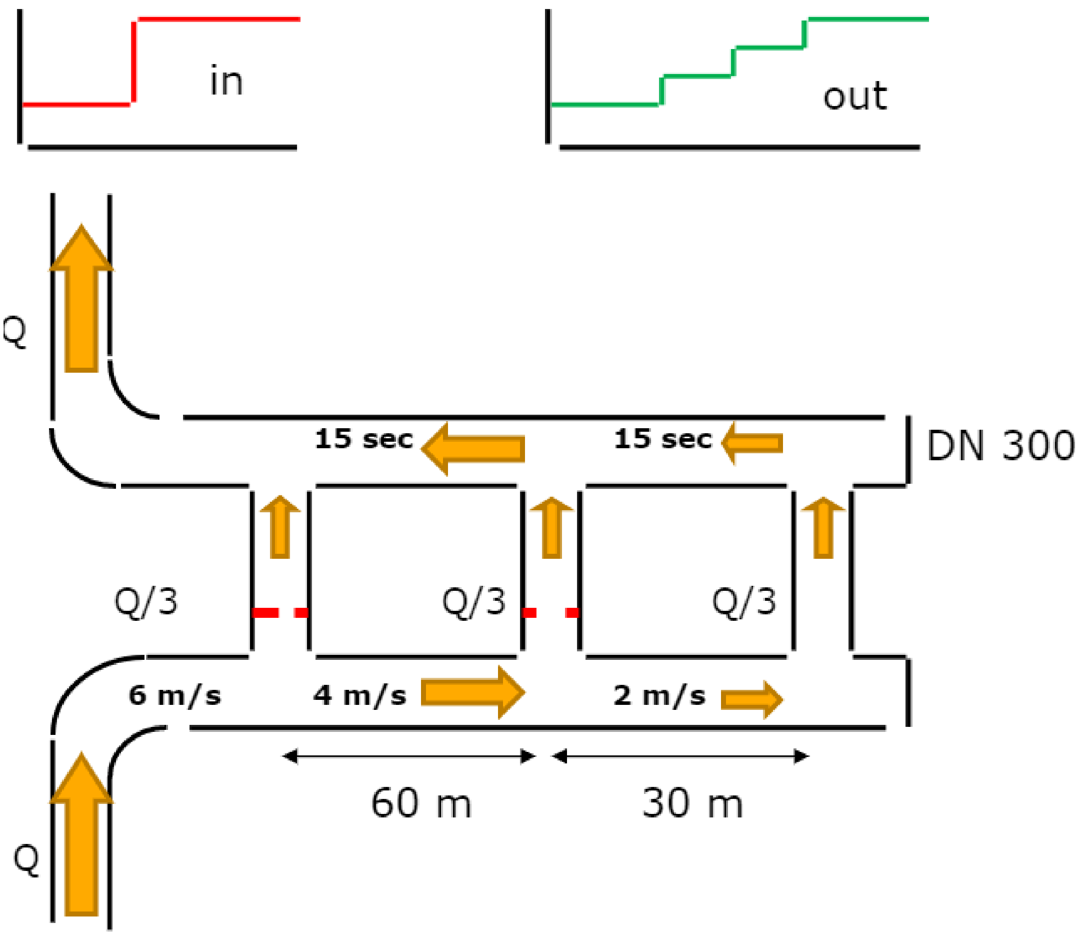
— provision of gradual change of gas quality change at the entry point when getting gas from a source with a very different gas quality

— application of modern adaptive combustion control technologies (CO, O2, ionization, etc.), including the acceleration of the replacement of t residual non-changeable stock of gas appliances/applications

NOTE Technical mitigation solutions for gas quality variations for small domestic appliances do exist and are for the most already available and to some extend integrated in new products commercially available on the market (gas turbines with feed forward, gas boilers with combustion controls, etc.)

— others.

The identification of most efficient mitigation measures needs to be carried out in cooperation between all stakeholders (see Clause 6) cost-benefit analysis is needed to understand the benefits and costs of it (i.e. cost efficient and cost effective solutions).



Key

Q = 30,000 m3/h @ 20 bar(g)	
ΔW = 3 MJ/m3 -> 3x1 MJ/m3	
Yellow arrow	Describes gas flow and gas speed [meter/second]

Figure A.6 — Example of a mixing facility - A so-called mixing organ that smooths a sudden change in gas quality

Annex B
(informative)

On-site adjustment of the end-use applications related to the WI exit proposal (5.2)

Complementary to chapter 8.4, this annex is meant to bring some further insight in the on-site adjustment of combustion processes and applications.

B.1 Combustion

Combustion is a fast chemical reaction between substances, usually including oxygen and accompanied by the generation of heat and light in the form of a flame. It is a complex chemical process involving many steps that depend on the properties of the combustible substance[2], but also the composition of the oxidizer, temperatures and pressure.

Combustion in heating appliances and applications is a chemical reaction between a combustible substance, called a fuel, and oxygen, most often supplied by the ambient air.

The general formula of an ideal combustion process of methane, the main component of natural gas, with air is:

$CH_4 + 2\ (O_2 + 3{,}76\ N_2) \rightarrow CO_2 + 2\ H_2O + 7{,}52\ N_2$

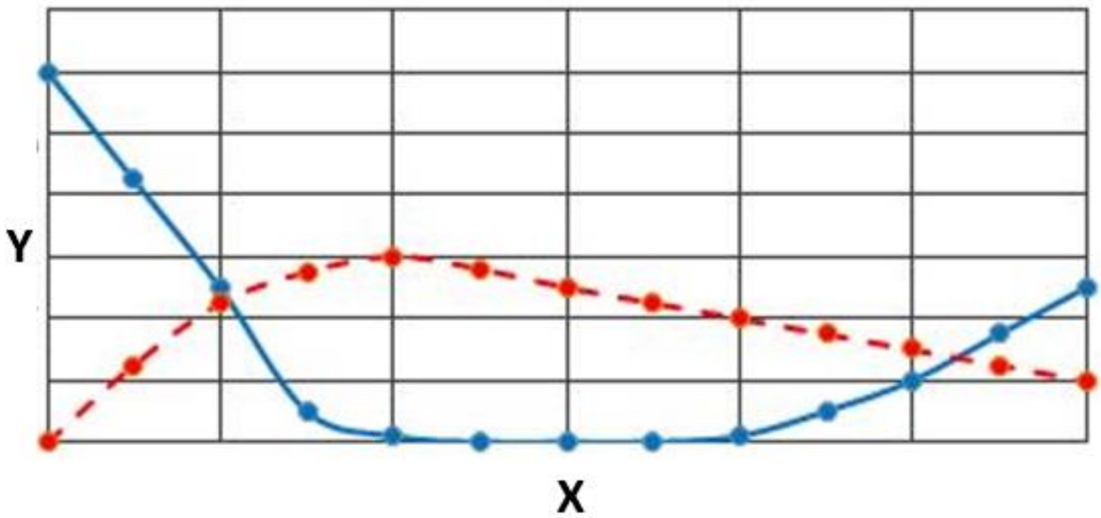
In this ideal process (a so-called stoichiometric combustion) only the amount of air is supplied which is required to completely consume the fuel, i.e. after the combustion process, no fuel and no oxygen remain. This minimum amount of air is dependent only on the chemical composition of the fuel. So, when the fuel composition of the fuel changes (and thus, also the Wobbe Index and calorific value), the minimum air requirement will change as well.

In a real-life gas combustion process, it is practically impossible to have a stoichiometric combustion process without unacceptably high CO emissions. Therefore, combustion processes are usually operated with a certain amount of excess air. The air/gas ratio is an important process parameter for any combustion process.

A major factor impacting the combustion result is the air/gas ratio. Too little air will lead to incomplete combustion and by consequence higher CO concentrations. Too much air will lead to flame lift and an unstable burning process which may also result in higher CO concentrations. Also other emissions, efficiency and properties like e.g. flame temperature and flame speed are impacted by the air/gas ratio. Without going into more detail as it is not the purpose of this annex and as lots of scientifical literature on combustion exist, the conclusion is that WI impacts the air/gas ratio which in turn impacts the combustion unless there is some kind of control which changes the air supply to enforce a constant

[2] Source: https://www.britannica.com/science/combustion

air/gas ratio. The general trends of CO and NO_x emission in function of the air/gas ratio are illustrated in Figure B.1.



Key:

X Air ratio λ

Y CO and NO in flue gas

CO

NO

Figure B.1 —Trends of pollutant emissions as function of the air/gas ratio as seen in many applications [Source: GWI]

Besides the manufacturer's design of the appliance/application the major combustion settings consist of adjusting the appropriate primary air flow rate to the desired gas flow rate. Apart from appliances/applications equipped with auto-adaptive controls this air/gas ratio is set under the same gas and air supply conditions but is impacted when these conditions change. Some of these may change continuously like the Wobbe Index of the gas, the air temperature and humidity (especially when taken directly from outside), etc. Also wear tear and pollution of components have an impact on the gas air ration. Proper maintenance has the purpose to restore the original gas air ratio. A lack of regular maintenance or in adequate maintenance may influence the gas air ration.

Wobbe Index changes also affect the output power of the appliance/application. Depending on the difference with the desired output power this can be an issue for the fitness for purpose of power sensitive applications like e.g. instantaneous hot water production in residential appliances and most industrial processes.

B.2 Combustion settings

A vast majority of appliances of category I_{2H} and $I_{2E(+)}$ covered by Regulation (EU) 2016/426 are put on the market with combustion settings adjusted in the factory by using a reference gas, called G20 (cf. EN 437), having a WI of 50,72 MJ/m^3 (15 °C/15 °C). This setting allows proper functioning within a specific WI bandwidth around this WI value adapted to the H-gases distributed in the country of destination. The operational WI bandwidth depends on the technology and the applicable requirements. On basis of the Simple Scenario Assessment Survey outcome a 5,7 MJ/m^3 bandwidth seems acceptable for residential appliances of certain appliance categories when set in a factory for the local appropriate gas quality – this requires the knowledge of the local gas quality at the time of adjustment. This bandwidth is narrower if installed in areas where strict emission requirements apply.

Other appliances, like forced draught burners, and industrial applications are tailor-made and have to be adjusted on-site. Their required fitness for a specific purpose often narrows the operational WI bandwidth significantly compared to most of the residential appliances. They may also rely on other gas quality criteria than the Wobbe Index.

B.3 On-site adjustment of combustion settings

Depending on the local condition it is clear from Figure B.1 above that the factory settings not necessarily correspond to optimized function of the appliance/application on the installation site and so an on-site adjustment may be appropriate or even required.

NOTE Adjustment to the local WI range optimizes performance but will most likely compromise safe operation over the whole WI entry range.

Another occurrence requiring adjustment on-site is the replacement of defective safety and control devices for combustion-related settings as spare parts are mostly supplied without adapted settings.

The adjustment of combustion settings on-site is generally limited to adjusting

— the gas flow rate to obtain the desired output power and/or;

— the air/gas ratio to optimize the function, the safety and the environmental performance (i.e. emissions and efficiency).

This is done based on measurement of resp. the gas flow rate and the concentration of a relevant combustion product (i.e. O_2 or CO_2) (using O_2 is preferred). The air/gas ratio is generally adjusted to the single value indicated in the manufacturer's instructions. The operation is obviously carried out with the gas supplied at that moment, but without knowing its real-time WI value. The real-time WI value may not be indispensable if the local WI bandwidth is small, but it becomes clearly more important with bigger fluctuations.

NOTE The real-time Wobbe index value of the gas supplied at each appliance/application is not available today. It would require specific measurement or, if not possible, reliable calculation based on upstream measurement.

In case of wider local WI fluctuation, the current practice of on-site adjustment would have to be adapted and to be based on the real-time WI value of the gas supplied. The set value of the concerned combustion product (i.e. O_2 or CO_2) concentration should then be based on

— the difference between the real-time gas supply conditions (including WI) and the reference conditions of the local gas supply (see also B.4) and

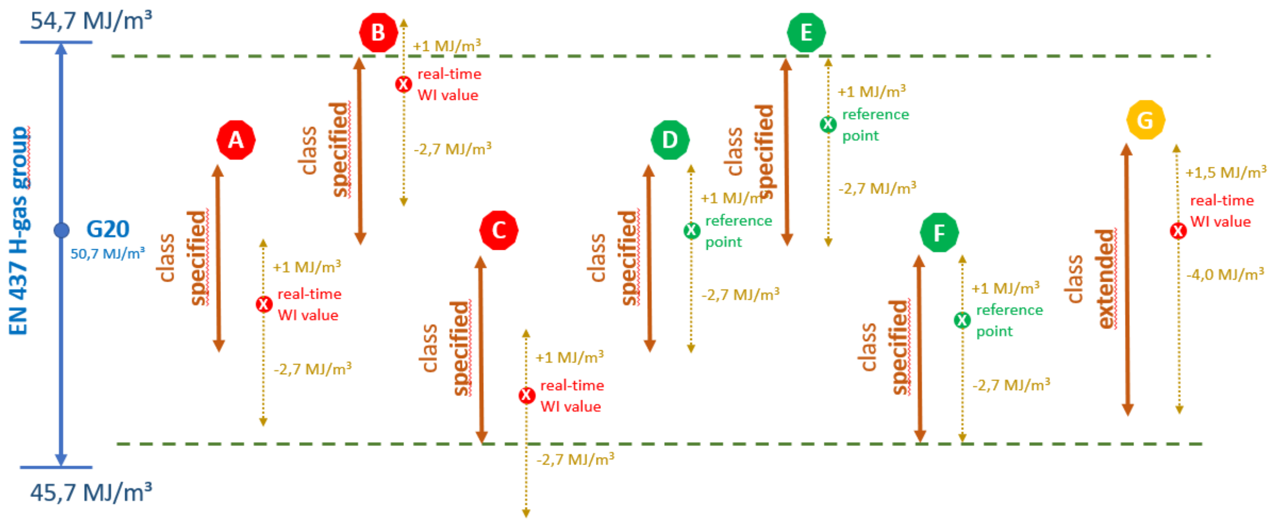
— the difference between the real-time air supply conditions and the reference conditions used for defining the set values indicated by the manufacturer.

B.4 On-site adjustment vs. WI classes assigned to exit points

The use of WI classes for exit points has an advantage for appliances/applications requiring on-site adjustment as the classes' purpose is to give more precise information on the WI values to expect. Today the only available information on the WI values to expect is generally limited to a WI range often significantly wider than the local WI range (cf. survey 2).

The proposed classes allow to define an appropriate reference WI value for the gases that are supplied to the appliance/application. This reference point corresponds to a WI value that allows for proper functioning over the whole class' WI range and would have to be defined by the manufacturer. The manufacturer has the responsibility to provide the information on how to use the information on local gas qualities to adequately adjust the appliance.

Even in a specified class with a bandwidth of 3,7 MJ/m^3 it is required to define such a reference WI value to which the appliances/applications are to be adjusted if the manufacturer requires so; see example in Figure B.2.



