# GAS GOES GREEN

# IGEM's peer review consultation for gas quality and changes to GS(M)R

09 July 2020

DELIVERING THE PATHWAY TO NET ZERO

# Welcome

- For technical issues please email GasGoesGreen@energynetworks.org
- Please ensure that your microphone is switched to 'mute' to avoid background noise, and that your camera is not in use
- You may ask questions or make comments via the chat function throughout the meeting, we will address as many of these as possible during the presentation, and publish a collection of responses shortly after the meeting
- This meeting is recorded and the recording will be available shortly after the meeting
- If you are unable to use chat functionality, try joining the Teams meeting via the Web app using incognito / private browsing (preferably with Chrome or Edge)
- If you would like to receive information about Gas Goes Green or have any feedback, please get in touch with us at GasGoesGreen@energynetworks.org

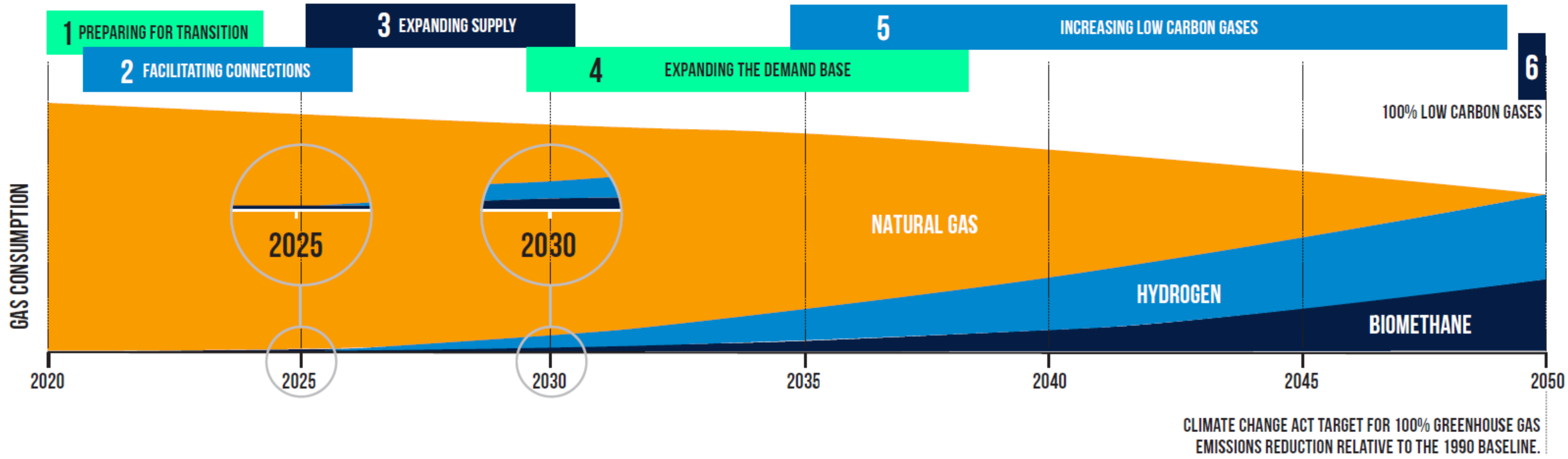
# Gas Goes Green

- Gas Goes Green is the gas network plan to deliver net zero

- Workstream 2 – Gas quality and safety

- Existing gas legislation and regulation will need to change to allow for greater proportions of net zero compliant gases

# Pathway to net zero



# Objectives for today

- Understand the timelines for GS(M)R changes
- Understand the timelines for IGEM's Gas Quality Standard
- Understand the evidence base to date
- Identify the gaps in understanding

# Agenda

| | |
|---|---|
| **Welcome** | Dr Thom Koller, Gas Goes Green Programme Lead, ENA |
| **A New IGEM Gas Quality Standard for Net Zero Emissions** | Ian McCluskey, Head of Technical Services and Policy, IGEM |
| **Dutton revisited** | Dave Lander, Dave Lander Consulting |
| **Widening the Wobbe Index: Domestic Customers Case for Change** | Dr Martin Brown, Principal Specialist, DNV GL |
| **Widening the Wobbe Index: Gas Quality Variations and Industrial & Commercial Customers Case for Change** | Dr Sarah Kimpton, Senior Principal Consultant, DNV GL |
| **Network Safety** | Dave Lander, Dave Lander Consulting |
| **Closing remarks** | Dr Thom Koller, Gas Goes Green Programme Lead, ENA |

# A New IGEM Gas Quality Standard for Net Zero Emissions

Ian McCluskey, IGEM

GAS GOES GREEN



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# About IGEM - Our Heritage

Founded 1863
Royal Charter 1929
Patron: Her Majesty the Queen

Engineering Council

- Formed in 1863
- Awarded Royal Charter 1929
- Global Membership Individuals and Organisations
- Registered Charity
- Licensed by the Engineering Council for the award of professional titles
  - Engineering Technician (EngTech)
  - Incorporated Engineer (IEng)
  - Chartered Engineer (CEng)
- Standards for:
  - Transmission and distribution
  - Safety
  - Legislation
  - Measurement
  - Utilisation
  - General
  - Industry Guidance


UKAS MANAGEMENT SYSTEMS 001

IGEM
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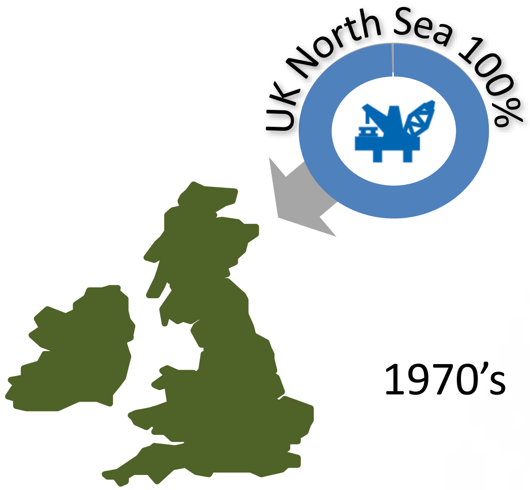
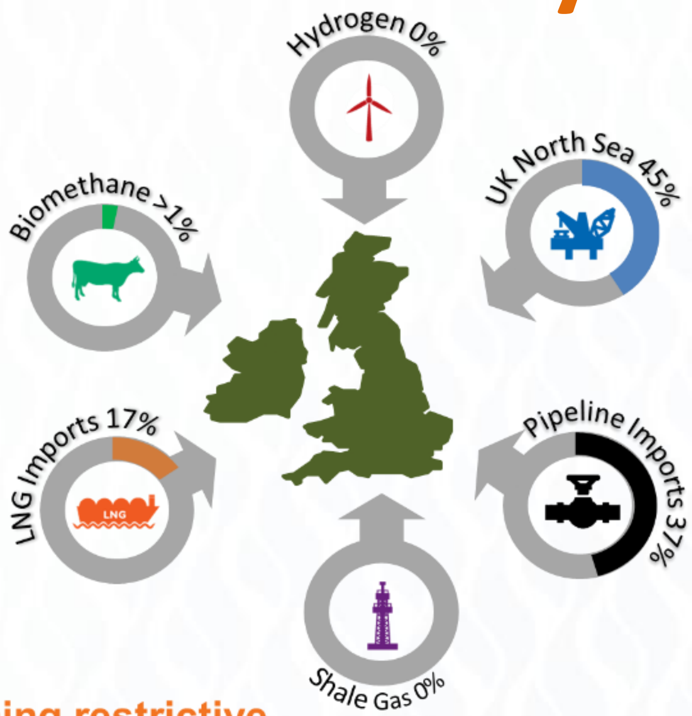
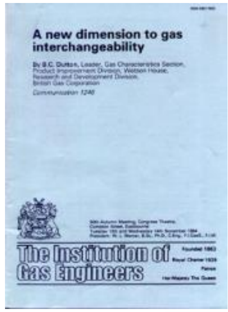
# Gas Quality Standard – Reasons Why?




1970's

Now

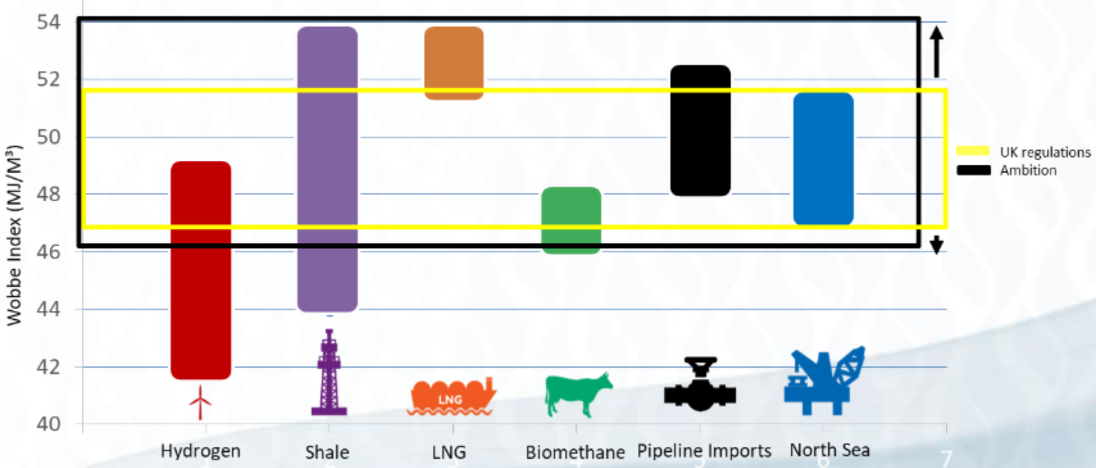




A new dimension to gas interchangeability

The Institution of Gas Engineers

In 1984 the Institution published communication 1246 "A new dimension to gas interchangeability"

- Current limits are becoming restrictive

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# Gas Quality Working Group

- 2016 Meetings with OFGEM, DECC, HSE and IGEM
- Set up an industry working group to investigate gas quality
- Set the parameters for Wobbe Index initially upper end
- Examine further widening for lower Wobbe
- Examine the case for change of other parameters
- Review process examine previous and current studies
- Assess impact on Industrial and Commercial equipment

# Gas Quality Working Group

Department for Business, Energy & Industrial Strategy

Progressive energy

AMPS

WALES&WEST UTILITIES

Cadent
Your Gas Network

nationalgrid

Northern Gas Networks

SGN
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kiwa
Partner for progress

HSE
Health & Safety Executive

DNV·GL

davelanderconsulting

Energy UK

HHIC
HEATING & HOTWATER INDUSTRY COUNCIL

ICOM
Energy Association

bsi.

Gas Networks Ireland

NEPTUNE ENERGY

NPL

CRU
An Coimisiún um Rialáil Fóntais
Commission for Regulation of Utilities

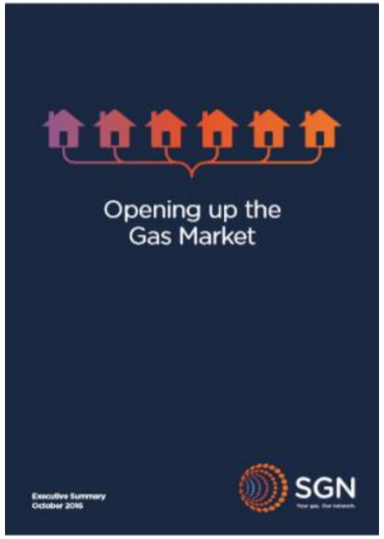
ANCALA

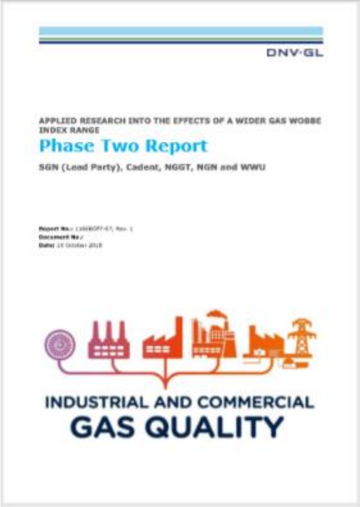
# Gas Quality Standard - Aims

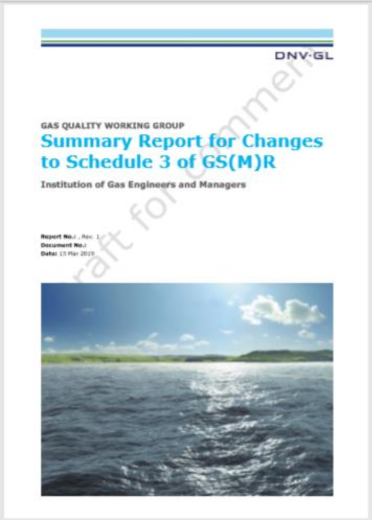
| Gas quality standard aim | Securing UK gas supplies | Deep decarbonisation |
|---|---|---|
| Facilitating the safe injection of a wider range of gases | UKCS gas | Reducing processing emissions |
| | LNG imports | |
| | Interconnectors | Biomethane |
| | | Hydrogen |

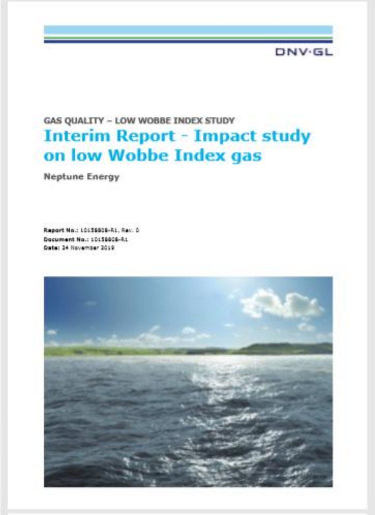
**It is important to remember that the GS(M)R are primarily intended to ensure the safety of the public – this will continue to be the primary aim of the new gas quality standard**

# Gas Quality Standard - Evidence Reports





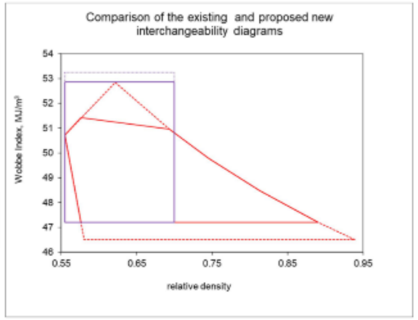



Figure 13: Final form of the proposed new interchangeability diagram, compared with the existing diagram of the GSMR

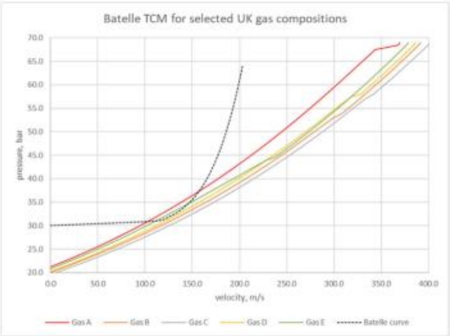




Figure 2: Battelle TCM plots for UK pipeline gases

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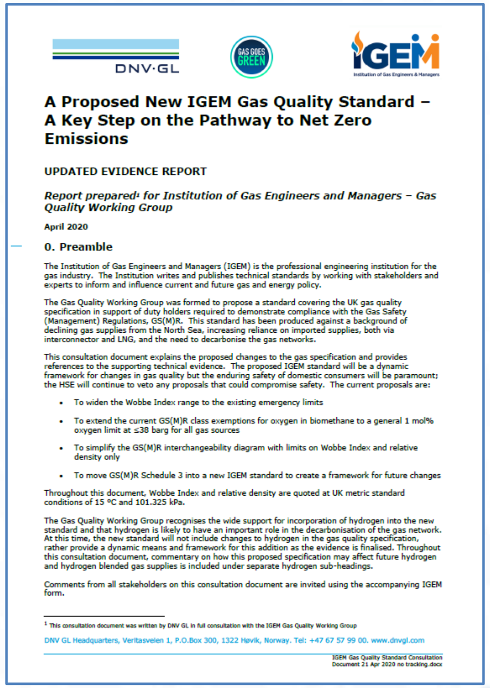
# Gas Quality Standard – Industry Peer Review

- Key Milestone Reached – Industry Consultation Period
- Evidence Reports supporting changes
- Existing Gas Quality Issues – Estimate Future Issues
  - Variations across UK
  - Impacts on Power Stations
  - Impacts on Gas Users
- Updated Dutton Interchangeability Diagram
- Case for Change Domestic Users
- Case for Change on Commercial Users
- Gas Network Safety


DNV·GL   GAS GOES GREEN   IGEM Institution of Gas Engineers & Managers

**A Proposed New IGEM Gas Quality Standard – A Key Step on the Pathway to Net Zero Emissions**

**UPDATED EVIDENCE REPORT**

***Report prepared[1] for Institution of Gas Engineers and Managers – Gas Quality Working Group***

**April 2020**

**0. Preamble**

The Institution of Gas Engineers and Managers (IGEM) is the professional engineering institution for the gas industry. The Institution writes and publishes technical standards by working with stakeholders and experts to inform and influence current and future gas and energy policy.

The Gas Quality Working Group was formed to propose a standard covering the UK gas quality specification in support of duty holders required to demonstrate compliance with the Gas Safety (Management) Regulations, GS(M)R. This standard has been produced against a background of declining gas supplies from the North Sea, increasing reliance on imported supplies, both via interconnector and LNG, and the need to decarbonise the gas networks.

