CODE OF OPERATIONS MODIFICATION PROPOSAL

MODIFICATION DETAILS				
Modification Number: A113	**Modification Title : Amendment to Code Of Operations to amend gas quality requirements at Entry Points**			
Modification Proposer:	**Modification Representative:**	**Modification Representative Contact Details (email address):**	**Date Submitted**:	**Proposed Implementation Date:**
Gas Networks Ireland	Michael Crowley	Michael.Crowley@gasnetworks.ie	11/08/2023	ASAP

Proposal (including rationale):

The proposal is to revise certain of the parameters to the Gas Quality Specification of natural gas at IP Entry Points and Entry Points i.e.

(i) Revise the WOBBE Index (real gross dry) range to 46.5 -51.41 MJ/m3 and
(ii) replace the Incomplete Combustion Factor (ICF) and Soot Index parameters with a Relative Density (RD) limit<0.7.

Rationale for the proposed changes is to reflect proposed changes to Great Britain (GB) gas quality and thus facilitate the continued acceptance of natural gas tendered for delivery to the GNI System at the Moffat IP.

Proposed Implementation Date:

ASAP

Proposed section of the Code to be modified:

Part G Appendix 1.

MODIFICATION MOTIVATION

Intended Outcome of the Proposed Modification:

To align the quality specification of natural gas at Entry Points to the GNI System with the quality specification of natural gas in GB and facilitate the continued acceptance of natural gas tendered for delivery to the GNI System at the Moffat IP.

Benefits of implementing this Modification:

To facilitate continued acceptance of natural gas tendered for delivery at the Moffat Interconnection Point and avoid potential gas supply deficit where due to gas quality issues natural gas tendered for delivery at the Moffat IP cannot be accepted.

Consequences of not making this Modification:

GNI would be obliged to refuse acceptance of natural gas tendered for delivery at the Moffat IP where such gas fails to meet the Gas Quality Specification in the Code of Operations.

Regulatory Impact Assessment:

None.

Illustrative Example (Please enter a scenario where the issue and solution are illustrated):

Approx 80% of natural gas demand in Ireland is expected to be delivered through the Moffat Interconnection Point; if Natural gas tendered for delivery is at a WOBBE level of 46.7; this is below the current WOBBE limit in the Code of Operations and accordingly, GNI would be required: (i) to request National Gas in the UK to discontinue flows of gas at the Interconnection Point and instruct shippers that gas tendered for delivery is non-compliant and to discontinue deliveries; or (ii) allow the non-compliant gas to enter the GNI System under emergency limits specified in the natural gas emergency plan.

GAS QUALITY

Impact assessment of changes to the UK Gas Safety (Management) Regulations

Gas Networks Ireland

Report No.: 10363124/1, Rev. 3
Document No.: 1606428
Date: 2023-08-11

Project name:	Gas Quality	DNV - Energy Systems
Report title:	Impact assessment of changes to the UK Gas Safety (Management) Regulations	GL Industrial Services UK Ltd Holywell Park, Ashby Road,
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Project No.:	10363124	
Organisation unit:	O&G UK GLIS - Gas Consulting	
Report No.:	10363124/1, Rev. 3	
Document No.:	1606428	

Applicable contract(s) governing the provision of this Report: PO 6025133

Objective:

Assessment of the impact of changes to the Gas (Safety) Management regulations on the Republic of Ireland

Prepared by:	Verified by:	Approved by:
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1	2023-05-16	First issue	MB, MJM	SK	SK
2	2023-07-19	Second draft	MB, MJM	SK	SK
3	2023-08-11	Issued version	MB, MJM	SK	SK

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1 EXECUTIVE SUMMARY

Twenty-five years has passed since the Gas Safety (Management) Regulations, 1996 (GS(M)R) came into force in Great Britain (GB). In that time the GB gas market has been liberalised, new producers have entered the market, the supply mix for GB gas demand has shifted from domestic production to imports and there is new emphasis on making energy consumption greener. Although the underlying benefits and overall performance of gas networks has been good with regard to gas quality, it is clear that some changes to the regulations are required to account for new developments and the changes to gas supply options. Updates to the regulations have been consulted upon with the aim of modernising them to ensure safety standards are consistently applied across the network. The Gas Safety (Management) (Amendment) Regulations 2023 commence on 6th April 2023, with the exception of change to the lower Wobbe Index limit which commences on 6th April 2025.

Since GS(M)R quality gas is imported through the interconnectors into the Irish gas network there is a need to consider the impact on GNI's network and end users of changes to GS(M)R. With regard to the changes to GS(M)R to form GS(M)(A)R, the main factors for GNI to consider are:

- The Lower Wobbe Index limit (reducing from 47.2 to 46.5 MJ/m^3);
- The change in the gas interchangeability parameters, with replacement of the Sooting Index (SI) and Incomplete Combustion Factor (ICF) by the Relative Density, and the consequential impact on the upper Wobbe Index limit.
- The calorific value range, as lower calorific values may be associated with the lower Wobbe Index gas including the carbon dioxide content (which may increase if lower Wobbe Index gas is introduced at St Fergus (the main supply source for gas through the interconnector from Moffat);

There were a number of other changes to the GS(M)R regulations that are not directly applicable to GNI, and are not discussed further in this report, namely increasing the Oxygen (O2) content to 1.0% (mol) for system pressures < 38 barg, requirement for biomethane pipelines to have a Safety Case, duty of cooperation for Liquefied Natural Gas (LNG) and the Emergency Reporting Service for GB.

As an overarching conclusion, the introduction of the updated gas quality regulations through the Gas Safety (Management) (Amendment) Regulations 2023 will not impact on the acceptable gas quality ranges or gas quality operations, but some data logging and SCADA systems may need to be modified to avoid operational issues.

For GNI, the introduction of a new lower Wobbe Index will not compromise the GCV limit, in fact the GCV limit will constrain the acceptable Wobbe Index and provide an additional layer of control on introduction of new gas supplies. The dual-action of the Wobbe Index limits and GCV range in the specification provides effective control and ensures that gas qualities received by end-uses will be safe to use.

As the emergency limits for Wobbe Index have not changed, the actions required by GNI do not need to be adjusted. The acceptance of the new lower Wobbe Index limit of 46.5 MJ/m^3 has been investigated and the HSE have determined that this is safe to use. There is thus no requirement to change the GNI approach for declaration of gas supply emergency based on the gas quality of the supplied gas.

For end-users, as domestic and most commercial appliances confirm to the EU Gas Appliance Regulations (GAR), they should be able to operate safely and effectively on the acceptable Wobbe Index range detailed in GS(M)(A)R, assuming that appliances are at factory settings and have not been adjusted during installation or servicing. If any adjustment is required then this must follow the appliance/equipment manufacturers recommendations (or guidance) and any changes to be made by a suitably qualified, competent person.

Some larger industrial equipment (including power generation) may need to readjust control settings to optimise their equipment and GNI should engage with industrial users to highlight that some intervention may be required, and also to raise awareness of gas quality information that is available on their website.

It is recommended that GNI considers installation of new gas analysers at main entry points to provide additional measurements on gas quality and compliance.

2 ABBREVIATIONS

ALARP	As low as is reasonably practicable
CBA	Cost benefit analysis
CNG	Compressed natural gas
CO_2	Carbon dioxide
CRU	Commission for the Regulation of Utilities
CV	Calorific value
GB	Great Britain
GCoTER	Gas (Calculation of thermal Energy) Regulations, 1996 [GB statutory instrument]
GNI	Gas Networks Ireland
GS(M)R	Gas Safety (Management) Regulations, 1996 [GB statutory instrument]
GS(M)(A)R	Gas Safety (Management) (Amendment) Regulations, 2023 [GB statutory instrument]
H_2	Hydrogen
HSA	Health and Safety Authority
HSE	Health and Safety Executive (GB)
ICF	Incomplete combustion factor
IGEM	Institution of Gas Engineers and Managers
LTS	Local Transmission System (GB)
LDZ	Local Distribution Zone (GB)
LNG	Liquified natural gas
PRCI	Pipeline Research Council International
NGT	National Gas Transmission (GB) – formerly National Grid Gas Transmission
NTS	National Transmission System (GB)
RD	Relative density
SI	Sooting index
UKCS	United Kingdom Continental Shelf
WI	Wobbe index

3 INTRODUCTION

Gas Networks Ireland (GNI) operates gas transmission and distribution pipelines in the Republic of Ireland., and also includes NI / SWSOS/IOM The Irish network is connected to the National Transmission System (NTS) operated by National Gas Transmission (NGT) in Great Britain (GB) through an interconnector from Scotland that GNI is responsible for. Therefore any change in gas quality in GB will directly impact the Irish network.

Natural gas quality in GB must comply with the legislation and support the overall safety case for gas. The original regulations for control of gas quality were the Gas Safety (Management) Regulations 1996 (GS(M)R), but as the range of gas sources has widened, together with issues over security of supply, and an overall aim to enable more biomethane to be used, the original legislation has had exemptions but an updated, amended regulation was deemed appropriate.

Significant background work on suitable limits and overall gas interchangeability was undertaken and consultation with key stakeholders including gas transmission and distribution companies, power generators, IGEM, biomethane producers, ENA, and a case for amendment was sent to the HSE.

Amendments to the Gas Safety (Management) Regulations 1996 have been approved by government and the regulatory changes are being made through the Gas Safety (Management) (Amendment) Regulations 2023 (GS(M)(A)R) and came into force from 6 April 2023.[1] The changes include:

- Gas that is permitted in gas networks in Great Britain must have a relative density of ≤0.700. The incomplete combustion factor and sooting index values are no longer required in order to comply with Schedule 3;

Additionally:

- The lower Wobbe Number limit for gas permitted in gas networks in Great Britain will change to ≥46.5 MJ/m^3 on 6 April 2025; and

These changes will maintain and improve the standards of safety that have been achieved to date by the Gas Safety (Management) Regulations 1996 in extending existing provisions to relevant stakeholders and duty-holders.

With the interconnector providing natural gas to Ireland, the changes also need to be reviewed from an Ireland gas network viewpoint.

[1] For further links and information see: https://consultations.hse.gov.uk/hse/cd291-revision-gas-safety-management-regulations/?utm_source=govdelivery&utm_medium=email&utm_campaign=guidance-push&utm_term=gsmar-2&utm_content=gas-regs-11-apr-23 (accessed 11 April 2023.

4 THE CURRENT GAS QUALITY SPECIFICATION IN IRELAND

In Ireland the gas quality specification is detailed in the Code of Operations, Part G (Technical) in Appendices 1 and 2 [2] and shown in the following tables and pages. The specific values are based on the GS(M)R values or those listed in National Gas Ten Year Statement.[3]

QUALITY SPECIFICATION OF NATURAL GAS AT ENTRY POINTS

Parameter	**Entry**
Total Sulphur	< 50 mg/m^3 (including H_2S)
Oxygen	< 0.2 mol% * See Renewable Natural Gas Notes
Carbon Dioxide	< 2.5 mol% See Note 1
Hydrogen Sulphide	< 5 mg/m^3
Water Content	< 50 mg/m^3
Gross Calorific Value (Real Gross Dry)	36.9 – 42.3 MJ/m^3
Wobbe Index (Real Gross Dry)	47.2 – 51.41 MJ/m^3
Contaminants & Odour	See Notes 2 and 3
Incomplete Combustion Factor	< 0.48
Delivery Temperature	1 °C to 38 °C
Hydrogen	< 0.1 mol%
Soot Index	< 0.60
Organo Halides	< 1.5 mg/m^3
Radioactivity	< 5 Becquerels/g
Ethane	< 12 mol%
Nitrogen	< 5 mol%
Hydrocarbon Dewpoint	< –2°C up to 85 barg

Reference Conditions

All measurements at 15 °C and 101.325 kPa

Note 1 The CO_2 limit of 2.5% will not be considered breached if the total inerts (including CO_2) in the gas is less than 8 % where:

“inerts” in natural gas means carbon dioxide (CO_2), nitrogen (N_2), helium (He), argon (Ar), and oxygen (O_2).

Note 2 Natural Gas shall not contain solid liquid or gaseous material which may interfere with the integrity or operation of pipes or any Natural Gas appliance which a consumer or transporter could reasonably be expected to operate. With respect to Mist, Dust, Liquid, gas delivered shall be technically free in accordance with BS 3156 11.0 [1998].

[2] For further details on the Code of Operations, see website: https://www.gasnetworks.ie/docs/corporate/gas-regulation/PART-G-(Technical)- (final-clean)-Version-5.03- .pdf (accessed 11 April 2023).

[3] For further details of the National Gas Ten Year Statement see website: https://www.nationalgas.com/document/137861/download (accessed 11 April 2023). Note that this links to the 2021 version. The 2022 version contains less detail on the gas quality specification.

Note 3 Natural Gas shall have no odour that might contravene the obligation of the Transporter to transmit gas which possesses a distinctive and characteristic odour. Where the Transporter requires gas to be odourised, the gas shall be odourised in accordance with the following specification:

- Odour intensity of 2 olfactory degrees on the SALES Scale (Ref. IGE/SR/16/1989); or
- Such other specification determined by the Transporter acting as an RPO.

Emergency Gas Quality Specification

In the event of an Emergency, and at the sole discretion of the National Gas Emergency Manager, gas outside of the Entry Specification may be admitted to the system. Without prejudice to the generality of this, the emergency limits as outlined in the Natural Gas Emergency Plan NGEP may be adopted by the Transporter. The NGEP current limits are that the Wobbe Index of the gas is between 46.5 – 52.25 MJ/m^3.

Renewable Natural Gas Notes

1. Oxygen content for gas derived from Renewable Natural Gas at an RNG Entry Point connected to the Distribution System shall be up to 1 mol% where there is provision for automatic discontinuation of gas flows for non-compliance with the applicable Entry Specification. Such automatic discontinuation shall comprise of the discontinuation of gas flow based on pre-programmed criteria, such criteria determined by the Transporter and embodied in an automated process, all as outlined in the applicable CSA.

2. The CSA in respect of any RNG Delivery Facility may subject to the approval of the Commission specify additional gas quality parameters (which may for avoidance of doubt be subsets of the parameters set out above) and associated limits in respect of such parameters to apply at the individual RNG Entry Point or category of RNG Entry Point in which case the gas quality parameters so specified shall (subject to Renewable Natural Gas Note 1 above) apply at such RNG Entry Point(s) in addition to the parameters set out above.

QUALITY SPECIFICATION OF NATURAL GAS AT OFFTAKE POINTS OR CSEP

(A) **Gas Combustion Characteristics**

Type of Gas	2nd Family Group H [4]
Wobbe Index	45.7 to 54.7 MJ /m^3 (Real Gross Dry)

(B) **Upper Limits of Natural Gas Impurities**

Hydrogen Sulphide Content	Not more than 5 mg/m^3
Total Sulphur Content	Not more than 50 mg/m^3
Oxygen Content	(i) Not more than 0.2% (molar) (for Offtake Points and CSEP's connected to the Transmission System) (ii) Not more than 1.0% (molar) for Offtake Points connected to the Distribution System.
Contaminants	Natural Gas shall not contain solid matter which would have a material adverse impact on the ability to use Natural Gas at an Offtake Point.

Reference Conditions

All measurements at 15 °Celsius and 101.325 kPa.

[4] For details on gas families and groups see EN 437:2021 "Test gases. Test pressures. Appliance categories"

With regard to the changes to GS(M)R to form GS(M)(A)R, the main factors for GNI to consider are:

- The Lower Wobbe Index limit;
- The calorific value range, as lower calorific values may be associated with the lower Wobbe Index gas;
- The change in the gas interchangeability parameters, with replacement of the Sooting Index (SI) and Incomplete Combustion Factor (ICF) by the Relative Density, and the consequential impact on the upper Wobbe Index limit.