Key

A to C	examples of Class Specified
D to G	examples of Class Extended
green dot	reference point
red dot	real time WI value

Figure B.2 — Example of on-site adjustment of appliances in relation to the proposed WI exit classification

Cases A to G are described as follows:

- cases A, B and C: the appliances/applications are adjusted with the gas supplied at that moment without knowing the real-time WI and its position within the class' range; this leads to inappropriate adjustment for the concerned WI class; furthermore in cases B and C the range of proper functioning is partly lost as outside of the WI entry range; in case B the adjustment may lead to flame lift and increased CO emissions when supplied with gases with a WI that is more than 2,7 MJ/m^3 lower than the WI of the setpoint (while still in the limits of the concerned specified class); in case C the adjustment may lead to thermal overload and increased CO and NO_x emissions when supplied with gases with a WI that is more than 1 MJ/m^3 higher than the WI of the setpoint (while still in the limits of the concerned specified class);

- cases D, E and F: the appliances/applications are properly adjusted to the reference WI value for a specified class e.g. defined at -1 MJ/m^3 from the upper limit of the specified class (= +2,7 MJ/m^3 from the lower limit); if in case D it concerns a residential appliance adjusted to G20 in the factory, it will obviously not need to be adjusted on-site;

- case G: an example of an extended class; all above principles are equally valid for an extended class, but obviously more appliances/applications will be sensitive and will require appropriate mitigating measures to be able to cope with the corresponding WI range.

NOTE The figures used are common for residential appliances (cf. German Hauptstudie).

Changing the current WI exit class to another class (whether specified or extended) requires a reassessment and possibly a readjustment of the combustion settings of all on-site adjusted appliances/applications without combustion control systems. This is nevertheless not caused by use of the WI class system as every relevant change of a local WI range today also would require on-site adjusted appliances /applications to be readjusted. The WI class system would however allow for clear information before such a relevant WI range change occurs while today it is often only discovered during the next inspection/maintenance with combustion products measurement.

B.5 Auto-adaptive control of combustion settings

OEMs have developed a range of auto-adaptive control technologies, which allow new residential, commercial and industrial appliances/applications to handle gas quality fluctuations (Wobbe Index, GCV) broader than today. These technologies are available on the market and make use of indicators upstream, in or downstream of the combustion process:

a) **pre-combustion:** control based on measurement of gas and air properties at the appliance's entry point (e.g. density, viscosity, thermal conductivity, speed of sound, gas composition); the high cost of this method currently limits its use to industrial applications;

b) **in-combustion:** using flame quality sensors to analyse combustion quality is primarily being used for premix gas burners in the residential sector; ionization current measurement is widely spread; evaluating flame heat or UV radiation is also possible, but not commonly used;

c) **post-combustion:** sensors analysing the flue gas are used for applications typically above 70 kW for commercial and industrial use; these sensors are measuring the residual O_2 content in the flue gas and/or other emissions like NO_x or CO.

The information is then used to change the volume flow of air in order to maintain a set air/gas ratio.

Auto-adaptive combustion controls can obviously handle a wider Wobbe Index bandwidth while still satisfying all the applicable requirements as they optimize the combustion for the current gas and air supply conditions. By consequence they do require much less or even no on-site adjustment of combustion settings.

The existing control systems are not necessarily designed for coping with the whole proposed WI entry range from 46,44 MJ/m^3 to 54,00 MJ/m^3 (15°C/15°C). Further investigation and research are required (see also chapter 8.4 on the open issues).

Annex C
(informative)

Conversion factors between reference conditions

Attention need to be given to the use of reference conditions and also units. This standard uses the reference conditions set in EN ISO 13443.

Table C.1 gives the factors to convert the Wobbe Index to the different reference temperatures, used in the gas sector.

Table C.1: Conversion factors between reference conditions.

Reference temperature (combustion, volume)	25 °C/20 °C to 15 °C/15 °C	25 °C/0 °C to 15 °C/15 °C	0 °C/0 °C to 15 °C/15 °C
Conversion factor for Wobbe Index (for real gas)	1,019	0,949	0,946
NOTE 1 These coefficients are approximations; their use may introduce a bias that can reach 0.03 % for H gases. Thus, it is recommended to calculate those properties directly from composition in the desired reference conditions. NOTE 3 The conversion factor between MJ/m^3 to kWh is 3.6.			

Annex D
(informative)

Consultation on CEN SFGas GQS draft proposal in October/November 2019 – Basis for the present CEN SFGas GQS proposal

D.1 Questions on Wobbe Index proposal (2019-19-30) subject to CEN SFGas GQS consultation

RESPONDENT
Name
Contact data (e-mail address and phone number)
Are you officially replying in the name of a sector organization? (Yes/No)
If 'yes', which one?
Are you officially replying in the name of a national mirror committee? (Yes/No)
If 'yes', which country?
If 'yes', which stakeholder groups are represented in this national mirror committee? (producers, TSO's, DSO's, suppliers, manufacturers, end users, ...) ***In case of manufacturers specify of which kind of gas applications – stationary engines, turbines, boilers, radiant heaters, water heaters, cookers, ...*** ***In case of end users specify what type of end users – industrial, power generation, residential, ...***
CONSULTATION
1. Does the sector organization/mirror committee agree with the proposed EU wide WI entry range of 46,44 up to 54,00 MJ/m³ (15/15°C)? (Yes/Yes if/No)
If 'yes if' then complete.
If 'no', why?
If 'no', do you have another proposal and if so, describe the proposal and the reasoning behind.
2. Does the sector organization/mirror committee agree with the proposed WI exit classification as described in decision 25/2019? (Yes/Yes if/No) *See table of conclusion 25/2019 illustrated with an example in annex B.*
If 'yes if' then complete

If 'no', why?
If 'no', do you have another proposal and if so, describe the proposal and the reasoning behind it.

RESPONDENT
Name
Contact data (e-mail address and phone number)
Are you officially replying in the name of a sector organization? (Yes/No)
If 'yes', which one?
Are you officially replying in the name of a national mirror committee? (Yes/No)
If 'yes', which country?
If 'yes', which stakeholder groups are represented in this national mirror committee? (producers, TSO's, DSO's, suppliers, manufacturers, end users, ...) ***In case of manufacturers specify of which kind of gas applications – stationary engines, turbines, boilers, radiant heaters, water heaters, cookers, ...*** ***In case of end users specify what type of end users – industrial, power generation, residential, ...***
CONSULTATION
1. Does the sector organization/mirror committee agree with the proposed EU wide WI entry range of 46,44 up to 54,00 MJ/m³ (15/15°C)? (Yes/Yes if/No)
If 'yes if' then complete.
If 'no', why?
If 'no', do you have another proposal and if so, describe the proposal and the reasoning behind.
2. Does the sector organization/mirror committee agree with the proposed WI exit classification as described in decision 25/2019? (Yes/Yes if/No) *See table of conclusion 25/2019 illustrated with an example in annex B.*
If 'yes if' then complete

If 'no', why?
If 'no', do you have another proposal and if so, describe the proposal and the reasoning behind it.

D.2 Wobbe Index classification proposal (2019-10-30) illustrated with an example

ANNEX B — WI exit classification proposal illustrated with an example

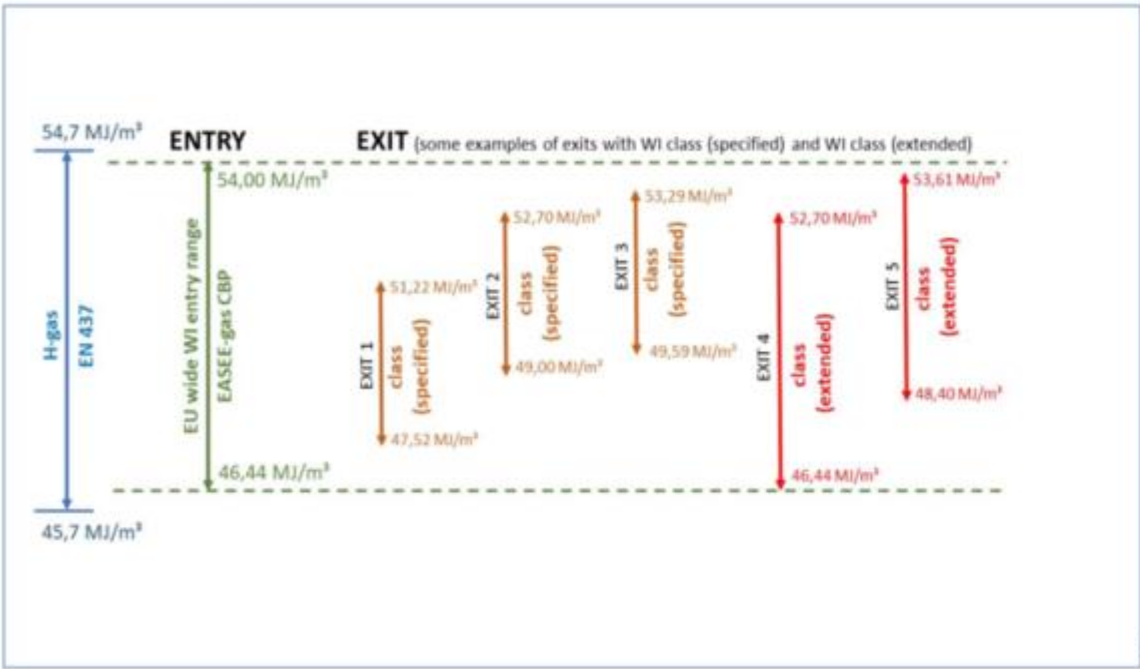
Classes	WI range	Bandwidth	Percentiles
Class (specified)	With indication of WI limits defined per exit point, based on the distributed gas, within WI entry.	Below or equal to 3,7 MJ/m³ with specifying the actual bandwidth.	1-99
Class (extended) If deviating bandwidth. Case by case assessment (rules to be specified in legal process).	With indication of WI limits defined per exit point, based on the distributed gas, within WI entry.	Above 3,7 MJ/m³ with specifying the actual bandwidth.	1-99

EXPLANATION:

If the WI range of gases supplied to the concerned exit point or exit area ≤ 3,7 MJ/m³ its class will be assigned by defining a lower WI limit and a higher WI limit but always covering a range of 3,7 MJ/m³.

If the WI range of gases supplied to the concerned exit point or exit area > 3,7 MJ/m³ its class will be assigned by defining a lower WI limit and a higher WI limit covering a range exceeding 3,7 MJ/m³.

ILLUSTRATION WITH EXAMPLES :



D.2.1 First question (see D.1) related to the agreement with the proposed entry range

Table D.1 — Replies relate to the proposed entry range

Organisation/Mirror Committee	Are you officially replying in the name of a sector organization/Mirror Committee? (Yes/No)	In case of mirror committee; which organisations are represented (specify gas applications/type of end-user)	1. Does the sector organization/mirror committee agree with the proposed EU wide WI entry range of 46,44 up to 54,00 MJ/m³ (15/15°C)? (Yes/Yes if/No)	If no/If yes: reasoning	if no: alternative proposal with reasoning
CEFACD	yes		yes	no further comment	
CEFIC	Yes		yes, if	exemptions can be made for domestic use on a country-by-country basis and the TSOs are able to provide the proper exit specification at industrial consumers. This would allow some member states the continuing injection of indigenous gas according to the H-GAS EN 437 standard. For the exemptions, the lower limit for entry points should be set at 45.66 MJ/m³ as defined in the EN437 standard (Test gases. Test pressures. Appliance categories.) and adaptions of the upper limit might be required as well. For cross-border points we agree with the proposed higher entry point. This means that national TSOs should be able to provide the proper exit specification. For the chemical industry continuous gas supply is essential. In principle, reducing the entry range is not desirable as it limits the availability/supply and the security of supply for natural gas. Going beyond the principle, current example demonstrates that in the CEE region due to geopolitical issues and the conditions of the gas	

				supply system there is considerable risk that without indigenous gas supply operators will be exposed to gas supply disruption risks.	
CEN/TC 131			No	In the enclosed slides a description is enclosed that the proposed range of the distributed gases at the upper or lower end at the exit points are out of spec and have no safety margins in respect to the EN 437. Further the proposed range of 3,7 MJ/m^3 is in the opinion of CEN/TC 131 too wide as the EN 676 describes a maximum tolerance of ± 2 %. Based on the upper value 54,7 MJ/m^3 are that e.g. ± 1,1 MJ/m^3. As a forced draught burner have no fixed setpoint but will be adjusted based on the distributed gas the information of this quality and possible fluctuation at the exit point is needed.	
DIN NAGas	yes	Producers, TSO, DSO, suppliers, manufacturers of residential, commercial and industrial appliances, industrial end users	yes, if	• Biomethane injection into a gas net is covered. • Feed in/back from distribution net to high pressure transport grid is covered • The mirror committee agrees with the principle. However, the exact range should be discussed: There is not sufficient distance between a possible distributed high Wobbe gas (54MJ/m^3) and the current extreme limit gases as specified in EN 437. In this regard, a slightly lower upper limit appears advisable, still covering almost all gas qualities present in European grids. • It must be clear that the discrepancy between a wide entry specification and a much narrower exit point specification puts some strain on TSO's and DSO's. Thereof, TSO's are, as proposed, directly connected to an entry point and in some cases have facilities to adjust the CV or Wobbe value of a given gas, e. g. by conditioning or storage, to buffer variations. However, DSO's normally have no such technical possibility, and will have some entry points in particular for renewable gases, which could make stable delivery conditions to a given exit point specification a major challenge.	
DK (DS)	yes	Authorities, biogas association, boiler supplier, gas distribution, gas competence centre, gas engine suppliers, gas producers, gas storage, gas	Yes, if	Yes if it is confirmed that, upon the inclusion of the WI range, the standard will remain as voluntary adoption, with Member States retaining the competence for establishing the Wobbe Index range. The Danish mirror group see the competence at the Member States as key tool to ensure the safe use of gas at end-user level. The suggested entry range is evaluated by the Danish mirror as a balanced approach that keep safety margins between the extremes and the test gasses according EN 437, that gives room for both high Wobbe Index gas as the Danish gas production in the North Sea and the green gasses that is crucial for the decarbonization of the gas system.	