This consultation document explains the proposed changes to the gas specification and provides references to the supporting technical evidence. The proposed IGEM standard will be a dynamic framework for changes in gas quality but the enduring safety of domestic consumers will be paramount; the HSE will continue to veto any proposals that could compromise safety. The current proposals are:

- To widen the Wobbe Index range to the existing emergency limits
- To extend the current GS(M)R class exemptions for oxygen in biomethane to a general 1 mol% oxygen limit at ≤38 barg for all gas sources
- To simplify the GS(M)R interchangeability diagram with limits on Wobbe Index and relative density only
- To move GS(M)R Schedule 3 into a new IGEM standard to create a framework for future changes

Throughout this document, Wobbe Index and relative density are quoted at UK metric standard conditions of 15 °C and 101.325 kPa.

The Gas Quality Working Group recognises the wide support for incorporation of hydrogen into the new standard and that hydrogen is likely to have an important role in the decarbonisation of the gas network. At this time, the new standard will not include changes to hydrogen in the gas quality specification, rather provide a dynamic means and framework for this addition as the evidence is finalised. Throughout this consultation document, commentary on how this proposed specification may affect future hydrogen and hydrogen blended gas supplies is included under separate hydrogen sub-headings.

Comments from all stakeholders on this consultation document are invited using the accompanying IGEM form.

[1] This consultation document was written by DNV GL in full consultation with the IGEM Gas Quality Working Group

DNV GL Headquarters, Veritasveien 1, P.O.Box 300, 1322 Høvik, Norway. Tel: +47 67 57 99 00. www.dnvgl.com

IGEM Gas Quality Standard Consultation Document 21 Apr 2020 no tracking.docx

# Gas Quality Standard – Summary of Changes

| Content or characteristic | Current schedule 3 of GS(M)R | New IGEM standard |
|---|---|---|
| **Part I Requirements under normal conditions** | | |
| **Hydrogen sulphide content** | ≤5 mg/m$^3$ | No change |
| **Total sulphur content (including hydrogen sulphide)** | ≤50 mg/m$^3$ | No change |
| **Hydrogen content** | ≤0.1% (molar) | No change |
| **Oxygen content** | ≤0.2% (molar) | ≤1% (molar) at pressures below 38 barg |
| **Impurities** | Shall not contain solid or liquid material which may interfere with the integrity or operation of pipes or any gas appliance (within the meaning of Regulation 2(1) of the 1998 Regulations)[1] which a consumer could reasonably be expected to operate | No change |
| **Hydrocarbon dewpoint and water dewpoint** | Shall be at such levels that they do not interfere with the integrity or operation of pipes or any gas appliance (within the meaning of Regulation 2(1) of the 1998 Regulations) which a consumer could reasonably be expected to operate | No change |
| **Wobbe Index** | ≤51.41 MJ/m$^3$ and | ≤52.85 MJ/m$^3$ |
| | ≥47.20 MJ/m$^3$ | ≥46.50 MJ/m$^3$ |
| **Incomplete combustion factor** | ≤0.48 | Removed |

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# Gas Quality Standard – Summary of Changes

| Content or characteristic | Current schedule 3 of GS(M)R | New IGEM standard |
|---|---|---|
| **Sooting index** | ≤0.60 | Removed |
| **Relative density** | Not present | ≤0.700 |
| **Odour** | The gas shall have been treated with a stenching agent to ensure that it has a distinctive and characteristic odour which shall remain distinctive and characteristic when the gas is mixed with gas which has not been so treated, except that this paragraph shall not apply where the gas is at a pressure of above 7 barg. | |
| **Pressure** | The gas shall be at a suitable pressure to ensure the safe operation of any gas appliance (within the meaning of Regulation 14(1) of the 1998 Regulations) which a consumer could reasonably be expected to operate. | |
| **Part II Requirements for gas conveyed to prevent a supply emergency** | | |
| **Wobbe Index** | ≤52.85 $MJ/m^3$ | Removed |
| | ≥46.50 $MJ/m^3$ | Removed |
| **Incomplete combustion factor** | ≤1.49 | Removed |

# Gas Quality Standard Consultation

- A draft of IGEM standard IGEM/GL/10 Gas Quality Specification for Conveyance of Group H Gases of the Second Gas Family is available for comment
- https://www.igem.org.uk/technical-services/comment-on-draft-standards/
- Comment period ends on 30th July

# Agenda

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# Dutton Revisited

Dave Lander, Dave Lander Consulting

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# Overview

- **UK approach to natural gas interchangeability**
  - Historical context
  - Appliances generally installed at the time
- **Description of the “Dutton” method**
  - The “equivalent mixture”
  - Incomplete Combustion Factor, Lift index and Sooting Index

# Overview

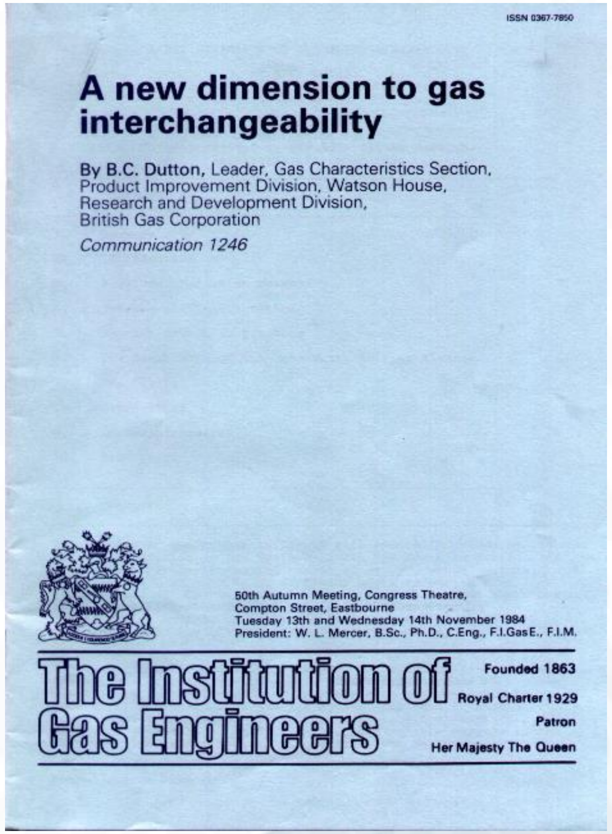
- **Choice of Limit values**
  - Then
  - Now
- **The second of the two interchangeability parameters**
  - Dutton/GSMR interchangeability diagram
  - Wobbe index – relative density diagram

# Historical Context

- **1970s, 1980s**
- **Southern North Sea fields**
  - Anticipated decline
  - To be replaced by other sources (different, more variable)
  - And, eventually, manufactured SNGs
- **Drivers for interchangeability method**
  - Safety: domestic appliances have limited tolerance to variation in combustion characteristics, so gas has to suit the appliance – not vice versa
  - Commercial: reduced gas treatment costs

# British Gas Corporation's approach

- **B.C.Dutton**
  - Watson House, Research and Development Division
  - IGE Communication 1246 (1984)
- **New Approach**
  - Appliance effects and flame phenomena related to gas composition
  - Previous approach related to calculated functions (usually related to burning velocity)
  - Consistent with developments in gas analysis
- **Implemented (<u>in simplified form</u>) into the Gas Safety (Management) Regulations 1996**



ISSN 0367-7850

A new dimension to gas interchangeability

By B.C. Dutton, Leader, Gas Characteristics Section, Product Improvement Division, Watson House, Research and Development Division, British Gas Corporation

*Communication 1246*

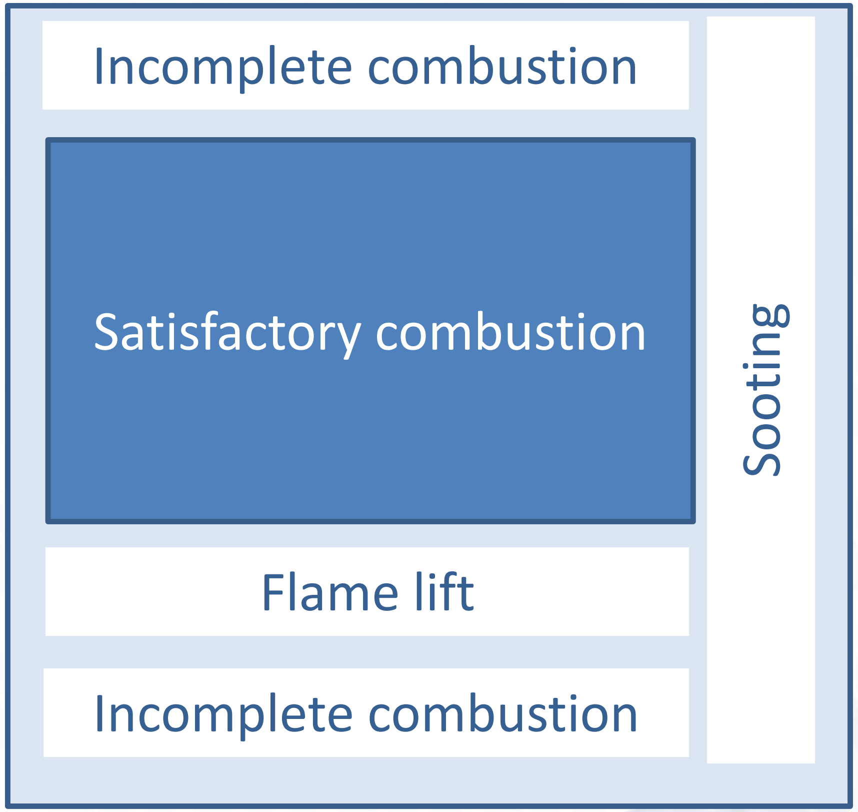
50th Autumn Meeting, Congress Theatre, Compton Street, Eastbourne
Tuesday 13th and Wednesday 14th November 1984
President: W. L. Mercer, B.Sc., Ph.D., C.Eng., F.I.GasE., F.I.M.

The Institution of Gas Engineers

Founded 1863
Royal Charter 1929
Patron
Her Majesty The Queen

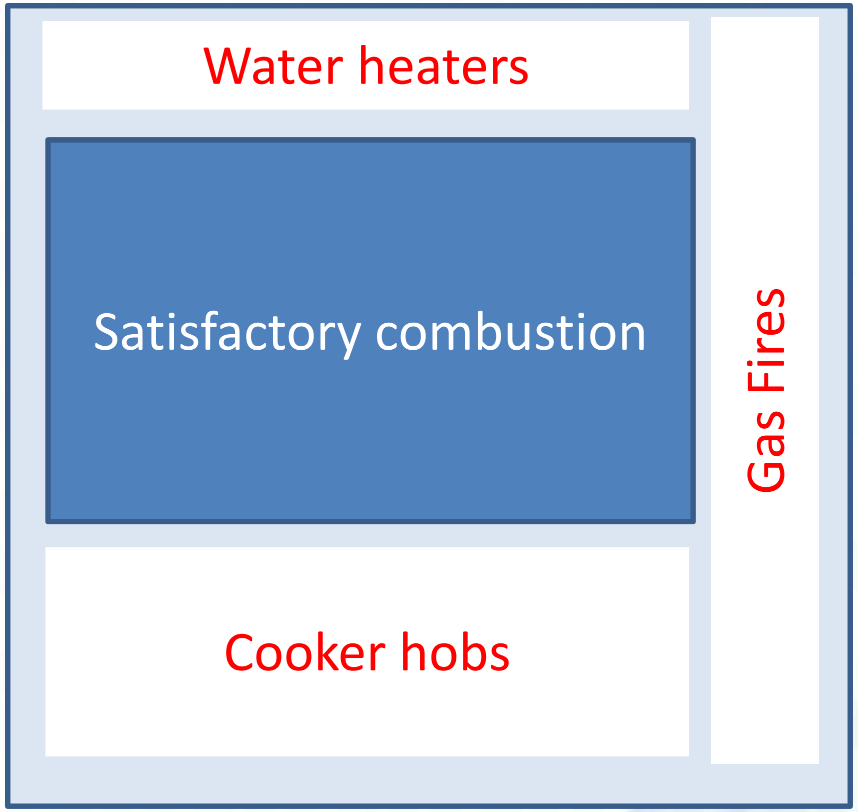
# The Dutton approach

- **Poor combustion indicators**
  - Incomplete combustion
    - generally seen at high WI and at low WI
  - Flame lift
    - generally seen at low WI
  - Sooting
    - generally seen with higher density gases with higher hydrocarbons



# The Dutton approach

- **Poor combustion indicators**
  - Incomplete combustion
  - Flame lift
  - Sooting
- **Appliances selected**
  - Instantaneous water heaters
  - Cooker hobs
  - Radiant gas fires

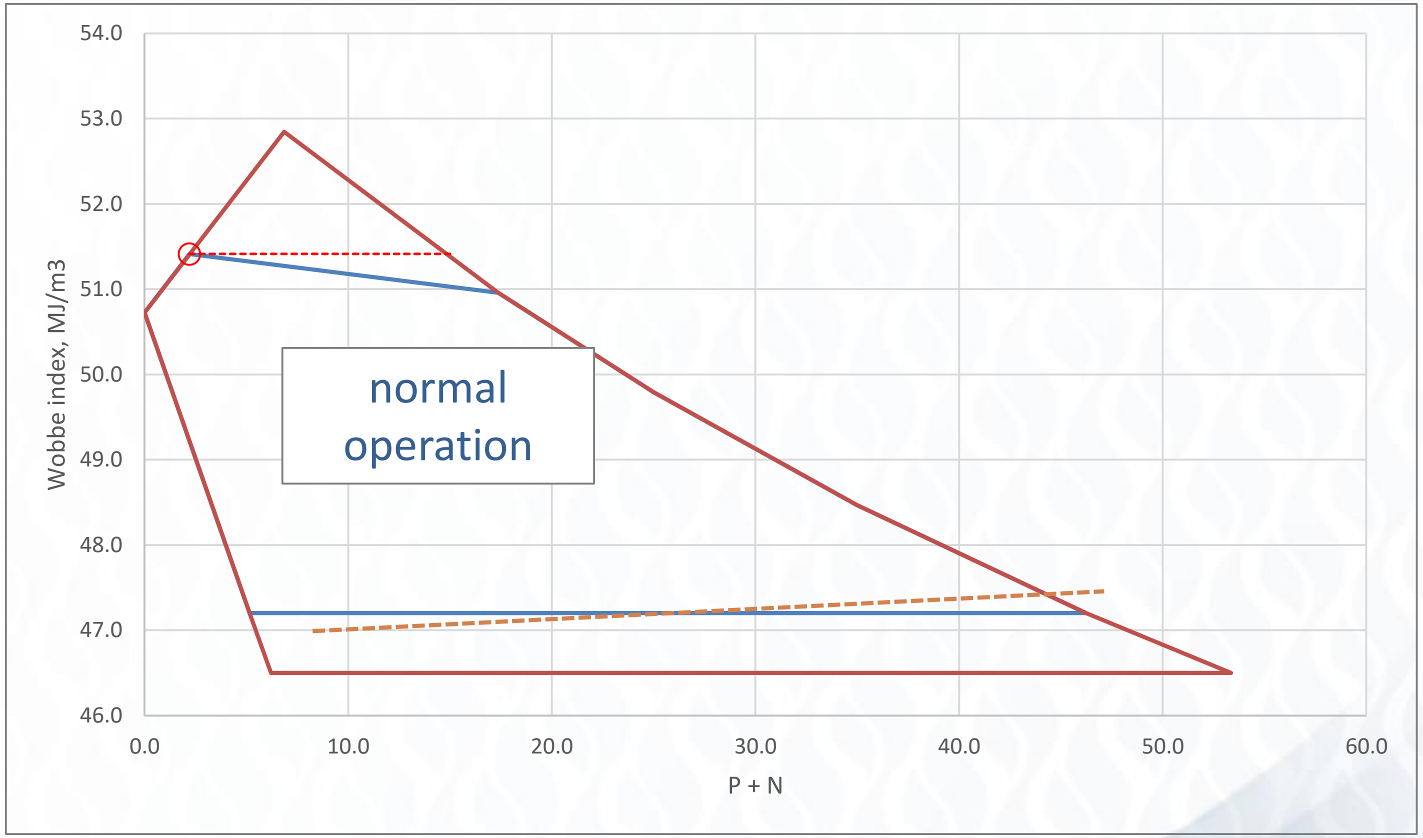


# The Dutton approach

- **First step: simplification of the gas composition**
  - Convert to the equivalent mixture of methane, propane, nitrogen (and hydrogen)
  - Hydrocarbons replaced with equivalent amount of methane and propane
  - Nitrogen adjusted to preserve the Wobbe index of the original gas mixture
- **Calculate three interchangeability parameters from the composition of the equivalent mixture**
  - Incomplete Combustion Factor (ICF)
  - Lift Index (LI)
  - Sooting Index (SI)
- **Compare all three against suitable limiting values (for normal and emergency use)**