Other factors including oxygen limit are important. However, GNI are proposing a limit of 0.5 mol%, and as natural gas from the GB NTS will contain a maximum of 0.2 mol%, then the proposed amendment to the oxygen limit should not impact on GNI operations.

5 DISCUSSION ON GAS QUALITY CHANGES

From a gas quality viewpoint, the key changes to GS(M)R and agreement of the amended regulations relate value of the lower Wobbe Index limit and the use of relative density as a key interchangeability parameter. In addition there are potential changes to the lower calorific value, and that higher carbon dioxide content may occur in lower Wobbe Index gas, and to the oxygen content. The effect on pipeline integrity and the estimate of the water dewpoint are also reviewed.

These points are considered in the following sub-sections.

5.1 The change to the Lower Wobbe Index limit

The change to the lower Wobbe Index limit from 47.2 MJ/m^3 to 46.5 MJ/m^3 is primarily focused on enabling more UKCS gas to enter the UK network for security of supply requirements, and also to potentially widen opportunities for biomethane connections. This change lowers the Wobbe Index limit to a value that was the emergency lower Wobbe Index Limit. As part of the evidence considered by the UK HSE, it was shown that the lower Wobbe Index could be used without significant impact on emissions for domestic appliances, and industrial and commercial end users were also consulted and no barriers to its introduction were raised.

In the consultation process, one respondent stated that the new lower Wobbe Index limit would be identical to the current emergency limit and that this impacted on the overall ethos of emergency limits. This comment was considered but as no instances of lower emergency limit being invoked had been evident over the last twenty years at least, this view was not upheld.

Further information from National Gas Transmission following studies they performed on expected gas quality variations from the terminal entry points[5] has shown that for the St Fergus terminal (which is the main source of gas for the GNI interconnector) the expected minimum Wobbe Index is 46.9 MJ/m^3 and that this will only be seen on up to 18 days a year.

The UK HSE has decided to retain the lower emergency limit at within ≥46.5 MJ/m^3 within the regulations just to ensure absolute clarity in what the limit is, and the HSE further stated that:

"There had been no request or evidence provided for a new lower emergency limit, possibility due to the absence of any commercially viable gas below the new lower limit."

However, the upper Wobbe Index emergency limit will be retained to prevent a gas supply emergency.

For GNI, the GS(M)(A)R changes to the lower Wobbe Index limit are not expected to impact on overall system operations and end use operability.

5.2 The difference in the interchangeability diagram with RD rather than ICF, SI and PN number

The use of relative density (RD) rather than Incomplete Combustion Factor (ICF), Sooting Index (SI) and Propane-nitrogen number (PN) brings the gas quality reporting in line with other European countries and complies with the EU gas quality standard (EN12676). It also addresses some of the general comments about gas interchangeability that PN is not intuitive and that ICF and SI were originally based on older types of appliance that are not in use anymore.

The use of RD rather than PN does have a minor change to the traditional interchangeability diagram (Dutton diagram) and this is shown below (Figure 5-1).

[5] Information provided to GNI from National Gas |Transmission.

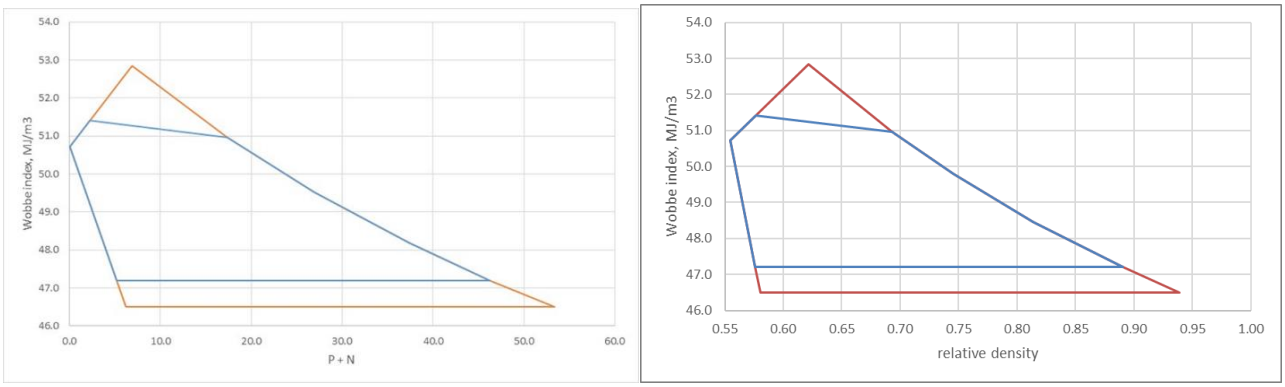

Figure 5-1: Comparison of interchangeability diagrams- with RD used instead of PN[6]

The left-hand diagram is the original approach and the right-hand diagram introduces RD on the x-axis – whilst keeping the current ICF and SI limit lines.

So the introduction of the new limit at RD equals 0.7 provides a truncated diagram without the values associated mostly with the gas qualities closer to the SI limit but it also includes the Wobbe Index limit at 51.4 MJ/m^3 without the ICF drop in values to around 51 MJ/m^3. (see Figure 5-2):

This means that the changes to the GS(M)R not only impact on the lower Wobbe Index limit but also have a minor impact on the upper Wobbe Index limit.

The new limits are shown as the dotted blue line at RD of 0.7, and a dotted red line with Wobbe Index of 51.4 MJ/m^3 (see Figure 5-2)

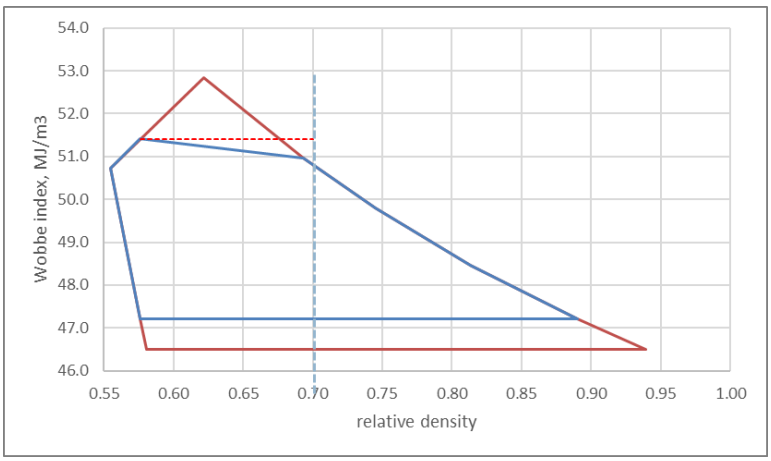

Figure 5-2: Superimposed original ICF and SI gas interchangeability limits together with new RD limit

The interchangeability range involving the area with RD greater than 0.7 is no longer acceptable (see Figure 5-2, and the right hand side of the diagram and interchangeability envelope) and in first appearance does seem to be a significant reduction in the overall operability area. This can be investigated through consideration of historical gas quality data.

[6] Information discussed during IGEM Gas quality discussions (available on the IGEM website) and analysis by Dave Lander.

Some information obtained by DNV from individual GC measurements at a number of sites in the UK (in excess of 5000 individual measurements) shows that the majority of gas quality measurements have Wobbe Index values between 48 – 51 MJ/m^3, and with a PN value lower than 20 which is approximately an RD of 0.7 (see Figure 5-3).

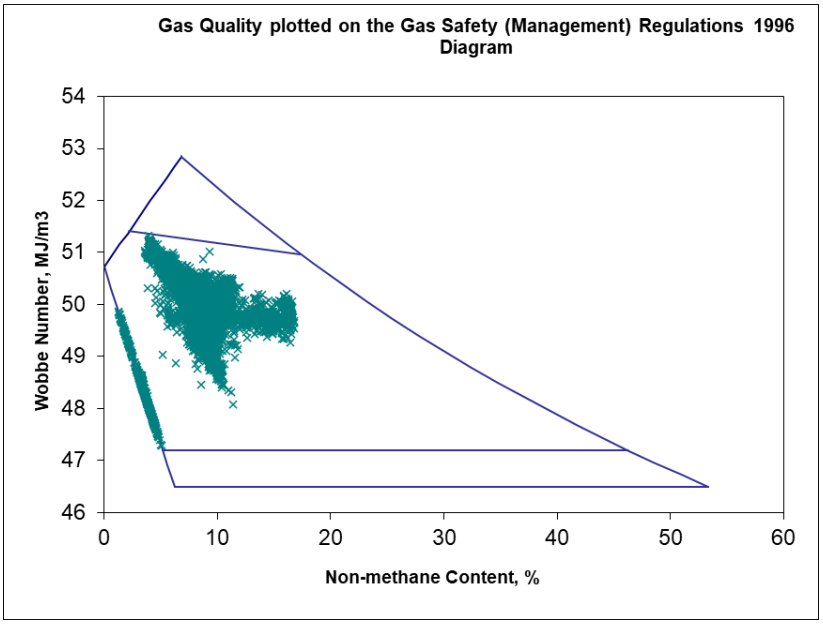

Figure 5-3: Measured historical gas quality data and the distribution of Wobbe Index

Thus the adoption of RD limit of 0.7 will not cause any overall impact on the acceptable range of distributed gas qualities.

5.3 The impact of the change to the Lower Wobbe Index limit on Calorific Value

The current range for acceptable calorific value is 36.9 – 42.3 MJ/m^3 (real gas, gross, dry).

If the distributed gas was 100 % methane, then this would have a GCV of 37.8 MJ/m^3, and to match the 36.9 MJ/m^3 lower limit for GCV, approximately 2.5% of inert gas (nitrogen or carbon dioxide) is required, but this resultant gas still has a Wobbe Index greater than 48 MJ/m^3.

Information from National Gas Transmission, together with details of GB code modifications through the Uniform Network Code (UNC) process available from the Gas Governance team[7], has indicated that changes to supplies from the UK continental shelf (UKCS) especially at St Fergus through the Rhum field and operation of the NSMP could result in supply of gas with higher carbon dioxide content and lower Wobbe Index and Calorific Value than is typically supplied. However, these gases will still be within the GS(M)(A)R and will not impact on GNI operations.

For GNI, the introduction of a new lower Wobbe Index limit will not compromise the GCV limits, in fact the GCV limit constrain the acceptable Wobbe Index and provide an additional layer of control on introduction of new gas supplies. In addition National Gas have confirmed with the NSMP terminal that the minimum GCV of any low Wobbe Index gas will be > 36.9 MJ/m3 (i.e. the current lower GCV limit in the Code).

[7] Seehttps://www.gasgovernance.co.uk/ for more specific UNC modification details.

Figure 5-4 shows indicative gas quality ranges for pipeline gas, ballasted LNG and biomethane and their typical positions in the Wobbe Index versus RD interchangeability diagram. The grey lines are associated with GCV of 36.9, 39 and 42.3 MJ/m^3 , showing the acceptable gas quality range for compliance with GNI specifications (see Section 4). The changes to the UK GS(M)R will not impact on the acceptable calorific value range for GNI distributed gases.

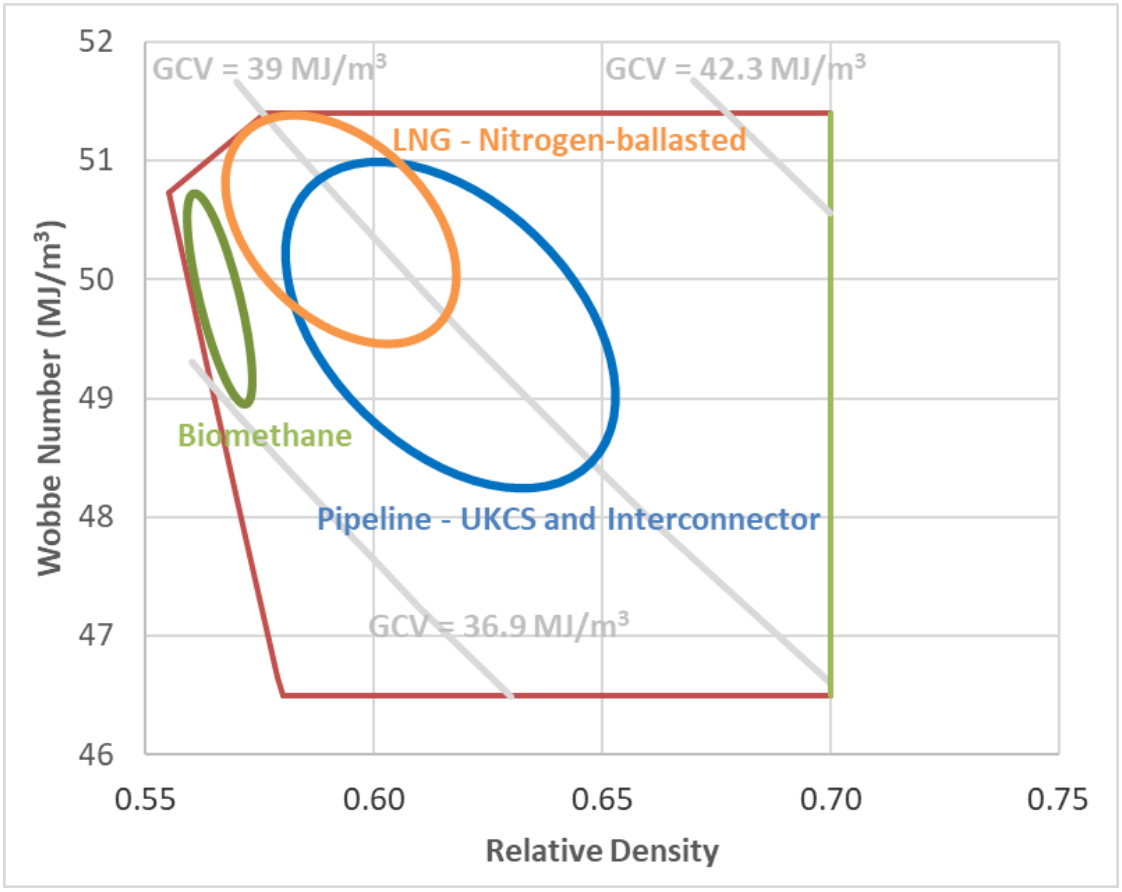

Figure 5-4: Indicative gas qualities of different gas supply categories and the new GS(M)(A)R limits together with calorific value limits

National Gas has confirmed that the GCV of gas from St Fergus and transported through the interconnector from Moffat/Beattock will not fall below 36.9 MJ/m^3 [8] .

5.4 The maximum oxygen content.

In addition to the changes to the Wobbe Index, there is a change in the amended regulations relating to the acceptable oxygen content.

The oxygen content limit for pipeline operating pressure up to 38 barg is being increased from 0.2 mol% to 1 mol%. This change is principally to support biomethane connections and avoiding the requirement to issue an operating exemption.

This GS(M)R change will not have any impact on the ROI, since GNI is supplied from a higher pressure 85 barg system at Moffat, where the O_2 limit will remain at 0.2 % (mol).

[8] Private communication from National Gas.

5.5 Comment on pipeline integrity

Although changes to carbon dioxide and oxygen limits can impact on the corrosion rates and the overall pipeline integrity, the main factor for pipeline integrity is water content. Good control of the water content in line with the quoted values in EN 16723 will ensure that there is no significant impact associated with the GS(M)(A)R, and this is supported by the Penspen study [9]

Penspen concluded that. "Increasing the oxygen content to 1% will have a negligible effect on the steel distribution and transmission networks" and further qualified the conclusion stating that "the inclusion of 1% oxygen would not cause significant additional corrosion".

5.6 Comment on water dewpoint and water content

The change in the gas quality regulations, will not have a significant impact on the water dewpoint limits.

According to European Standard, EN 16726:2015+A1:2018 Gas infrastructure. Quality of gas. Group H, the quoted limit for water dewpoint is -8°C at 70 bar and for hydrocarbon dewpoint it is -2°C at 70bar (absolute pressure). The RD limit and lower Wobbe Index limit will not impact on the dewpoint limits.