		turbine service company, industrial burner supplier, industrial burner service company, gas transmission.		Together this covers both the security of supply for the Danish marked and the necessary green transition.	
EASEE-gas	yes		yes, if	it is confirmed that, upon the inclusion of the WI range in the EN 16726, the standard will not be binding but will remain as voluntary adoption, with Member States retaining the competence for establishing the Wobbe Index range. The approval of the technical standard should be guided with clear definitions of the regulatory framework and related procedures, responsibilities and liabilities.	
EBA	yes		yes	Yes. A minimum value of 46,44 MJ/m^3 for the EU wide WI entry range is acceptable for the European Biogas Association. When a higher WI would be required, either the efforts of upgrading in terms of cost and energy rises significantly or propane must be added.	
EHI	yes		no	No because: (see also statement in annex) In the enclosed slides a description is enclosed that the proposed range of the distributed gases at the upper or lower end at the exit points are out of spec and have no safety margins in respect to the EN 437. For gas boilers the range should be defined as 46,4 – 52,2 MJ/m^3 and set points should be described. Further for gas forced draught burners the proposed range of 3,7 MJ/m^3 is too wide as the EN 676 describes a maximum tolerance of ± 2 %. Based on the upper value 54,7 MJ/m^3 are that e.g. ± 1,1 MJ/m^3. As a forced draught burner have no fixed set-point but will be adjusted based on the distributed gas the information of this quality and possible fluctuation at the exit point is needed.	
ETN	yes		yes, if	We would agree with the proposed EU-wide WI entry range provided: a. This is an absolute limit and is NOT subject to a statistical range such that 1st to 99th percentiles of readings lie within this limit. Any such statistical relaxation of the overall limit could in principle allow ANY gas	

				to enter the system for short periods and could result in significant safety, integrity and operational issues. b. This should be an overall limit EU-wide limit. More restrictive limits, within this overall range, could be defined at specific entry points irrespective of whether these entry points are entry points to the EU-wide system or entry points between sub-systems within the EU-wide system. c. More restrictive requirements are set at transfer and exit points within the system, in line with our responses to Question 2. d. For countries with gas resources (e.g. local gas production, biogas etc.) that lie outside this EU-wide entry range limit, wider limits may be set. This should only be allowed under exceptional circumstances with appropriate due diligence and appropriate means to ensure gas outside the EU-wide entry range limit could not enter the rest of the EU-wide system. Areas where limits are outside the EU-wide entry range should be considered to be outside of the EU-wide system but connected to it.	
ENTSOG	yes		yes, if	Yes if it is confirmed that, upon the inclusion of the WI range, the standard will remain as voluntary adoption, with Member States retaining the competence for establishing the Wobbe Index range. This would be in line with the conclusion of the European Commission following the examination of the implementation issues associated with EN 16726:2015 that was led by ENTSOG in 2016. This is without prejudice to the classification system for exit points being enforced in the relevant regulatory framework. The approval of the technical standard should only proceed when the regulatory framework and related procedures, responsibilities and liabilities have been clearly defined	
EUROMOT	yes		yes, if	EUROMOT would agree with the proposed EU wide WI entry range provided: a. There is a technical and legal certainty that TSOs will ensure that the exit points for the users and DSOs will not exceed the preferred WI exit range (see answer to question n. 2 below), although we know that this would be extremely difficult to ensure with such a	

				wide entry range. b. The EUROMOT proposal for a preferred WI range at exit points is accepted by the group (see answer to question n. 2). This preferred range should be the guide value for import contracts and for renewable gases to be injected in natural gas. c. Countries with indigenous gas resources can deviate from the preferred range, although the local TSOs should investigate the technical and economical possibilities for converging to the preferred WI range.	
EUTurbines	yes		yes		
ES	Yes	Groups represented in the national committee are TSO's, DSO's, test houses, national and regional authorities, installers, manufacturers of appliances and components for gas appliances (CEN/TC 58) and gas installations, biogas producers and engineering companies. Appliance manufacturers	Yes	Yes, if it is ensured that the implementation of the proposed solution is on a voluntary basis. Exit ranges should remain as a merely probabilistic approach. We would like to highlight that a clear regulatory framework linked to the proposal has not been defined yet. This should not introduce unnecessary additional obligations, complexity or costs to the gas infrastructure operators, especially in countries where gas quality has never been an issue. National/local solutions should remain being the priority tool at national level to solve local issues. Gas operators can neither provide a firm guarantee on exit bandwidth(s) nor have any liabilities if off-class gas arrives to the exit point. Gas grids are operated according to the gas demand in each moment, and never based on gas quality. Finally, it is paramount to ensure that any costs related to the implementation of this proposal are recovered by the gas operators.	

		are of those products covered by CEN/TCs 48 (water heaters), 49 (domestic cooking), 109 (boilers), 180 (air heaters and radiant heaters). CEN/TC 106's (catering appliances) interest in our case is covered by a test house, no any manufacturer.			
FR	yes	TSO, DSO, LNG Operator, Storage Operator, Suppliers, GAR French Notified Body, Gas appliances manufacturers (boilers, overhead radiant heaters), Testing laboratory. (All stakeholders listed in the group receive the documents but do not regularly attend	yes	no further comment	

		the meetings nor answer the consultations)			
GIE	yes		yes, if	Yes if it is ensured that the implementation of this range will not be binding. GIE proposal is in line with the conclusion of the European Commission following the examination of the implementation issues associated with EN 16726:2015 that was led by ENTSOG in 2016. In addition, GIE would like to highlight that the definition of the Wobbe Index range should be discussed at national level together with clear regulatory rules, procedures, responsibilities and liabilities. Cooperation at cross-border points is key to avoid any issue related to gas quality and WI range accordingly.	
HU	yes	Hungarian Horizon Energy Ltd., MOL Hungarian Oil c Gas Plc., O&GD Central Ltd., Riverside Ltd., Tét-3 Gázkút Ltd., Vermilion Energy Hungary Ltd. The above companies cover all HC production in Hungary.	no	We propose to the change the lower value to 45.66 MJ/m^3. The upper value may remain the same but may be reduced by 0.78 MJ/m^3 to compensate for the proposed lower value. Unfortunately, the introduction of the above range will result in the decrease in natural gas production in Hungary, as it will limit the marketability of certain gas reserves. A reduction in production would have the following undesirable effects: - The Hungarian state would lose tax and royalty revenue. - Security of gas supply of the country would be jeopardized. - Instead of cheap domestic gas, Hungarian consumers would have to buy more expensive imports, which would have an effect on gas prices. We request the development of a WI range that does not curtail the current production. In Hungary, the lower end of the range of Wobbe Index value of indigenous gas production that can enter the interconnected TSO network is at 45.66 MJ/m^3. So, the values of 46.44 MJ/m^3 or higher are not suitable as a lower end would constitute a limit for Hungarian producers. Thus, the currently used low threshold of Wobbe value of 45.66 MJ / m^3 is appropriate for the Hungarian production.	
IFIEC	yes		yes	The current H-gas quality specifications of supply and demand are different in Europe, varying between the EASEE-gas CBP of 2005. Reducing the entry ranges are not desirable as long as the TSOs are able to provide the proper exit specifications taken into account the interests of end-consumers.	

IOGP			yes, if	IOGP supports the ongoing work by CEN on developing a Wobbe Index proposal to be included in the standard EN 16726. We also support the EASEE-gas range for WI which is used in the current proposal. The reason why we have answered this question with 'Yes if' is to express the following concerns: ▪ IOGP holds the view that the standard EN 16726 should not be a legally binding specification that results in rejecting natural gas which is outside this standard but can be accepted without impacting the quality at exit points. For indigenous production in some Member States the lower Wobbe Index is set below 46. 44 MJ/m^3 proposed by CEN (such as 45.66 MJ/m^3 in Hungary) and this gas should not be restricted by the standard EN 16726. The same would apply to injecting hydrogen into the natural gas system: hydrogen is outside the standard but can be accepted in limited quantities and should not be restricted by EN 16726. ▪ The standard EN 16726 should not require changes to national systems which have a Wobbe Index entry specification which is more narrow than the current proposal, unless changes would be justified based on a full cost-benefit analysis.	
Marcogaz	yes	Authorities, regulators, producers/suppliers, TSO, DSO's, heating appliance manufacturers, cogeneration manufacturers/ end users, technological industry, industrial gas consumers,	yes	no further comment	

		notified body, test lab.			
NBN	Yes	Authorities, regulators, producers/suppliers, TSO, DSO's, heating appliance manufacturers, cogeneration manufacturers/ end users, technological industry, industrial gas consumers, notified body, test lab.	Yes, if	Yes if • at least the gas applications covered by the Gas Appliances Regulation 2016/426 satisfy the essential safety requirements over this whole WI entry range; • WI values not experienced so far (for BE : > 53,25 MJ/m³) have proven not to compromise the safe use of the existing gas applications stock; and if so, the regulatory framework should allow Member States not to accept gases with these WI values until safe use would no longer be compromised. "*In addition the Belgian mirror committee considers the following :* · *- important for end users is stability over time and a bandwidth of 4,25 MJ/m³ (1%-99%) would clearly be more appropriate for resilience to changes of market conditions, to competitiveness and security of supply (further deployment of LNG supplies) and to the desired decarbonisation of natural gas (injection of renewable and low-carbon gases);* · *- a conflicting situation exists between the widespread practice of onsite adjustment for optimizing performance and a requirement to stay safe over the whole entry range.*"	
NEN	yes	TSO, DSO's, suppliers, testing and certification institute, manufacturers; stationary engines, turbines, boilers, radiant heaters, water heaters	yes		

		end users; industrial			
PL	yes	Producers, DSOs, TSOs	yes, if	Yes if it is confirmed that, upon the inclusion of the WI range, the standard will remain voluntary, with Member States retaining the competence for establishing the Wobbe Index range in theirs grids. This would allow for individual Member States to assess the technical and safety aspects of the gas infrastructure, as well as national production potential. In Poland the higher limit of WI is acceptable , however the lower WI limit can create a problem because of national production. This is due to the fact that Polish gas production, which accounts for around 20% of natural gas demand, is characterized by lower WI that this specified above. Gas of lower WI range is injected into the grid and handled safely.	
UK BSI Shadow Groups GSE/33 and GSE/-/05: Gas Infrastructure	yes	UK Oil and Gas Producers, a Gas Terminal owner/operator , Large Gas Generation Users and various Industrial, Commercial and Domestic users and appliance manufacturing interests, all as specified below. Yes, all the above stakeholder groups are represented in this UK response. Also, below, the UK stakeholder groups commenting	Please Note that the diverse interests along the gas supply chain require this Consultation to be answered in several parts, which are given in an extra table in this file		

		here represent the manufacturing categories itemised below:- Manufacturers: boilers, radiant heaters, water heaters, cookers, End-users: All these above types, including Industrial, Commercial, Residential and Own-Use by the TSO's for their normal operational purposes and for standby/emergency power support. For example, these operations depend upon the reliable and efficient operation of gas-turbines and engines.			
UK Response No1: OGUK	yes		yes	Overall OGUK members support the proposed range for entry capacity. This is wider than the range currently allowed by the UK current regulatory framework (GSMR). However, the wider range would allow	

(Producers - Oil and Gas UK)				more diverse gas supplies to be delivered to the EU market through a. indigenous gas production, especially in the central and southern North Sea, and richer gas fields on the Norwegian continental shelf such as Edvard Greig and LNG imports which currently have to be ballasted at some cost to users. A wider specification will also help facilitate the development of new gases such as biogases and Hydrogen and, as a result, help make progress to decarbonisation of gas that is required to contribute to the UK and European climate objectives. The IGEM process in the UK is currently reviewing the GSMR specification that was introduced in 1996 and has not been modified since that date. More diverse supplies and reduction of processing costs are both strongly in the interests of consumers. The evidence from safety analysis is that a wider range can be accommodated.	
UK Response 2: North Sea Midstream Partners Ltd, NSMP. As a gas terminal owner and operator: David O'Donnell	[NB: This response is included as part of the UK Response along the UK Gas Supply Chain and is made via BSI Stakeholder/mirror Committees BSI GSE/33 and BSI/GSE/-/05: Gas Infrastructure. Malcolm Howe Chairman		yes		

	GSE/33 and GSE/-/05: Gas Infrastructure]				
UK Response 3: GB National Grid: Gas, which is the GB TSO and makes gas available for offtake at Moffat from the UK to Dublin (2), Isle of Man and Northern Ireland (1). National Grid Gas also operates the Bacton Terminal into which both the BBL and Interconnector UK pipelines are connected. National Grid Gas. Philip Hobbins	This reply is by National Grid Gas, which is the GB TSO and Bacton Terminal Operator etc. NGG is part of the GB Response to the Consultation via the GB BSI Stakeholder Groups BSI GSE 33 and GSE/-/05: Gas Infrastructure. Malcolm Howe Chairman BSI GSE/33 and GSE/-/05.		no	No, because at present, National Grid could not apply the proposed EU wide WI entry range because the parameters are outside the UK's national legislation contained in the Gas Safety (Management) Regulations 1996 which require the gas conveyed on UK networks to be between 47.20 MJ/m^3 and 51.41 MJ/m^3 under normal operational circumstances. Work is underway in GB with a view to expanding this range, but this has not yet produced a final proposal. However, our understanding is that upon the inclusion of the WI range, the status of the standard will remain as 'voluntary adoption', with Member States retaining the competence for establishing the national gas quality specification. This would be in line with the conclusion of the European Commission following the examination of the implementation issues associated with EN 16726:2015 that was led by ENTSOG in 2016.	

UK Response 4: Large Gas Generation Users (CCGTs), *Energy UK. Ms Julie Cox*	Replying as part of the BSI GSE/33 and BSI GSE/-/05 Gas Infrastructure Response		yes, if	We would agree with the proposed EU-wide WI entry range provided: a. This is an absolute limit and is NOT subject to a statistical range such that 1st to 99th percentiles of readings lie within this limit. Any such statistical relaxation of the overall limit could in principle allow ANY gas to enter the system for short periods and could result in significant safety, integrity and operational issues. b. This should be an overall limit EU-wide limit. More restrictive limits, within this overall range, could be defined at specific entry points irrespective of whether these entry points are entry points to the EU-wide system or entry points between sub-systems within the EU-wide system. c. More restrictive requirements are set at transfer and exit points within the system, in line with our responses to Question 2. d. For countries with gas resources (e.g. local gas production, biogas etc.) that lie outside this EU-wide entry range limit, wider limits may be set. This should only be allowed under exceptional circumstances with appropriate due diligence and appropriate means to ensure gas outside the EU-wide entry range limit could not enter the rest of the EU-wide system. Areas where limits are outside the EU-wide entry range should be considered to be outside of the EU-wide system but connected to it.	
UK Response 5: Utilisation, which represents various Trade Associations, i.e. 5 Heating and Hot Water Industry Council, HHIC. Neil Macdonald	This Part 5 response from HHIC is part of the UK response along the UK Gas Supply Chain, via Gas Industry Stakeholders represented in BSI GSE/33 and GSE/-/05: Gas Infrastruct		yes, if	It is HHIC's understanding that UK gas appliance manufacturers have no fundamental objection to standardising the gas quality in the distribution of gas between member states. As this gas enters the individual member states high pressure system from the European distribution network, then the gas must be mixed/treated to come within the individual member state gas quality. In the UK this is governed by The Gas Safety (Management) Regulations, specifically Schedule 3. We repeat, how gas is grouped into geographical areas for transport of gas around Europe, may not be a concern, as long as the gas entering the UK's high pressure national transmission system (NTS), and subsequent pressure tiers, maintains a gas quality which is safe and of an acceptable level to meet the requirements of at least the existing installed appliance pool.	