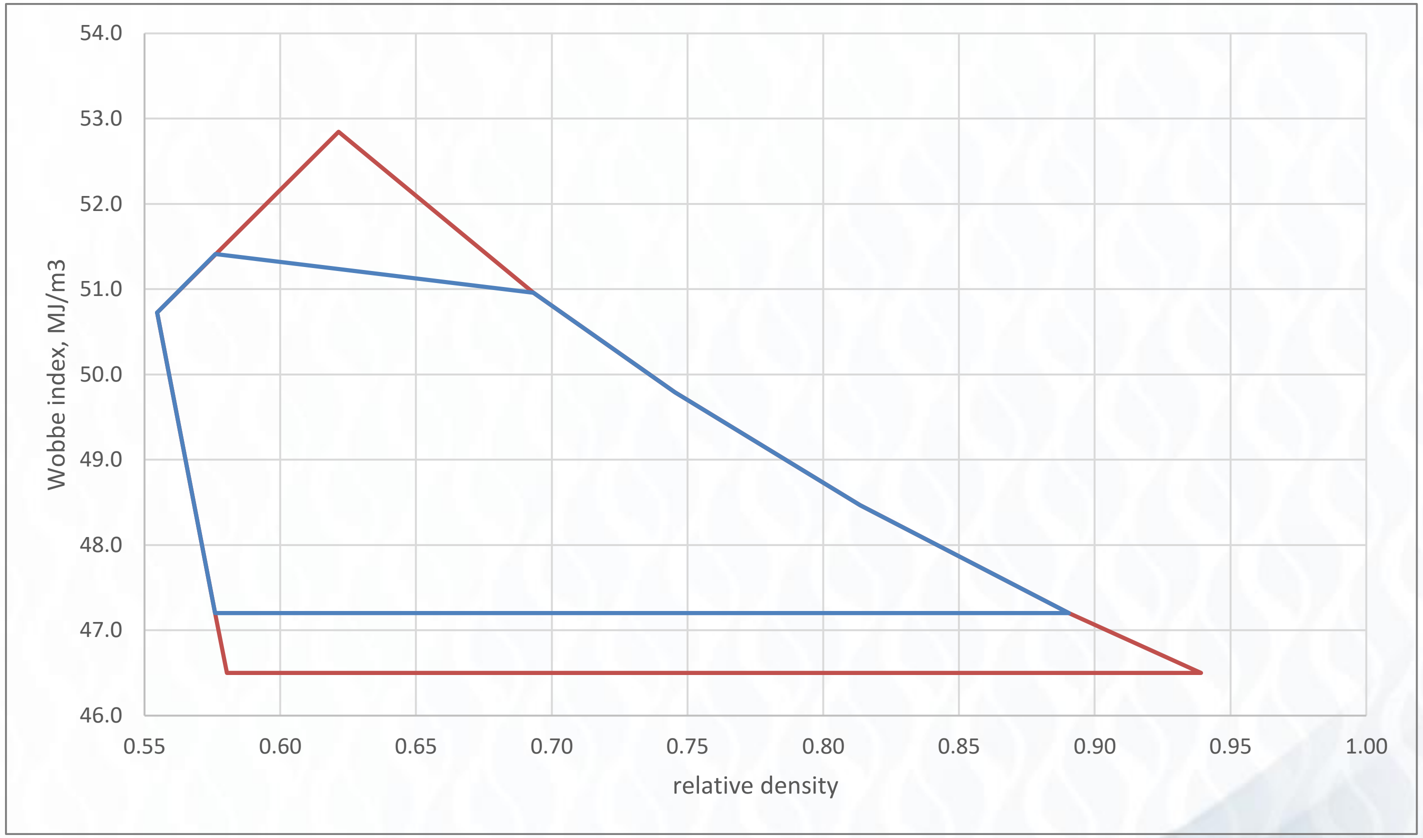
# The Dutton diagram(as simplified by the GSMR)

- **P + N**
  - sum of nitrogen and propane in the equivalent mixture
- **Upper limit**
  - For normal operation is at ICF=0.48
  - WI = 51.41 MJ/m3
- **Lower limit for normal operation**
  - WI = 47.2 MJ/$m^3$
  - Set for heat service limitations and not flame lift considerations
- **Lower emergency limit**
  - WI = 46.5 MJ/$m^3$
  - GSMR simplification of LI = 1.16 (dotted line)



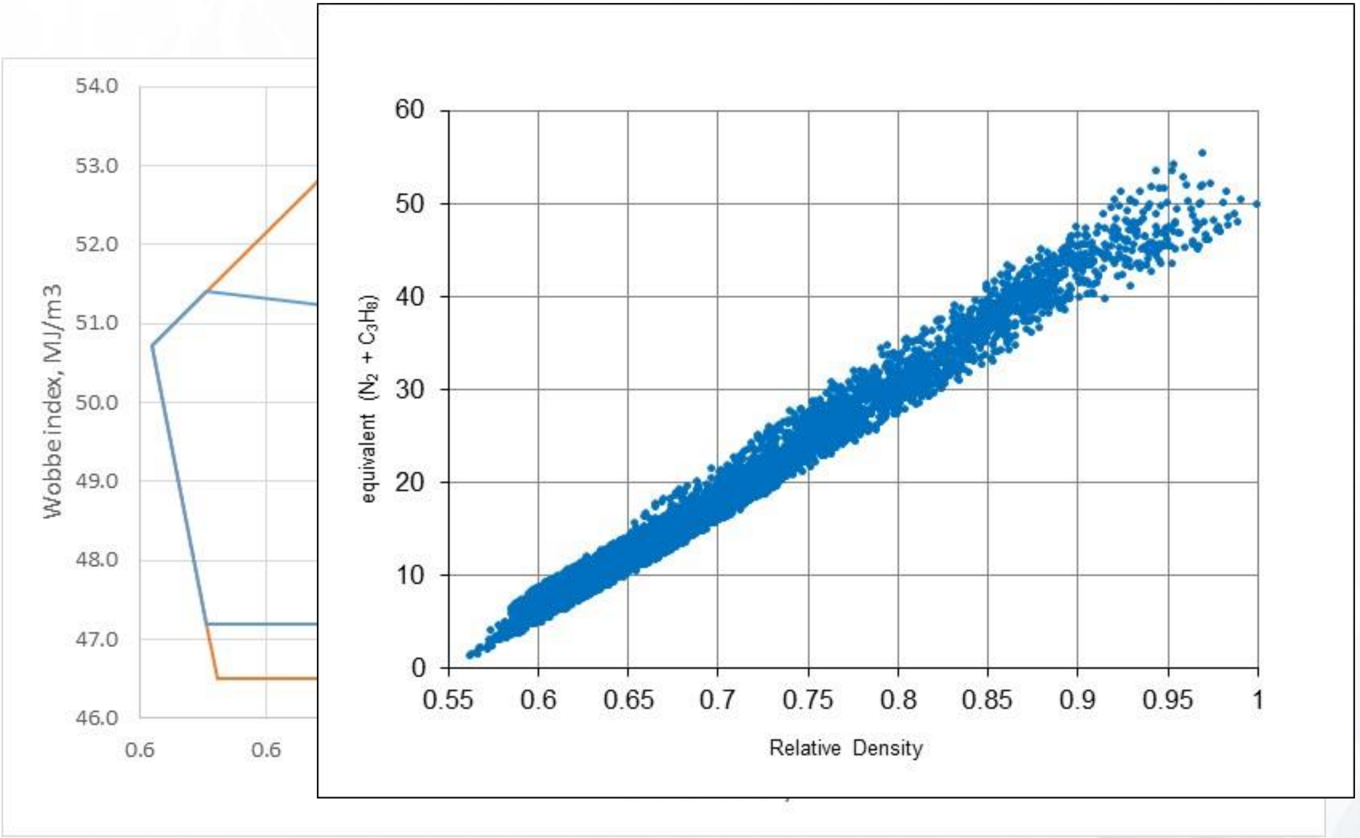
# Proposed revisions of the Dutton approach

- **Relative density as the secondary parameter**
  - Consistent with practice elsewhere (Europe, Western Australia, US)
  - P+N is not an intuitive gas property parameter



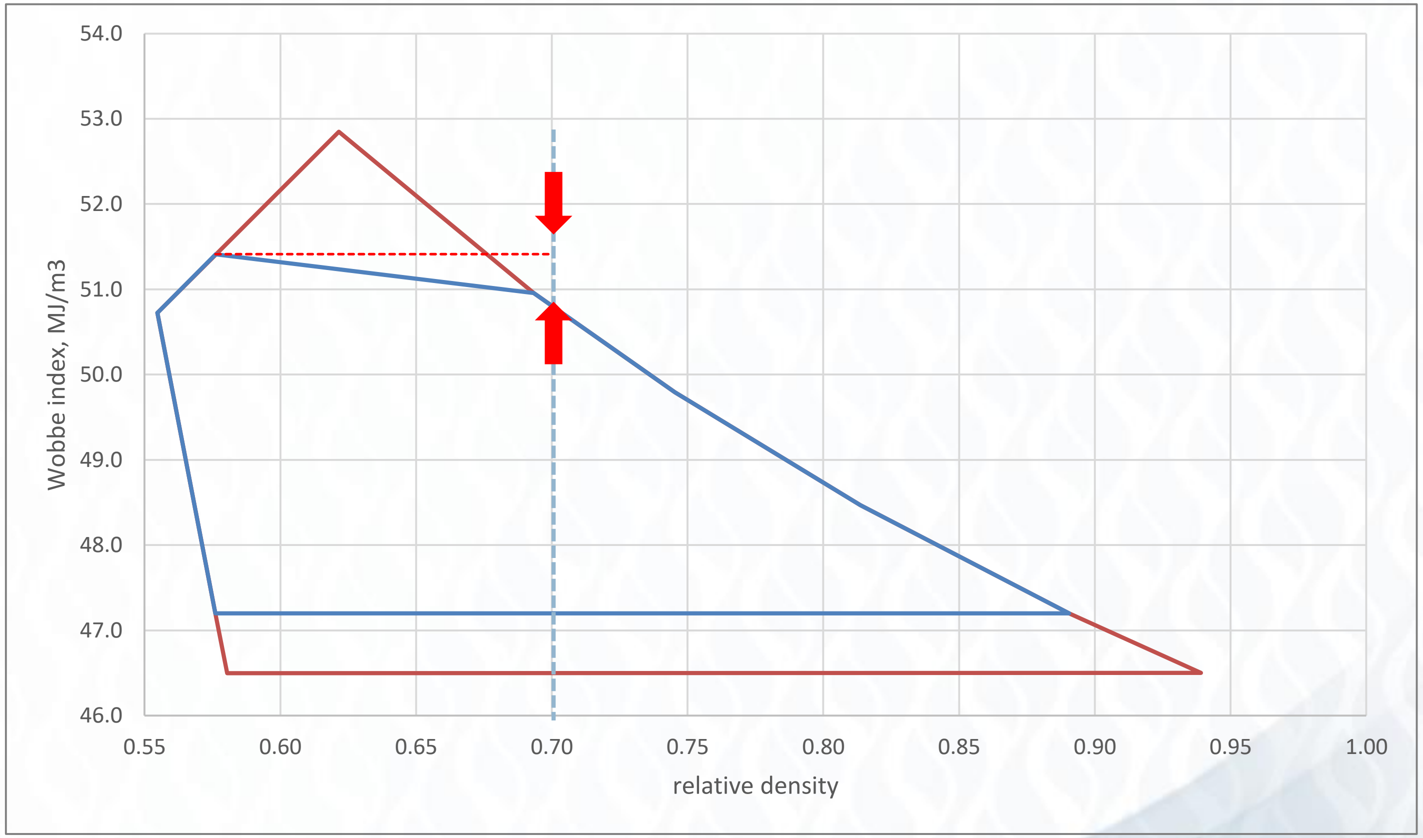
# Proposed revisions of the Dutton approach

- **Relative density as the secondary parameter**
  - Consistent with practice elsewhere (Europe, Western Australia, US)
  - P+N is not an intuitive gas property parameter
  - RD is a good proxy for P+N



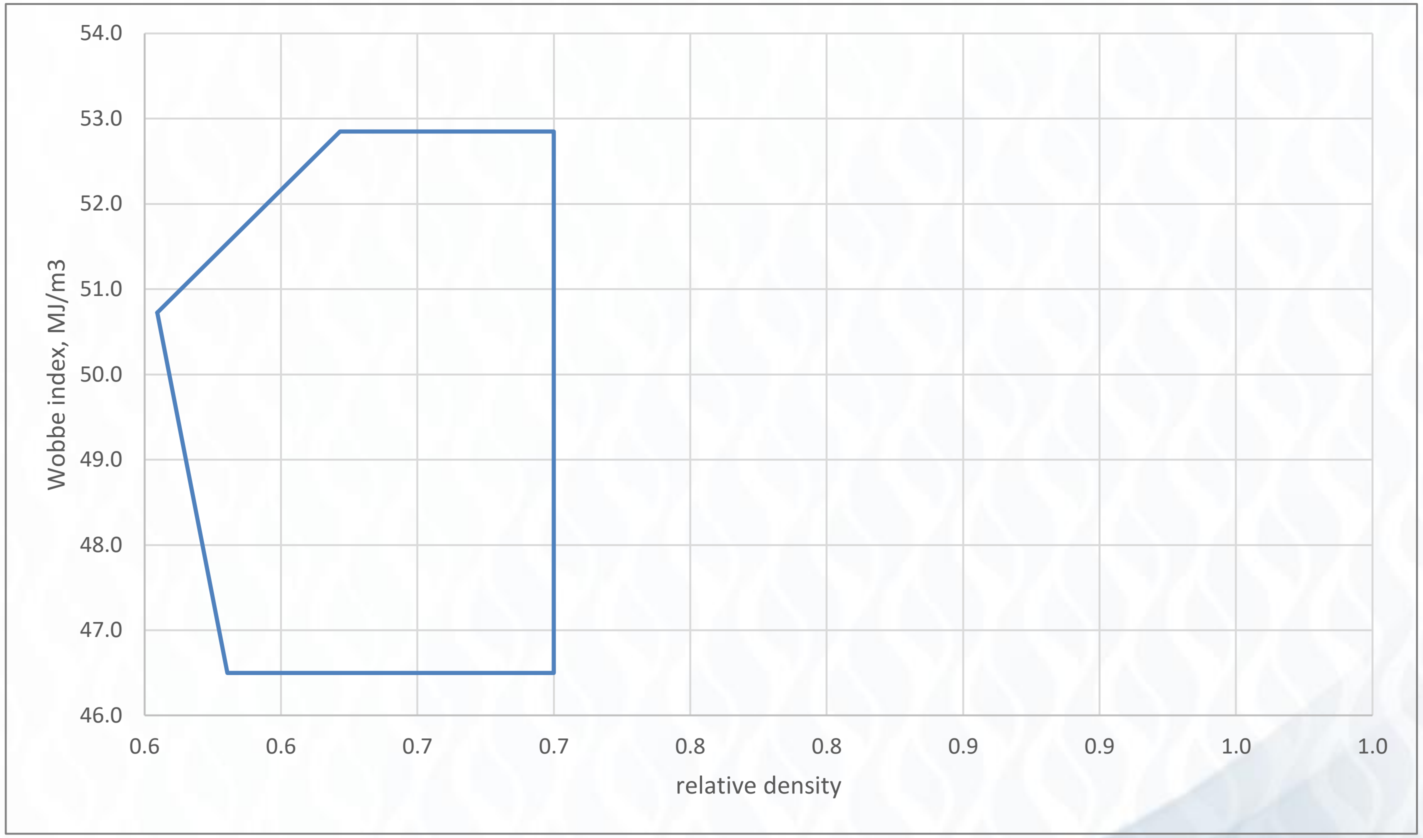
# Proposed revisions of the Dutton approach

- **Relative density as the secondary parameter**
- **Limit value of 0.7**
  - Consistent with EN12676 (which was adopted as a BS)
  - SI limit of 0.6 not safety-related
  - Limits "drop in WI"



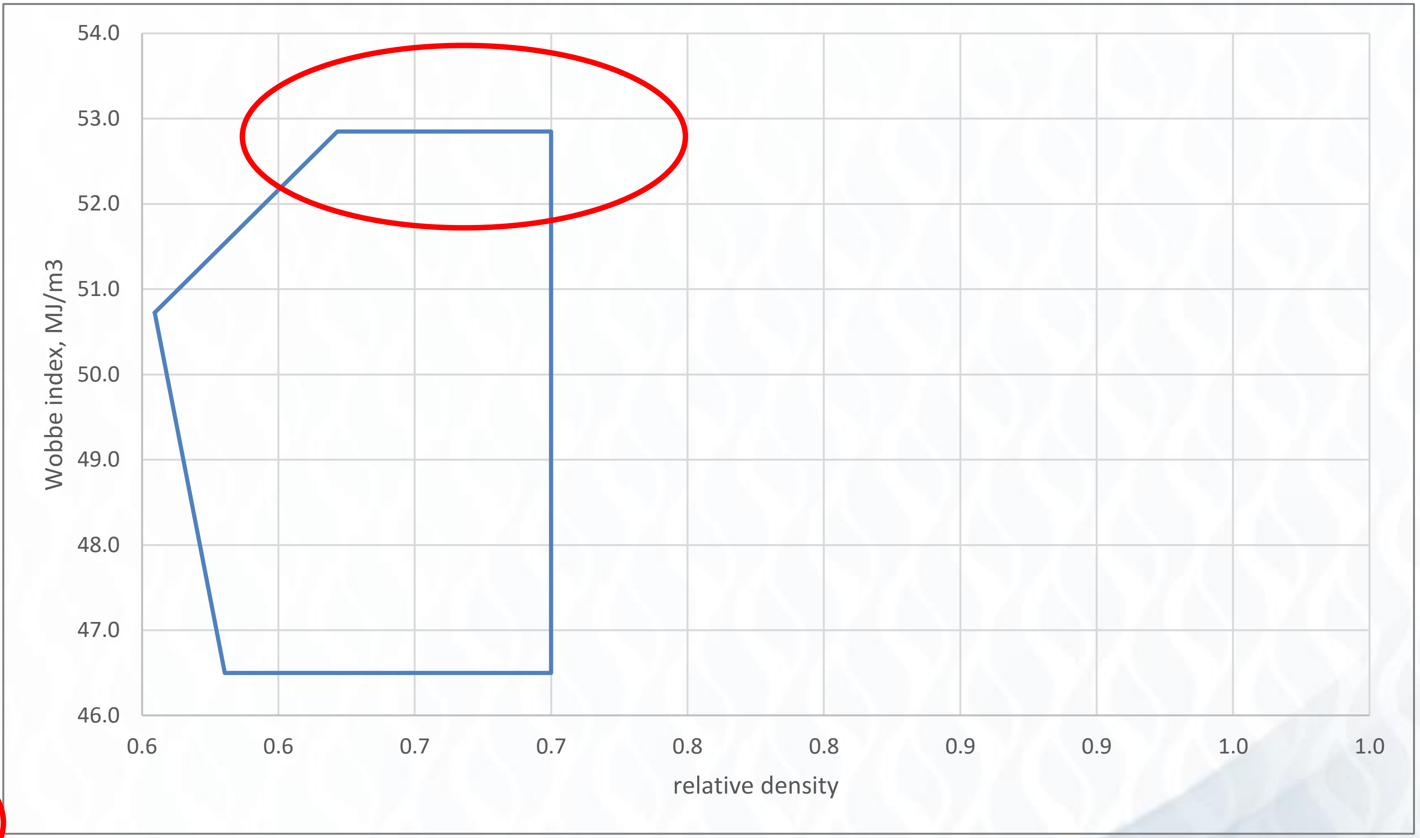
# Proposed revisions of the Dutton approach