GNI gas quality regulations quotes a hydrocarbon dewpoint of -2°C at 85 bar, and the water content is a maximum of 50 mg/m^3 (see Section 4).

Table 5-1 shows indicative maximum water content as a function of the temperature and pressure. For temperatures of -8°C. the maximum water content is 52 or 57 mg/m^3 depending on the pressure, and these data show that the GNI limit of 50 mg/m^3 means that all gas will comply.

Temperature (°C)	Pressure (bar)	Maximum water content (mg/m^3) to meet the dewpoint criteria
-8	70	57
-8	85	52
-10	70	50
-10	85	45

Table 5-1: Indicative maximum water content calculated using thermochemical properties and a representative gas composition.

Information from National Gas [10] confirms that gas received by GNI through the interconnector will meet the required dewpoint limit.

[9] The report by Penspen on the impacts off oxygen can be found at: https://www.gasnetworks.ie/docs/corporate/gas-regulation/Oxygen-concentration-report-17985-AI-RPT-001-Rev-5-Biomethane-review-Penspen.pdf

[10] For details of the range of UK National Gas, gas quality parameters, including dewpoints see: https://www.gasgovernance.co.uk/sites/default/files/ggf/book/2022-05/NTS%20Gas%20Quality%20Parameters%20at%20NTS%20Entry%20Points%2003%20May%202022.pdf

6 THE EVIDENCE PRESENTED FOR THE GAS QUALITY REGULATION CHANGES AND OTHER USEFUL DATA

The applicability of the proposed new gas quality interchangeability specification in the UK concerns GNI and the end-users of Ireland, as the majority of gas supply is through the interconnector with National Gas Transmission in the UK and the supplies in the UK National Transmission System (NTS).

There are also further considerations, related to any future expansion in the use of biomethane, and it is important to provide an overview of the evidence that was included in the HSE assessment, together with other useful and relevant data [11].

In section 5, the overall confirmation of suitability was discussed, based on the UK HSE considerations and evaluation. In this section, additional technical information is discussed to support the acceptability of the proposed new lower Wobbe Index limit.

6.1 Reducing the lower Wobbe Index limit

There is a significant number of technical studies investigating the impact of Wobbe Index on safe and efficient operation of combustion equipment and appliances that has been undertaken since the initial use of natural gas, and many of the concepts were first developed for Town gas. Gas interchangeability studies have underpinned appliance certification and have been considered as a key aspect for developments on the use of biomethane, hydrogen/natural gas blends and in recent times the specification for hydrogen in pipelines.

Burners can be adapted to many different fuels, but for safe and efficient use they are often constrained by interchangeability limits and this gives rise to a working range of Wobbe Index.

For the lower Wobbe Index limit, the operability characterisation is often associated with flame lift, as this can lead to flame blow-off and the flame instabilities can give rise to increased emissions, but the original gas interchangeability studies noted that the lower Wobbe Index proposed was more closely linked to heat service and perceived reduction in heat output and change to cooking times. These aspects are mostly anecdotal, and modern appliances will not be adversely impacted.

The following sub-sections consider the combustion aspects of operation on lower Wobbe Index gas, the impact on the interchangeability diagrams and range of acceptable gas qualities and the impact on Wobbe Index limits invoked in emergency situations that might result from supply security considerations.

6.1.1 Combustion tests

Combustion tests underpin the knowledge of gas appliance operation and are primary requirements from the viewpoint of end-user safety. There is substantial knowledge on the impact of gas quality and a summary of some of the relevant studies are described below:

- Certification

  Appliances in Ireland will have been installed almost entirely after the introduction of the EU gas appliance directive (GAD), and as a consequence meet the compliance and safety requirements for certification to ensure that CE marking is appropriate. In April 2018, the GAD was withdrawn and replaced by the Gas Appliance Regulation (GAR) (EU 2016/426) for appliances burning gaseous fuels, but the test regime to ensure compliance is still the same, with specific EU standards developed and applied for all domestic appliances and

[11] Note: some of the data included tests using hydrogen blends. The current changes to GS(M)R do not include changes to the hydrogen limit, but hydrogen blend data does provide information on the use of lower Wobbe Index gas and assists in the discussion of impacts.

many industrial and commercial ones too. Having common test requirements also ensured that an adopted gas quality range was agreed, and appliances compliant with GAD are certified against the H-gas gas quality range going from 45.7 to 54.7 MJ/m^3. Full details of the test gas compositions are quoted in EN 437.

As all the domestic (and many commercial) appliances have been certified to comply with standards and as such will be able to operate on the proposed new GS(M)(S)R lower Wobbe Index limit of 46.5 MJ/m^3.

- UK government (DTI) test programme (2004 and 2006 – two projects)

  The pilot study [12]was undertaken to provide preliminary data on the dependence of the operation of a small number of selected domestic appliances to changes in Wobbe Index.

  The study comprised a number of individual tests on five gas appliances, two new appliances (condensing boiler and cooker) and three used ones (instantaneous water heater, gas fire and a standard boiler). Twenty one gas compositions were used covering a Wobbe Index range from 46 to 56 MJ/m^3.

  The work investigated the impact on appliance performance and operability when using each test gas and included ignition behaviour, emissions (CO, CO_2, NOx, soot), flue gas temperature, appliance surface temperatures and heat efficiency.

  From the point of view of end user safety, there was a significant focus on the impact on CO emissions. The trend in CO emissions for the standard boiler with variation in Wobbe Index of the fuel is shown in Figure 6-1.

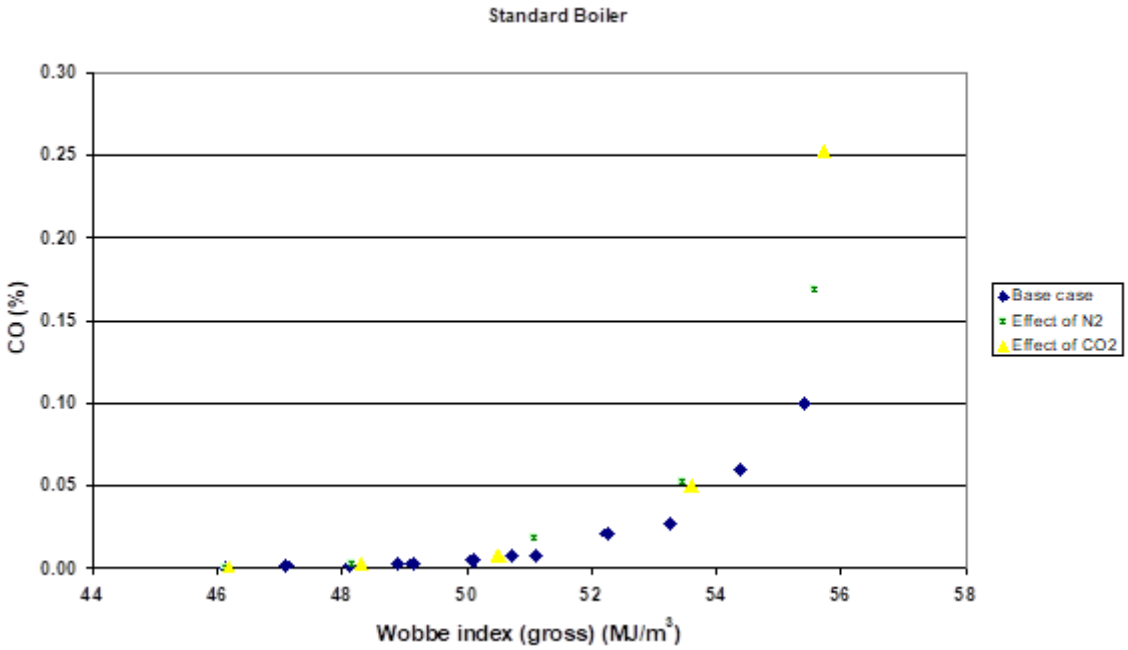

Figure 6-1: Variation in CO emission with Wobbe Index (standard boiler)

A similar trend was observed for the CO emissions from a more modern condensing combi boiler and these are shown in Figure 6-2.

[12] For access to the DTI gas quality studies – use website: https://webarchive.nationalarchives.gov.uk/20070101093922/http://www.dti.gov.uk/energy/markets/gas-quality/index.html

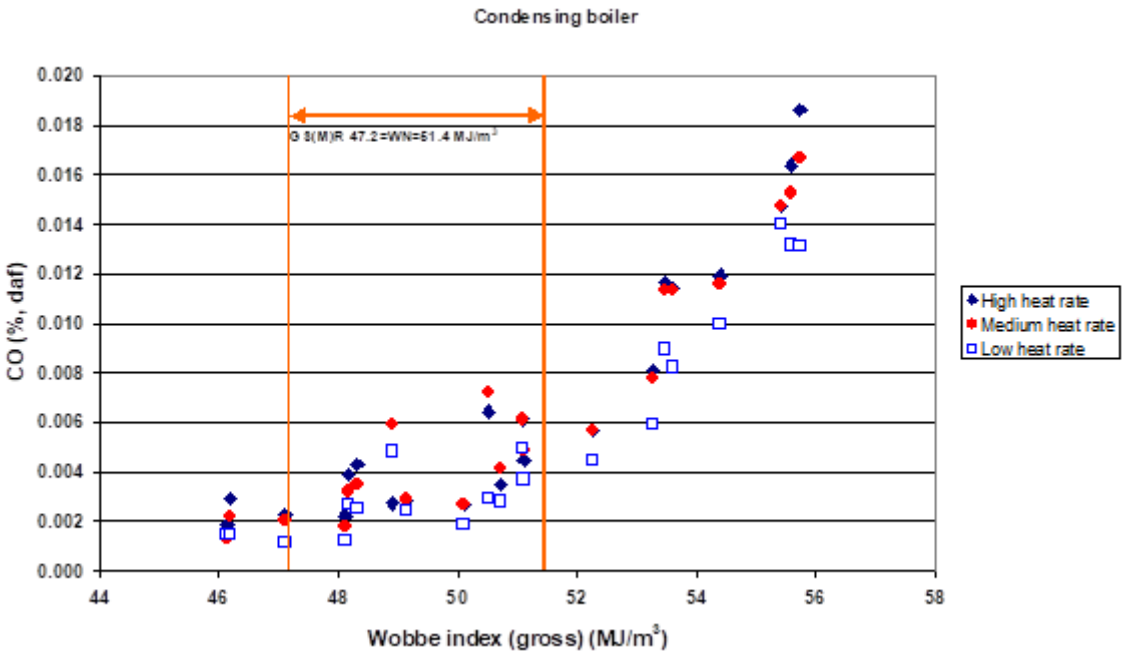

Figure 6-2: Variation in CO emission with Wobbe Index (Condensing combi boiler)

Following the conclusion of the pilot study, a more extensive project was initiated to investigate the impacts on a wider range of appliances, consider the impact of appliance maintenance and servicing, and evaluate the impacts of nitrogen ballasting (often used when importing LNG). Data for a condensing boiler are shown in Figure 6-3.

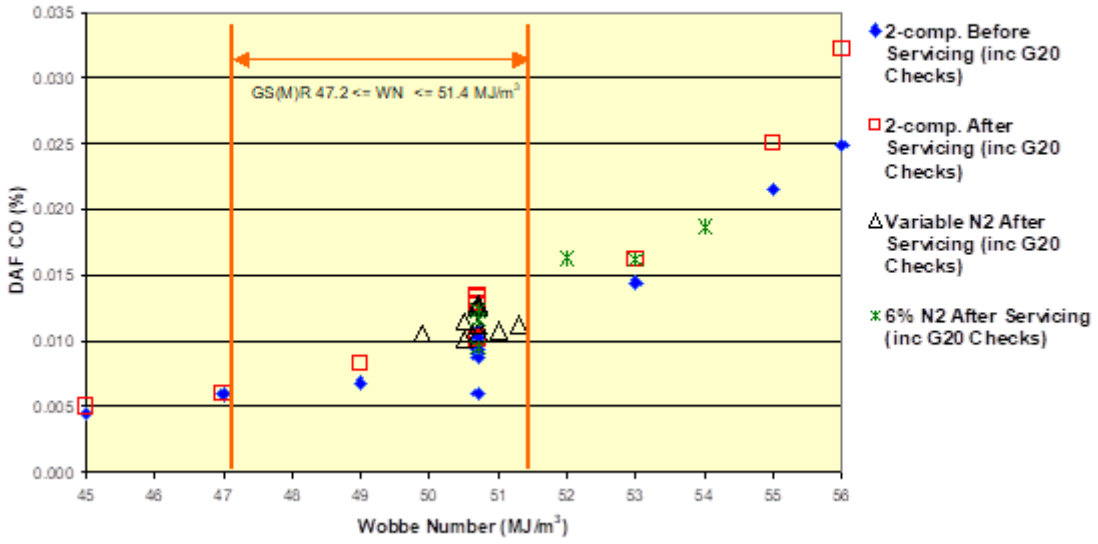

Figure 6-3: Variation in CO emission with Wobbe Index (Condensing boiler)

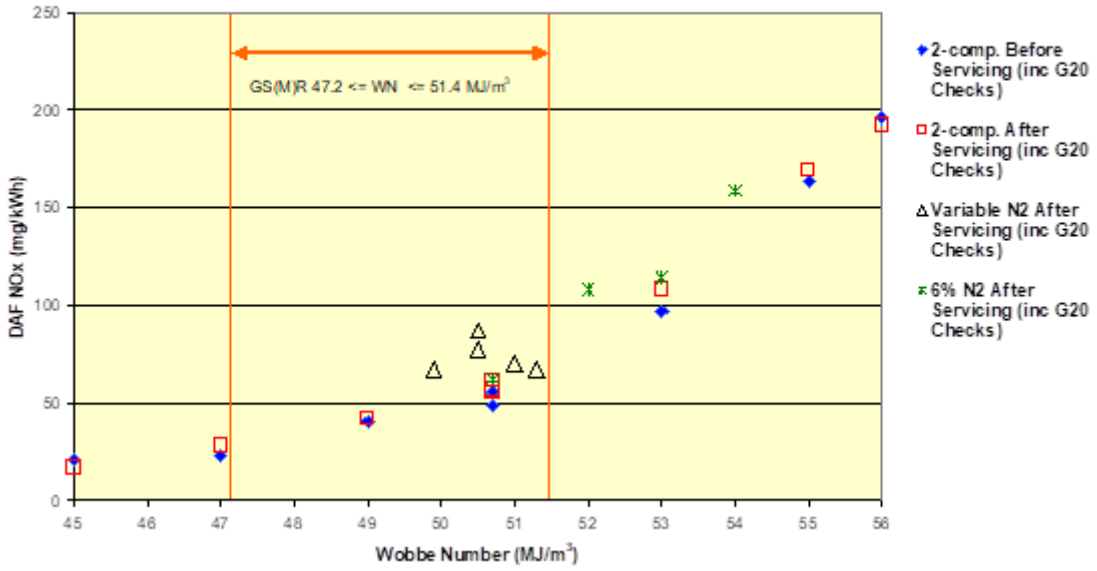

Figure 6-4: **Variation in NOx emission with Wobbe Index (Condensing boiler)**

In addition to the impact on CO emission, changes to NOx emission with change in Wobbe Index were also investigated and, in many cases, NOx emissions reduced with Wobbe Index as shown in Figure 6-4.

The studies concluded that: ***"The use of 45 and 47 MJ/m^3 Wobbe Index gas in the majority of cases did not result in any significant impact on emissions and efficiency. There may be scope for lowering the current limit of 47.2 MJ/m^3 Wobbe Index gas."***

- GasQual

  GASQUAL was an EU-funded project set up to address Mandate M 400, to evaluate the impact of H gas quality variations on the behaviour of GAD compliant appliances in terms of safety, emissions and efficiency.