	ure. Malcolm Howe, Chairman of these committees.				
UK Response 6: The Industrial and Commercial Energy Association, ICOM, Ross Anderson, and the Energy and Utilities Alliance, EUA. Peter Day. (ICOM Energy Association represents the commercial/industrial heating equipment manufacturers.)	Yes, via *BSI GSE/33 and GSE/-/05: Gas Infrastructure*: Chairman Malcolm Howe		yes, if	The proposed entry gas quality specification for inter-border transportation is not an issue for the manufacturers, as long as the member states control the specification at the entry to their specific network. For the UK, this needs to be in line with the gas specification detailed in schedule 3 of the Gas Safety Management Regulation (GSMR), having a WI range of 47.20 to 51.46 MJ/m^3 .	
UK Response 7: Cadent (DSO) Cadent falls in the UK Gas Supply Chain between the National Grid Gas, as the GB TSO, 3, then Cadent a DSO and the Large Scale Generators, at 4.	Yes, via *BSI GSE/33 and GSE/-/05: Gas Infrastructure*: Chairman Malcolm Howe		no	Although the aims of the Committee are recognised and there are benefits in establishing an acceptable Wobbe Index range, it is not the only parameter that needs to be considered with regard to ensuring that the end user receives gas of a quality that is suitable. This is detailed in EN 16726, where other factors are identified. In the UK, gas quality is controlled and managed at the main transmission system entry points to ensure compliance with appropriate legislation and network requirements. The concept of introducing a wide network entry point range but narrower exit point range does not match the overall network operation. In most instances, the exit point range is not controlled, and it relies on control of the entry specification to ensure compliance. This is also the case for smaller embedded biomethane entry connections. Interconnected gas networks with many entry points need to have a specified gas quality range but the quoted range from 46.44 to 54.00	

				MJ/m^3 (15/15°C) is too wide. This was confirmed by the EU-funded GasQual study, and this conclusion has been endorsed by other studies. The upper and lower Wobbe Index values are close to the current EN 437 limit gas and do not provide sufficient safety headroom. As noted in part of the supporting information, there are concerns over appliances and combustion equipment that has been adjusted to be optimised for the prevailing gas quality. To ensure the future safety of end-users the entry point gas quality range should be narrowed to avoid possible increased emissions or impacts on safety. Within the definition quoted in Conclusion 24/2019, and exit point on a gas transmission network could be the same as an entry point on a gas distribution network. It seems in this instance that the entry point range is redundant, as it clearly must be equivalent to the exit point range.	
SE (SIS)	Yes	TSO's, DSO's, suppliers, end users (industrial, power generation, renewable production)	Yes		
Individual replies:					
Assotermica Assotermica is the Italian association representing manufacturers of heating appliances and components. It associates more than 60 companies that are active in the residential and non-residential sector and it represents more	yes		Yes, if	The entry range would fit if an upper limit were set to the WI exit range. There is not sufficient distance between a possible distributed high Wobbe gas and the current extreme limit gases as specified in EN 437. See also enclosed slides summarizing the situation. We propose to set an additional upper limit to the exit point at 52,2 MJ/m^3. The reasoning behind is that whatever the entry point is, a maximum exit point should be set to guarantee a safe use of the appliance in each condition.	

than 90% of the domestic market. In Italy Assotermica is part of ANIMA - the Federation of the Italian Associations of Mechanical and Engineering Industries, one of the major Federations of Confindustria. In EU it is also a member of the Board of EHI, the European Heating Industry.					
FNBgas	yes		yes, if	From the technical point of view the Wobbe Index range of 46,44 up to 54,00 MJ/m³ (15/15°C) is in general technical feasible for a Transmission System Operator (TSO). Yes, if Entry and Exit points are defined more clearly and a ruleset for national and international Grid Connection Points is developed simultaneously. It must be made clear which rules apply for connections between e.g. national or international TSOs and DSOs. From the operational point of view for the gas transmission a defined Wobbe Index range only on the UPSTREAM Entry (like 46,44 up to 54,00 MJ/m³ (15/15°C)) and a differing Wobbe Index range on the DOWNSTREAM Exit (e.g. any specified class) is infeasible and not acceptable for a regulated TSO, who is embedded in a contractual and liability context to Up- and Downstream System operators (3rd energy package).	
Glendimplex (Faber)	no		yes		

D.3 Compiled results of Wobbe Index consultation as documented in CEN GQS TF1 N 148

D.3.1 First question (see D.1) related to the agreement with the proposed entry range

Table D.2 — Replies relate to the proposed entry range

Organisation/Mirror Committee	Are you officially replying in the name of a sector organization/Mirror Committee? (Yes/No)	In case of mirror committee; which organisations are represented (specify gas applications/type of end-user)	1. Does the sector organization/mirror committee agree with the proposed EU wide WI entry range of 46,44 up to 54,00 MJ/m³ (15/15°C)? (Yes/Yes if/No)	If no/If yes: reasoning	if no: alternative proposal with reasoning
CEFACD	yes		yes	no further comment	
CEFIC	Yes		yes, if	exemptions can be made for domestic use on a country-by-country basis and the TSOs are able to provide the proper exit specification at industrial consumers. This would allow some member states the continuing injection of indigenous gas according to the H-GAS EN 437 standard. For the exemptions, the lower limit for entry points should be set at 45.66 MJ/m3m³ as defined in the EN437 standard (Test gases. Test pressures. Appliance categories.) and adaptions of the upper limit might be required as well. For cross-border points we agree with the proposed higher entry point. This means that national TSOs should be able to provide the proper exit specification. For the chemical industry continuous gas supply is essential. In principle, reducing the entry range is not desirable as it limits the availability/supply and the security of supply for natural gas.	

				Going beyond the principle, current example demonstrates that in the CEE region due to geopolitical issues and the conditions of the gas supply system there is considerable risk that without indigenous gas supply operators will be exposed to gas supply disruption risks.	
CEN/TC 131			No	In the enclosed slides a description is enclosed that the proposed range of the distributed gases at the upper or lower end at the exit points are out of spec and have no safety margins in respect to the EN 437. Further the proposed range of 3,7 MJ/m^3 is in the opinion of CEN/TC 131 too wide as the EN 676 describes a maximum tolerance of ± 2 %. Based on the upper value 54,7 MJ/m^3 are that e.g. ± 1,1 MJ/m^3. As a forced draught burner have no fixed setpoint but will be adjusted based on the distributed gas the information of this quality and possible fluctuation at the exit point is needed.	
DIN NAGas	yes	Producers, TSO, DSO, suppliers, manufacturers of residential, commercial and industrial appliances, industrial end users	yes, if	• Biomethane injection into a gas net is covered. • Feed in/back from distribution net to high pressure transport grid is covered • The mirror committee agrees with the principle. However, the exact range should be discussed: There is not sufficient distance between a possible distributed high Wobbe gas (54MJ/m^3) and the current extreme limit gases as specified in EN 437. In this regard, a slightly lower upper limit appears advisable, still covering almost all gas qualities present in European grids. • It must be clear that the discrepancy between a wide entry specification and a much narrower exit point specification puts some strain on TSO's and DSO's. Thereof, TSO's are, as proposed, directly connected to an entry point and in some cases have facilities to adjust the CV or Wobbe value of a given gas, e. g. by conditioning or storage, to buffer variations. However, DSO's normally have no such technical possibility, and will have some entry points in particular for renewable gases, which could make stable delivery conditions to a given exit point specification a major challenge.	
DK (DS)	yes	Authorities, biogas association, boiler supplier, gas distribution, gas competence centre, gas	Yes, if	Yes if it is confirmed that, upon the inclusion of the WI range, the standard will remain as voluntary adoption, with Member States retaining the competence for establishing the Wobbe Index range. The Danish mirror group see the competence at the Member States as key tool to ensure the safe use of gas at end-user level. The suggested entry range is evaluated by the Danish mirror as a	

		engine suppliers, gas producers, gas storage, gas turbine service company, industrial burner supplier, industrial burner service company, gas transmission.		balanced approach that keep safety margins between the extremes and the test gasses according EN 437, that gives room for both high Wobbe indexWobbe Index gas as the Danish gas production in the North Sea and the green gasses that is crucial for the decarbonization of the gas system. Together this covers both the security of supply for the Danish marked and the necessary green transition.	
EASEE-gas	yes		yes, if	it is confirmed that, upon the inclusion of the WI range in the EN 16726, the standard will not be binding but will remain as voluntary adoption, with Member States retaining the competence for establishing the Wobbe Index range. The approval of the technical standard should be guided with clear definitions of the regulatory framework and related procedures, responsibilities and liabilities.	
EBA	yes		yes	Yes. A minimum value of 46,44 MJ/m^3 for the EU wide WI entry range is acceptable for the European Biogas Association. When a higher WI would be required, either the efforts of upgrading in terms of cost and energy rises significantly or propane must be added.	
EHI	yes		no	No because: (see also statement in annex) In the enclosed slides a description is enclosed that the proposed range of the distributed gases at the upper or lower end at the exit points are out of spec and have no safety margins in respect to the EN 437. For gas boilers the range should be defined as 46,4 – 52,2 MJ/m^3 and set points should be described. Further for gas forced draught burners the proposed range of 3,7 MJ/m^3 is too wide as the EN 676 describes a maximum tolerance of ± 2 %. Based on the upper value 54,7 MJ/m^3 are that e.g. ± 1,1 MJ/m^3. As a forced draught burner have no fixed set-point but will be adjusted based on the distributed gas the information of this quality and possible fluctuation at the exit point is needed.	
ETN	yes		yes, if	We would agree with the proposed EU-wide WI entry range provided: a. This is an absolute limit and is NOT subject to a statistical range such	

				that 1st to 99th percentiles of readings lie within this limit. Any such statistical relaxation of the overall limit could in principle allow ANY gas to enter the system for short periods and could result in significant safety, integrity and operational issues. b. This should be an overall limit EU-wide limit. More restrictive limits, within this overall range, could be defined at specific entry points irrespective of whether these entry points are entry points to the EU-wide system or entry points between sub-systems within the EU-wide system. c. More restrictive requirements are set at transfer and exit points within the system, in line with our responses to Question 2. d. For countries with gas resources (e.g. local gas production, biogas etc.) that lie outside this EU-wide entry range limit, wider limits may be set. This should only be allowed under exceptional circumstances with appropriate due diligence and appropriate means to ensure gas outside the EU-wide entry range limit could not enter the rest of the EU-wide system. Areas where limits are outside the EU-wide entry range should be considered to be outside of the EU-wide system but connected to it.	
ENTSOG	yes		yes, if	Yes if it is confirmed that, upon the inclusion of the WI range, the standard will remain as voluntary adoption, with Member States retaining the competence for establishing the Wobbe Index range. This would be in line with the conclusion of the European Commission following the examination of the implementation issues associated with EN 16726:2015 that was led by ENTSOG in 2016. This is without prejudice to the classification system for exit points being enforced in the relevant regulatory framework. The approval of the technical standard should only proceed when the regulatory framework and related procedures, responsibilities and liabilities have been clearly defined	
EUROMOT	yes		yes, if	EUROMOT would agree with the proposed EU wide WI entry range provided: a. There is a technical and legal certainty that TSOs will ensure that the	

				exit points for the users and DSOs will not exceed the preferred WI exit range (see answer to question n. 2 below), although we know that this would be extremely difficult to ensure with such a wide entry range. b. The EUROMOT proposal for a preferred WI range at exit points is accepted by the group (see answer to question n. 2). This preferred range should be the guide value for import contracts and for renewable gases to be injected in natural gas. c. Countries with indigenous gas resources can deviate from the preferred range, although the local TSOs should investigate the technical and economical possibilities for converging to the preferred WI range.	
EUTurbines	yes		yes		
ES	Yes	Groups represented in the national committee are TSO's, DSO's, test houses, national and regional authorities, installers, manufacturers of appliances and components for gas appliances (CEN/TC 58) and gas installations, biogas producers and engineering companies.	Yes	Yes, if it is ensured that the implementation of the proposed solution is on a voluntary basis. Exit ranges should remain as a merely probabilistic approach. We would like to highlight that a clear regulatory framework linked to the proposal has not been defined yet. This should not introduce unnecessary additional obligations, complexity or costs to the gas infrastructure operators, especially in countries where gas quality has never been an issue. National/local solutions should remain being the priority tool at national level to solve local issues. Gas operators can neither provide a firm guarantee on exit bandwidth(s) nor have any liabilities if off-class gas arrives to the exit point. Gas grids are operated according to the gas demand in each moment, and never based on gas quality. Finally, it is paramount to ensure that any costs related to the implementation of this proposal are recovered by the gas operators.	

		Appliance manufacturers are of those products covered by CEN/TCs 48 (water heaters), 49 (domestic cooking), 109 (boilers), 180 (air heaters and radiant heaters). CEN/TC 106's (catering appliances) interest in our case is covered by a test house, no any manufacturer.			
FR	yes	TSO, DSO, LNG Operator, Storage Operator, Suppliers, GAR French Notified Body, Gas appliances manufacturers (boilers, overhead radiant heaters), Testing laboratory. (All	yes	no further comment	

		stakeholders listed in the group receive the documents but do not regularly attend the meetings nor answer the consultations)			
GIE	yes		yes, if	Yes if it is ensured that the implementation of this range will not be binding. GIE proposal is in line with the conclusion of the European Commission following the examination of the implementation issues associated with EN 16726:2015 that was led by ENTSOG in 2016. In addition, GIE would like to highlight that the definition of the Wobbe Index range should be discussed at national level together with clear regulatory rules, procedures, responsibilities and liabilities. Cooperation at cross-border points is key to avoid any issue related to gas quality and WI range accordingly.	
HU	yes	Hungarian Horizon Energy Ltd., MOL Hungarian Oil c Gas Plc., O&GD Central Ltd., Riverside Ltd., Tét-3 Gázkút Ltd., Vermilion Energy Hungary Ltd. The above companies cover all HC production in Hungary.	no	We propose to the change the lower value to 45.66 MJ/m3.m^3. The upper value may remain the same but may be reduced by 0.78 MJ/m3m^3 to compensate for the proposed lower value. Unfortunately, the introduction of the above range will result in the decrease in natural gas production in Hungary, as it will limit the marketability of certain gas reserves. A reduction in production would have the following undesirable effects: - The Hungarian state would lose tax and royalty revenue. - Security of gas supply of the country would be jeopardized. - Instead of cheap domestic gas, Hungarian consumers would have to buy more expensive imports, which would have an effect on gas prices. We request the development of a WI range that does not curtail the current production. In Hungary, the lower end of the range of Wobbe Index value of indigenous gas production that can enter the interconnected TSO network is at 45.66 MJ/m^3. So, the values of 46.44 MJ/m^3 or higher are not suitable as a lower end would constitute a limit for Hungarian producers. Thus, the currently used low threshold of Wobbe value of 45.66 MJ / m^3 is appropriate for the Hungarian production.	