- **Wobbe index as the primary limiting parameter instead of ICF**
  - Upper limit: ICF lines are close to horizontal over the proposed RD range (especially if upper limit is increased)
  - Consistent with practice elsewhere (Europe, Western Australia, US)



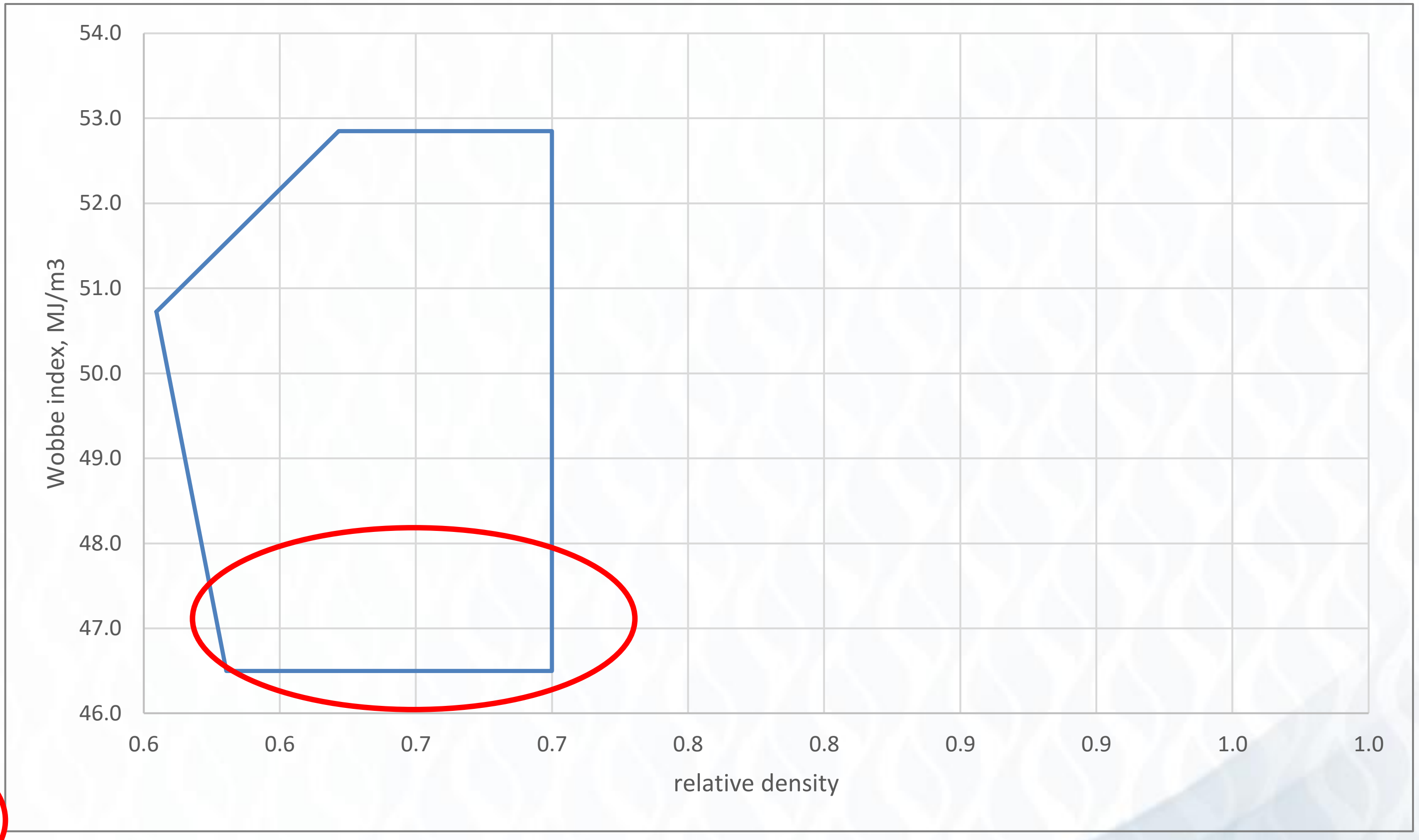
# Proposed revisions of the Dutton approach

- **Wobbe index as the primary limiting parameter instead of ICF**
  - Upper limit: ICF lines are close to horizontal over the proposed RD range (especially if upper limit is increased)
  - Consistent with practice elsewhere (Europe, Western Australia, US)
  - Upper limit value of 52.85 MJ/m$^3$



# Proposed revisions of the Dutton approach

- **Wobbe index as the primary limiting parameter instead of ICF**
  - Upper limit: ICF lines are close to horizontal over the proposed RD range (especially if upper limit is increased)
  - Consistent with practice elsewhere (Europe, Western Australia, US)
  - Lower limit value of 46.5 MJ/m$^3$



# Why set WI upper limit to 52.85 $MJ/m^3$?

- **Main outcome from the OGM project**
  - Domestic and small commercial appliances, correctly installed serviced and operated, can safely burn gas of WI up to 54.7 $MJ/m^3$
  - Consistent with the main findings of GASQUAL studies
  - Consistent with earlier testing in support of the UK tripartite gas quality study

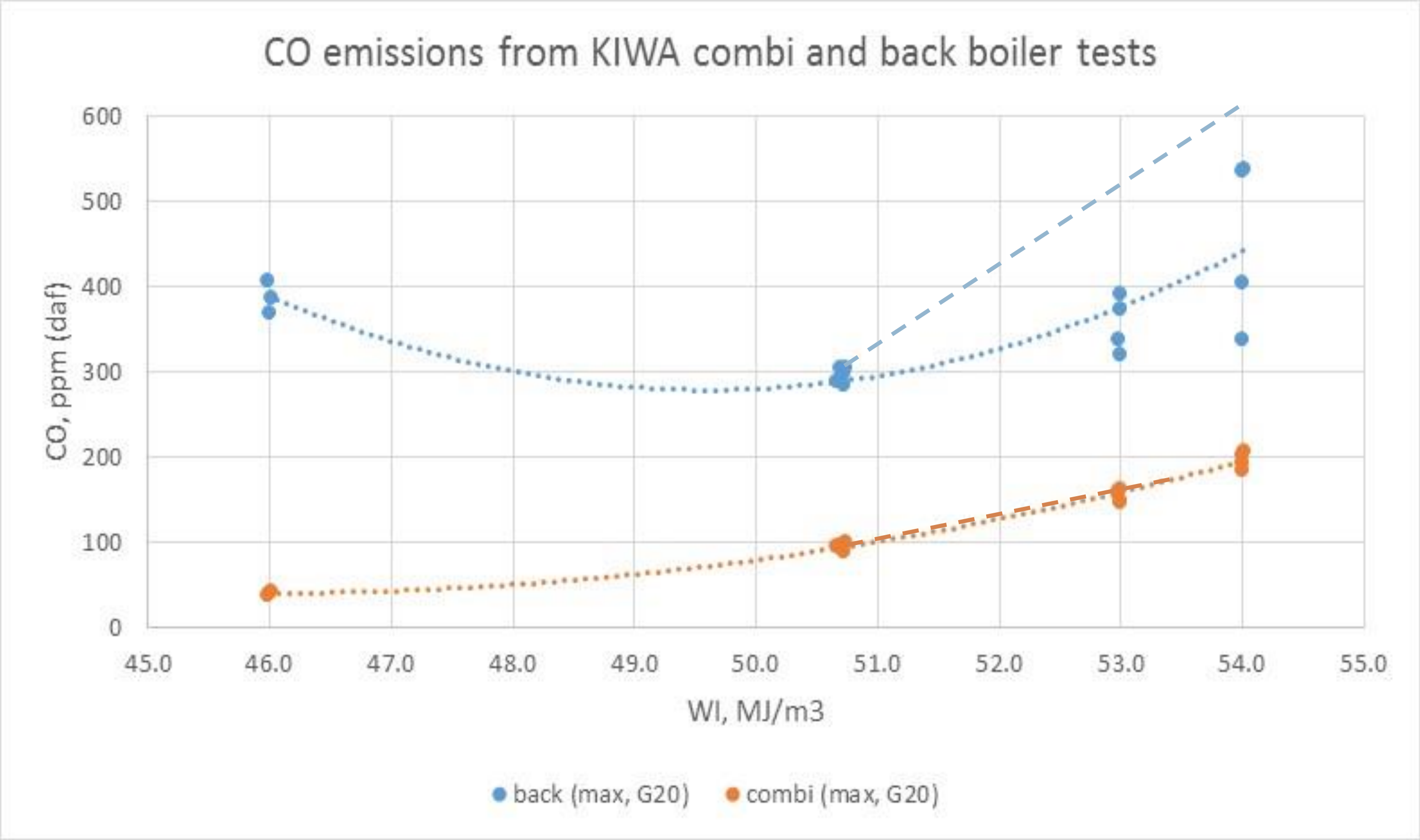
# Why set WI upper limit to 52.85 MJ/m³?

- **Main outcome from the OGM project**

- **Origins of Dutton's ICF**
  - Number of times the $CO/CO_2$ ratio on the reference gas has to be doubled to give that of the test gas $$\frac{CO/CO_{2\,Test}}{CO/CO_{2\,Ref}} = 2^{ICF}$$
  - Appliance chosen for determining incomplete combustion limit was the instantaneous water heater (often unflued)
    - Typically $CO/CO_2$ ratio doubled every 1.5 MJ/m³
    - Arguably today's equivalent appliance is the central heating / hot water boiler
    - Typically $CO/CO_2$ ratio doubles every 3 MJ/m³
    - As a result the calculated ICF does not correspond to today's appliance performance

# Why set WI upper limit to 52.85 MJ/m$^3$?

- **KIWA testing**
  - combi-boiler and back-boiler
  - CO levels double at least every 3 MJ/m$^3$

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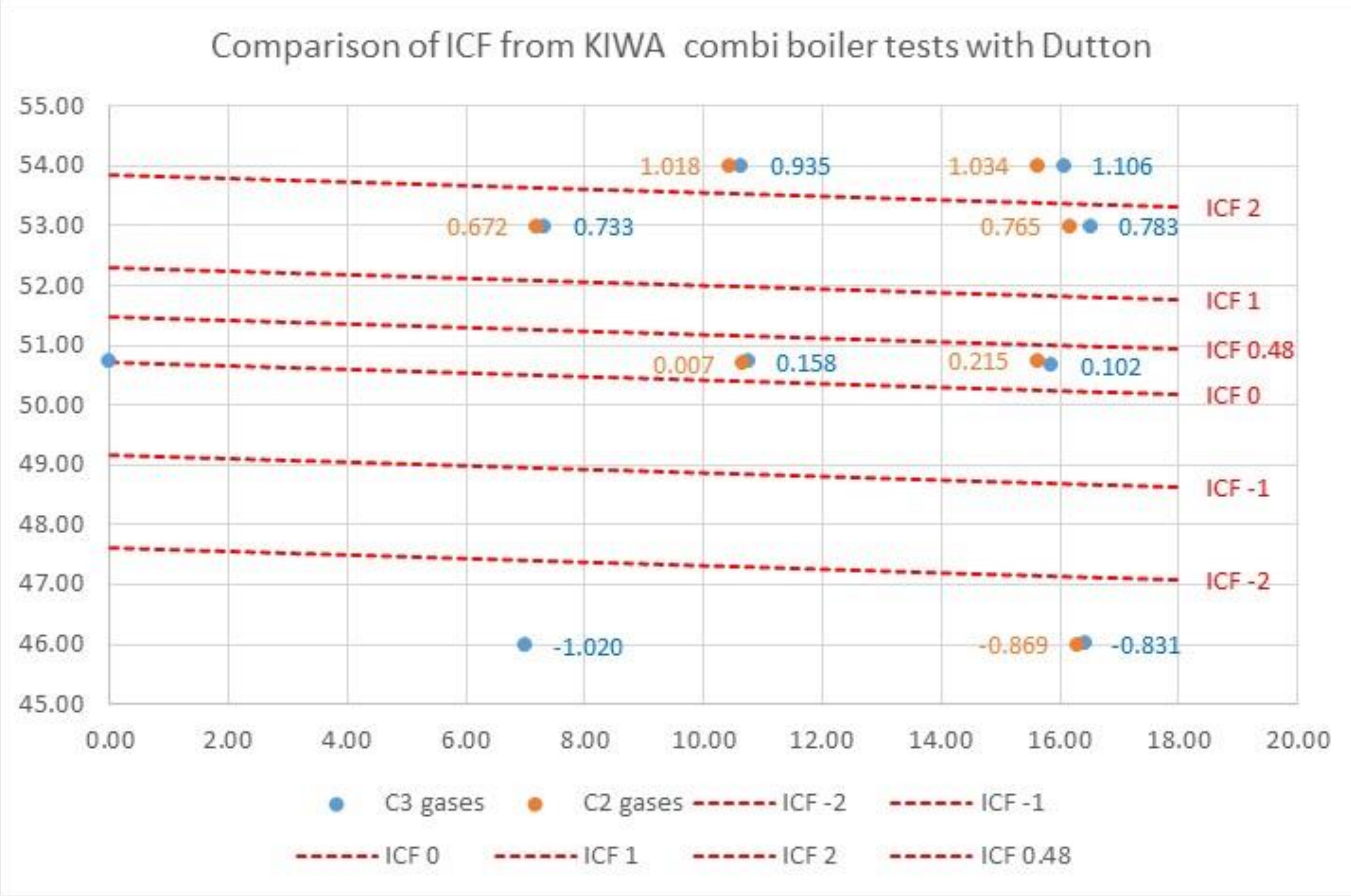
# Why set WI upper limit to 52.85 MJ/m³?