  The main objectives included:

  - Collate information on EU GAD (now GAR) appliance market
  - Evaluate impact of gas quality variation on safe operation, efficiency and pollutant emissions of GAD compliant appliances
  - Assess trends in performance and characterise results to establish a "safe" operating range

  The overall programme involved many European companies and was led by the Danish Gas Technology Centre. Several separate Work Packages were set up to address topics relating to appliance populations, appliance characterisation, standards and test methods, and practical tests on over 100 appliances in five leading test facilities.

  At this time, the EU population of domestic appliances was assessed to be about 167 million, and the overall population was sub-divided into 29 "segments" according to the appliance type (product standards), burner technology, and other characteristics.

The test programme was designed to evaluate the magnitude of gas quality variations within the H-gas Wobbe Index range that was acceptable for each appliance tested without significant modification of its operability in term of safety, emissions, efficiency and reliability. The test programme included a procedure to simulate field adjustment on gases slightly outside the current range of H gases distributed in EU. The project involved 16 Companies/Organisations (from 9 Countries around EU), and 5 independent laboratories were involved in the appliance test work.

An overview of the project is shown in Figure 6-5:

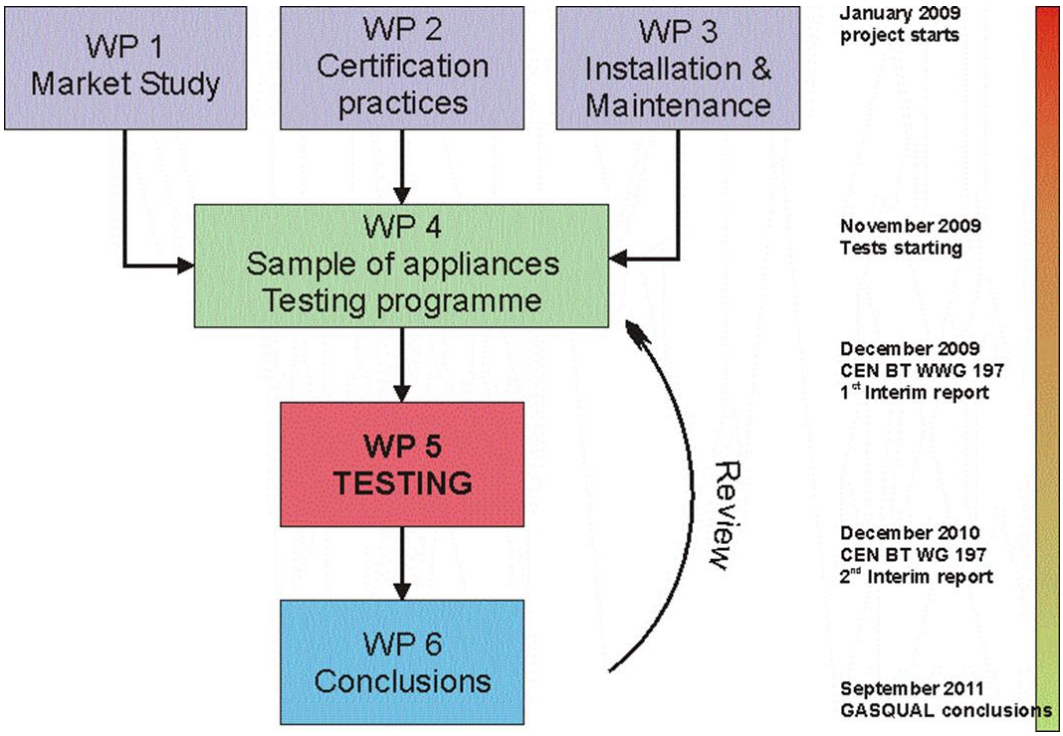

Figure 6-5: Overview of the GASQUAL project plan

The appliances categorised into 29 separate "segments" with the different certification standards used for the appliances. The test gas range is shown in Figure 6-6 with Wobbe Index lower limit values of 45.7 MJ/m^3 and also RD to just over 0.7.

The results obtained when observing the impacts of changing gas quality on the behaviour of an appliance were classified into several categories:

- Impact on CO emissions (as the primary hazard generated through gas combustion)
- Impact on NOx and soot (linked to local air quality and indoor air quality)
- Impact on safety devices (in case the appliance operation is compromised)
- Impact on operability (linked to reliability, operational trips and appliance operational behaviour)
- Impact on efficiency (to ensure that the appliance still maintained the high efficiency levels expected from a gas appliance)

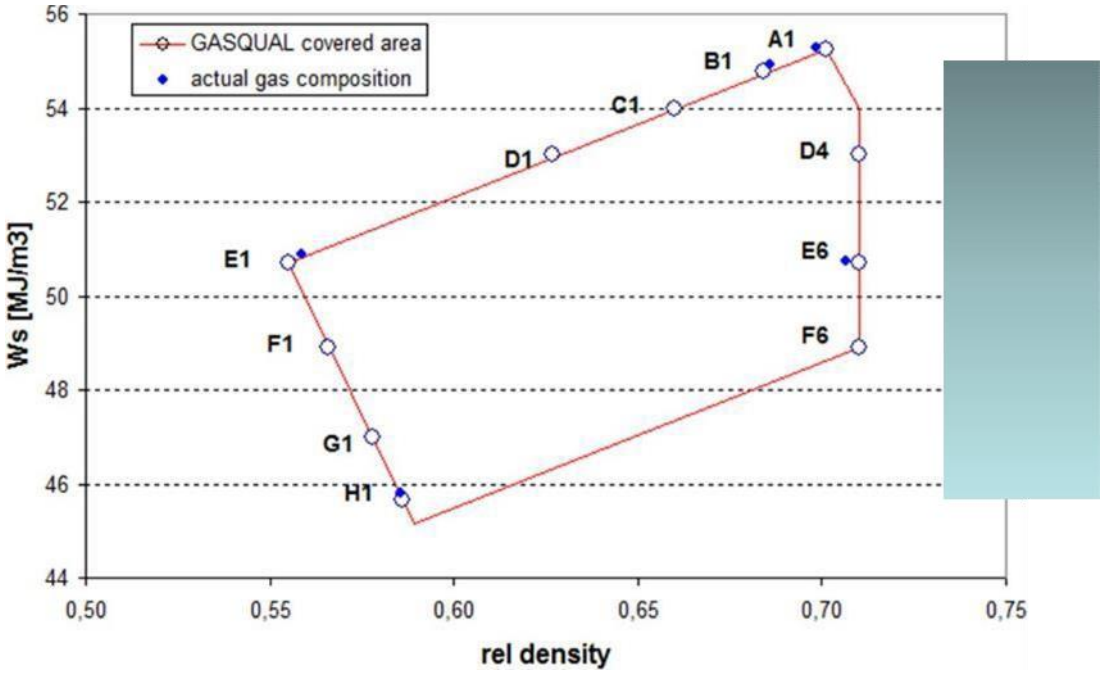

Figure 6-6: GASQUAL test gas envelope

The experimental results were analysed focusing on the CO emission concentration, evaluating the change in absolute CO emission as a function of the change in Wobbe Index from the G20 reference gas performance, and also the rate of change in emissions.

From the viewpoint of lower Wobbe Index values, no significant barriers were found to use on all unadjusted appliances.

- Oban (SGN's "Opening up the Gas Market" study

  SGN undertook a study to support development of options for the Scottish Independent Undertakings (SIUs) following the closure of Glenmavis peak shaver. Although this project primarily focused on the higher Wobbe Index limit in GS(M)R, SGN undertook a substantial number of appliance tests with gas both above and below the existing GS(M)R limits.'

  A two-pronged approach was taken, firstly looking at laboratory-based appliance tests with a range of Wobbe Index gases, and also from installed appliance checks that involved testing of the appliances in the homes of most Oban residents with the H-gas reference and limit gases – G20, G21 and G23 (from a bottle truck).

  The data produced from the installed appliance measurements constitutes one of the most extensive gas quality impact data sets from any study around Europe.

  As with most of the previously mentioned gas quality studies, the key measurements were on CO emissions, together with NOx emissions and appliance operability.

  Tests on over 2000 installed appliances were made together with supporting laboratory studies on 18 appliances (detailed testing over a wide range and investigating emissions and operability).

  - All the practical tests highlights that the general trends of increase of CO and NOx emission with

increasing Wobbe Index (with one or two exceptions)

- Laboratory and installed appliance tests have shown that in the majority of instances the utilisation of lower Wobbe Index gas (down to the G23 value of 45.7 MJ/m^3) does not lead to significant performance changes.
- Changing the upper Wobbe Index limit to 52.85 MJ/m^3 will result in increased CO and NOx emissions compared to the current limit of 51.41 MJ/m^3 – but the changes will be modest in the majority of cases.
- If appliances have been adjusted from "factory settings" then this could give rise to more significant changes to emissions
- Appliance servicing and maintenance is recommended to ensure performance is acceptable across a wide Wobbe Index range.

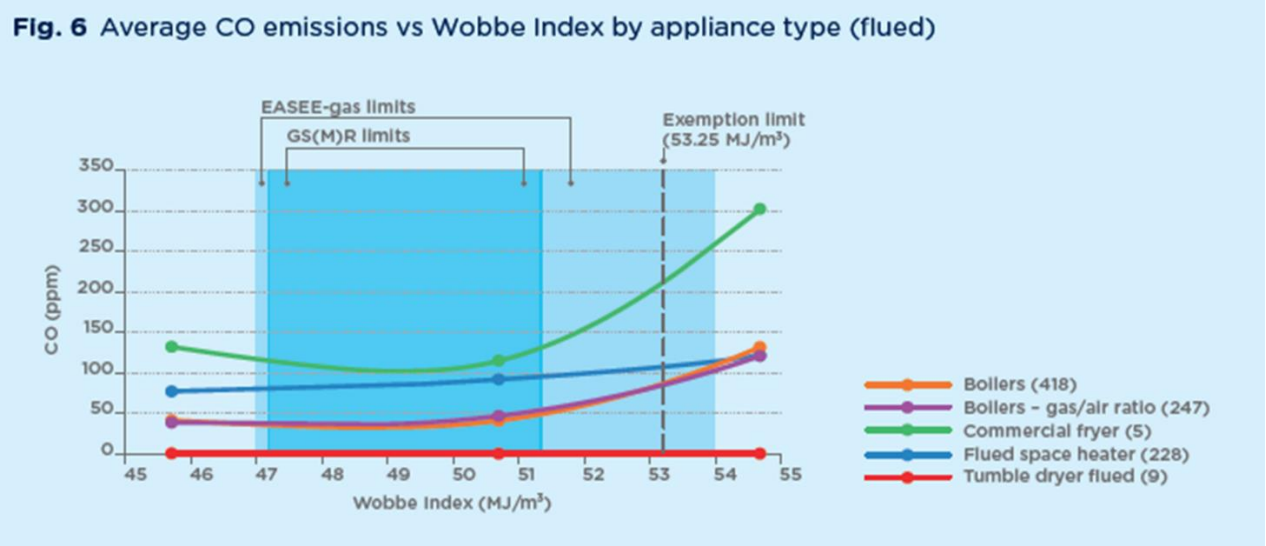

Figure 6-7: Average CO emissions vs Wobbe Index by appliance type (flued)

Figure 6-7 and Figure 6-8 show the overview results from the test programme highlighting the numbers of individual tests on appliances and the overall range of appliance types.

The general trends are clear in that CO emissions increase with Wobbe Index for nearly all flued and flueless appliances tested.

[Note although curves are drawn in the figures from the report from the study, as there is only three points per trend line, it is important to focus on the absolute values and not the shape of the curve.]

Only the commercial fryers (flued) and commercial grill (flueless) show CO emissions greater for G23 test gas than G20, and these are still significantly lower than appliance certification emission test limits. In all other cases CO emission decrease as the Wobbe Index of the fuel gas decreases.

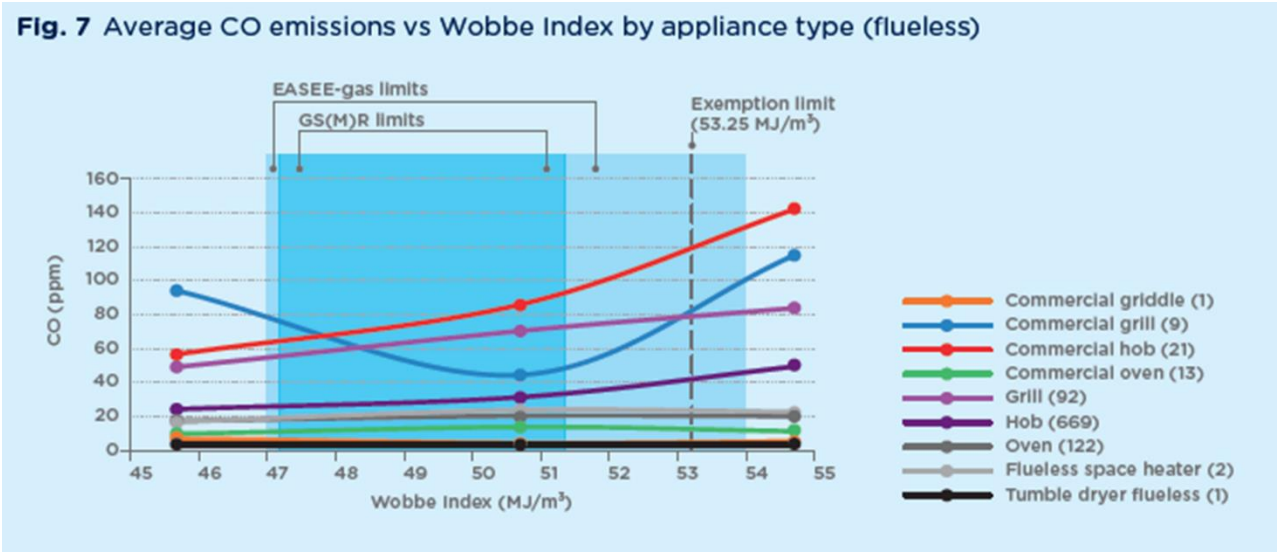

Figure 6-8: Average CO emissions vs Wobbe Index by appliance type (flueless)

The study concludes that "***This project did not find any safety issues from the testing on gases with a Wobbe Index of 45.66 MJ/m^3.***" No change in the lower WI limit was proposed at the time, although it was noted that there was scope for revision should assessment of future gas quality scenarios incorporating unconventional and renewable gases require this.

- HyDeploy

  HyDeploy[13] was an Ofgem Network Innovation Competition (NIC) project exploring the feasibility of injecting up to 20 mol% hydrogen into the public gas network[14].

  The project had three stages:

  - HyDeploy stage 1 – Closed private network, Keele University, 101 residential properties and 30 university buildings
  - HyDeploy stage 2 – Closed public network, Winlaton, Gateshead, 668 properties including a Church and a school
  - HyDeploy stage 3 – Enabling government policy, addressing remaining evidence to support the UK governments policy on blending in 2023

  HyDeploy stage 1 was the first blending project of its kind in the UK. The project involved a consortium of companies/experts to deliver the project including Northern Gas Networks , Cadent Gas, Progressive Energy, Keele University, ITM Power and The Health and Safety Executive – Science Division.

  Stage 1 of the project was split across three phases:

  - Phase 1 – Evidence gathering and Customer engagement;
  - Phase 2 – Installation of Compound and Network Equipment
  - Phase 3 – The Hydrogen Blend Trial

[13] Gas NIC submission: National Grid Gas Distribution - HyDeploy | Ofgem

[14] HyDeploy, Demonstrating non-disruptive carbon savings through hydrogen blending, August 2021 https://hydeploy.co.uk/app/uploads/2018/02/21063_HyDeploy_Carbon_Savings_Report1_DIGITAL.pdf

The aim of Phase 1 was to generate all the evidence required to support a positive decision from the Health and Safety Executive to allow blending to commence. The evidence generated spanned across the following areas; appliances; gas characteristic; gas detection; and materials/assets. Key results of the findings from this research are outlined below.