IFIEC	yes		yes	The current H-gas quality specifications of supply and demand are different in Europe, varying between the EASEE-gas CBP of 2005. Reducing the entry ranges are not desirable as long as the TSOs are able to provide the proper exit specifications taken into account the interests of end-consumers.	
IOGP			yes, if	IOGP supports the ongoing work by CEN on developing a Wobbe Index proposal to be included in the standard EN 16726. We also support the EASEE-gas range for WI which is used in the current proposal. The reason why we have answered this question with 'Yes if' is to express the following concerns: ▪ IOGP holds the view that the standard EN 16726 should not be a legally binding specification that results in rejecting natural gas which is outside this standard but can be accepted without impacting the quality at exit points. For indigenous production in some Member States the lower Wobbe Index is set below 46. 44 MJ/m^3 proposed by CEN (such as 45.66 MJ/m^3 in Hungary) and this gas should not be restricted by the standard EN 16726. The same would apply to injecting hydrogen into the natural gas system: hydrogen is outside the standard but can be accepted in limited quantities and should not be restricted by EN 16726. ▪ The standard EN 16726 should not require changes to national systems which have a Wobbe Index entry specification which is more narrow than the current proposal, unless changes would be justified based on a full cost-benefit analysis.	
Marcogaz	yes	Authorities, regulators, producers/suppliers, TSO, DSO's, heating appliance	yes	no further comment	

		manufacturers, cogeneration manufacturers/ end users, technological industry, industrial gas consumers, notified body, test lab.			
NBN	Yes	Authorities, regulators, producers/suppliers, TSO, DSO's, heating appliance manufacturers, cogeneration manufacturers/ end users, technological industry, industrial gas consumers, notified body, test lab.	Yes, if	Yes if • at least the gas applications covered by the Gas Appliances Regulation 2016/426 satisfy the essential safety requirements over this whole WI entry range; • WI values not experienced so far (for BE : > 53,25 MJ/m^3) have proven not to compromise the safe use of the existing gas applications stock; and if so, the regulatory framework should allow Member States not to accept gases with these WI values until safe use would no longer be compromised. "In addition the Belgian mirror committee considers the following : - important for end users is stability over time and a bandwidth of 4,25 MJ/m^3 (1%-99%) would clearly be more appropriate for resilience to changes of market conditions, to competitiveness and security of supply (further deployment of LNG supplies) and to the desired decarbonisation of natural gas (injection of renewable and low-carbon gases); - a conflicting situation exists between the widespread practice of onsite adjustment for optimizing performance and a requirement to stay safe over the whole entry range."	
NEN	yes	TSO, DSO's, suppliers, testing and certification institute, manufacturers; stationary engines, turbines,	yes		

		boilers, radiant heaters, water heaters end users; industrial			
PL	yes	Producers, DSOs, TSOs	yes, if	Yes if it is confirmed that, upon the inclusion of the WI range, the standard will remain voluntary, with Member States retaining the competence for establishing the Wobbe Index range in theirs grids. This would allow for individual Member States to assess the technical and safety aspects of the gas infrastructure, as well as national production potential. In Poland the higher limit of WI is acceptable , however the lower WI limit can create a problem because of national production. This is due to the fact that Polish gas production, which accounts for around 20% of natural gas demand, is characterized by lower WI that this specified above. Gas of lower WI range is injected into the grid and handled safely.	
UK BSI Shadow Groups GSE/33 and GSE/-/05: Gas Infrastructure	yes	UK Oil and Gas Producers, a Gas Terminal owner/operator , Large Gas Generation Users and various Industrial, Commercial and Domestic users and appliance manufacturing interests, all as specified below. Yes, all the above stakeholder groups are represented in this UK response.	Please Note that the diverse interests along the gas supply chain require this Consultation to be answered in several parts, which are given in an extra table in this file		

		Also, below, the UK stakeholder groups commenting here represent the manufacturing categories itemised below:- Manufacturers: boilers, radiant heaters, water heaters, cookers, End-users: All these above types, including Industrial, Commercial, Residential and Own-Use by the TSO's for their normal operational purposes and for standby/emergency power support. For example, these operations depend upon the reliable and efficient operation of gas-turbines and engines.			

UK Response No1: OGUK (Producers - Oil and Gas UK)	yes		yes	Overall OGUK members support the proposed range for entry capacity. This is wider than the range currently allowed by the UK current regulatory framework (GSMR). However, the wider range would allow more diverse gas supplies to be delivered to the EU market through a. indigenous gas production, especially in the central and southern North Sea, and richer gas fields on the Norwegian continental shelf such as Edvard Greig and LNG imports which currently have to be ballasted at some cost to users. A wider specification will also help facilitate the development of new gases such as biogases and Hydrogen and, as a result, help make progress to decarbonisation of gas that is required to contribute to the UK and European climate objectives. The IGEM process in the UK is currently reviewing the GSMR specification that was introduced in 1996 and has not been modified since that date. More diverse supplies and reduction of processing costs are both strongly in the interests of consumers. The evidence from safety analysis is that a wider range can be accommodated.	
UK Response 2: North Sea Midstream Partners Ltd, NSMP. As a gas terminal owner and operator: David O'Donnell	[NB: This response is included as part of the UK Response along the UK Gas Supply Chain and is made via BSI Stakeholder/mirror Committees BSI GSE/33 and BSI/GSE/-		yes		

	/05: Gas Infrastructure. Malcolm Howe Chairman GSE/33 and GSE/-/05: Gas Infrastructure]				
UK Response 3: GB National Grid: Gas, which is the GB TSO and makes gas available for offtake at Moffat from the UK to Dublin (2), Isle of Man and Northern Ireland (1). National Grid Gas also operates the Bacton Terminal into which both the BBL and Interconnector UK pipelines are connected. National Grid Gas. Philip Hobbins	This reply is by National Grid Gas, which is the GB TSO and Bacton Terminal Operator etc. NGG is part of the GB Response to the Consultation via the GB BSI Stakeholder Groups BSI GSE 33 and GSE/-/05: Gas Infrastructure. Malcolm Howe Chairman BSI GSE/33		no	No, because at present, National Grid could not apply the proposed EU wide WI entry range because the parameters are outside the UK's national legislation contained in the Gas Safety (Management) Regulations 1996 which require the gas conveyed on UK networks to be between 47.20 MJ/m^3 and 51.41 MJ/m^3 under normal operational circumstances. Work is underway in GB with a view to expanding this range, but this has not yet produced a final proposal. However, our understanding is that upon the inclusion of the WI range, the status of the standard will remain as 'voluntary adoption', with Member States retaining the competence for establishing the national gas quality specification. This would be in line with the conclusion of the European Commission following the examination of the implementation issues associated with EN 16726:2015 that was led by ENTSOG in 2016.	

	and GSE/-/05.				
UK Response 4: Large Gas Generation Users (CCGTs), *Energy UK. Ms Julie Cox*	Replying as part of the BSI GSE/33 and BSI GSE/-/05 Gas Infrastructure Response		yes, if	We would agree with the proposed EU-wide WI entry range provided: a. This is an absolute limit and is NOT subject to a statistical range such that 1st to 99th percentiles of readings lie within this limit. Any such statistical relaxation of the overall limit could in principle allow ANY gas to enter the system for short periods and could result in significant safety, integrity and operational issues. b. This should be an overall limit EU-wide limit. More restrictive limits, within this overall range, could be defined at specific entry points irrespective of whether these entry points are entry points to the EU-wide system or entry points between sub-systems within the EU-wide system. c. More restrictive requirements are set at transfer and exit points within the system, in line with our responses to Question 2. d. For countries with gas resources (e.g. local gas production, biogas etc.) that lie outside this EU-wide entry range limit, wider limits may be set. This should only be allowed under exceptional circumstances with appropriate due diligence and appropriate means to ensure gas outside the EU-wide entry range limit could not enter the rest of the EU-wide system. Areas where limits are outside the EU-wide entry range should be considered to be outside of the EU-wide system but connected to it.	
UK Response 5: Utilisation, which represents various Trade Associations, i.e. 5 Heating and Hot Water Industry Council, HHIC. Neil Macdonald	This Part 5 response from HHIC is part of the UK response along the UK Gas Supply Chain, via Gas Industry Stakeholders represente		yes, if	It is HHIC's understanding that UK gas appliance manufacturers have no fundamental objection to standardising the gas quality in the distribution of gas between member states. As this gas enters the individual member states high pressure system from the European distribution network, then the gas must be mixed/treated to come within the individual member state gas quality. In the UK this is governed by The Gas Safety (Management) Regulations, specifically Schedule 3. We repeat, how gas is grouped into geographical areas for transport of gas around Europe, may not be a concern, as long as the gas entering the UK's high pressure national transmission system (NTS), and subsequent pressure tiers, maintains a gas quality which is safe and of	

	d in BSI GSE/33 and GSE/-/05: Gas Infrastructure. Malcolm Howe, Chairman of these committees.			an acceptable level to meet the requirements of at least the existing installed appliance pool.	
UK Response 6: The Industrial and Commercial Energy Association, ICOM, Ross Anderson, and the Energy and Utilities Alliance, EUA. Peter Day. (ICOM Energy Association represents the commercial/industrial heating equipment manufacturers.)	Yes, via *BSI GSE/33 and GSE/-/05: Gas Infrastructure*: Chairman Malcolm Howe		yes, if	The proposed entry gas quality specification for inter-border transportation is not an issue for the manufacturers, as long as the member states control the specification at the entry to their specific network. For the UK, this needs to be in line with the gas specification detailed in schedule 3 of the Gas Safety Management Regulation (GSMR), having a WI range of 47.20 to 51.46 MJ/m^3 .	
UK Response 7: Cadent (DSO) Cadent falls in the UK Gas Supply Chain between the National Grid Gas, as the GB TSO, 3, then Cadent a DSO and the Large Scale Generators, at 4.	Yes, via *BSI GSE/33 and GSE/-/05: Gas Infrastructure*: Chairman Malcolm Howe		no	Although the aims of the Committee are recognised and there are benefits in establishing an acceptable Wobbe Index range, it is not the only parameter that needs to be considered with regard to ensuring that the end user receives gas of a quality that is suitable. This is detailed in EN 16726, where other factors are identified. In the UK, gas quality is controlled and managed at the main transmission system entry points to ensure compliance with appropriate legislation and network requirements. The concept of introducing a wide network entry point range but narrower exit point range does not match the overall network operation. In most instances, the exit point range is not controlled, and it relies on control of the entry specification to ensure compliance. This is also the case for smaller embedded biomethane entry connections.	

				Interconnected gas networks with many entry points need to have a specified gas quality range but the quoted range from 46.44 to 54.00 MJ/m^3 (15/15°C) is too wide. This was confirmed by the EU-funded GasQual study, and this conclusion has been endorsed by other studies. The upper and lower Wobbe Index values are close to the current EN 437 limit gas and do not provide sufficient safety headroom. As noted in part of the supporting information, there are concerns over appliances and combustion equipment that has been adjusted to be optimised for the prevailing gas quality. To ensure the future safety of end-users the entry point gas quality range should be narrowed to avoid possible increased emissions or impacts on safety. Within the definition quoted in Conclusion 24/2019, and exit point on a gas transmission network could be the same as an entry point on a gas distribution network. It seems in this instance that the entry point range is redundant, as it clearly must be equivalent to the exit point range.	
SE (SIS)	Yes	TSO's, DSO's, suppliers, end users (industrial, power generation, renewable production)	Yes		
Individual replies:					
Assotermica Assotermica is the Italian association representing manufacturers of heating appliances and components. It associates more than 60 companies	yes		Yes, if	The entry range would fit if an upper limit were set to the WI exit range. There is not sufficient distance between a possible distributed high Wobbe gas and the current extreme limit gases as specified in EN 437. See also enclosed slides summarizing the situation. We propose to set an additional upper limit to the exit point at 52,2 MJ/m^3. The reasoning behind is that whatever the entry point is, a maximum exit point should be set to guarantee a safe use of the appliance in each condition.	

that are active in the residential and non-residential sector and it represents more than 90% of the domestic market. In Italy Assotermica is part of ANIMA - the Federation of the Italian Associations of Mechanical and Engineering Industries, one of the major Federations of Confindustria. In EU it is also a member of the Board of EHI, the European Heating Industry.					
FNBgas	yes		yes, if	From the technical point of view the Wobbe Index range of 46,44 up to 54,00 MJ/m^3 (15/15°C) is in general technical feasible for a Transmission System Operator (TSO). Yes, if Entry and Exit points are defined more clearly and a ruleset for national and international Grid Connection Points is developed simultaneously. It must be made clear which rules apply for connections between e.g. national or international TSOs and DSOs. From the operational point of view for the gas transmission a defined Wobbe Index range only on the UPSTREAM Entry (like 46,44 up to 54,00 MJ/m^3 (15/15°C)) and a differing Wobbe Index range on the DOWNSTREAM Exit (e.g. any specified class) is infeasible and not acceptable for a regulated TSO, who is embedded in a contractual and liability context to Up- and Downstream System operators (3rd energy package).	
Glendimplex (Faber)	no		yes		

D.3.2 Second question (see D.1) related to the agreement on the proposed Wobbe Index exit classes and classification

Table D.3 — Replies on the proposed Wobbe Index exit classes and classification

Organisation/Mirror Committee	Are you officially replying in the name of a sector organization/Mirror Committee? (Yes/No)	In case of mirror committee; which organisations are represented (specify gas applications/type of end-user)	2. Does the sector organization/mirror committee agree with the proposed WI exit classification as described in decision 25/2019? (Yes/Yes if/No) See table of conclusion 25/2019 illustrated with an example in annex B.	if no (or condition for yes, if) See table of conclusion 25/2019 illustrated with an example in annex B.
CEFACD	yes		no	WI exit range classification for EN 16726 is ok but as gas fireplace manufactures we are missing the max allowed PE value for the distributed gas. The max PE value is also missing in the EN 16726. A value over 10% PE will cause high soot deposit in gas fire places. For most gases PE= 0.5*(CH2H6)+1*(C3H8)+1.5*(C4H10) + 2*(C5H12) + 2.5*C6H14)
CEFIC	Yes		yes, if	the TSOs are able to provide the proper exit specification based on the CEN proposal, which comprises an agreement for specified regional Wobbe Index ranges of < 3,7 MJ/m³ (15:15) and a com- promise that an extended range should be possible, on the condition that its range should be

				properly substantiated including a consultation with "eligible" end-users on how they can safeguard their interests. This is backed by the conclusions of the 29 th Madrid Form on 16 October 2016, which acknowledged the interests of the end-users and requested to elaborate on the possibility of re- gional bands to be included in the updated standard while ensuring the integrity of the existing standard. As volatility and plug flow remain a difficult problem to manage for TSOs, we agree with a compromise of an explanatory annex to the standard which acknowledge that plug flow may be detrimental for specific end-use applications, including chemical feedstock.
CEN/TC 131			Yes, The Class (specified) with a Range of 3,7MJ/m³ would fit only if there would be a defined appliance set point for an appropriate setting and the set point(s) is (are) within the overall range with safety margins.	
DIN NAGas	yes	Producers, TSO, DSO, suppliers, manufacturers of residential, commercial and industrial	yes, if	• A clear, unmistakable different definition of “exit point” is required. The proposed definition “point at which gas leaves the distribution or gas transmission system for end use” contradicts existing agreements and real contracts (e.g.: exit points to gas storages). Use different expression as e.g. “end use point” • Clearly define not only entry and exit points, but also for those transfer of custody points in between. • Procedures for information of gas quality changes across the gas chain, by e.g.: TSO/DSO,

		appliances, industrial end users		have to be foreseen in CEN TC 234. Covers part of the rate of change aspects • Depending on their side of the market, there are proposals to widen the range up to 4,0 MJ/m³ or to narrow it well beyond 3,7 MJ/m³. Which range proofs to be practicable, and when and how the concept of "Extended ranges" applies or instead the gas is delivered as "unspecified", experience may show: The indicated range should cover more than 95% of deliveries in a given exit area. From an appliance manufacturer's view, it is important to define proper set points for the gas delivered to the appliances to allow smooth operation of the appliances in an exit area. • Still to be addressed are the question of fluctuation in case of the entry of renewable gases, "floating Wobbe zones" in case of alternating delivery to local areas with two different gases, etc.. Question: where? EN 16726 – probably not, since entry of renewables is yet the subject of EN 16723-1. EN ISO 15112 – needs to be more requiring, then. Network code – will it cover such eventualities? • If “class specified exit WI range” may change (as to be expected in a renewable world), who bears the costs for renovation/changes in end use appliances. • In this concept, the responsibilities and liabilities of the different actors/market partners need to be clearly identified.The standard EN 16726 cannot address such items, therefore a parallel, interactive development of the network code/legal framework is required. • Narrowing the Wobbe range between entry and exit point will require more control along the way. Whilst many TSO's have modernized their steering and control systems in the last decade, providing a seamless online control of the system including gas quality, for most DSO's such systems will require large investments.
DK (DS)	yes	Authorities, biogas association, boiler supplier, gas distribution, gas competence centre, gas engine suppliers,	yes, if	Yes if the classes have a usable “lifetime” of several years at the end-users that gives real possibility to achieve any benefits of local optimisation. The administrative burden of quantification, management and communication of the classes may be significant for the relevant parties in the value chain. The Danish mirror group stress that the upsides of the classification systems must without doubt be bigger than this administrative task before final decision.