- **KIWA testing**
  - combi-boiler and back-boiler
- **Dutton's ICF formula**

$$ICF = \frac{WN - 50.73 + 0.03PN}{1.56} - 0.01H_2$$

  - under-predicts ICF for today's appliances



# Why set WI upper limit to 52.85 MJ/m$^3$?

- **Main outcome from the OGM project**
- **Origins of Dutton's ICF**

- **Origins of Dutton's limit value for ICF**
  - Traditionally, rich gas limit was set at 105% of the reference gas limit
    - Should have been 53.3 MJ/m$^3$
    - (Although the IGEM communication cites this as the "wet gas" value of 52.1 MJ/m$^3$)
    - Lowered to 51.2 MJ/m$^3$ following 1978 survey of appliances
  - ICF = 0.48 corresponds approximately to this WI
  - Almost certainly corresponds to performance of converted towns gas appliances (conversion lasted from April 1968 – September 1977)

# Why set WI lower limit to 46.5 MJ/m$^3$?

- **Today's testing shows CO emissions not a major issue**
  - And was not a concern when Dutton considered low limit values
- **46.5 MJ/m$^3$ corresponds to Dutton's flame lift limit (LI=1.16)**
- **Existing lower limit (47.2 MJ/m$^3$) was set as a heat service limit and was not safety-related**
  - Instantaneous water heaters
  - Today's combi boiler performance

# Summary

- **IGEM standard proposes adoption of limits based solely on Wobbe index and relative density**
  - Use of ICF and P+N adds complexity without material advantage
  - ICF calculated from the original Dutton relationship under-predicts performance of today's appliances
  - Consistency with practice in other countries
- **Increase in the upper Wobbe index limit to 52.85 $MJ/m^3$**
  - More reflective of the performance of today's appliances
  - Allows safety margin of 1.85 $MJ/m^3$ over in-premises testing in OGM project
- **Decrease in the lower Wobbe index limit to 46.5 $MJ/m^3$**
  - CO not an issue
  - Dutton's flame lift limit
  - Existing lower limit was set on the basis of heat service

# Dutton Revisited

## Q&A

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# Widening the Wobbe Index: Domestic Customers Case for Change

Dr Martin Brown, DNV GL

# Overview

- **Wobbe Index and combustion**
  - Why does Wobbe Index matter?
  - The link between Wobbe Index and "Excess Air"
- **Domestic appliances – burner operation**
  - Burner types and carbon monoxide emissions profiles
- **Practical test results**
  - DTI
  - Gasqual
  - SGN "Opening up the Gas Market" (OGM)

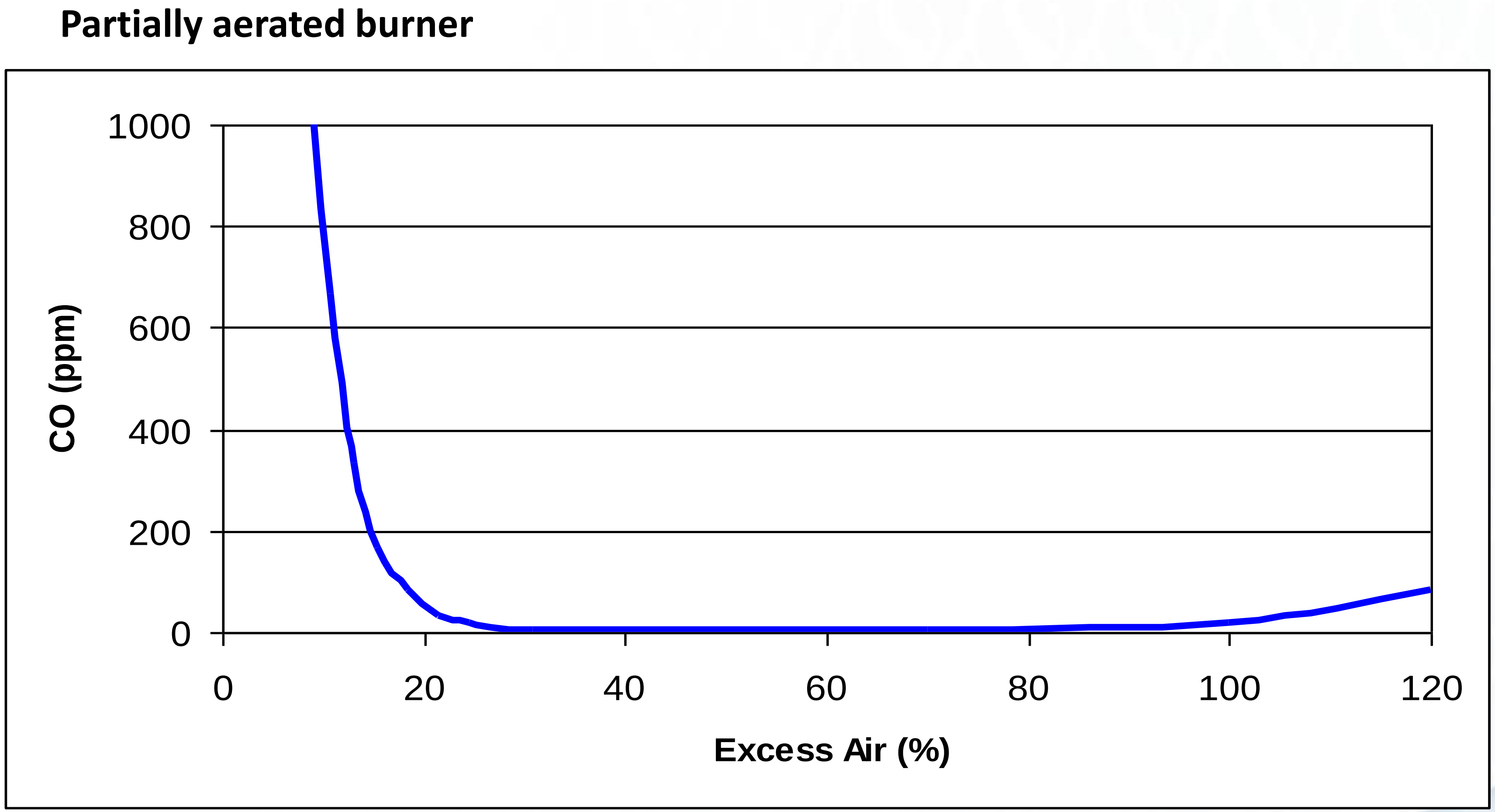
# Wobbe Index and combustion

- One of the ways in which gas quality is measured and discussed is by the Wobbe Index. This is used as the key parameter world-wide.

- The Wobbe Index is important for determining the interchangeability of different gases, and it is the heat rate at the burner (through the nozzle). Different gases with the same Wobbe Index should give the same overall burner performance.

- Wobbe Index has been shown to be inversely related to “Excess Air”. (*AGA White Paper on Natural Gas Interchangeability and Non-combustion End Use*)

# Burner combustion performance – Excess Air

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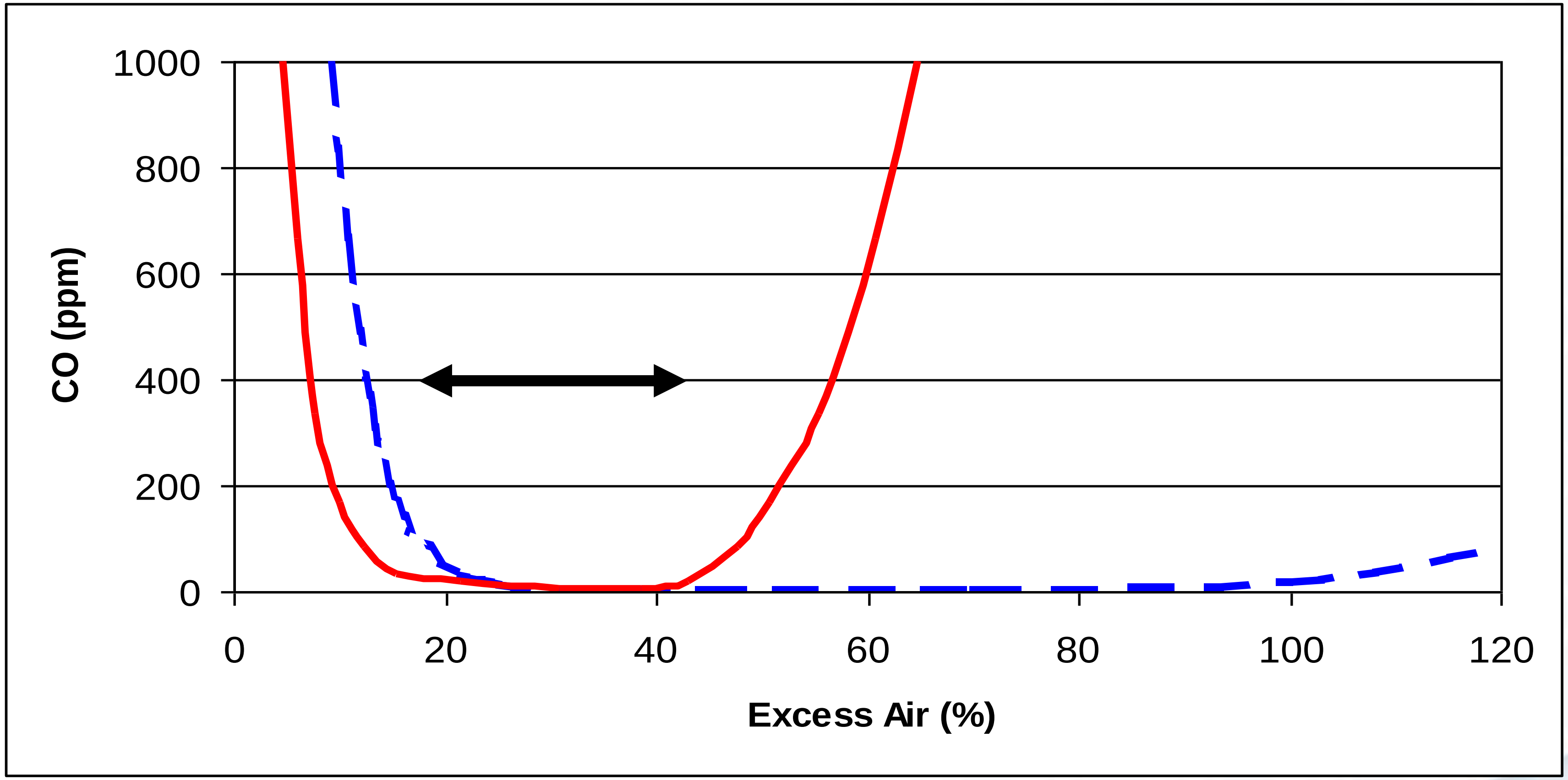
# Burner combustion performance – Excess Air

**Fully premixed burner**



# Detailed studies - impact of Wobbe Index

- DTI studies on Gas Quality
    - Pilot study (2004)
    - Main study (2006)
- EU Gasqual study (2011)
- SGN OGM (2013)