Appliances: The laboratory appliance testing had two overarching objectives: 1. Understand the performance implications of introducing a hydrogen blend, across a wide range of appliances. 2. Understand the limit of operability for a select number of appliances with regards to hydrogen content within the fuel. The work stream consisted of selecting a broad range of domestic gas appliances, including gas cookers, fires and boilers. Each appliance was fed with 13 test gases at a constant test pressure, each designed to promote a different response or flame characteristic.

Gas characteristics: The gas characteristics of natural gas containing up to 20 mol% hydrogen, in comparison to natural gas, was an important area of understanding to underpin the quantitative risk assessment and support appropriate supplementary guidance for operational procedures to be developed, where needed. The focus of the gas characteristics workstream was to understand the pertinent safety related characteristics of the gas relative to natural gas, including: 1. Dispersion characteristics in the event of a leak; 2. Flammability characteristics; 3. Combustion characteristics in the event of ignition.

Materials and assets: The interaction of hydrogen with materials is an important area which must be understood when evaluating hydrogen blending. The initial stage in this workstream was to develop a comprehensive asset register of the Keele University gas network to evaluate the spectrum of materials for laboratory testing. Then a process of testing was undertaken to understand any material effects and implications for operational procedures.

Gas detection: Accurate gas detection is a fundamental requirement for the safe operation of a gas distribution network. An experimental programme was therefore undertaken to test commonly used gas detectors, including domestic detectors, at hydrogen blends of varying concentrations and map the output responses of the instruments.

Quantitative risk assessment: To allow a discrete comparison of risk between natural gas and a hydrogen blend to be computed, a Quantitative Risk Assessment (QRA) was developed. The QRA enabled the causal relationships to be understood between public risk and the characteristics of a gas conveyed within a gas network, both in relation to the network itself and downstream usage within buildings. Risk was defined as the risk to life due to exposure to carbon monoxide (CO) or as a consequence of fires/explosions.

Customer engagement: involving communication and interaction with customers to support them during the project, address concerns and highlight the benefits of the overall project.

Metering and billing: Extensive engagement with Ofgem and Keele University enabled a project-specific gas billing mechanism to be utilised for the trial, the principles of which were to assume gas qualities in favour of the consumer throughout the trial and to ensure no consumer paid for the hydrogen received through the blend supplied.

GS(M)R exemption: The Exemption application was submitted on 25th June 2018. This was followed by a process of detailed challenge and review with over 140 clarification questions which were addressed by the project team. A final determination was made on 1st November 2018, granting an Exemption to operate the trial at 20 mol% blend on the Keele network.

In Phase 2, the practical aspects of equipment design, build and installation was undertaken to ensure that the network was ready for the hydrogen blend trial. Additional network monitoring equipment was installed and a Boiler Research Facility was created/: One of the larger boiler houses at Keele was adjacent to both the

blended hydrogen network as well as one of the other natural gas networks which had no hydrogen injected into it. This provided an opportunity to install a bank of boilers, with two from each of the leading boiler manufacturers, one operating on the blend and the other on natural gas. An intensive operational regime was defined, with some boilers operating continuously at maximum load, some at minimum load and others cycling between the two.

In Phase 3, the Hydrogen blend trial was successfully delivered on its objective demonstrating the technical and operational feasibility of distributing and using hydrogen blends. Over the course of the trial 42,000 scm of hydrogen were delivered to the Keele University network, which abated over 27 tonnes of CO_2. A controlled process was undertaken to cease blending operations.

The trial at Keele was then extended to a second demonstration at NGN's Winlaton network. Here, the blend was distributed to the wider general public and the overall project was successful. This highlighted that domestic and small commercial appliances could operate safely with a blend that has a lower Wobbe Index and calorific value than the underlying natural gas.

- THyGa

The Testing Hydrogen Admixtures for Gas Appliances (THyGa) project[15] aimed to develop and present a detailed understanding of the impact of different blends of natural gas and hydrogen on end-use applications in the domestic and commercial sector. It was delivered by organisations from across Europe, funded through the European Commission Horizon 2020 programme.

The objectives of the THyGA project are to:

- Evaluate the portfolio of technologies in the domestic and commercial sectors and assess the theoretical impact of hydrogen / natural gas admixture in order to determine a quantitative segmentation of the gas appliance market
- Test up to 100 existing residential and commercial gas appliances in 40 different segments (hobs, boilers, micro-CHP, heat pumps, etc.), which will give information on how European gas appliances will react to various H_2 concentrations
- Benchmark and develop pre-certification protocols for different levels of H_2 in natural gas for integration in existing standards; these protocols will be validated through tests
- Provide recommendations for manufacturers, decision-makers and end-users along the gas value chain to enable mitigation strategies for retrofit.

The project has:

- Established the maximum concentration hydrogen admixture that can be implemented in the domestic and commercial sector without changing the existing certification of appliances
- Established that the existing certification shall be updated to allow higher concentrations, including the related additional costs and the required changes to common gas burners
- Improved knowledge on the effect of hydrogen and natural gas on common burner types including necessary adjustments and design changes.

The THyGa project, like the HyDeploy project, has shown that hydrogen blends can be safely and efficiently used in many gas appliances, highlighting that lower Wobbe Index and Calorific Value gas can be accommodated within gas appliances that comply with the Gas Appliance Regulations.

[15] For more detail on the THyGa project see website: https://thyga-project.eu/

- Neptune

  As part of the IGEM studies to support updating the gas quality standards and regulations, Neptune Energy supported practical test work and stakeholder engagement to understand the potential impact if appliances operated on lower Wobbe Index gas.

  Tests were performed on six typical appliances using both G20 and G23 certification gases, with G20 being the reference gas and G23 the flame lift limit gas, operating at full rate and a lower “turndown” rate.

  No problems related to emissions, ignition, flame stability or flame lift were observed for the appliances tested. The appliances operated satisfactorily during all tests, although it was evident that they were sensitive to the change in heat content (CV) of the low Wobbe Index gas.

  The summarised test results are shown in Table 6-1.

  The measured combustion efficiencies are similar for both G23 and G20, although the values are slightly lower for some appliances.

  No problems related to emissions, ignition, flame stability or flame lift were observed and the appliance operated satisfactorily during all tests.

  For appliances fitted with flame supervision devices (FSD), the operation time was not significantly different for G23 than for G20, and in all tests complied with the appliance certification test requirement.

  For the gas fires, the atmospheric sensing device (ASD) shuts down at a lower CO% with the Low Wobbe Index gas compared to that obtained with the G20 reference gas (CO measured at shut-down 28 ppm and 47 ppm respectively). The measured CO emissions were comfortably less than the limits specified in the appliance standards (200 ppm at shut-down) for all gases.

  For the vitiation test on the flueless gas fire, the measured CO_2 is lower with the low Wobbe Index gas (G23) compared to that obtained with the G20 reference gas.

  For the gas fires, in order produce a decorative “flame effect”, the nature of the combustion is such that the flames are slightly yellowish even on ”normal” gas. The use of the Low Wobbe Index gas produced a slightly less yellow (shorter) flame.

  A stakeholder engagement exercise with HHIC and ICOM members was organised, to discuss the data and gain feedback. The overall conclusion from the discussion at the meeting supports the view that the lower Wobbe Index gas will be acceptable from a safety viewpoint .

	Fire		Flueless fire		Boiler (1)		Boiler (2)	
	G20	G23	G20	G23	G20	G23	G20	G23
Max rate								
CO %DAF	0.0202	0.0157	0	0	0.0103	0.0063	0.0101	0.0033
NOx (ppm)	7.8	3.1	27.1	23.3	16	6.2	14.1	5.2
Turndown rate								
CO %DAF	0.0161	0.0123	0.0007	0	0.0036	0.0068	0.0001	0.0002
NOx (ppm)	6.1	1.7	11.4	9.9	4.3	3.6	9.6	4
	Cooker (1)							
	Large hob burner		Small hob burner		Grill		Oven	
	G20	G23	G20	G23	G20	G23	G20	G23
Max rate								
CO %DAF	0.039	0.013	0.0028	0.002	0.0076	0.026	0.0149	0.0046
NOx (ppm)	23.2	20	10	9.8	20.5	4.3	9.8	13.7
Turndown rate								
CO %DAF	0.0095	0.0114	0.0089	0.0047	N/A	N/A	N/A	N/A
NOx (ppm)	9.6	7.3	8.6	6.4	N/A	N/A	N/A	N/A
	Cooker (2)							
	Large hob burner		Small hob burner		Grill		Oven	
	G20	G23	G20	G23	G20	G23	G20	G23
Max rate								
CO %DAF	0.0437	0.0161	0.0055	0.0027	0.0313	0.0278	0.0043	0.0019
NOx (ppm)	21.3	29	9.2	14.8	7.1	6.3	16.1	28.8
Turndown rate								
CO %DAF	0.038	0.0237	0.0275	0.0413	0.041	0.0612	0.041	0.0181
NOx (ppm)	5.9	7.3	6	5.1	6	5.3	4.7	6

Table 6-1: Summary data from combustion tests on six typical appliances – focusing on impact of lower Wobbe Index gas

In summary, this study found that operation of the appliances on gas with a Wobbe Index of 45.7 MJ/m^3 was safe and acceptable.

- Overview summary of combustion testing using lower Wobbe Index gas

  From the initial work by Dutton and the development of the GS(M)R, it was recognised that the so-called "flame lift" limit was more a "heat service" limit, and that the initial test work demonstrated that gases with slightly lower Wobbe Index than the 47.2 MJ/m^3 limit would be acceptable. It was suggested that gases up to a lift index of 1.38, corresponding to test gas G23 (45.7 MJ/m^3), may be permitted.

  Since 2004, there have been several laboratory studies and reviews on impacts of wider gas quality ranges, including projects for both the UK and EU governments. The over-riding outcome is that use of gases with Wobbe Index down to the G23 value of 45.7 MJ/m^3 does not lead to significant performance changes.

  The SGN Oban study (Opening up the Gas Market and the supporting studies in the SIUs) took the tests one stage further and tested installed appliances in properties (homes and small commercial properties) using a mobile "bottle truck". The tests used the reference and limit gases (G20, G21 and G23) and these installed appliance tests have shown that in the majority of instances the utilisation of lower Wobbe Index gas is acceptable.

  Lower Wobbe Index gas is used in some parts of Europe (in appliances similar to those used in the UK and certified using the EN 437 test gases), in particular the Netherlands, Germany and Poland, and there are no reported difficulties operating on the Lower Wobbe Index, H-group gas.

  Overall low Wobbe Index gas, with a Wobbe Index of 45.7 MJ/m^3, has been shown to operate safely on a wide range of domestic and commercial appliances. Therefore, the proposed new limit of 46.5 MJ/m^3 will result in no decrease in safety and could be used by appliances and equipment without adverse impact.

6.2 Additional aspects to consider on gas quality impacts on installed equipment.

In previous sections the impact on regulations and outcomes from previous studies have been provided. In this section two additional aspects relating to impacts on installed equipment are considered.

6.2.1 Compliance with Gas Appliance Regulations (formerly Gas Appliance Directive)

The legal framework for the placing on the market and putting into service of gas appliances and their fittings is Regulation (EU) 2016/426EN on appliances burning gaseous fuels (GAR)[16]. It became fully applicable as of 21 April 2018, replacing the previous Directive 2009/142/EC.

The scope of the GAR is restricted to appliances burning gaseous fuels used for cooking, heating, hot water production, refrigeration and washing. Regulating, controlling and safety devices and sub-assemblies intended to be incorporated into appliances or assembled to constitute appliances – so-called fittings – are also covered.

Appliances specifically designed for use in industrial processes carried out on industrial premises, as well as for research purposes for temporary use in laboratories are excluded.

Appliances installed in RoI (primarily domestic but also some commercial types) will meet the requirements of GAR and have been type tested using test gases detailed in EN 437 covering the Wobbe Index range from 45.7 to 54 MJ/m^3.

[16] For more details on the scope of the GAR and the details therein see: https://single-market-economy.ec.europa.eu/sectors/pressure-equipment-and-gas-appliances/gas-appliances-sector/gas-appliances-regulation_en

This indicates that appliances installed will be able to use gases that meet the GS(M)(A)R specification and should operate safely and efficiently.

6.2.2 Impact of in-service combustion control adjustment (factory settings)

In some instances, burner control valves are adjusted at the time of installation or servicing. This is unlikely for domestic appliances where factory settings are recommended with a central setting on G20 enabling operation of the appliances across the full Wobbe Index range. However, for some large commercial and industrial applications setting of the controls is common to optimise the process. This means that the gas quality on the day of adjustment will influence the operability of the combustion equipment and could impact on efficient combustion. As these types of equipment are likely to be industrial applications (including power generation) there is a high likelihood that regular checks on the control equipment will be made and correction of any misaligned setpoints. However, it is recommended that GNI engages with industrial consumers to highlight the potential impacts, and also raise awareness of the accessible gas quality data on GNI's website.

6.3 Replacing the ICF and SI limits with a RD limit

It is recognised that the Wobbe Index is the primary gas interchangeability parameter, as it relates to the heat flux to an appliance based on flow through a burner nozzle. However, the wide variation in chemical composition of natural gas means that higher hydrocarbon species may be present in significant concentrations and these may give rise to elevated CO emissions or produce soot in some burner types in a few appliances. The Dutton (GB) interchangeability approach introduced Incomplete Combustion Factor (ICF) and Sooting Index (SI) limits to provide additional interchangeability parameters primarily related to the higher hydrocarbon content.

In Europe, the ICF and SI limits have not been used, and RD has been adopted by many member states. Marcogaz has proposed the use of RD and it has been used in gas quality specifications in France, Spain and Germany, and it is also detailed within the European gas quality standard (EN 16726).

As part of the HSE review of gas quality regulations, they have determined that RD is appropriate to introduce into the UK specification to replace ICF and SI as it does provide control of the higher hydrocarbon content and also provides consistency with European approaches to interchangeability. The RD limit is also support through hydrocarbon dewpoint limits and provides a measurable quantity to establish the overall interchangeability diagram. The graphical representation of the change was shown in Figure 5-2, and is a simplified diagram to the original Dutton approach.

The HSE concluded that the RD limit provides a reasonable alternative approach for controlling the higher hydrocarbon content of gas and does not appear to have any significant adverse safety implications.

6.4 Consideration of the Emergency Limits

The development of the GS(M)(A)R has not changed the status or designation of the gas supply emergency limits. The upper emergency limit remains the same, with a Wobbe Index of 52.85 MJ/m^3, but the lower emergency limit is actually the same as the "new" lower Wobbe Index limit.

The HSE believes that the new lower limit of 46.5 MJ/m^3 and the fact that this is the same as the emergency limit is not an issue, but want to have both ,limits stated to avoid confusion.

The likelihood that gas will be conveyed outside of these limits is extremely unlikely, and if gas outside of the limits, then a gas supply emergency will be put in place in both the UK and in RoI. With gas for RoI predominantly originating from St Fergus, it is unlikely that gas will be outside of the typical Wobbe Index range.

As the emergency limits have not changed, the actions required by GNI do not need to be adjusted. The acceptance of the new lower Wobbe Index limit of 46.5 MJ/m^3 has been investigated and the HSE have determined that this is safe to use. There is thus no requirement to change the GNI approach for declaration of gas supply emergency based on the gas quality of the supplied gas.

7 ASSESSMENT OF IMPACTS OF GS(M)R CHANGES ON GNI GAS OPERATIONS

The following table provides an overview.