		gas producers, gas storage, gas turbine service company, industrial burner supplier, industrial burner service company, gas transmission.		The Danish mirror group is concerned whether the proposed classification system is the most economic and efficient one and suggest that a cost-benefit analysis is performed before any finalization of regulation that implements the classification system. The Rate of Change (RoC) of WI is a complex dynamic interplay of supply quality, off-take, end-user start-up/shut-down, grid operation and the pipeline geometry for which no single party of the value chain have the measures to control the RoC in the point where the gas is used. Therefore defining a RoC limit value in a gas quality standard makes no sense. The Danish mirror group recognises that a minority of the sensitive end-users have challenges due to rapid change in gas quality and acknowledge the need for development of technical solutions. In Denmark demonstrations project have shown good perspectives with the use of gas quality sensors that need further development. Sharing current gas quality data for the end-users either public or directly is evaluated as a simple but cost-effective tool to help the end-users and could be considered as a supplement to the classifications system.
EASEE-gas	yes		Yes, if	The approval of the technical standard is guided with clear definitions of the regulatory framework and related procedures, responsibilities and liabilities. This regulatory framework should be based on the in 25/2019 proposed probabilistic approach. Any costs related to the implementation of this proposal need to be recovered by the system operators. This proposal should therefore not introduce unnecessary additional obligations, complexity or costs to the gas infrastructure operators, especially in countries where gas quality has never been an issue, to avoid unnecessary additional costs for the network users.
EBA	yes		yes	Yes, the European Biogas Association agrees with the scenario presented at conclusion 25/2019. If the gas industry wants to survive in the future and accept injection of biomethane, hydrogen and synthetic gas, indeed a wide range of specifications is required. In this manner, Europe’s gas industry will be helped to replace natural gas with 100% renewable gases by 2050. Gas industry needs to be reasonable and ambitious at the same time. The division of Europe’s network

				in different classes will allow a wide range of specification at entry points and low WI band width for end-users at the same time.
EHI	yes		yes	Class (specified) with a Range of 3,7MJ/m³ would fit if there would be a set point for an appropriate setting. E.g. +1MJ/m³ and -2,7MJ/m³. Only a plus or minus in one direction does not fit.
ETN	yes		no	The proposed classes are not consistent with the previous definitions of classes A to C defined in CEN SFGas GQS TF1 N 120: Draft reflection paper for the further development of the Integrated Scenario/classification approach provided by AhG, 2019-07- 9 and presented at the Madrid Forum, June 2019. These definitions covered the possible situations well. The two proposed classes are not materially different as they both require that the WI be within the overall entry range and be specified. The only difference is whether the range is greater or less than 3.7 MJ/m³. Neither class allows for fuels outside the EU-wide entry range that may be required to accommodate local gas production. We do not believe that this provides a workable classification system.
ENTSOG	yes		yes, if	If 'yes if' then complete ENTSOG recognises that the proposed solution with a wide EU Entry WI range and a classification system at Exit is a compromise that tries to give an answer to the competing requirements of both sides of the gas value chain (the security, diversification and decarbonisation of the gas supply, at the same time as a safe and efficient end use with as low GHG emissions as possible). ENTSOG supports that compromise in principle, but there are a number of issues to address before it could be implemented. Forecasting the WI range at individual exit points is not a capability that TSOs have at present and

				it may be difficult to achieve a robust assessment, particularly for networks with a high level of supply diversity and variable demand patterns. The proposal may therefore not deliver the value that exit points, that are sensitive to WI variation, envisage, and TSOs must not be held liable for any commercial lost for End-users, if the WI deviates from the forecast. TSO cannot provide a firm guarantee of whether the WI will be within the 3.7 MJ/m³ range for Specified class sites. The resulting flows in the system are a product of the whole gas sector value chain's dynamics (e.g. nomination and allocation), and the TSOs have no measure to control the flow at all exit points. The definition of the classes must therefore have a probabilistic approach, and ENTSOG support the approach of using percentiles to define the classes. As a consequence, the gas applications must be able to react safely within the whole entry range defined by the relevant member state. Additionally, the impact of supply sources (e.g. injection of renewable gases) would need to be managed by legal requirement for access of third parties, which would alter flow patterns in that area of the network and could change the TSO's view of the gas quality that a particular offtake is likely to receive. A procedure for reassessing the classification range for an exit area must be developed taking into account the future dynamics of the changes in supply sources driven by the energy transition towards renewable energy.

				Regarding points of Extended class, the End-users might want advanced provision of information regarding the WI. New tools would need to be developed to do this, potentially requiring either additional chromatographs to be installed upstream of offtake points or the implementation of capability to track WI through the network. These investments must be recovered by the Operator (i.e. as part of the regulatory assets base (RAB)). Extended class related procedures need careful consideration taking into account the foreseeable increase of renewable gases (e.g. hydrogen). It's not given, that the proposed numerical solution is the most economic and efficient one. Opening too many Extended class procedures and too frequent changes of classification may lead to additional cost for the involved parties. Therefore, ENTSOG advises CEN stakeholders to further elaborate on reasoning of the chosen values of bandwidth (3.7 MJ/m³) and percentiles (1-99%). ENTSOG has also not seen any evidence, that the proposed classification solution is more economic than the exit points, that are sensitive to WI change, making changes at their sites to address the impacts, they experience due to variation in WI. ENTSOG therefore suggests, that a cost/benefit analysis should be completed to demonstrate whether this could generate an inappropriate cross-subsidy whereby all consumers would be funding the TSO investments to

				deliver this solution for the benefit of a section of large-scale industrial consumers that are sensitive to WI variation.
EUROMOT	yes		no	Such a proposal would be against the aim of Mandate M/400, which is, ultimately, a harmonisation to a preferred EU wide WI range. Moreover, such a proposal would result in: • Variable equipment performance (with regard to both efficiency and emissions) • Increased safety risks • Occasional and destabilising changes in equipment settings and tuning • Difficulties in guaranteeing performance by the manufacturers • A trip of an electricity generator caused by gas quality changes would have substantial financial consequences • Variable product qualities
EUTurbines	yes		yes	Gas turbines are able to cover qualities in the H-gas range EN437. In case of huge rates of WI changes, the GT can still be controlled via the average of the measured turbine exit temperatures (by means of thermocouples). Only in case of very transient operation, like load rejection or ignition or fuel transfer from oil to gas or synchronization with the grid, the gas turbine might be controlled in an “open loop control cycle” commanding a changing fuel mass flow based on a design gas composition. Then the control valve stroke is commanded with maybe a gradient in control valve stroke. The thermocouple signal would be delayed (too slow). These fast transient operation modes had led to the fact that Wobbe Index change rate requirements for gas turbines had been given in x% per second and not minutes, well knowing that a measurement device would not be fast enough to detect or measure this. This could happen if there is a sharp plug-flow change characteristics from one gas quality to another. These superposition of fast transient operation and huge WI gradients are considered very unlikely to happen.

ES	Yes	Groups represented in the national committee are TSO's, DSO's, test houses, national and regional authorities, installers, manufacturers of appliances and components for gas appliances (CEN/TC 58) and gas installations, biogas producers and engineering companies. Appliance manufacturers are of those products covered by CEN/TCs 48 (water heaters), 49 (domestic cooking), 109 (boilers), 180 (air	Yes, if	Yes, if it is ensured that the implementation of the proposed solution is on a voluntary basis. Exit ranges should remain as a merely probabilistic approach. We would like to highlight that a clear regulatory framework linked to the proposal has not been defined yet. This should not introduce unnecessary additional obligations, complexity or costs to the gas infrastructure operators, especially in countries where gas quality has never been an issue. National/local solutions should remain being the priority tool at national level to solve local issues. Gas operators can neither provide a firm guarantee on exit bandwidth(s) nor have any liabilities if off-class gas arrives to the exit point. Gas grids are operated according to the gas demand in each moment, and never based on gas quality. Finally, it is paramount to ensure that any costs related to the implementation of this proposal are recovered by the gas operators.

		heaters and radiant heaters). CEN/TC 106's (catering appliances) interest in our case is covered by a test house, no any manufacturer.		
FR	yes	TSO, DSO, LNG Operator, Storage Operator, Suppliers, GAR French Notified Body, Gas appliances manufacturers (boilers, overhead radiant heaters), Testing laboratory. (All stakeholders listed in the group receive the documents but do not regularly attend the meetings nor	Yes, if and only if	Yes if and only if: It is specified that - the upper and lower limits of the specified class are given locally by TSO/DSO with a bandwidth of 3,7 MJ/m³ (to remove "with specifying the actual bandwidth") - For both classes, concerning the WI range, it should be written "with indication of WI limits defined per "WI Range exit area" (i.e. geographical area with the same WI range), based on the distributed gases, within the entry range" We would like to propose another wording for the classes: - specified class becomes safety and performance class - Extended class becomes safety class France would like to state that the biomethane market is growing exponentially in France and that most of the biomethane injections within an "LNG area" will fall into the "extended class", which in return may hamper the development of the biomethane sector. As we stated before while presenting the French case study during a TF1 meeting, a "specified class" of 4 MJ/m³ would be more realistic for the classification purpose. Difficulties were met while trying to define a legal framework and the role and responsibilities of the different stakeholders involved. Legal framework should be dealt within a specific working group involving the European commission, the national authorities

		answer the consultations)		and the regulatory bodies as well as the EU affairs department from the different gas companies/stakeholders [competent authorities] Meanwhile the methodology behind the classification of exit points has to be dealt with in a relevant working group by the people responsible of the gas flow, and who have the knowledge of Gas Quality data i.e. the gas operators. Needless to say that it is crucial that those two points (classification methodology and legal framework) have to be handled and agreed before voting on the revision of EN 16726 standard.
GIE	yes		yes, if	GIE supports the wide EU entry WI range and a classification system at exit. But the implementation of the classification of the WI exit should not introduce unnecessary additional obligations, complexity or costs to the gas infrastructure operators. GIE would like to highlight that operators cannot provide a firm guarantee to comply with the exit bandwidth(s) proposed. Therefore, GIE supports the use of percentiles in the definition of the exit classes. In addition, operators should not have any legal responsibility at the exits due to this narrower range. It's not justified that the proposed numerical solution is the most economic and efficient one. Opening too many Extended class procedures and too frequent changes of classification may lead to additional unnecessary costs for the involved parties. Therefore, GIE proposes to further elaborate on reasoning of the chosen values of bandwidth (3.7 MJ/m^3) and percentiles (1-99%). It should be ensured to the operators that any costs related to the implementation of this classification system will be recovered. A cost/benefit analysis would be helpful to demonstrate the right solution for the benefit of end-users overall. This cost/benefit analysis should include the possibility the exit points, that are sensitive to WI change, to make changes at their sites to address the impacts, they experience due to variation in WI.
HU	yes	Hungarian Horizon Energy	yes	

		Ltd., MOL Hungarian Oil c Gas Plc., O&GD Central Ltd., Riverside Ltd., Tét-3 Gázkút Ltd., Vermilion Energy Hungary Ltd. The above companies cover all HC production in Hungary.		
IFIEC	yes		yes	confirmative comment: The 29th Madrid Form on 16 October 2016 acknowledged the interests of the end-users and requested to elaborate on the possibility of regional bands, to be included in the updated standard while ensuring the integrity of the existing standard. After 3 years discussions CEN succeeded to reach an agreement for specified regional Wobbe Index ranges of < 3,7 MJ/m³ (15:15) and a compromise that an extended range should be possible, on condition that its range should be properly substantiated including a consultation with "eligible" end-users on how they can safeguard their interests. As volatility and plug flow remains a difficult problem to manage for TSOs, we agree with a compromise of an explanatory annex to the standard which an acknowledgement that plug flow may be detrimental for specific end-use applications including chemical feedstock
IOGP			no reply to this question	
Marcogaz	yes	Authorities, regulators, producers/suppliers, TSO, DSO's,	yes	Yes with the possibility of regional/national/local WI exit bands, as far as the integrity and the free circulation of the existing European gas system is not hampered. It should remain clear that the

		heating appliance manufacturers, cogeneration manufacturers/end users, technological industry, industrial gas consumers, notified body, test lab.		class system in the CEN Standard is based on a probabilistic approach (voluntary bases) and not regulatory at European level.
NBN	Yes	Authorities, regulators, producers/suppliers, TSO, DSO's, heating appliance manufacturers, cogeneration manufacturers/end users, technological industry, industrial gas consumers, notified body, test lab.	yes, if	Yes if • the investment costs for implementing such a general classification of exit points/areas is considered as part of the TSO/DSO regulatory asset base (if a preceding cost/benefits analysis gives a positive conclusion); • the regulatory framework and related procedures, responsibilities and liabilities are clearly defined; • at least the installed gas applications covered by the Gas Appliances Regulation 2016/426 satisfy the essential safety requirements over the whole WI entry range at all time; • an assessment of the proper functioning of art. 17 and 18 of the existing network code on interoperability and data exchange is conducted; based on the outcome of this assessment any appropriate measures, if needed, could be taken on the level of the network code and/or its national implementation.