- More recently there's data from HyDeploy

Plus additional studies from USA, China, Korea and more

# DTI – pilot study 2004

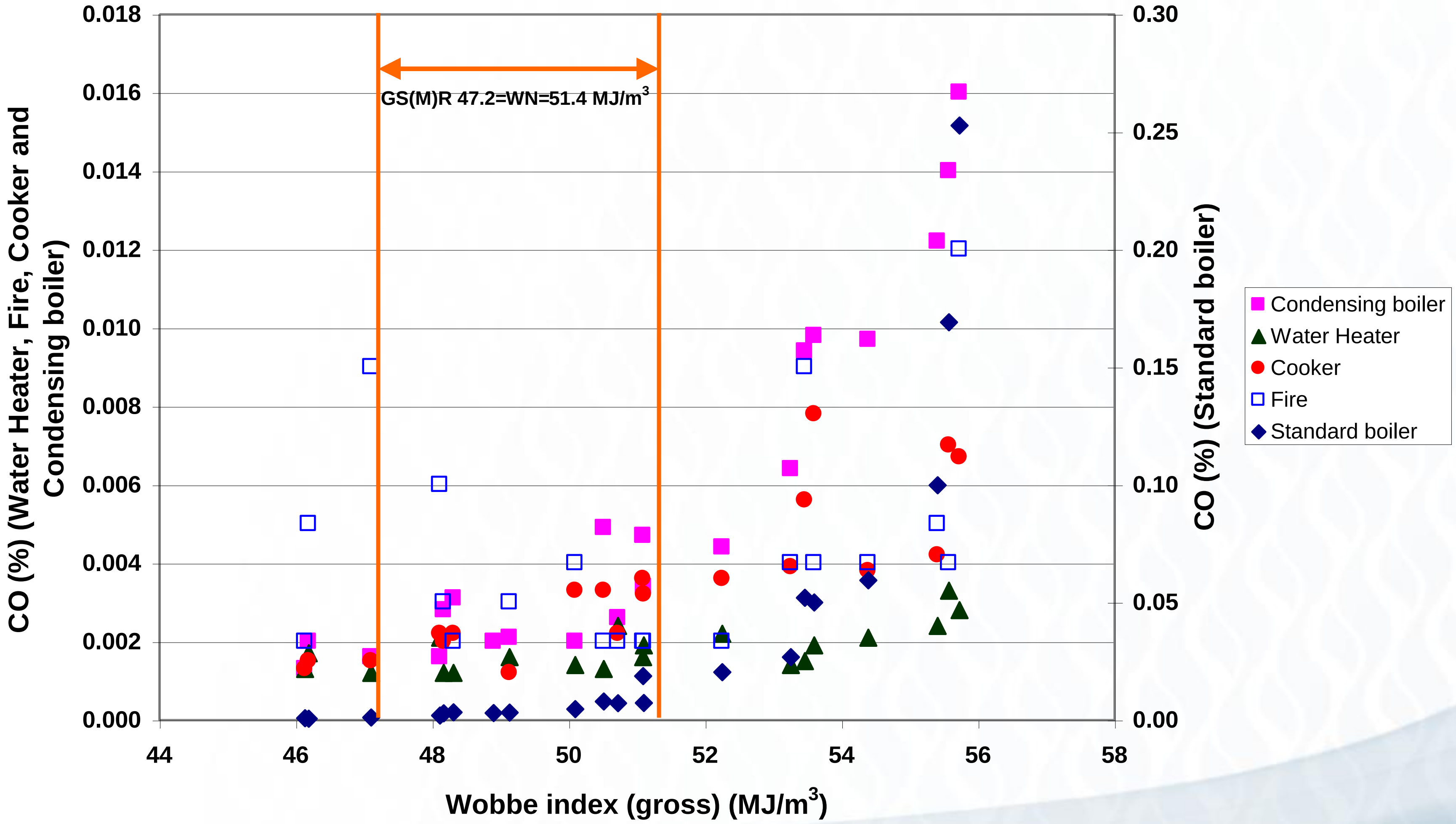
– Five (used) appliances tested

– Wobbe Index range from 46 to 56 $MJ/m^3$

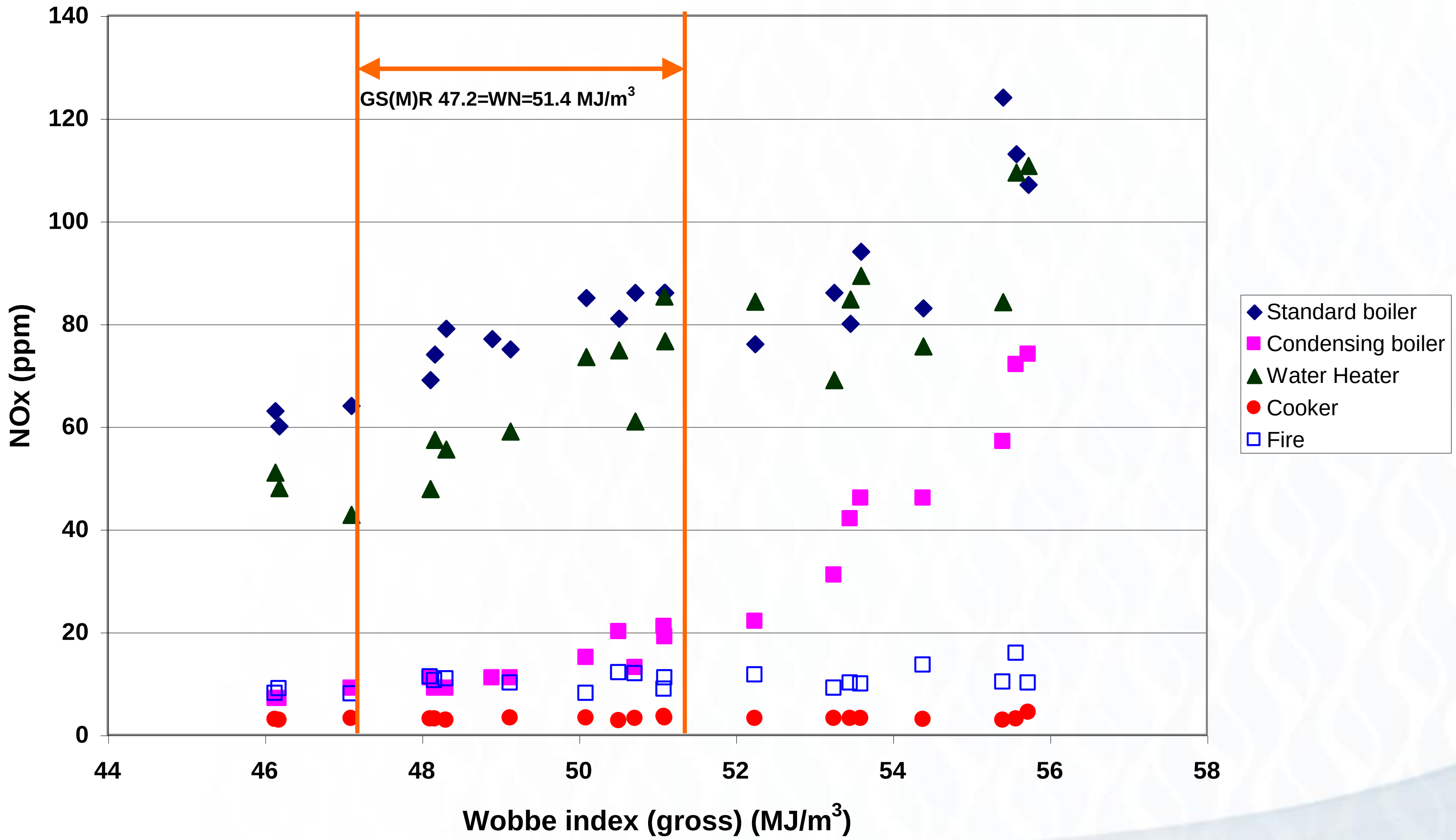
– Focus on CO and NOx emissions

– Calculated efficiency impact

# Carbon Monoxide (CO) Emissions – maximum heat input



# NOx Emissions – maximum heat input

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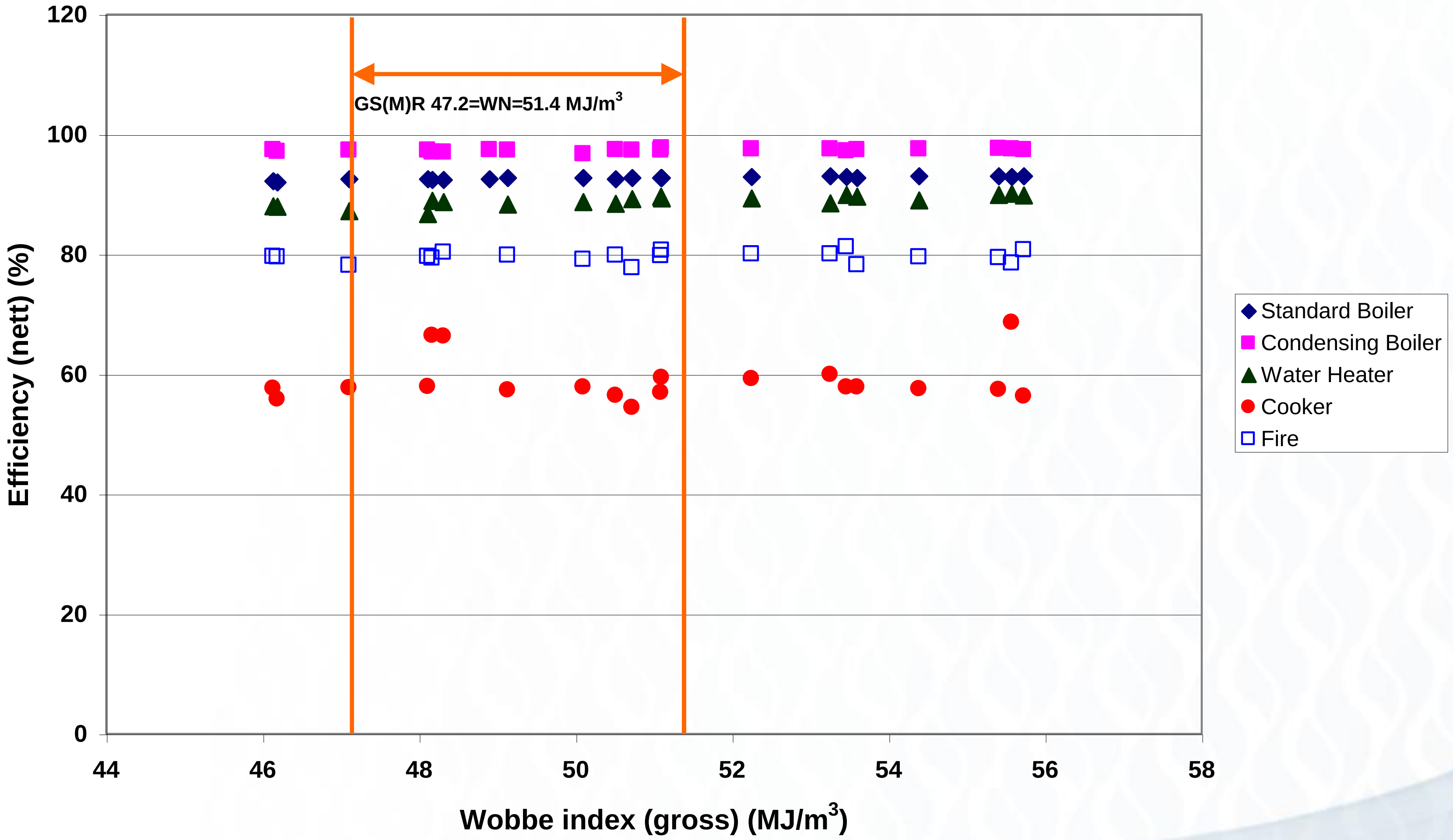
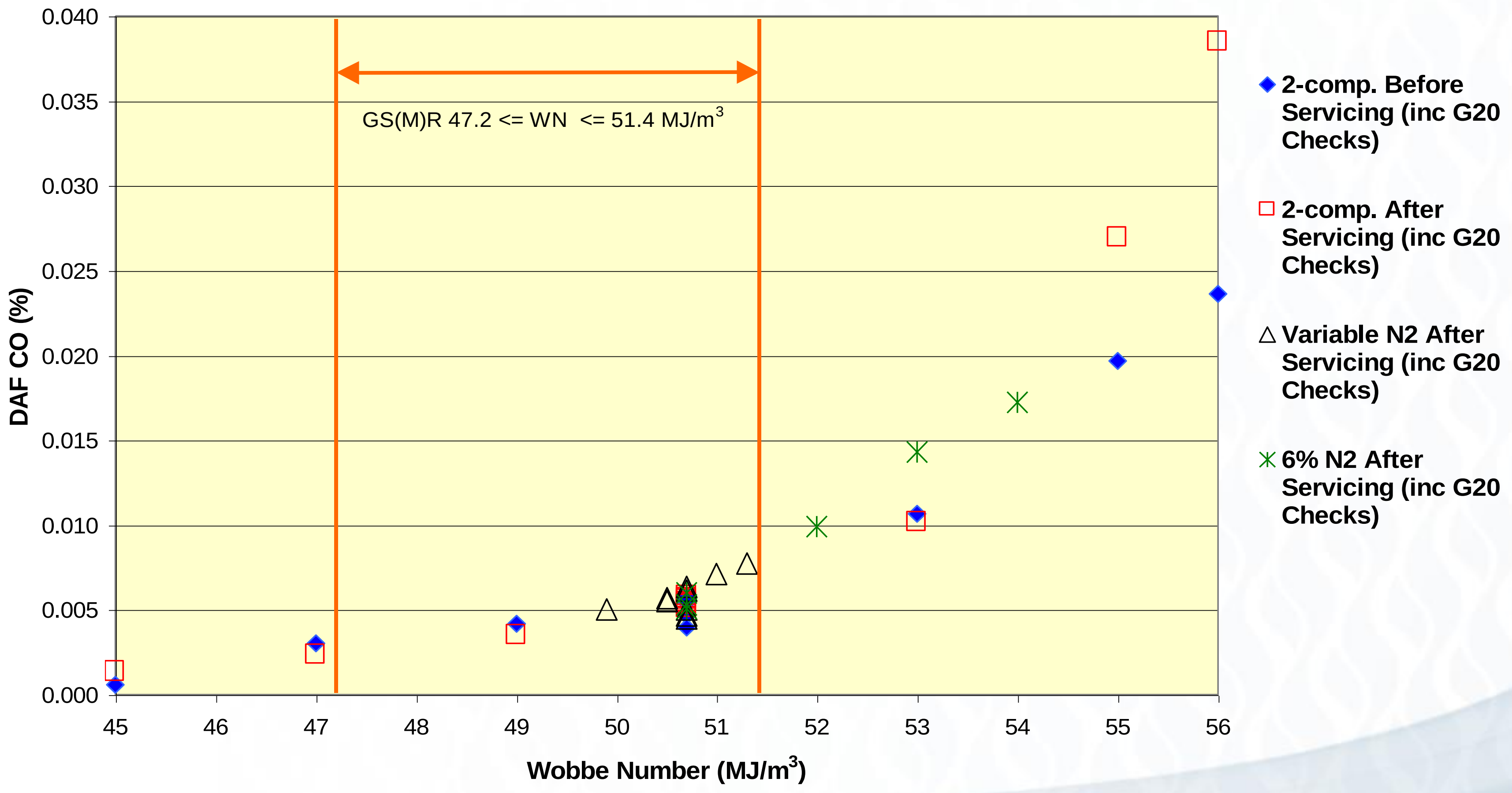
# Efficiency – maximum heat input



# DTI Gas quality exercise - 2006

- Twenty appliances tested – mostly used but some new ones
- Wobbe Index range from 45 to 56 $MJ/m^3$
- Focus on CO and NOx emissions
- Investigated impact on safety controls (FSD, ODS)
- Calculated efficiency impact
- Evaluated impact of appliance “servicing”

# Condensing boiler - Premix burner (high rate) - CO

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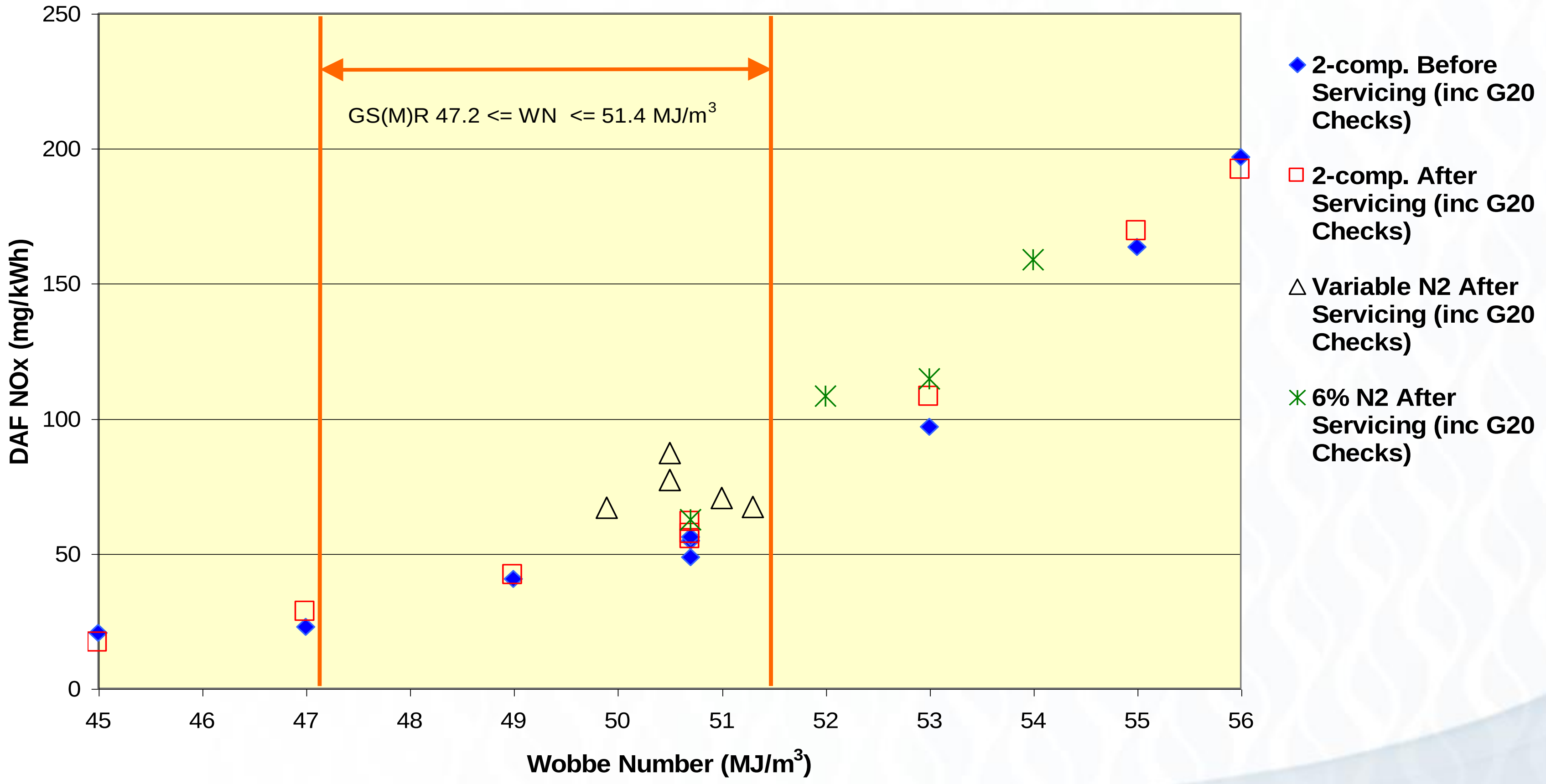
# Condensing boiler - Premix burner (high rate) - NOx

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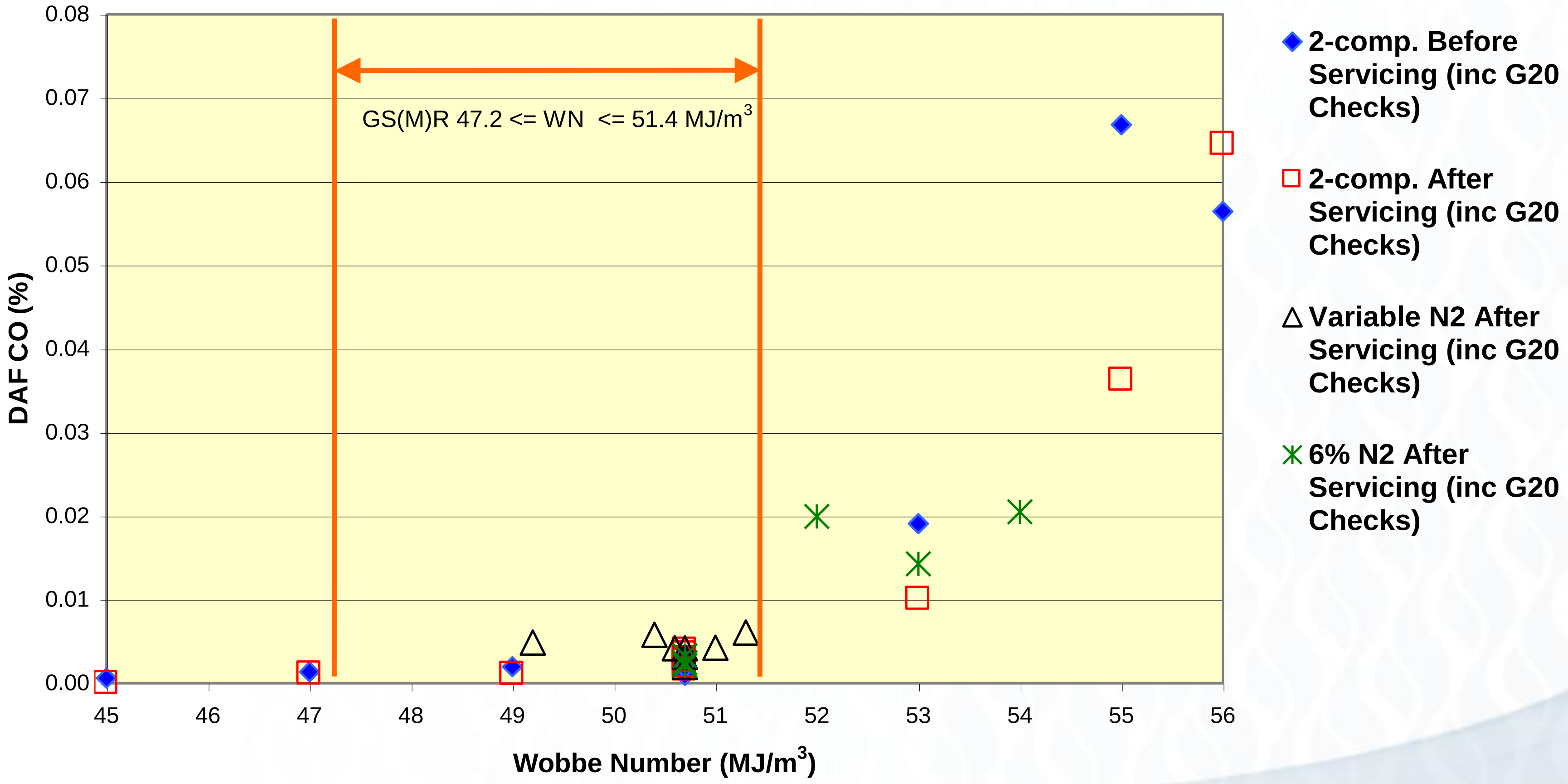
# Open flued boiler – high rate - CO