Technical area	Description of amendment	Discussion on potential impact	Rating
Wobbe Index limits	Lower Wobbe index limit for gas permitted in gas networks in Great Britain will change to ≥46.5MJ/m^3 on 6 April 2025 These gases will flow through the interconnector and supply Ireland.	The proposed new lower Wobbe Index limit will enable a wider range of gas qualities to be present but the change is relatively small and may lead to slight increases in the inert gas content. For GNI with GCV limit ranges the impact of any Wobbe Index limit will be mitigated and it is not anticipated that the new lower Wobbe Index limit will affect end users. The changes will impact on the upper limit as a consequence of the removal of the ICF limit. It is not anticipated that the new limits will impact on the in-line gas analysis by gas chromatographs, but this should be reviewed. The new Lower Wobbe Number limit will need inputting into all SCADA and control systems to avoid system alarms. This factor changes the status from Green to Amber, but there is time to address the impacts as the change is from April 2025.	
Oxygen content of distributed gas	Gas that is permitted in gas networks in Great Britain may have an oxygen content of ≤1% (molar) so long as it is conveyed at pressures ≤38 barg. The permitted oxygen content for gases conveyed at pressures above 38 barg will remain ≤0.2% (molar) This approach matches the existing gas quality limits for GNI for gas in Ireland.	This change to 1 mol% has no impact on GNI Gas Quality operations. The gas from the NTS will still contain low oxygen concentrations, and the expectation is that the higher values will arise from biomethane sources, most of which will be connected into distribution pipeline networks.	
Gas interchangeability parameters	Gas that is permitted in gas networks in Great Britain must have a relative density of ≤0.700. The incomplete combustion factor and sooting index values are no longer required in order to comply with Schedule 3. The changes to the interchangeability parameters and the overall description of the acceptable range will require consideration.	This change does not directly impact on gas quality composition ranges but is associated with reporting. RD is used widely in Europe and although there is no direct impact, there will be some requirement for GNI to consider the required changes for SCADA and data logging/control systems in the future.	
LNG import	Liquified natural gas import facilities will be subject to the co-operation requirements set down by the regulations	This change is not expected to impact on GNI Gas Quality operations.	
Gas emergency telephone service	The gas emergency telephone service is now known as the Emergency Reporting Service. The function of the service is remaining the same however no gas network may operate without an Emergency Reporting Service Provider in place and a new schedule has been created outlining the particulars to be included in the safety case of the Emergency Reporting Service Provider.	This change is not expected to impact on GNI Gas Quality operations.	

Technical area	Description of amendment	Discussion on potential impact	Rating
Biomethane pipeline	Pipelines conveying biomethane must be operated with a safety case – this will come into force 6 April 2023. However, duty-holders will have until 6 October 2024 to prepare and submit a safety case to the HSE if they are not already operating with one. Biomethane can continue to be conveyed to treatment or blending points if the gas requires them in order to bring it into conformity with Schedule 3 gas quality specifications	As GNI already manages biomethane connections, it is suggested that this amendment is targeting separate, stand-alone biomethane pipelines to align the procedures with Gas Network safety cases. This change is not expected to impact on GNI Gas Quality operations.	

8 OVERALL SUMMARY ON IMPACTS OF GS(M)R CHANGES ON GNI GAS OPERATIONS AND RECOMMENDED ACTIONS

As an overarching conclusion, the introduction of the updated gas quality regulations through the Gas Safety (Management) (Amendment) Regulations 2023 should not impact on the acceptable gas quality ranges or gas quality operations, but some data logging and SCADA systems may need to be modified to avoid operational issues.

For GNI, the introduction of a new lower Wobbe Index will not compromise the GCV limit, in fact the GCV limit will constrain the acceptable Wobbe Index and provide an additional layer of control on introduction of new gas supplies. The dual-action of the Wobbe Index limits and GCV range in the specification provides effective control and ensures that gas qualities received by end-uses will be safe to use.

As the emergency limits for Wobbe Index have not changed, the actions required by GNI do not need to be adjusted. The acceptance of the new lower Wobbe Index limit of 46.5 MJ/m^3 has been investigated and the HSE have determined that this is safe to use. There is thus no requirement to change the GNI approach for declaration of gas supply emergency based on the gas quality of the supplied gas.

For end-users, as domestic and most commercial appliances confirm to the EU Gas Appliance Regulations (GAR), they should be able to operate safely and effectively on the acceptable Wobbe Index range detailed in GS(M)(A)R, assuming that appliances are at factory settings and have not been adjusted during installation or servicing.

Some larger industrial equipment (including power generation) may need to readjust control settings to optimise their equipment and GNI should engage with industrial users to highlight that some intervention may be required, and also to raise awareness of gas quality information that is available on their website.

8.1 Recommended future actions.

To ensure that all aspects of GS(M)(A)R are evaluated it is recommended that:

1. Consider a future review of the gas chromatograph equipment to ensure that it will be able to analyse any change to component ranges that result from the GS(M)(A)R.
    a. The suitability for hydrogen analysis in blends could be undertaken at the same time.
2. Consider an awareness and engagement exercise to communicate with industrial and large commercial end users regarding the Wobbe Index changes that will come into force in April 2025, and also the availability of “live” gas quality information from the GNI website.
3. Further engagement with end users regarding adjustment of gas controls, especially for the domestic and commercial sectors. If any adjustments are required then the adjustment process must follow the appliance/equipment manufacturers recommendations (or guidance) and any changes to be made by a suitably qualified, competent person.

APPENDIX A
Risk Assessment

8.2 Approach

Qualitative risk analysis was carried out using bandings of consequence and frequency (Table 8-1) defined in GNI's HSQE/PR/127 – Risk Assessment Management Procedure, which combined together give a risk banding shown in Figure 8-1.

Table 8-1 Probability and consequence criteria

		Probability criteria	Consequence criteria
0	Not credible	The hazard does not exist or has been eliminated completely.	
1	Very low	Inconceivable. May never happen. Only in exceptional circumstances.	▪ Minor injury (i.e. first aid case only) to GNI staff or contractor – return to work the same day. ▪ Exposure unlikely to result in damage to health.
2	Low	Possible, but considered unlikely.	▪ Minor injury of first aid treatment case to e member of the public / staff / contractors. ▪ Chronic or acute exposure with potential to be harmful to health.
3	Medium	Possible. Circumstances can be envisaged when it could happen.	▪ Lost Time Incident (more than 3 days away from work) and/or injury requiring in patient medical treatment for GNI staff or contractor; or ▪ Injury to member of the public requiring medical attention requiring notification to the CRU and/or HSA. ▪ Chronic or acute exposure harmful to health to person(s).
4	High	Likely to happen. Quite conceivable.	▪ Single fatality or multiple serios injury to GNI staff or contractor. ▪ Serious injury to member of the public. ▪ Short term exposure harmful to health.
5	Very high	Will happen, or very likely to happen.	▪ Multiple fatalities to GNI staff or contractors. ▪ Fatality (serious/multiple) to member(s) of the public. ▪ Any exposure harmful to health.

5 Very high	5 Medium	10 Medium	15 High	20 Very high	25 Very high
4 High	4 Low	8 Medium	12 Medium	16 High	20 Very high
3 Medium	3 Low	6 Medium	9 Medium	12 Medium	15 High
2 Low	2 Very low	4 Low	6 Medium	8 Medium	10 Medium
1 Very low	1 Very low	2 Very low	3 Low	4 Low	5 Medium
	1 Very low	2 Low	3 Medium	4 High	5 Very high

Figure 8-1 Risk score matrix.

8.3 Risk assessment

<table>
<tr><td></td><td colspan="2">Form</td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2">HSQE/FM/074</td><td colspan="4">SAFETY HAZARD IDENTIFICATION AND RISK ASSESSMENT FORM</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2">Scope/Title of Assessment</td><td>Date:</td><td>Address</td><td>Author / Attendees</td><td></td><td></td></tr>
<tr><td></td><td colspan="2" rowspan="2">A broadening in Wobbe Index operating range of approximately 1.5 % on the lower limit. This proposed change will lead to a larger potential variation in hydrocarbon composition only.</td><td rowspan="4"></td><td rowspan="4">Gas Networks Ireland activities in Republic of Ireland</td><td rowspan="4"></td><td>Assessment No.</td><td>Rev.</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td rowspan="2">Job No. (If appropriate)</td><td rowspan="2">To realign the ROI gas quality specification in the Code of Operations to that of GS(M)R.
The HSE(UK) has recently approved changes to the gas quality specification in the GS(M)R. The changes relevant to the ROI gas market, include:
• Decreasing the lower Wobbe Index limit from ⩾47.2 MJ/m^3 to ⩾ 46.5 MJ/m^3
• • Replacing the Incomplete Combustion Factor (ICF) and Soot Index (SI) with a Relative Density (RD) limit ⩽0.7</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="6">Methodology: HSQE/PR/127 - Risk Assessment Management Procedure</td><td></td><td></td></tr>
<tr><td></td><td colspan="6">Comment: The UK HSE and National Grid are strongly indicating that the sales gas composition will expand in line with the above-mentioned scope with an unknown timeline for implementation as of yet. GNI will inevitably be affected by such a change and the following risk assessment is to highlight the safety concerns only with the proposed change. Operating risks will not be assessed within. It is assumed that all other operating parameters such as pressure, temperature and water dewpoint specs will not be affected as a result of this change. Only the hydrocarbon dew point may be affected.</td><td></td><td></td></tr>
</table>

Activity	Initiating Event	Hazard	Initial			Control Measures/Documents	Action	Responsible Person / Group	Residual			Target Rating		
			Probability	Consequence	Risk				Probability	Consequence	Risk	Probability	Consequence	Risk
Gas Quality-changes to Wobbe Index	Out of spec gas entering the network	Potential for gas supply interruptions at Moffat due to differences in the Wobbe Index limit	2	5	10	Realign the WOBBE and replace the ICF and SI with a relative density limit in line with the new GS(M)R specification. Continuous monitoring and alarms on GNI SCADA with call-out procedures in place. GNI to carry out gas sampling in line with current monitoring regime for entry points. Spot sampling will be carried out to verify parameters within specification. Emergency due to off-spec gas as per the NGEM procedure. Gas quality forum in place (quarterly meetings) to monitor all gas quality issues and risks raised and monitored on Pentana, where required.	Code Mod forum to accept and approve the gas quality specification changes.	Asset Operations	1	5	5	1	5	5

Gas Quality-changes to Wobbe Index	Controlling the production of excess CO and soot	Malfunction of appliances	**2**	**5**	**10**	Measurement of RD at the entry points. HSE(UK) estimate that the risk will be reduced due to lower CO from malfunctioning appliances due to lower GCV of lower Wobbe gas. Continuous monitoring and control of gas quality at entry points. Continuous remote monitoring and alarms on GNI SCADA with call-out procedures in place. Emergency NGEM procedure process due to off-spec gas.	GNI as a prudent operator is satisfied based on the HSE(UK) assessment, the work of MARCOGAZ and experience of other European countries, that it is reasonable and safe to replace the ICF and SI with a RD limit ≤0.7. GNI will measure RD instead of SI and ICF. Asset steward to check if RD is monitored at Moneynieren. Include RD calculation into SCADA at Bellenaboy.	**1**	**5**	**5**	**1**	**5**	**5**

Gas Quality- changes to Wobbe Index	Lower Wobbe Index gas caused by higher CO2 content which may impact the integrity of the system.	Higher CO2 content could cause corrosion of pipelines.	**2**	**5**	**10**	Water content is restricted by Vermillion at their entry point to less than -10 degrees C dewpoint (50mg/m3) which ensures the gas is dry and prevents any increase in material corrosion. CO2 limit remains unchanged- the same control remains in place. Continuous monitoring and alarms on GNI SCADA for Bellenaboy entry point with call-out procedures in place. Two moisture analysers installed at Moneyneiren and alarmed back to SCADA. GNI carry out gas sampling in line with current monitoring regime for entry points. Spot sampling will be carried out to verify parameters within specification. Emergency due to off-spec gas as per the NGEM procedure.	As an additional control measure, GNI plan to install moisture analyser at Beattock as per PC5 submission.		**1**	**5**	**5**	**1**	**5**	**5**

Gas Quality-changes to Wobbe Index	GNI boilers/waterbaths and compressors may not function correctly with the lower Wobbe Index gas	Loss of gas supply	**2**	**5**	**10**	Operational maintenance to continue as per OEM guidance. GNI will implement any new guidance issued by OEMs as a result of this change	GNI to review EffecTech ISO 10725 annual GC calibration checks. Boiler/Water-baths: Asset Steward and Asset Manager need to consult with OEMs and update internal procedures/work instructions as required. Compressors: Asset Steward and Asset Manager need to consult with OEMs and update internal procedures/work instructions as required. Toolbox talks for asset operations personnel for familiarisation with gas quality changes and possible impacts on assets	Asset Operations Asset Management	**1**	**5**	**5**	**1**	**5**	**5**

Gas Quality-changes to Wobbe Index	Domestic appliances not being able to function correctly	Ability of gas applications to safely burn gas at the lower Wobbe Index limit, and the applicability of the HSE(UK) safety analysis to the ROI market.	**2**	**5**	10	Gas appliances manufacturers and distributors in ROI are certified to the same requirements as GB in line with the European Gas Appliance Regulations and the technical standard EN437 Appliances should only be adjusted in the field according to the manufacturer's instructions and guidance. Studies carried out by HSE(UK) demonstrated the ability of end-user appliances to safely burn low WOBBE gas. e.g. OBAN Study, the Neptune study,	GNI to continue to raise awareness of the issue within the industry e.g. Code Mod Forum, EAI, NSAI TC1, TC2, TC11.		**1**	**5**	5	**1**	**5**	5
Gas Quality-changes to Wobbe Index	Large I/C gas applications impacted by the lower Wobbe Index	Ability of gas applications to safely burn gas at the lower Wobbe Index limit, and the applicability of the HSE(UK) safety analysis to the ROI market. End user process may be impacted by the change in gas quality.	**2**	**5**	10	Gas appliances manufacturers and distributors in ROI are certified to the same requirements as GB in line with the European Gas Appliance Regulations and the technical standard EN437 for smaller I/C applications. Large I/C customers need to follow OEM recommendations and other industry standards in this area when operating and maintaining appliances and implement any new guidance issued by OEM.	GNI and shippers to raise awareness within the industry e.g. through the Code Mod Forum and RGI	GNI Shippers	**1**	**5**	5	**1**	**5**	5

Gas Quality-changes to Wobbe Index	Lower Wobbe Index gas may impact operation of gas turbines in power stations: - Increases to CO emissions; - Increased combustion dynamics that can potentially lead to increased pressure oscillations and equipment wear and tear; - Increased probability of start-failure due to flame stability issues.	Potential impact of the proposed new lower Wobbe Index limit on power generation and the security of electricity supplies.	**2**	**5**	**10**	GNI and EIRGRID are coordinating emergency response plans to mitigate any impact on the power sector. Implementation of the new lower Wobbe Index limit not coming into effect until 06/04/2025 to allow market participants to prepare for the change.	Inform the major end users of the new specification of gas. GNI to continue discussion with the CRU and EIRGRID. Power generators to look into more advanced control systems and review/discuss with their own OEMs.	GNI EIRGRID Power Generators	**1**	**5**	**5**	**1**	**5**	**5**

About DNV

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Memorandum of Explanation
Code Modification Proposal A113

Amendment of Gas Quality requirements at Entry Points pursuant to the Code of Operations.

Point 5 – 51.41 MJ/m3; and to replace the Soot Index (SI) and Incomplete Combustion Factor (ICF) parameters with a new parameter i.e. Relevant Density RD) with a limit of ≤0.7.

The Health and Safety Executive (HSE) in the UK has recently approved changes to the Great Britain (GB) gas quality specification in the Gas Safety Management Regulations (GSMR). The relevant changes approved by HSE include the reduction in the lower WOBBE limit to 46.5 MJ/m3 and the replacement of the Incomplete Combustion Factor and Soot Index with the relevant density limit of ≤0.7. The replacement of ICF and SI with a RD limit has become effective in the UK as of 6 April 2023.