NEN	yes	TSO, DSO's, suppliers, testing and certification institute, manufacturers; stationary engines, turbines, boilers, radiant heaters, water heaters end users; industrial	yes, if	If it is noted that the suggested range of 3,7 MJ/m 3 may not be suitable for all installed applications. Shifting of the range should be part of a regulated process considering the interests of all parties concerned. Modification of an extended range should follow the same procedure. This position was not supported by the Dutch sector organization (Plagamo/DGTA) of gas turbines and engines.
PL	yes	Producers, DSOs, TSOs	yes, if	Polish mirror committee accepts the proposal on classification on exit points, however asks CEN to clarify beforehand issues such as: 1. long-term forecast on gas quality at exit points or WI range exit areas should be considered as probabilistic forecast, therefore TSOs must not be held liable for any commercial or legal lost for end-users, in case the real WI deviates from the forecast. 2. the actual gas that end-user is receiving is a product of what is injected into the system at entry point and possibility to co-mingle it in the system considering different supplies. Therefore, TSOs can deliver gas which quality is a derivative of actual flows and technical possibility of gas infrastructure to mingle or redirect the flows. It should be clarified that the definition of the exit range must have a probabilistic approach. 3. the impact of new sources or connections to the quality of gas in the grid can change the range of WI for each specified exit point or WI range exit area. A procedure for reassessing the range for an exit point/ WI range exit area must be developed taking into account the future supply sources changes. 4. for exit points/ WI range exit areas with high possibility of receiving WI outside the maximum range defined under "specified" class, the end-users might request for advanced provision of information regarding the WI. If this request is triggering new investments it can be considered only after performing cost-benefit analysis and only if it is to be a part of the regulatory assets base (RAB).

UK BSI Shadow Groups GSE/33 and GSE/-/05: Gas Infrastructure	yes	UK Oil and Gas Producers, a Gas Terminal owner/operator, Large Gas Generation Users and various Industrial, Commercial and Domestic users and appliance manufacturing interests, all as specified below. Yes, all the above stakeholder groups are represented in this UK response. Also, below, the UK stakeholder groups commenting here represent the manufacturing categories itemised below:- Manufacturers:	Please Note that the diverse interests along the gas supply chain require this Consultation to be answered in several parts, which are given in an extra table in this file	

		boilers, radiant heaters, water heaters, cookers, End-users: All these above types, including Industrial, Commercial, Residential and Own-Use by the TSO's for their normal operational purposes and for standby/emergency power support. For example, these operations depend upon the reliable and efficient operation of gas-turbines and engines.		
UK Response No1: OGUK (Producers - Oil and Gas UK)	yes		no reply	OGUK does not represent downstream businesses or users and, as a result, does not have a position on the various exit specifications. However, members identified a range of questions raised by the proposals as follows: • wider question around allocation of costs to users of dealing with different gas qualities and specification,

				• the requirements for additional measurement and metering equipment, • the impact of rates of change in the Wobbe within the exit range, • monitoring and enforcement of the requirements, in particular avoiding that the exit standards impact entry requirements on a de facto basis as a result of contractual arrangements at entry points.
UK Response 2: North Sea Midstream Partners Ltd, NSMP. As a gas terminal owner and operator: David O'Donnell	[NB: This response is included as part of the UK Response along the UK Gas Supply Chain and is made via BSI Stakeholder/mirror Committees BSI GSE/33 and BSI/GSE/-/05: Gas Infrastru		no	It is unclear how this would work in practice. Having different exit specifications to entry specifications implies that the system operators will be responsible for blending. At present there is no mechanism for this to occur. If the exit spec were to be different from entry who will take the liability if exit spec is not met? Who would carry the costs of blending (for example, N2 to blend rich gas or propane to blend leaner gas)? How will exit points close to inlet points be served? In such instances, in order to meet a tighter exit specification a system operator could impose an entry specification limit that is tighter than that currently set which could leave some shippers in a worse position than they are today.

	cture. Malcolm Howe Chairman GSE/33 and GSE/-/05: Gas Infrastructure]			
UK Response 3: GB National Grid: Gas, which is the GB TSO and makes gas available for offtake at Moffat from the UK to Dublin (2), Isle of Man and Northern Ireland (1). National Grid Gas also operates the Bacton	This reply is by National Grid Gas, which is the GB TSO and Bacton Terminal Operator etc. NGG is part of the GB Response to the Consultation via the GB BSI Stakeholder		no	NO. National Grid does not support the WI exit classification proposal as it currently stands because we have a number of concerns about its validity and viability. In addition, there are areas where further clarity is needed. We recognise the challenge that CEN has tried to address; namely a wide Wobbe Index (WI) range being desirable at EU entry points for security of supply and for facilitating delivery both of rich gases such as LNG as well as leaner gases such as biomethane and hydrogen blends, whilst some end users of gas that are sensitive to variation wish to maintain a stable gas quality at the point of use. We consider that the de-coupling of entry and exit specifications as proposed via the exit point classification approach is a possible concept that could be used to resolve this challenge but there are a number of issues to address before it could be implemented. As a TSO, we are obliged to accept gas that is tendered for delivery at each GB system entry point in accordance with the legal specification for WI that currently applies. We understand that the classification concept is for each TSO and DSO to make a prediction of the WI range that each of its exit points for end use is expected to offtake. (We assume that this would not extend to domestic offtakes although this is not specifically stated). Where the TSO/DSO determines that the range is expected to be within 3.7 MJ/m³ up to a 99th percentile, the offtake would be classified as 'specified' and otherwise would be

Terminal into which both the BBL and Interconnector UK pipelines are connected. National Grid Gas. Philip Hobbins	Groups BSI GSE 33 and GSE/-/05: Gas Infrastructure. Malcolm Howe Chairman BSI GSE/33 and GSE/-/05.			classed as 'extended'. We further understand that this 3.7MJ/m³ range would have upper and lower limits that would be specific to each exit point and that (although not stated in the Annexes) it has been suggested that TSOs/DSOs be required to provide information to exit points in advance where a 3.7 MJ/m³ range is expected to be exceeded. There are a number of practical challenges that we would face to produce such a classification. Whilst historical WI data at entry and exit points may serve to inform the assessment, we would also need access to information about the future WI of gases that upstream parties plan to deliver and a means by which the resulting blend of WI could be modelled through the transmission system. At present, we have neither of these. Also, we are not in control of the quantities of gas that are delivered at each GB entry point, nor the pattern of demand across the network, which changes from day to day, and even within a gas day which affect the WI that individual exit points receive. The GB network has a high level of supply diversity with network entry points in the north, east and west that deliver gas at both the higher and lower end of the allowable WI range. The volumes delivered at these points vary; as an example, LNG importation terminals have the capability to deliver significant quantities of gas to our network but whether they do so is subject to a global market. When LNG is not flowing, demand has to be met from other sources of supply with a different WI which would have an impact on the WI of gas that many GB exit points would receive. Variations in demand patterns also mean that the majority of GB exit points could receive a commingled WI from more than one entry point on any particular day, making a WI range prediction difficult to achieve. Operational incidents that periodically occur such as compressor trips, pipe breaks or supply failures that necessitate gas flows to be re-routed would also compromise such an assessment. Confidence levels in a prediction of WI at exit points are likely to be higher where they are located close to entry points, yet even at entry points we experience WI variations due to the prevailing inputs from different fields and which fields may be subject to planned or unplanned outages.

				It is not clear how the impact of new connections would be managed, which could alter flow patterns in an area of the network. This could lead to a situation where an exit point designs its plant based on the classification it receives from a TSO/DSO which subsequently becomes inappropriate due to changed flow patterns and quality that arise due to a new exit point / storage point / entry point connecting in its vicinity. If end users that are sensitive to WI variation suffer commercial loss as a result, we are concerned that they may seek to recover this by holding the TSO/DSO liable, although we appreciate that the probabilistic approach recognises that a guarantee of whether the WI will be within the 3.7 MJ/m^3 range for 'specified' exit points cannot be provided. If gas is made available for offtake outside of a 3.7 MJ/m^3 range, we understand that a TSO/DSO may be required to provide advance notice on the day of how the WI may change. At present, we do not have the capability to make such an assessment. If we did, it would be a best view that carried a risk of error. In this scenario, if the TSO/DSO's prediction of WI change did not occur, an exit point may have taken mitigation measures (including ceasing to offtake gas) that were unnecessary, or, alternatively, if the WI of gas offtaken were to change which the TSO had not foreseen or communicated then the exit point may have continued to offtake gas when they would otherwise have not done so or taken mitigating action. Assuming it were feasible to model WI in order to generate a classification of exit points, National Grid would incur additional systems, process and resource costs to do so. If additional information were required to be provided, new tools would also be required; either additional chromatographs to be installed upstream of offtake points or a real-time capability to track WI through the network. We are concerned that the funding for this would generate a cross-subsidy whereby all consumers would be funding these investments for the benefit of a section of large-scale industrial consumers that are sensitive to WI variation. We have also not seen any evidence that the proposed classification solution is more economic than the exit points that are sensitive to WI change making changes at their sites

				to address the impacts they experience due to variation in WI. We therefore suggest that a cost/benefit analysis should be completed to demonstrate whether this is the right solution for the benefit of consumers overall. We also note that the proposal does not specify what the triggers for reassessment of the classifications would be or otherwise with what frequency TSOs / DSOs would be required to make such reassessments.
UK Response 4: Large Gas Generation Users (CCGTs), *Energy UK. Ms Julie Cox*	Replying as part of the BSI GSE/33 and BSI GSE/-/05 Gas Infrastructure Response		no	The proposed classes are not consistent with the previous definitions of classes A to C defined in CEN SFGas GQS TF1 N 120: Draft reflection paper for the further development of the Integrated Scenario/classification approach provided by AhG, 2019-07- 9 and presented at the Madrid Forum, June 2019. These definitions covered the possible situations well. The two proposed classes are not materially different as they both require that the WI be within the overall entry range and be specified. The only difference is whether the range is greater or less than 3.7 MJ/m³. Neither class allows for fuels outside the EU-wide entry range that may be required to accommodate local gas production. We do not believe that this provides a workable classification system.
UK Response 5: Utilisation, which represents various Trade Associations, i.e. 5 Heating and	This Part 5 response from HHIC is part of the UK response along the UK Gas		Yes, if	Again, of paramount importance here is the individual member states national gas quality specification, as governed by schedule 3 of GS(M)R in the UK. Gas qualities differ and gas appliances are designed to be safe for that particular gas quality. This is why member states must declare information about gas quality under the Gas Appliances Regulation (GAR) obligations (for examples gas pressure and Wobbe Index). This relates to achieving the essential safety requirements in the annex to the GAR. As regards gas quality in the UK currently, careful step by step consultations on various potential changes are being progressed, a process which must be maintained to ascertain

Hot Water Industry Council, HHIC. Neil Macdonald	Supply Chain, via Gas Industry Stakeholders represented in BSI GSE/33 and GSE/-/05: Gas Infrastructure. Malcolm Howe, Chairman of these committees.			the tolerability, or otherwise, of gas appliances to changes in the UK specification. This work encompasses H_2NG blending (HyDeploy), raising the normal upper limit of the UK WI (SGN's "Opening up the Gas Market"), and now new work by DNVGL on potentially lowering the normal lower limit of the permissible UK WI. This is not an exhaustive list, and it is feasible several of these changes could occur in combination in future. Such projects show the concerns in the UK on "broad brush" changes to regulations without full consideration on the appliances that utilise the gas supplied, and the health and safety of the installers and end users. This careful approach in the UK, we believe, supports our above statements and the topics from these studies have already shown limits to what is possible, and in the final distribution quality needing to be maintained. For example, the Oban study ("Opening up the Gas Market") concluded a narrower increase in WI than originally proposed was appropriate for safety, and this was itself a narrower band than proposed by EASEE gas. It may not be until relevant projects have concluded, and we have a holistic view of future gas quality potential in the UK, that we can more fully address some of these questions. It is pleasing to see greater cognisance given to the repercussions of any accompanying regulatory framework at EU level, but as with earlier comments to ENTSOG proposals (to link EN 16726 to the INT-NC and so make legally binding), this should be totally transparent first, as it will influence the technical agreements which may or may not be reached, through standardisation (i.e. EN 16726) within CEN on these matters. A 3.7 MJ/m^3 range for regular "class" may not in itself pose a concern, as the current UK "normal" range is 4.2 MJ/m^3, but it would need to fall specifically within the accepted UK WI range, for the reasons given. Wider class ranges would need to be similarly agreed within the UK regulatory framework, e.g. the current 4.2 MJ/m^3 range would likely be acceptable, but with the bespoke UK values applied for lower and upper WI limits.
UK Response 6:	Yes, via *BSI*		Yes, if	The current range of WI detailed in the UK GS(M)R is 4.21 MJ/m^3 and therefore the 3.7 MJ/m^3 proposed as the exit WI would be acceptable to the UK manufacturers providing

The Industrial and Commercial Energy Association, ICOM, Ross Anderson, and the Energy and Utilities Alliance, EUA. Peter Day. (ICOM Energy Association represents the commercial /industrial heating equipment manufacturers.)	*GSE/33 and GSE/-/05: Gas Infrastructure*: Chairman Malcolm Howe			that it is within the 47.20 to 51.46 MJ/m³ range as detailed in schedule 3 of the GS(M)R. In the table below, “Exit 1” would be acceptable under current UK legislation. There is no evidence as to whether WI ranges outside the current UK GSMR would be safe and not affect the life of the appliances and therefore at this time, we could not accept any of the other “Exit” specifications.
UK Response 7: Cadent (DSO) Cadent falls	Yes, via *BSI GSE/33 and GSE/-*		no	It is recognised that the proposed bandwidth does encompass the variation of gas quality at many exit (and entry) points at the current time, as confirmed by the studies undertaken by SFGas and ENTSOG. If the aim is to establish limits for the future then this is restrictive and the bandwidth could be larger.

in the UK Gas Supply Chain between the National Grid Gas, as the GB TSO, 3, then Cadent a DSO and the Large Scale Generators, at 4.	*/05: Gas Infrastructure*: Chairman Malcolm Howe			Current studies in the UK are focusing on extending the flexibility of the gas networks by enabling a wider range of gas types and qualities. The proposed gas quality bandwidth of 3.7 MJ/m³. Is already narrower than the current UK range of 4.2 MJ/m³. The aim in the UK is to widen the range and also enable hydrogen to be admitted. NB. The EN 437 composition for G23 mentioned in Conclusion 22/2019 is incorrect.
SE (SIS)	Yes	TSO's, DSO's, suppliers, end users (industrial, power generation, renewable production)	Yes* (see RoC)	
Individual replies:				
Assotermica […]	yes		Yes, if	Class (specified) with a Range of 3,7MJ/m³ would fit if there were a set point for an appropriate setting. E.g. +1MJ/m³ and -2,7MJ/m³. Only a plus or minus in one direction does not fit. Class (extended) should be limited. 3,7MJ/m³ plus xMJ/m³ should be limited to + xy MJ/m³ and -xy MJ/m³
FNBgas	yes		yes, if	We as FNBgas know that it is an enormous challenge for CEN to come up with an acceptable solution for an EU-wide Wobbe Index range at EU entry points. We are aware that the proposed solution with an EU wide Wobbe Index range in combination with a classification system at exit points is a compromise to meet all requirements such as security of supply, diversification and decarbonisation of gas supply in combination with a

				safe and efficient end use. We consider that the de-coupling of entry and exit specifications as proposed via the exit point classification approach is a could be a useful concept to resolve this challenge. Therefore, we support the chosen path. However, there are some major issues that need to be addressed in this context. However, as a TSO we cannot guarantee a Wobbe Index exit range smaller than the allowed entry range at any point in the network. Furthermore, the gas flow and gas quality in the Transport System is heavily influenced by nominations from shippers/transport customers and different gas sources. Therefore, we support this classification scheme if • a clear regulatory and legal framework in this context will be developed before or minimum in parallel to the revision of the gas quality standard. This regulatory and legal framework must give clear provisions in minimum for definition of points (entry, exit), definition of roles, responsibility and liability, definition of cost carrying and reimbursement, non-discrimination behaviour for all networks and system operators EU-wide. • Smart solutions to mitigate Wobbe Index related issues are preferred in contrast to major investments into the network (such as conditioning facilities at interconnection points or additional pipelines for blending purposes). • there are no penalties or disadvantages towards a TSO for assigning the extended class since the appropriate class for a certain exit point or area is usually not in the TSO’s control. • any investment costs for TSOs (such as additional PGCs, steering regulators, conditioning facilities, valves, etc.) are considered part of the regulatory asset base and any additional operational costs are covered by regulation. • TSOs are only obligated to provide predictions of future gas quality without being legally bound to provide the predicted gas quality. • there are no legally binding rules concerning rate of change since this can generally not be sufficiently controlled by TSOs (as described in conclusion 25/2019).