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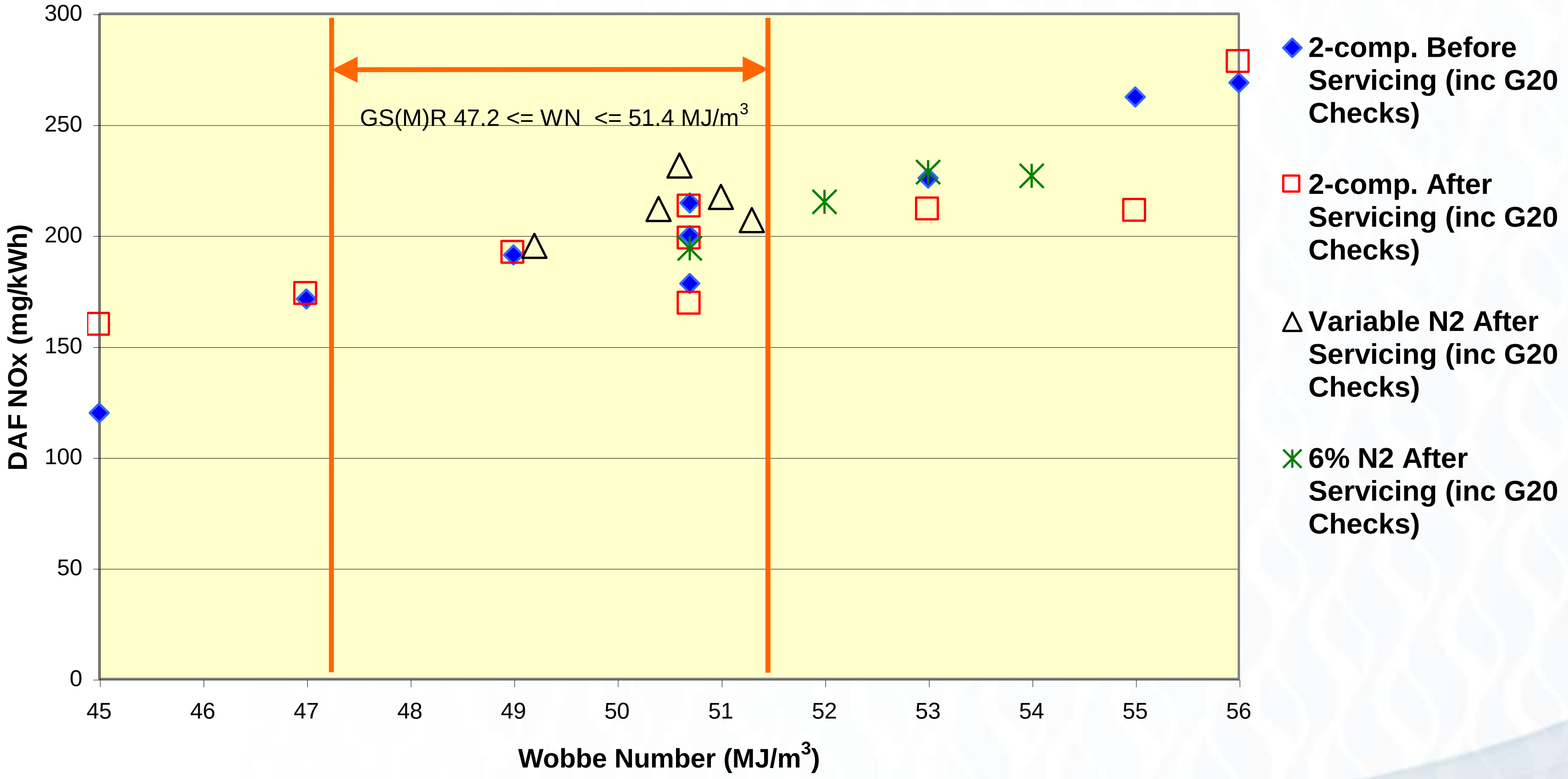
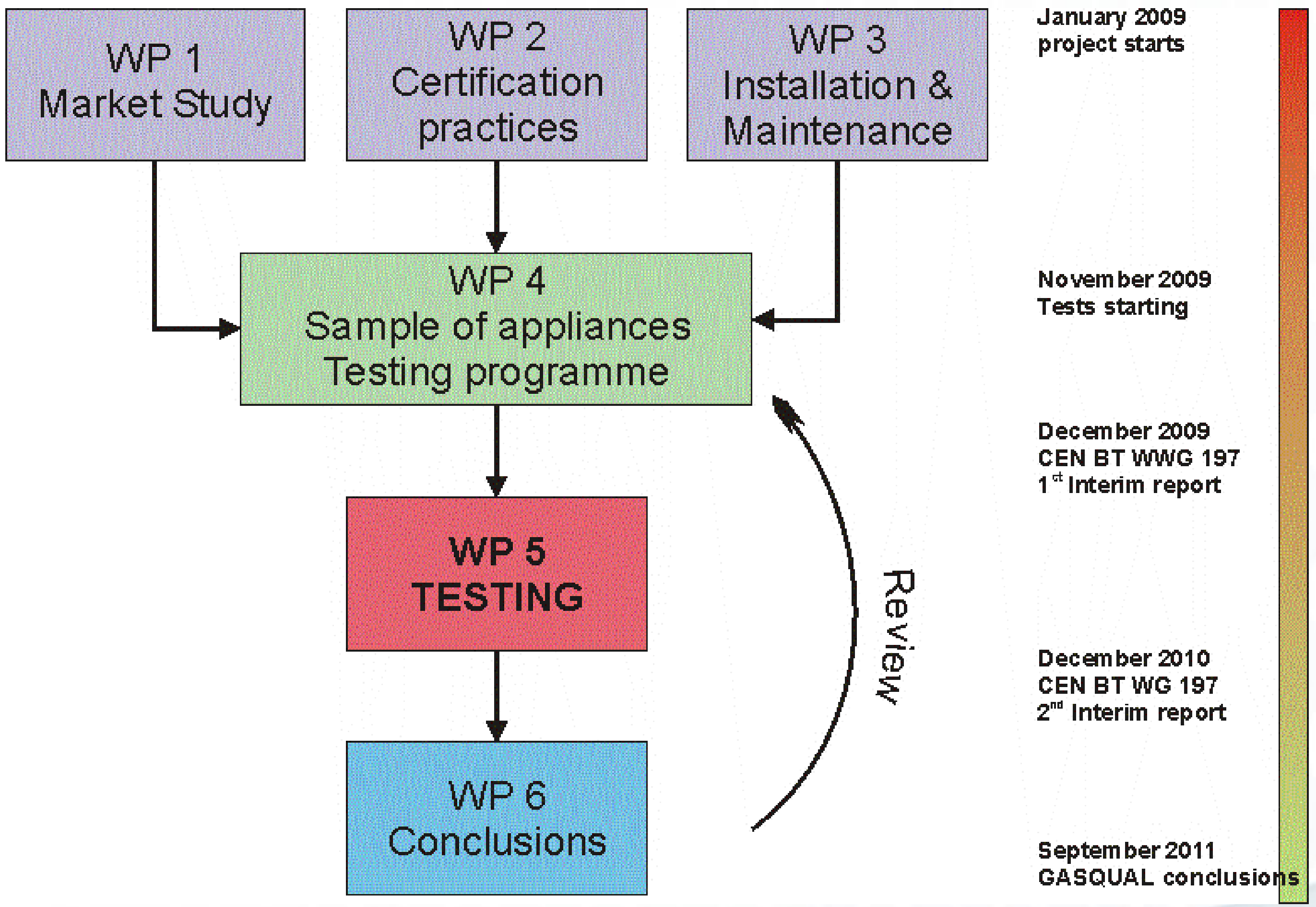
# Open flued boiler – high rate - NOx



# Gasqual - 2011

- **Objective:**
  – Evaluate impact of gas quality variation on safe operation, efficiency & environmental emissions of GAD (now GAR) appliances
    - 100 appliances tested
    - Wide gas quality range
    - 16 Companies/Organisations (from 9 Countries around EU)
    - 5 laboratories involved

# Organisation and timeline

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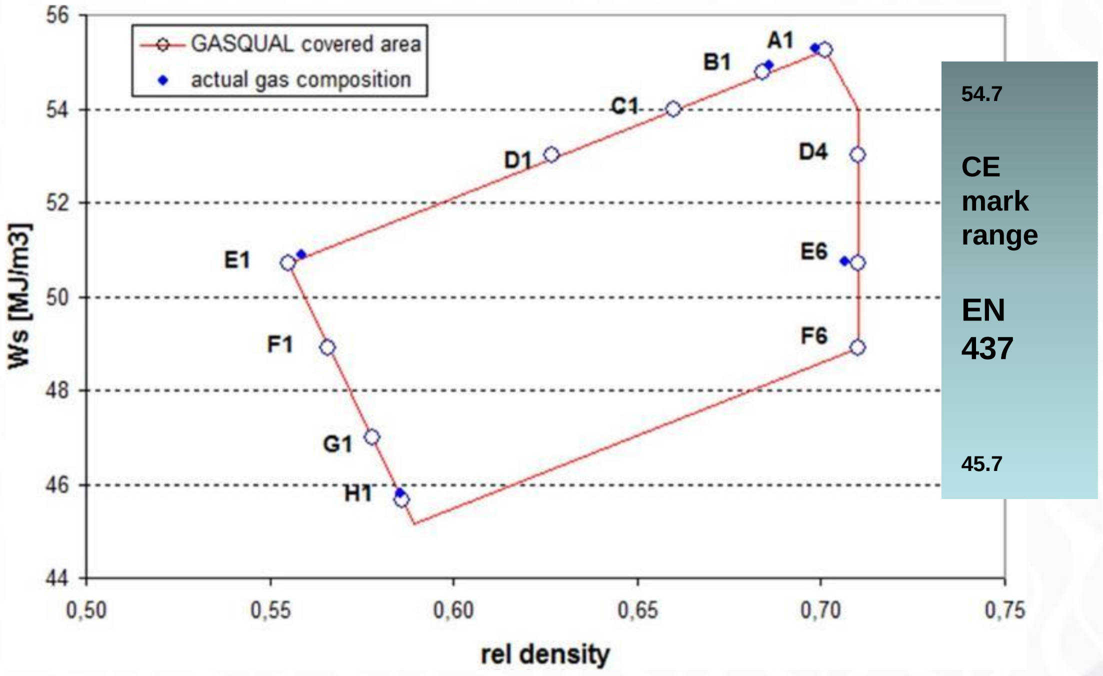
# Appliance Categories

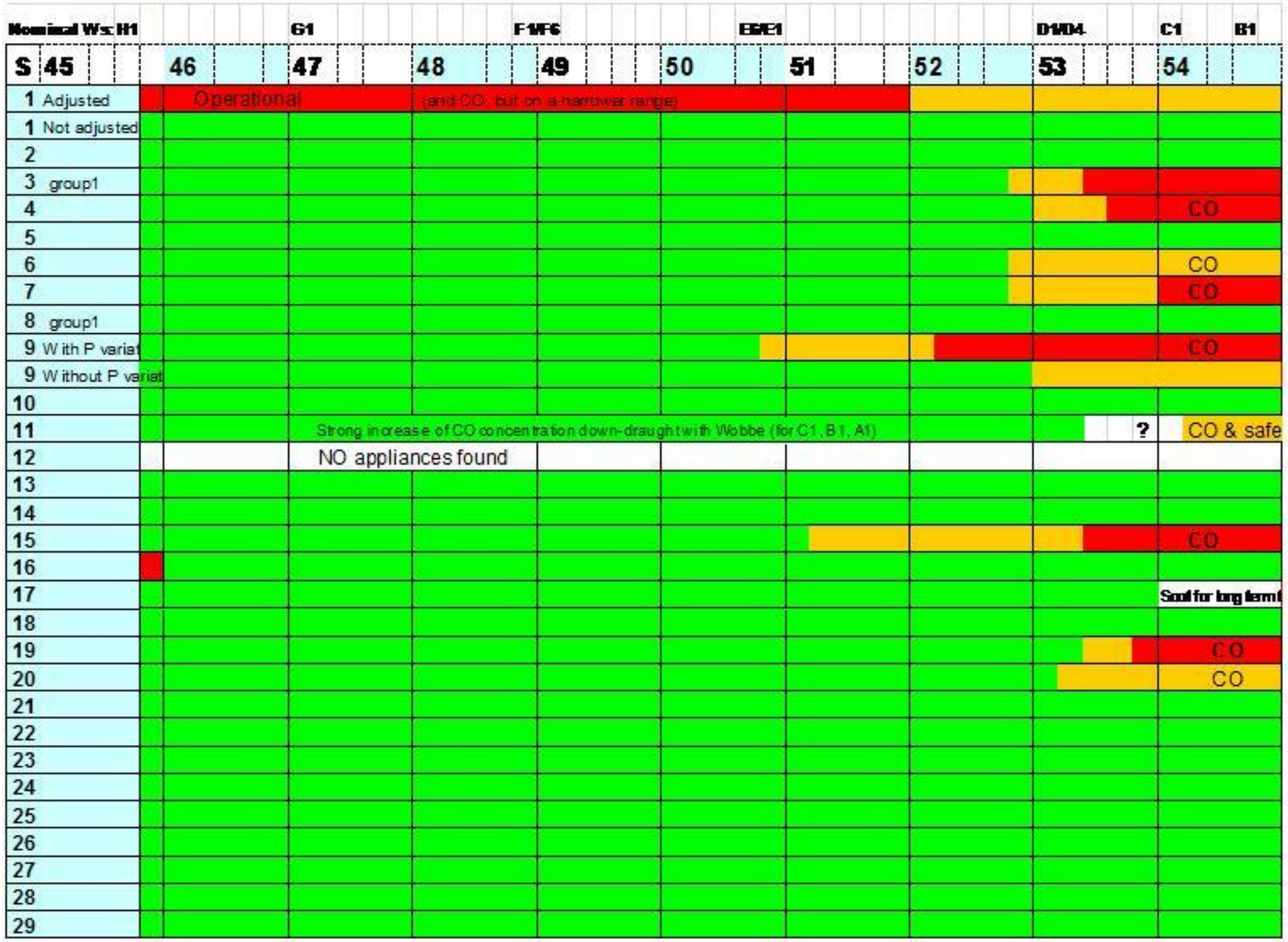
- Appliances categorised into 29 separate "segments"
- The segmentation was based on the different certification standards used for the appliances
- Numbers tested in each segment reflect the overall appliance population distribution (WP1)

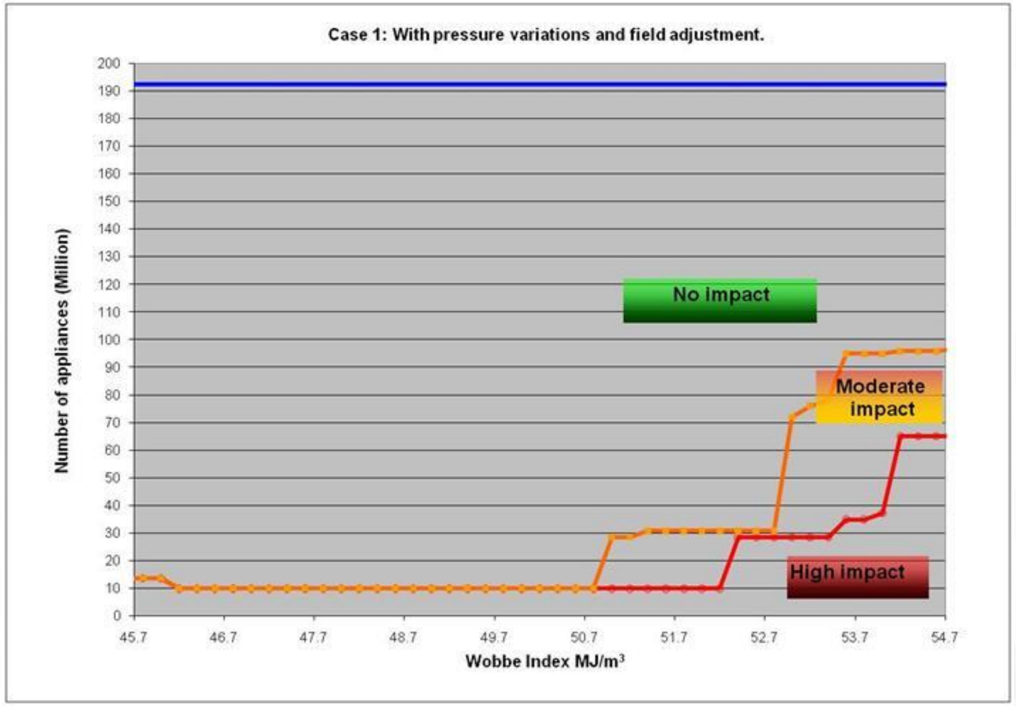
# Practical test programme

- **Study of the impact of gas quality variations on**
  - CO emissions
  - Other safety aspects (e.g. flame stability, safety devices operation)
  - NOx emissions
  - Efficiency



# Main results: Impact profile



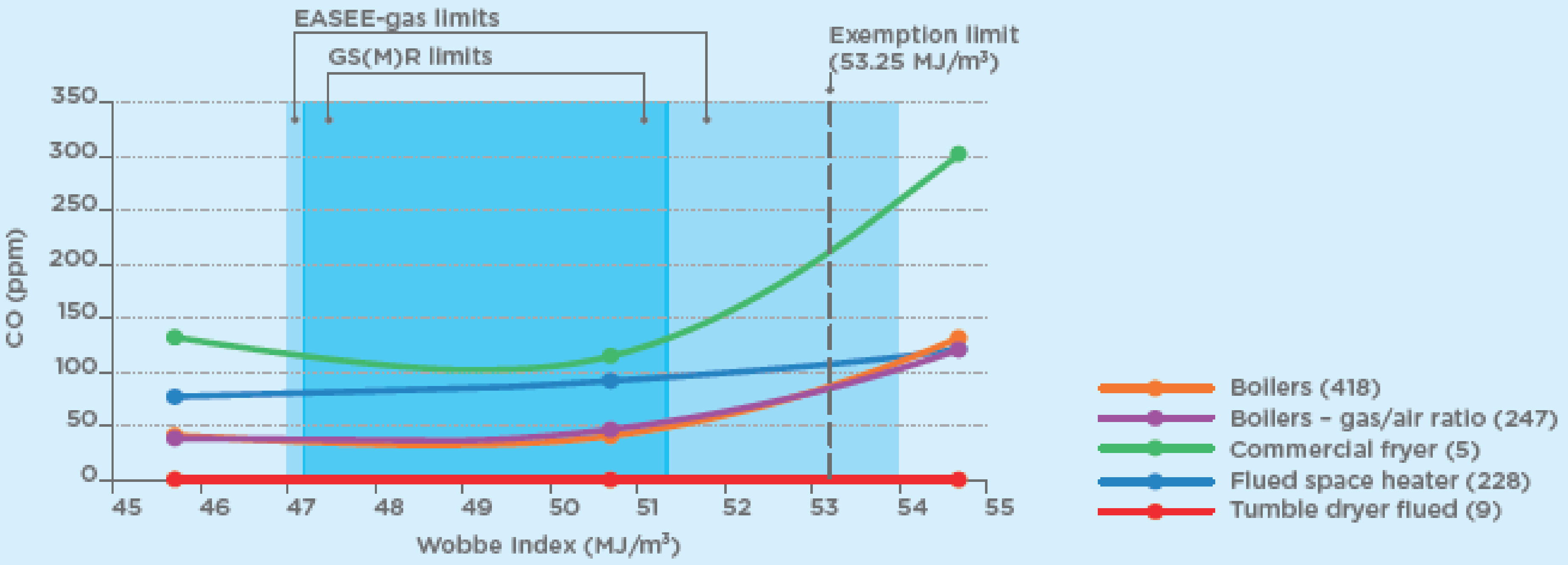
# Oban study – Opening up the Gas Market (2013)

- Testing undertaken with high and low Wobbe Index gases
- Lab studies on 18 appliances (detailed testing over a wide range and investigating emissions and operability)
- Installed appliance tests (over 2000)
  - Used H-gas reference and limit gases – G20, G21 and G23 (from a bottle truck)
  - Appliances tested in situ