The implementation of the lower WOBBE limit has been deferred until 06 April 2025 [to allow sufficient time for industry to prepare for the change (where necessary)].

The WOBBE index is a key safety parameter, that ensures the safe combustion of gas in end user appliances.

If the RoI retains the current lower WOBBE limits as outlined in the Code of Operations after 6 April 2025 then there is a risk that gas imports from GB could be curtailed for non-compliance with the Code prescribed Gas Quality Specification. This could have serious implications for security of RoI gas supplies particularly given that GB imports are expected to supply circa 81% of the RoI gas demand in 2022/2023 gas year.

Gas Network Ireland (GNI) has reviewed the implications of the planned changes to the GSMR specification and concluded it would be best to realign the RoI gas quality specification in the Code with the new GSMR specification. This recommendation is made for the following reasons:

- it will ensure continuity of gas supplies from GB and eliminate the potential for a natural gas supply emergency declaration and curtailment of GB gas imports due to differences in WOBBE limits.

- GNI is satisfied that the proposal will not result in any reduction in safety based on an extensive HSE safety analysis and [independent review by DNVGL on behalf of Neptune Energy.

- GNI is satisfied that the HSE conclusions are equally applicable to the RoI market.

- It will be necessary to decarbonise the natural gas system with renewable gasses and reduction of the lower WOBBE limit will provide greater flexibility to enable this transition.

GNI recognises that the reduction in the lower WOBBE limit may present some operational challenges to the power generation sector but believes the consequences of not implementing the change are not acceptable i.e. potential curtailment of GB gas imports to the RoI market.

It is noted that a reduction in WOBBE can be associated with a reduction in gross calorific value (GCV). GNI has received confirmation through National Gas that the GCV of any lower WOBBE gas will remain above the current lower limit of 36.9 MJ/m3 and therefore it is not proposed to amend the lower GCV limit at this time.

gasnetworks.ie

Supporting Memo to Gas Quality Code Modification

Date: 11-Aug-23

ABSTRACT
This supporting memo explains the rationale for the proposed changes to the gas quality specification in Part G of the Code – i.e. to reduce the lower WOBBE limit and replace the Incomplete Combustion Factor (ICF) and Soot Index with a Relative Density (RD) limit, and the Gas Networks Ireland (GNI) safety and risk assessment of those changes.

1 EXECUTIVE SUMMARY

The Health & Safety Executive (HSE) has recently approved changes to the Great Britain (GB) gas quality specification in the Gas Safety Management Regulations (GSMR)[1]. The relevant changes for the Republic of Ireland (ROI) gas market, include:

- Reducing the lower WOBBE limit from 47.2 to 46.5 MJ/m^3;
- Replacing the Incomplete Combustion Factor (ICF) and Soot Index (SI) with a Relative Density (RD) limit ≤0.7; *and*
- The HSE approved other changes, e.g. raising the Oxygen (O2) level – but these don't apply to the ROI, and are not discussed further (see Appendix No.1 for more details).

National Gas (NG) has already replaced the ICF and SI with a RD limit on the 06-Apr-23. The HSE has delayed the implenetation of the lower WOBBE limit until 06-Apr-25, to allow sufficient time to prepare for the change.

The planned reduction to the lower WOBBE limit, is the most significant change. The WOBBE index is a key safety parameter, that ensures the safe combustion of gas in end-user appliances. The ROI WOBBE limits are specified in Part G of the Code of Operations (the "Code"), and are aligned with the current GSMR limits (i.e. with a lower WOBBE limit of 47.2 MJ/m^3).

If the ROI retains the current lower WOBBE limits after 06-Apr-25 (when the GSMR limit will be revised downwards), then there is a risk that gas imports from GB could be curtailed for safety reasons - due to the differences in the lower WOBBE limits for each market.

This could have serious implications for the security of ROI gas supplies, particularly given that GB imports are expected to supply c. 81% of the ROI gas demand in the 2022/23 gas year. This percentage is expected to increase going forward, as indigenous production declines.

Gas Networks Ireland (GNI) has reviewed the implications of the planned changes to the GSMR specification, and concluded that it would be best to realign the ROI gas quality specification in the Code – with the new GSMR specification.

Although the probability of low WOBBE gas arriving at Moffat is considered low, GNI believes it would be more prudent to prepare for the change - rather than risk a Natural Gas Supply Emergency (NGSE) or potential curtailment of GB gas imports. GNI is recommending that the lower WOBBE limit is reduced from 47.2 to 46.5 MJ/m3 for the following reasons:

- It will ensure the continuity of gas supplies from GB, and eliminate the potential for a NGSE declaration and curtailment of GB gas imports - due to differences in WOBBE limits;
- GNI is satisfied that it will not result in any reduction to safety, based on the extensive HSE safety analysis and an independent review by DNV (on behalf of GNI) - and GNI is also satisfied that the HSE conclusions are equally applicable to the ROI market;
- GNI recognises the potential operational challenges to parts of the power sector, but believes the consequences of not changing would be worse – i.e. potential curtailment of GB gas imports to the ROI market (that would disproportionately impact the power sector); *and*
- It will be necessary to decarbonise the natural gas system with renewable gases, and reducing the lower WOBBE limit will provide greater flexibility to enable this transition.

Similarly GNI recommends replacing the ICF and SI with a RD limit ≤0.7 on the basis that it is primarily a technical simplification, that will not result in any reduction to safety – based on GNI's review of the HSE evidence, that of other European organisations and the relevant European technical standards.

A reduction in WOBBE can sometimes be associated with a reduction in Gross Calorific Value (GCV). GNI has received confirmation through National Gas (NG) that the GCV of any lower WOBBE gas at Moffat, will remain above the current lower limit of 36.9 MJ/m^3 - and, therefore, is not proposing to amend the lower GCV limit at this point in time.

GNI has also decided not to review the Exit Point gas quality specification at this point in time, and will instead review this matter when the revision of the European gas quality standard EN 16726 is completed (expected to be sometime in 2025) – as this will potentially introduce new requirements at the Exit (i.e. the proposed WOBBE classification system).

2 PROPOSED CODE MODIFICATION

GNI is proposing to make the following amendments to Appendix No.1 (Quality Specification of Natural Gas at IP Entry Points and Entry Points) in Part G (Technical) of the Code of Operations:

- Reduce the lower WOBBE limit from 47.2 to 46.5 MJ/m^3; *and*
- Remove the ICF and SI limits, and replace them with a new RD limit ≤ 0.7.

GNI is proposing that any reduction in the lower WOBBE limit wouldn't come into force until 6th April 2025 (in line with the GSMR approved changes in GB), to allow market participants to prepare for the change.

3 SUMMARY OVERVIEW OF HSE APPROVAL PAPER

Reducing lower WOBBE limit

The HSE concluded there would be substantial economic benefits from a lower WOBBE limit, in terms of the additional recovery of low WOBBE gas reserves from the North Sea, and the corresponding enhancement to the security of GB gas supplies. The HSE was satisfied a lower WOBBE limit wouldn't reduce safety, based on previous studies and referenced the:

- "Oban" or Opening the Gas Market (OGM) report;
- Neptune Lower WI Interim" report; *and*
- HyDeploy: Summary of Gas Appliance testing and Installation testing reports.

All the above studies demonstrated the ability of end-user appliances to safely burn low WOBBE gas. The HSE also forecast a minor reduction in Carbon Monoxide (CO) fatalities, as a lower Calorific Value (CV) would lead to lower CO production in mal-functioning appliances.

The HSE noted potential operational challenges and additional costs for the power generation sector. It determined that it was not possible to precisely quantify the impact of these operational challenges on electricity supplies, but concluded that they wouldn't create a risk to the security of electricity supplies.

The HSE proposed a 2-year implementation period for the lower WOBBE limit, to allow market participants to prepare for the change (to come into effect on 6th April 2025). Replacing the ICF and SI with a RD limit has already come into effect on 6th April 2023.

Replacing the ICF and SI with a RD limit

The HSE concluded that the RD limit provided a safe and alternative method for controlling the production of excess CO and soot, due to the presence of higher hydrocarbons in the gas (which cannot be controlled by the WOBBE alone). The RD limit was also both easier to understand and measure, than the ICF and SI.

The HSE noted concerns that the change could lead to increased soot production, but concluded that soot was primarily produced by mal-functioning or poorly ventilated appliances (rather than the gas quality controls) – i.e. such an appliance would continue to produce soot regardless of whether the SI or RD limit was used to control the gas quality.

4 GNI REVIEW OF PROPOSED GAS QUALITY CHANGES

Overview

GNI has reviewed the potential impact of the proposed changes on the ROI gas market and in particular the impact of a lower WOBBE limit on the security of gas supplies, safety of appliances and the security of electricity supplies, including the:

- Potential for gas supply interruptions at Moffat due to differences in the WOBBE limit;
- Ability of gas applications to safely burn gas at the lower WOBBE limit, and the applicability of the HSE safety analysis to the ROI market; *and*
- Potential impact of the proposed new lower WOBBE limit on power generation and the security of electricity supplies.

Probability of low WOBBE gas at Moffat

The impact of a lower WOBBE limit on the security of ROI gas supplies will depend on the likelihood of low WOBBE gas being delivered to Moffat. This is dependent on the likelihood of low WOBBE gas leaving the St Fergus Entry Point to the National Transmission System (NTS) - which is the predominant source of supply to Moffat[3].

National Gas (NG) has estimated the likelihood of low WOBBE gas being delivered to St Fergus as part of its "NTS Penetration Analysis" study[4], based on discussions with the sub-terminal operators, and its own network analysis studies. NG has concluded that:

- Low WOBBE gas is unlikely to enter the St Fergus terminal during **normal conditions** as any low WOBBE gas will continue to be blended with higher WOBBE gas, and the WOBBE of the overall blend will continue to exceed 47.2 MJ/m^3; *and*
- Low WOBBE gas may enter St Fergus when there is an outage to higher WOBBE gas fields, due to either planned maintenance or unplanned outages (e.g. offshore-trips).

There are three sub-terminals feeding into the St Fergus Entry Point. Only the NSMP sub-terminal indicated an interest in flowing lower WOBBE gas, in the range from 46.9 to 47.2 MJ/m3 - when there was an outage to higher WOBBE gas production. NG estimated the potential for low WOBBE gas from the NSMP terminal at c. 18-days per year out to 2027.

Even if low WOBBE gas was delivered by the NSMP sub-terminal, it would comingle with gas from the other two sub-terminals - and NG anticipate that the blended WOBBE of all three terminals would likely exceed 47.2 MJ/m3 (based on historic flows).

The probability of low WOBBE gas leaving St Fergus is probably lower than 18-days per year, and would likely require an outage to the other two sub-terminals (but hasn't been quantified by NG). In summary Moffat is unlikely to see the full reduction to the lower WOBBE limit, and only for relatively limited periods of time each year.

What if Lower WOBBE gas arrives at Moffat

If the ROI didn't reduce its lower WOBBE limit and low-WOBBE gas arrived at Moffat, then GNI would probably have to declare a Natural Gas Supply Emergency (NGSE) - and the National Gas Emergency Manager (NGEM) would essentially have two options:

- Interrupt gas supplies to a significant proportion of the ROI gas market; *or*
- Allow the "off-specification" gas to enter the GNI system under the "emergency-limits" referred to in the NGEM plan.

GNI believes that the most likely course of action is that the gas would be allowed to flow - as the new lower WOBBE limit is the same as the current lower WOBBE emergency limit, there are no identified safety issues, and it would prevent a major ROI gas supply interruption.

The alternative would be to curtail gas supplies at Moffat. This would disproportionately impact gas-fired power generation and the security of electricity supplies, as the power sector would be the first to be curtailed in any emergency.

On balance GNI believes the most prudent course of action is to adopt the new lower WOBBE limit of 46.5 MJ/m^3, and for market participants to implement mitigation measures to minimise any operational impacts. The alternative of doing nothing is worse, i.e. potentially having to curtail gas supplies to a significant proportion of the ROI gas market.

Safety of End Use Appliances

The HSE concluded that a lower WOBBE limit wouldn't reduce current safety standards based on the previous the Neptune and Oban reports. GNI has also reviewed those reports and agrees with the HSE analysis.

The Neptune Report[5] detailed the results of laboratory testing on a number of representative end-user appliances with the low-WOBBE G23 test gas (with a WOBBE index of 45.66 MJ/m^3), and also summarised the results of previous reports. It concluded:

- *"In summary no problems related to emissions, ignition, flame stability or flame lift were observed for the appliances tested"[5a];*
- The appliances operated satisfactorily during all tests, but noted some appliance may take longer to achieve the desired heat-output (due to the lower CV of the gas);
- The results for the low-WOBBE G23 gas were broadly consistent with previous studies, such as OBAN study (2013), the "DTI 3-Phase Gas Quality Study" (2006) and the "DTI Gas Quality Pilot Study" (2004):
  - *"The over-riding outcome is that the use of gases with WOBBE index down to the G23 value of 45.7 MJ/m3 does not lead to significant performance changes"[5b]*
- It noted the original limit of 47.2 MJ/m3 was set by British Gas for customer rather than safety considerations (i.e. to minimise complaints about insufficient heat output).

The Oban report summarised the ability of end-user appliances to safely burn both low and high WOBBE gases, based on laboratory and in-situ testing of customer gas appliances in the town of Oban (Scotland) - with various test gases (including the G23) – "*The project did not find any safety issues testing on gases as low as 45.66 MJ/m³"* (see also Appendix No.1) [6].

GNI is satisfied that these reports provide a solid scientific basis for reducing the lower WOBBE limit to 46.5 MJ/m³ (based on qualitative and quantitative assessments), and will not result in any reduction to end-user appliance safety. GNI is also satisfied that the above results are equally applicable to the ROI for the following reasons:

- Safety certification requirements of the European Gas Appliance Regulations (GAR)[7];
- Previous appliance studies completed in 2009 under Common Arrangements for Gas (CAG) - gas quality review[8]; *and*
- Discussions held with gas appliance manufacturers and distributors.

The GAR requires appliance manufacturers to certify that their gas appliances are safe for use in their intended market. This in turn requires manufacturers to select appropriate test gases, for the "expected" gas quality of their intended markets.

Gas quality can vary significantly across Europe, so the GAR essentially requires Member States to "declare their expected gas quality" using the classification system in EN 437[9], which in turn determines the choice of test-gases for testing and certifying the appliances:

- Both GB and the ROI have declared the appropriate gas family for their respective markets to be the "2nd Family, Group H" with a WOBBE range: 45.7 to 54.7 MJ/m³[10]; *and*
- The test gases for this gas family are the previously mentioned low-WOBBE G23 (flame-lift), and also G20 (methane -reference gas), G21 (ICF & SI) and G222 (light-back);

In summary all appliances sold into the ROI and GB markets for the last 25+ years have been certified using the same safety tests, the same test gases and test pressures. This alone gives GNI a high degree of confidence that the HSE safety analysis is also applicable to the ROI.

This same issue of appliance equivalence was also considered in the previous report prepared by DNV in 2008 "Final Report on the Requirements for a Single Natural Gas Quality Standard for Northern Ireland and the Republic of Ireland (ROI)", which concluded that:

- The gas appliance populations were broadly equivalent, and that the previous GB gas appliance testing performed on behalf of DETI in 2005 was also applicable to the ROI;
- The DETI testing covered all the appliances identified in the ROI market at the time, and that any conclusions from the DETI work were also relevant to the ROI[9]; *and*
- The Irish and UK gas boiler and water heater appliance populations are comparable in type with similar leading manufacturers and models.[11]

GNI has also engaged gas appliances manufacturers and distributors in the ROI including VOKERA and Potterton, and they have confirmed that appliances sold into the ROI market are certified to the same requirements as GB – and in many cases are manufactured at the same facility.