				It's not given, that the proposed numerical solution for the class "specified" is the most economic and efficient one. Opening too many Extended class procedures and too frequent changes of classification may lead to additional cost for the involved parties. Therefore, FNBGas advises CEN stakeholders to further elaborate on reasoning of the chosen values of bandwidth (3.7 MJ/m³) and percentiles (1-99%).
Glendimplex (Faber)	no		no	WI exit range classification for EN 16726 is ok but as gas fireplace manufactures we are missing the max allowed PE value for the distributed gas. The max PE value is also missing in the EN 16726. A value over 10% PE will cause high soot deposit in gas fire places. For most gases PE= 0.5*(CH2H6)+1*(C3H8)+1.5*(C4H10) + 2*(C5H12) + 2.5*C6H14)
Swedish Gas Association			yes	

D.3.3 Third question (see D.1) related to rate of change of Wobbe Index

Table D.4 — Replies on the rate of change of Wobbe Index

NOTE Only one descriptive reply is given on this question, therefore, only this is copied into this document.

Organisation/ Mirror Committee	Are you officially replying in the name of a sector organization/Mirror Committee? (Yes/No)	In case of mirror committee; which organisations are represented (specify gas applications/type of end-user)	RoC
SE (SIS)	Yes	TSO's, DSO's, suppliers, end users (industrial, power generation, renewable production)	*Even if Rate of Change (RoC) is taken out of the equation at the moment and not part of this consultation we would still like to comment on this particular topic. Though we agree that RoC-criterias are difficult to achieve with the measurement resolution (granularity/frequency) available today this should

			not restrain the natural gas industry from trying to assist industrial customers sensitive to plug flows.

D.4 CEN SFGas GQS TF 1 Conclusions related to Wobbe Index proposal (2019-10-30)

Number	Subject	Conclusion
20/2019	CEN competency regarding definition of WI aspects	Framework issues raised during discussions will be collected in a dedicated list and forwarded to EC together with the result of the SFGas GQS process results and with the recommendation to launch the required process.
21/2019	EU wide WI entry range – Definition	Use of the definition already given in EN 16726:2015:
		*“**entry point:** a point at which gas enters a gas distribution or gas transmission system”* [EN 16726, 3.2]
22/2019	EU wide WI entry range – Need and WI range limit values	An indication of WI limit values for the EU wide entry range in EN 16726 is requested.
		The WI range limits 46,44 MJ/m^3 to 54,00 MJ/m^3 (EASEE-gas CBP) are to be put in the consultation initiated by Conclusion 26/2019.
23/2019	EU wide WI entry range – WI set point of appliances and safety range	The fact that the whole safety range shifts with a shift of the set point is taken note of. Whilst the related responsibility/liability issue is not subject to the CEN process, technical standardisation work on adjustment of WI set points and on related requirements for installers could be initiated in a CEN Technical Committee which covers the corresponding scope.

24/2019	WI exit range– Definitions	• **exit area:** geographical area connected to the same grid in which all exit points receive the same gas quality.
		• **exit point:** point at which gas leaves the distribution or gas transmission system for end use.
		• **WI range exit area:** geographical area connected to the same grid in which all exit points receive the gas with the same WI range.
		These definitions will be forwarded to CEN/TC 234 as part of the final SFGas GQS process results/report for consideration in the revision of EN 16726:2015.
25/2019	Classification of WI exit – Proposal as basis of consultation	Referring to the proposal of a Class A with (pre)defined WI range values as described in SFGas GQS TF1 N 120rev, considering the presentation by JRC (SFGas GQS TF1 N 141) providing a sensitivity analysis of the classification as SFGas GQS TF1 N 120rev based on all Survey 2 data sets, SFGas GQS TF1/CAG concludes to delete Class A from the classification system, as there is no agreement on a class with (pre)defined WI range values possible.
		Referring to rate of change (RoC) as an element of the classification as described in SFGas GQS TF1 N 120rev, SFGas GQS TF1/CAG concludes that the rate of change cannot be part of the classification system, yet, as it can technically not be granted. (RoC cannot be measured with the needed granularity; thus, the occurrence of plug flow would not be detected with the possible measurement frequency.)

However, SFGas GQS TF1/CAG acknowledges that plug flow may be detrimental for specific end-use applications (e.g. engines, chemical feedstock) even in case of feedback control systems and shall be avoided at an utmost. Therefore, SFGas GQS TF1/CAG recommends to integrate an informal explanative annex into EN 16726. A draft could be provided with the final SFGas GQS results/report.

Reflecting the two aspects above, SFGas GQS TF1/CAG agrees on the following classification of WI at exit points/areas. This will be subject to the intended consultation (see Conclusion 26/2019):

Classes	**WI range**	**Bandwidth**	**Percentiles**	**RoC**
Class (specified)	With indication of WI limits defined per exit point, based on the distributed gas, within WI entry.	Below or equal to 3,7 MJ/m^3	1 to 99	**RoC is not part of the classification system, yet.**
		with specifying the actual bandwidth.		However, reference to Survey 2 report (page)
Class (extended)	With indication of WI limits defined per exit point, based on the distributed gas, within WI entry.	Above 3,7 MJ/m^3	1 to 99	(aim: avoidance plug flow; plug flow might be dealt with in informative, explanative annex)
If deviating bandwidth.		with specifying the actual bandwidth.		

		Case by case assessment (rules to be specified in legal process).				
		Procedures are to be provided to specify classes (incl. at least switch to other class, time scales, liabilities and responsibilities) in a parallel process on legal framework with European and national authorities.				
		As **side information**, JRC identifies a bandwidth that covers 98% of gases based on survey 2. The analysis gives an idea what the extended WI bandwidth could be.				
26/2019	Informative consultation on current proposal of integration of WI aspects at stakeholder/national mirror committee level	Organize an informative consultation on the current proposal on integration of WI aspects in EN 16726 at stakeholder and national mirror committee level. The aim is to share the current status of work with a broader group and to get feedback on the general acceptance.				
		Subjects to consultation:				
		— WI limit values for EU wide WI entry range (Conclusion 21+22/2019)				
		— Classification of WI exit (Conclusion 24+25/2019)				
		Timeline:				
		— launch: as soon as possible;				
		— deadline for reply: 11 December 2019.				
		The outcome will be subject to discussion at the next meeting on 18 December 2019.				

		Aim is to present a result of the SFGas GQS process to EC DG Energy after the next meeting, taking into account the expectation of DG Energy to receive a final WI proposal by end of 2019, expressed by Klaus-Dieter Borchardt at the 33rd MF and as announced by SFGas GQS at the 32nd MF.

Annex E
(informative)

Involvement of national mirror committees and European sector associations

E.1 CEN and CENELEC Members (NSBs and NCs),

AFNOR (F), ASI (A), BSI (UK), DIN (GE), DS (DK), NBN (B), NEN (NL), NSAI (IRL), NQIS ELOT (GR), MSZT (HU), PKN (PL), SIS (S), SIST (SLO), UNI (I), UNE (E)

E.2 European organizations/associations

- afecor
- CECOF
- C.E.F.A.C.D.
- CEFIC
- COGEN Europe
- EASEE-gas
- EBA
- EHI
- ELVHIS
- ENTSOG
- EUGINE
- EURO-AIR
- EUROGAS
- Euromot
- ETN European Turbine Network
- EUTurbines
- FARECOGAZ

— GIE

— IFIEC

— IOGP

— Marcogaz

— NGVA Europe

E.3 European Commission and EU agencies

EC DG JRC is participating actively in the project, carrying out data surveys and analysis and supporting the reporting towards DG Energy.

With EC DG Energy continuous exchange is given, including reporting to the Madrid Forum

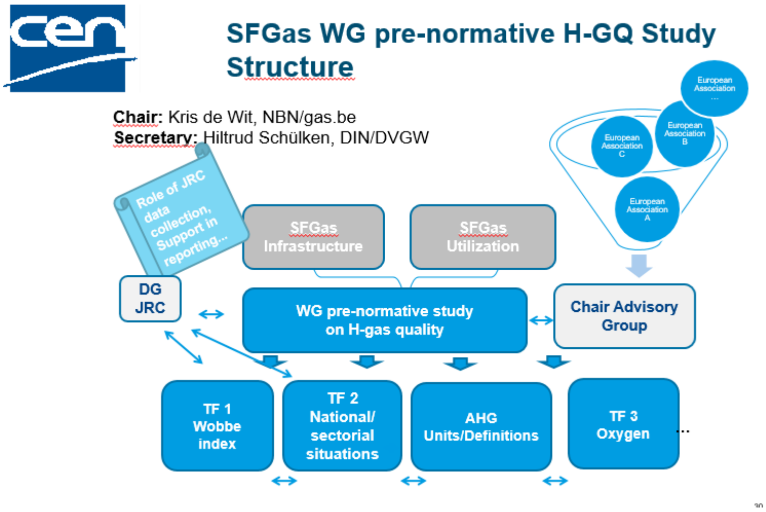


Figure E.1 — CEN SFGas WG pre-normative study on H-gas parameter (short: CEN SFGas GQS)

Annex F
(informative)

CEN-CENELEC Internal Regulations on normative requirements and normative recommendations in European standards

Normative requirements and recommendations in European standards are defined as follows:

Requirement
expression in the content of a standard that conveys objectively verifiable criteria to be fulfilled and from which no deviation is permitted if conformance with the document is to be claimed

Note 1 to entry: Requirements are expressed using the verbal forms specified in Table 3 [Table F.1 in this document] (shall)

[Source: CEN-CENELEC Regulations Part 3, 3.3.3 modified to be understood as alone-standing definition]

Table F.1 — Use of verbs to express a requirement in a European Standard

<table>
<tr><th>Preferred verbal form</th><th>Equivalent phrases or expressions for use in certain cases</th></tr>
<tr><td>shall</td><td>is to
is required to
it is required that
has to
only … is permitted
it is necessary</td></tr>
<tr><td>shall not</td><td>is not allowed [permitted] [acceptable] [permissible]
is required to be not
is required that … be not
is not to be
do not</td></tr>
<tr><td colspan="2">EXAMPLE 1
Connectors shall conform to the electrical characteristics specified by IEC 60603-7-1.</td></tr>
<tr><td colspan="2">Imperative mood:
The imperative mood is frequently used in English to express requirements in procedures or test methods.
EXAMPLE 2
Switch on the recorder.
EXAMPLE 3
Do not activate the mechanism before…</td></tr>
<tr><td colspan="2">Do not use "must" as an alternative for "shall". This avoids confusion between the requirements of a document and external constraints (see 7.6).
Do not use "may not" instead of "shall not" to express a prohibition.</td></tr>
</table>

Recommendation

expression in the content of a document (3.1.1) that conveys a suggested possible choice or course of action deemed to be particularly suitable without necessarily mentioning or excluding others

Note 1 to entry: Recommendations are expressed using the verbal forms specified in Table 4 [Table F.2 of this document] (should)

Note 2 to entry: In the negative form, a recommendation is the expression that a suggested possible choice or course of action is not preferred but it is not prohibited.

[Source: CEN-CENELEC Regulations Part 3, 3.3.4]

Table F.2 — Use of verbs to express a recommendation in a European Standard

Preferred verbal form	Equivalent phrases or expressions for use in certain cases
should	it is recommended that ought to
should not	it is not recommended that ought not to
EXAMPLE Wiring of these connectors should take into account the wire and cable diameter of the cables defined in IEC 61156.	
In French, do not use "devrait" in this context.	

European Standard
EN
document,

- established by consensus and approved by a recognized body (e.g. CEN), that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context

- adopted by CEN/CENELEC and carrying with it an obligation of implementation as an identical national standard and withdrawal of conflicting national standards

Note 1 to entry: Standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits.

Note 2 to entry: “Harmonised Standard” is a term used in Regulation (EU) No 1025/2012 of the European Parliament and of the Council, meaning a European Standard adopted on the basis of a request made by the Commission for the application of Union harmonisation legislation.

Note 3 to entry: EN 16726 is a harmonised standard.

Note 4 to entry: The application of a European standard is principally voluntary. However, the national standardisation bodies, members of CEN, committed to implement the European standards nationally.

[SOURCE: CEN-CENELEC Internal Regulations Part 3, 3.1.2, 3.1.9, combined and modified to be understood as alone-standing definition]

Annex G
(informative)

Abbreviations and acronyms

Table G.1 —Abbreviations and acronyms

Abbreviation/acronym	Explanation
CAG	CEN SFGas GQS Chair adisory group
CBP	Common Business Practice
CEN	
GVC	Gross (or Superior) Calorific Value
CEN SFGas GQS	CEN Sector Forum Gas WG 'Pre-normative study on H-gas quality parameter (Joint WG of CEN Sector Forum Gas infrastructure and CEN Sector Forum Gas utilisation)
DSO	Distribution system operator
EC	European Commission
EEC	The Council Of The European Communities
GAD	Directive (EEC) 90/396 Appliances Burning Gaseous Fuels COUNCIL DIRECTIVE of 29 June 1990 on the approximation of the laws of the Member States relating to appliances burning gaseous fuels
GAR	Regulation (EU) 2016/426 on appliances burning gaseous fuels
H2NG	Hydrogen/Natural Gas blend
GQS	Gas Quality Study = Pre-normative study on H-gas quality parameter
MF	Madrid Forum
MN	Methane Number
NG	Natural Gas
NRA	National Regulator Authority
NSB	National Standardisation Body
OEM	Original Equipment Manufacturer
OJ	Official Journal of the European Union

RoC	Rate of change
TF1	CEN SFGas GQS Task Force 1 'Wobbe Index
TSO	Transmission system operator
SFGas	Sector Forum Gas (composed of Sector Forum Gas infrastructure and Sector Forum Gas utilisation)
SSAS	Simple Scenario Assessment Survey
WG	Working group
WI	Wobbe Index

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