GNI is confident based on the above considerations that the HSE safety analysis is equally applicable to the ROI. This conclusion has also been confirmed by an independent third party study performed by DNV on behalf of GNI.

Large industrial gas users

The scope of the European GAR regulations includes gas appliances used for heating, cooking, hot-water, refrigeration, lighting and washing. It excludes gas appliances used for industrial process carried out on industrial premises (e.g. glass-making etc) and research purposes.

The operation, maintenance and field adjustment of these gas appliances tends to be specific to the particular gas application and associated industrial process, and would normally be based on the Original Equipment Manufactuerer (OEM) guidelines and recommendations.

GNI would advise such industrial end-users to consult with their OEM, to determine whether they would recommend any changes to their guidelines and recommendations (as a result of reducing the lower WOBBE limit).

GNI will continue to highlight the need for industrial users to consult with their OEMs at industry forums, to help raise awareness of the issue in advance of any planned changes to the lower WOBBE limit.

Impact on gas fired-generation

The WOBBE is an important parameter for gas-fired generation. Most gas-turbines with pre-mixed combustors are tuned to a tight WOBBE range for operational and emission purposes. Reducing the lower WOBBE limit increases the WOBBE range or "bandwidth", which makes tuning gas-turbines more challenging. The potential impact of low WOBBE gas may include[12]:

- Increases to CO emissions, particularly at part load;
- Increased combustion dynamics that can potentially lead to increased pressure oscillations and equipment wear and tear (and ultimately maintenance costs); *and*
- Increased probability of start-failure due to flame stability issues.

All of these issues are "operational challenges" rather than safety issues, as the gas turbine is designed to safely shut itself down. There are also potential solutions to these issues, including more advanced control systems - however, these require financial investments and potentially extended maintenance outages.

The HSE has also acknowledged these issues and the need for the power sector to make substantial financial investments (to mitigate any potential impact). This was also one of the main reason for allowing a 2-year implementation period in GB.

The Irish power-sector and Electricity Association of Ireland (EAI) have expressed similar to GNI, including potential risks to the ROI electricity supplies - due to the higher dependence on gas-fired generation, and the already tight power generation capacity margins.

GNI has also discussed this matter with EIRGRID, to both make them aware of the power sector concerns and to coordinate emergency plans - in the event of any unforseen consequences from the proposed changes to the GB gas quality specification.

GNI recognises the valid concerns of the ROI power sector, but believes that the die has already been cast – by the GB decision to adopt the lower WOBBE limit. The alternative is to do nothing, and risk curtailing gas supplies to a significant proportion of the ROI market (which in any case, would disproportionately impact the power sector).

GNI believes that the better approach would be to reduce the lower WOBBE limit from 47.2 to 46.5 MJ/m^3, and for the power sector to prepare in advance for the change – to try and mitigate the impact. GNI will also work with the power sector to help manage the impact of the change, through the provision of enhanced gas quality information.

Replacing the ICF and SI with a RD limit

Although the WOBBE index is the primary gas interchangeability safety parameter, it is not possible to derive all gas quality limits solely from gas combustion characteristics (and related parameters such as the WOBBE). The presence of higher hydrocarbons can potentially lead to excessive CO and soot production.

In GB the WOBBE index has historically been supplemented by the ICF and SI in the "Dutton interchangeability diagram" approach (in the previous GSMR). Alternative approaches have historically been considered by other organisations and countries, based on a RD limit:

- MARCOGAZ previously proposed a RD ≤ 0.7 to control soot production, and noted that there the RD correlated well with the higher hydrocarbon content[13];
- A number of European countries already use an upper RD limit ≤ 0.7 in their gas quality requirements based on a 2019 MARCOGAZ study, including France, Spain, Germany, Italy, Belgium, Switzerland and Sweden;[14] *and*
- The European technical standard for gas quality (EN 16726) includes a RD limit ≤ 0.7.

The HSE concluded that the RD limit provided a reasonable alternative approach for controlling the higher hydrocarbon content of gas, which did not appear to have any significant adverse safety implications.

GNI is satisfied based on the HSE assessment, the work of MARCOGAZ and experience of other European countries, that it is both reasonable and safe to replace the ICF and SI with a RD limit ≤ 0.7 - which also has the additional advantages of being both easier to understand and can actually be measured (as opposed to the relative complex calculations for the ICF and SI).

5 RISK ASSESSMENT FOR THE GNI SYSTEM

GNI has also completed a full risk assessment on the impact of a reduced lower WOBBE limit on the GNI gas Transmission (TX) and Distribution (DX) systems. This assessment highlighted the following risks:

- The change in underlying gas composition associated with the lower WOBBE gas, may adversely impact the integrity of the GNI TX and DX system – e.g. due to higher CO2 content etc; *and*
- The lower WOBBE gas may impact the normal function of the GNI TX and DX system components – e.g. the operation of gas turbines in compressor stations and gas pre-heating systems at pressure reduction stations etc (similar to the impact on other gas end-users discussed above).

GNI has concluded that there is no increased risk of corrosion to metallic pipes in the TX and DX systems, by virtue of the existing gas quality specification controls – and in particular the water content limit:

- The internal corrosion rate cannot increase without the presence of free standing water within the pipeline, regardless of the corrosion species (i.e regardless of whether the corrosion risk is due to increased CO2 or O2 levels etc);

- The gas quality specification in the Code restricts the water content to 50 mg/m^3, which is broadly equivalent to a water dew-point temperature of – 8 degree C at 85-bar – and means that it is very difficult for material quantities of free standing water to form within GNI pipelines (which are designed to normally operate at 0 degrees and above);
- The lack of free standing water in the pipeline means that the risk of increased corrosion is neglible, regardless of any increased CO2 content in the low WOBBE gas – and this conclusion is supported by other studies:
  - The HSE addressed this particular concern in their consultation response paper, and concluded that the risk was adequately controlled by the existing gas quality specification - and in particular the water dew-point requirement [15];
  - A seperate report prepared for GNI by PENSPEN in relation to increasing the O2 limit, similarly concluded that the risk of increased internal corrosion was minimal provided that the gas was dry (regardless of the corrosion species)

    "This is important as the key to maintaining acceptable corrosion rates within the pipeline systems is to limit the water / moisture content, rather than the corrosive species such as oxygen. Given that the gas in GNI's network is dry, corrosion should not be an issue in GNI's network."[16]
  - A similar conclusion has been reached in relation to Unified Code Modifications (UNC) in GB related to increasing the CO2 limit at Network Entry Points to the NTS - where NG has stated that the risk of increased internal corrosion due to CO2 is minimal provided that there is no free standing water in the pipeline:

    "Transportation of gas with a CO2 content of 5.5% would not increase corrosion risk if the network is dry or in the event that small amounts of water are present which result in thin aqueous films on the inner wall of a pipeline."[17]
- Finally it should be noted that the current upper limit for CO2 specified in the Code will remain unchanged, i.e. it will continue to be ≤ 2.5% (mol).

The potential impact and mitigation of a reduced lower WOBBE limit on the correct functioning of other TX and DX system conponents, is similar to that described earlier for other end-user gas appliances.

GNI will be consulting with the relevant OEMs to determine whether there is any change to their guidance and recommendations for the commissioning, operation and maintenance of relevant equipment – and in particular gas turbines and gas boilers.

In summary GNI concluded that the potential impacts of the proposed gas quality changes will not adversely impact the safety of the GNI system, provided that the existing safeguards are maintained – e.g. monitoring the gas quality at Entry Points (and in particular the water content) and following good practice as recommended by the equipment OEMs.

6 NEXT STEPS

- GNI will formally submit a Code Modification Proposal to reduce the lower WOBBE limit from 47.2 to 46.5 MJ/m^3 and to replace ICF and SI with a RD ≤ 0.7, together with the corresponding legal drafting;
- GNI will continue to engage with market participants to communicate the proposed changes, raise industry awareness and to discuss how best to mitigate any potential impacts;

- If the Code Modification is agreed with the market participants then GNI would propose to replace the ICF and SI with a RD ≤ 0.7 shortly afterwards, but would wait to implement the reduction of the lower WOBBE limit until 6th April 2025 - in line with GB (and to allow market participants an opportunity to prepare for the change);
- GNI will continue to work with market participants, industry stakeholders and NG on measures to help mitigate any potential impacts, including the provision of enhanced gas quality information and forecasts.

7 REFERENCES

[1]: The HSE response to their public consultation on proposed changes to the GB gas quality specification is set out in the document: "CD291 – Amendments to the Gas Safety (Management) Regulations 1996 Consultation Response" (published on the HSE website: 10-Mar-23); hse-consultation-response-for-gsmr-2023.pdf

[2] GNI "Gas Forecast Statement 2022" (see p.63 of Section 6 "Gas Supply" for an overview of the importance of the Moffat Entry Point for meeting the ROI gas demand);

[3] National Gas (formerly National Grid) "Gas Ten Year Statement 2022". Moffat is located in Zone 1 of the NTS. Section 3.2 "Options & Developments: Scotland and the North" (see p. 29) provides an overview of the Zone 1 gas flows: Currently the gas predominantly flows from North (St Fergus) to South, but this may change depending on future St Fergus gas flows.

[4] "GS(M)R Review: NTS Penetration Analysis" published by NG in Sep-22 to support the HSE review of the lower WOBBE limit. An overview of potential low WOBBE gas-flows to the St Fergus NSMP terminal is provide on Slide No.7;

[5] "Gas Quality – Low WOBBE Index Study, Interim Report – Impact Study on Low WOBBE Index Gas" (24-Nov-19) prepared by DNVGL on behalf of Neptune Energy and referenced in the IGEM Gas Quality Working Group evidence report to the HSE: "A Key Step on the Pathway to Net Zero Emissions – EVIDENCE REPORT" (24-Apr-20).

[5a] Quote taken from p. 22, Section No.5 (New Practical Domestic Appliance Testing) of the above "Neptune Report" by DNVGL;

[5c] A concise summary of all the previous testing is provided in Section No.7 (Summary of Information on Utilisation of Lower WOBBE index gas" of the above Neptune report by DNVGL;

[6] Quote taken from p. 20, Recommendation No.2 of the "Opening up the Gas Market", Final Report publish by SGN (Oct-16) – also referred to as the "OBAN" report.

NB: See also Appendix No. 1, for more details and context on this report recommendation.

[7] The original Gas Appliance Directive (GAD) – 90/396/EEC came into force in 1993, and its requirements were subsequently superseded and updated by the 2009/142/EC Directive, before being replaced by the European Gas Appliance Regulations (GAR) in 2016 – Regulation (EU) 2016/426;

[8] See Section 4 (DTI/BERR Gas Quality Programme) of "Final Report on the Requirements for a Single Natural Gas Quality Standard for Northern Ireland and the Republic of Ireland, CER/09/037" prepared by GTL Business International Ltd on behalf of the Commission for Energy Regulation (CER) and Northern Ireland Authority for Utility Regulation (02-Mar-09);

[9] European technical standard EN 437 (Test Gases – Test Pressures – Appliance Categories) and supports the requirements of 2.2 of the "Gas Appliances" Directive;

[10] Please refer to Table B1 (Category I (Single Categories) Marketed) of Annex B (Informative – National Situations) of EN 437;

[11] See the Executive Summary of report "Impact of Gas Quality on Gas Appliances" prepared by ADVANTICA on behalf of Bord Gais Networks (18-Feb-08);

[12] See "Potential Impact on Gas Turbines of Proposed Low WOBBE Gas" submission by UNIPER UK to - UNC Modification 0704 – Amendment to Network Entry Provision at Perenco Bacton Terminal;

[13] "Second Position Paper on European Gas Quality Specification for Natural Gas Interchangeability" UTIL-GQ-03-09 prepared by the MARCOGAZ WG "Gas Quality" (06-Aug-03):

NB: MARCOGAZ is the representative Technical Association of the Gas Industry in Europe

[14] Taken from MARCOGAZ document WG-GQ-187-BiomethaneSpecificationsForInjection (05-Feb-19): "Quality Values Required by Legislation in Some Countries in Europe for Biomethane Injection into Natural Gas Network";

[15] Taken from HSE response to their own gas quality public consultation – see paragraph No.35, page 12: *"...The risks of corrosion are also commonly referenced by controls on water content in network entry agreements and, it is in the interests of gas conveyors that their pipelines are dry therefore limiting the potential for corrosion."*

[16] Taken from Executive Summary, page 4 of the PENSPEN report: "Biomethane – 1.0 mol% Oxygen Content Assessment 20424-AI-RPT-001 Rev 3" (May 2023), and published in support of Code Modification Proposal A111.

[17] Taken from page.19, Section No.6 (d) "National Grid NTS' Assessment of its Operational Risks" of "UNC 0607S: Amendment to Gas Quality NTS Entry Specification at the St Fergus NSMP System Entry Point" (27-Jul-17).

8 APPENDIX NO.1

Other GSMR changes

The amended GSMR regulations also increased the O2 content to 1.0% (molar) for system pressures < 38 bar-g. This change does not apply to the ROI market, however, as GNI is supplied from a higher pressure 85-bar-g system at Moffat – where the O2 limit will remain unchanged at 0.2% (molar).

It should be noted that GNI is seperately proposing to increase the O2 limit for renewable gases on the TX system to 0.5% (molar). This change is to encourage the growth in renewable gases in the ROI, and is not related to the GSMR changes – and is subject to a seperate Code Modification.

There were also a number of other GSMR changes relating to the GB "Emergency Reporting System", cooperation requirements for Liquefied Natural Gas (LNG) terminals and requirement for biomethane pipelines to have a Safety Case. These relate to the safe operation of the gas market in GB, and are not applicable to the ROI market.

Oban Report

Recommendation No.2 from the Executive Summary of the Oban Report did not find any safety issues when testing appliances on gases as low as 45.66 MJ/m^3, but recommended further studies before reducing the lower WOBBE limit.

This recommendation was not related to any safety concerns around the ability of appliances to burn low WOBBE gases, but rather to the potential widening of the WOBBE range - if all of the Oban recommendations were implemented at the same time.

The primary purpose of the Oban Report was to provide a scientific basis for increasing the upper WOBBE limit to 53.25 MJ/m^3, to enable the supply of Liquefied Natural Gas (LNG) to four Scottish Independent Undertakings (SIUs) at Oban, Wick, Thurso and Campbeltown (without the need for ballasting).

These SIUs had been supplied with natural gas but never connected to the NTS, and were instead supplied by trucked LNG from liquefaction facilities on the NTS. The retirement of the liquefaction facilities meant an alternative source was required, including potential supplies from LNG terminals with a high WOBBE (i.e. without ballasting).

The Oban Study demonstrated that it was safe to burn gas at either 53.25 MJ/m^3 or 45.66 MJ/m^3, but there was a concern that the resulting WOBBE range of 7.59 MJ/m^3 would be too wide for some gas appliances.

This range was outside the 5 to 6 MJ/m^3 range safe operational range identified by the Oban project team. The concern was that if a condensing boiler was tuned to a low WOBBE gas, then it might produce high CO emission when it received high WOBBE gas.

The IGEM Gas Quality Working Group subsequently proposed a narrower WOBBE range in their proposals for amending the GSMR, i.e. from 46.50 to 52.85 MJ/m^3 (or a WOBBE range of 6.35 MJ/m^3).

The HSE subsequently rejected the IGEM proposal to increase the upper WOBBE limit and only approved the reduction of the lower WOBBE limit to 46.5 MJ/m^3. The potential WOBBE of GB gas will be from 46.50 to 51.41 MJ/m^3 – i.e. a range of 4.91 MJ/m^3, which is well inside the operational safety range identified by the project team.

In summary the HSE decision not to proceed with increasing the upper WOBBE limit, means that the original concerns around reducing the lower WOBBE limit are no longer valid – and that gas appliances should able to safely burn gas over the corresponding 4.91 MJ/m^3 range (which is well inside the 5 to 6 MJ/m^3 range identified by the Oban project-team).