    (a major testing challenge that was completed successfully)
- Focused on CO emissions but with some laboratory NOx measurements
- On-going spot checks taken to confirm appliance performance providing information on the operation of appliances on higher Wobbe Index gas

# Overview of results – CO emissions (1)

**Fig. 6** Average CO emissions vs Wobbe Index by appliance type (flued)

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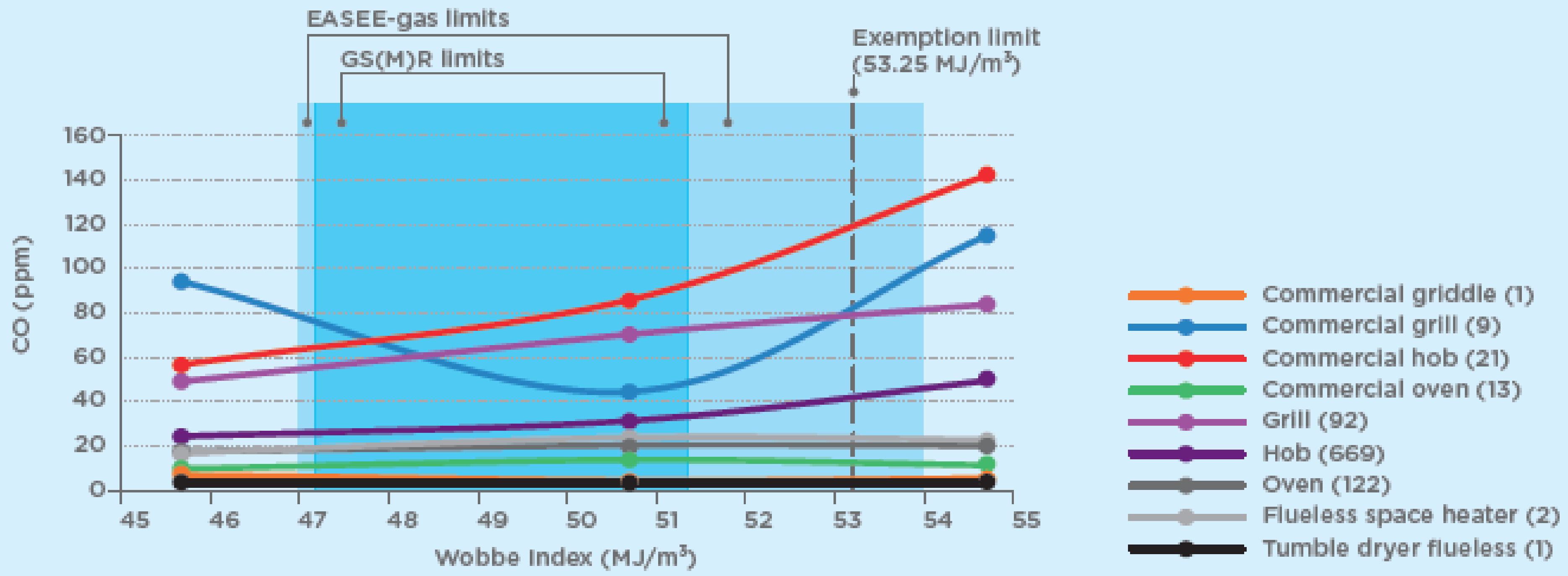
# Overview of results – CO emissions (2)

Fig. 7 Average CO emissions vs Wobbe Index by appliance type (flueless)

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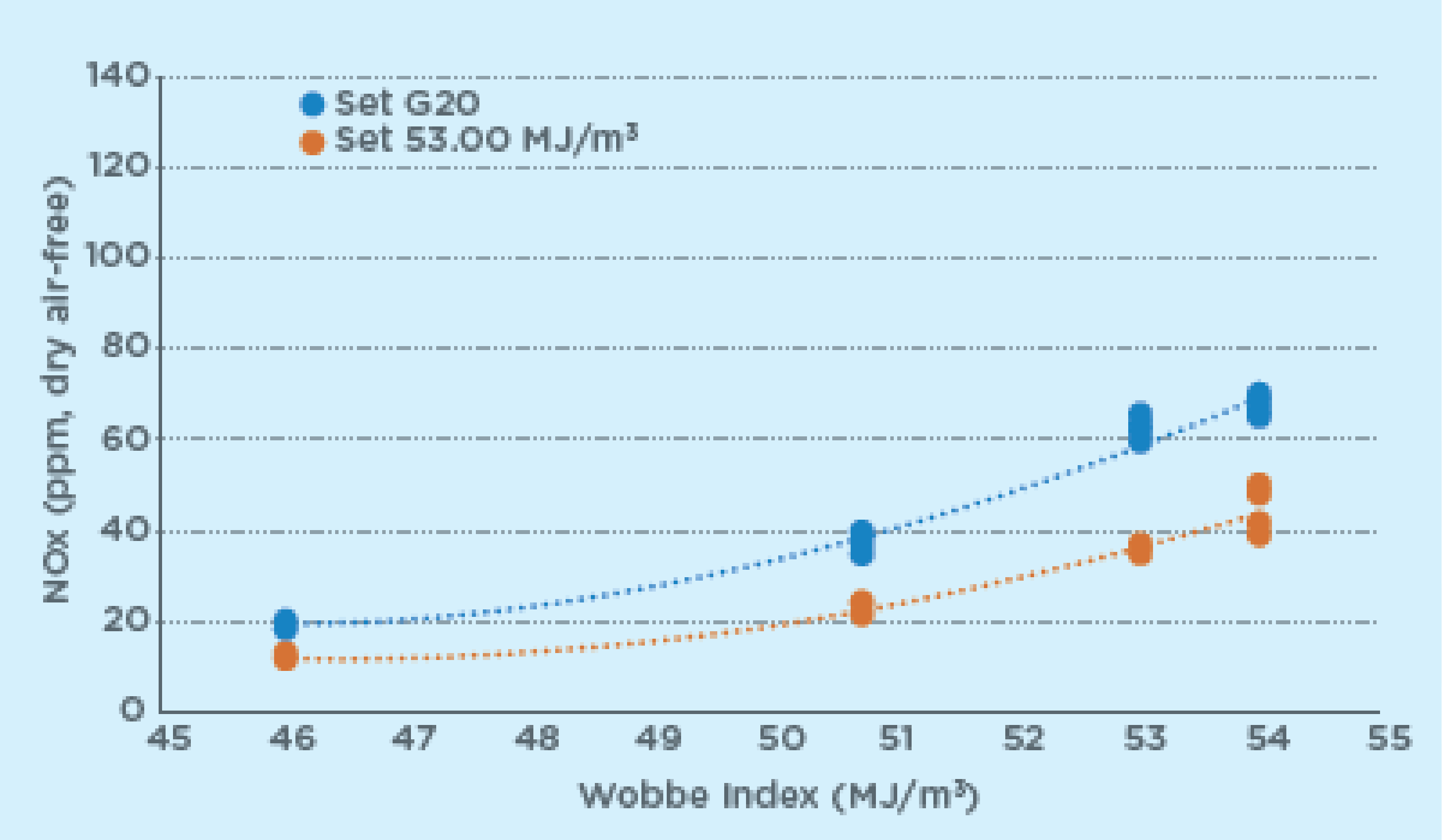
# NOx emissions from a boiler

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# Summary comments

- 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.

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# Widening the Wobbe Index: Domestic Customers Case for Change

## Q&A

# Widening the Wobbe Index: Gas Quality Variations and Industrial & Commercial Customers Case for Change

Dr Sarah Kimpton, DNV GL

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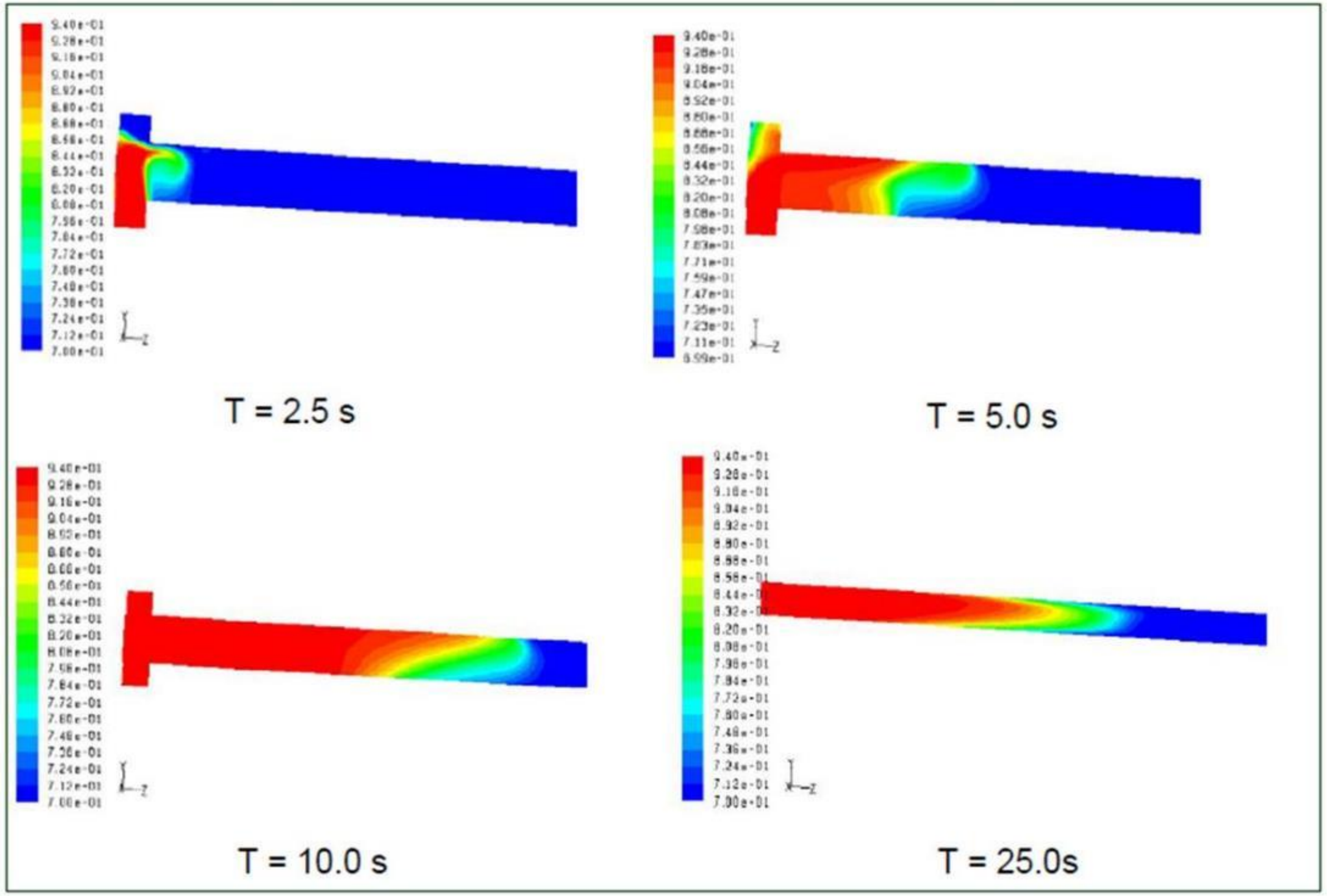
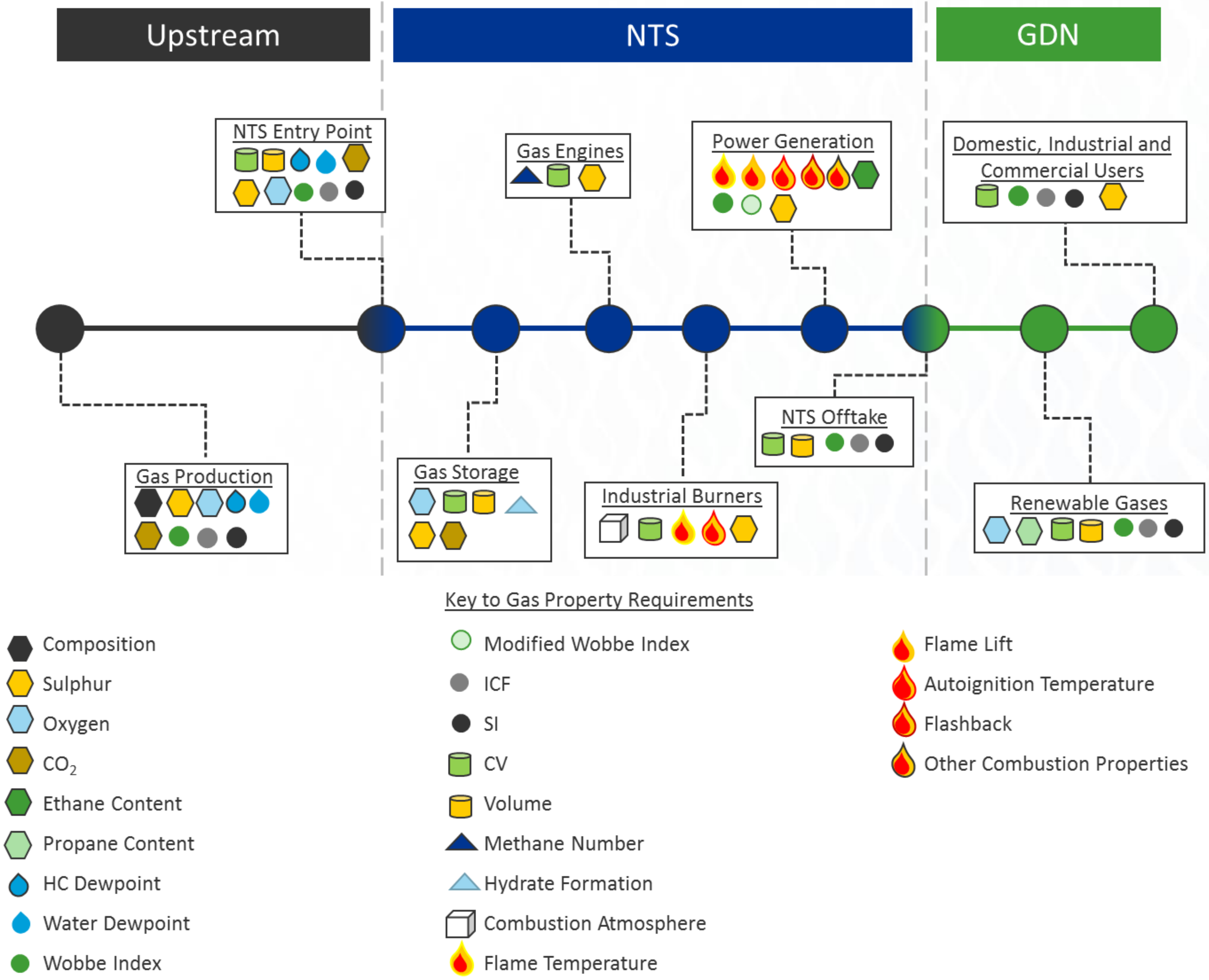
# Industrial and Commercial Customers

INDUSTRIAL AND COMMERCIAL
GAS QUALITY

- Established current status
- Engaged with trade associations, users and manufacturers
- IGEM workshop & questionnaire
- Assessed responses
- Included hydrogen

# Why Gas Quality Changes



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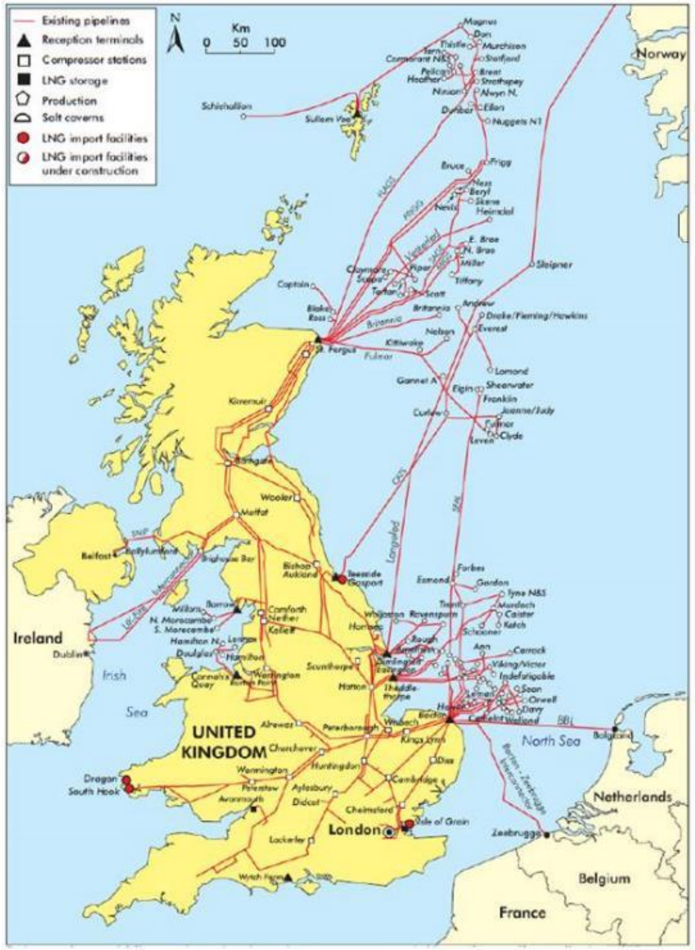
# GB may be an island….




…but the gas networks are highly interconnected

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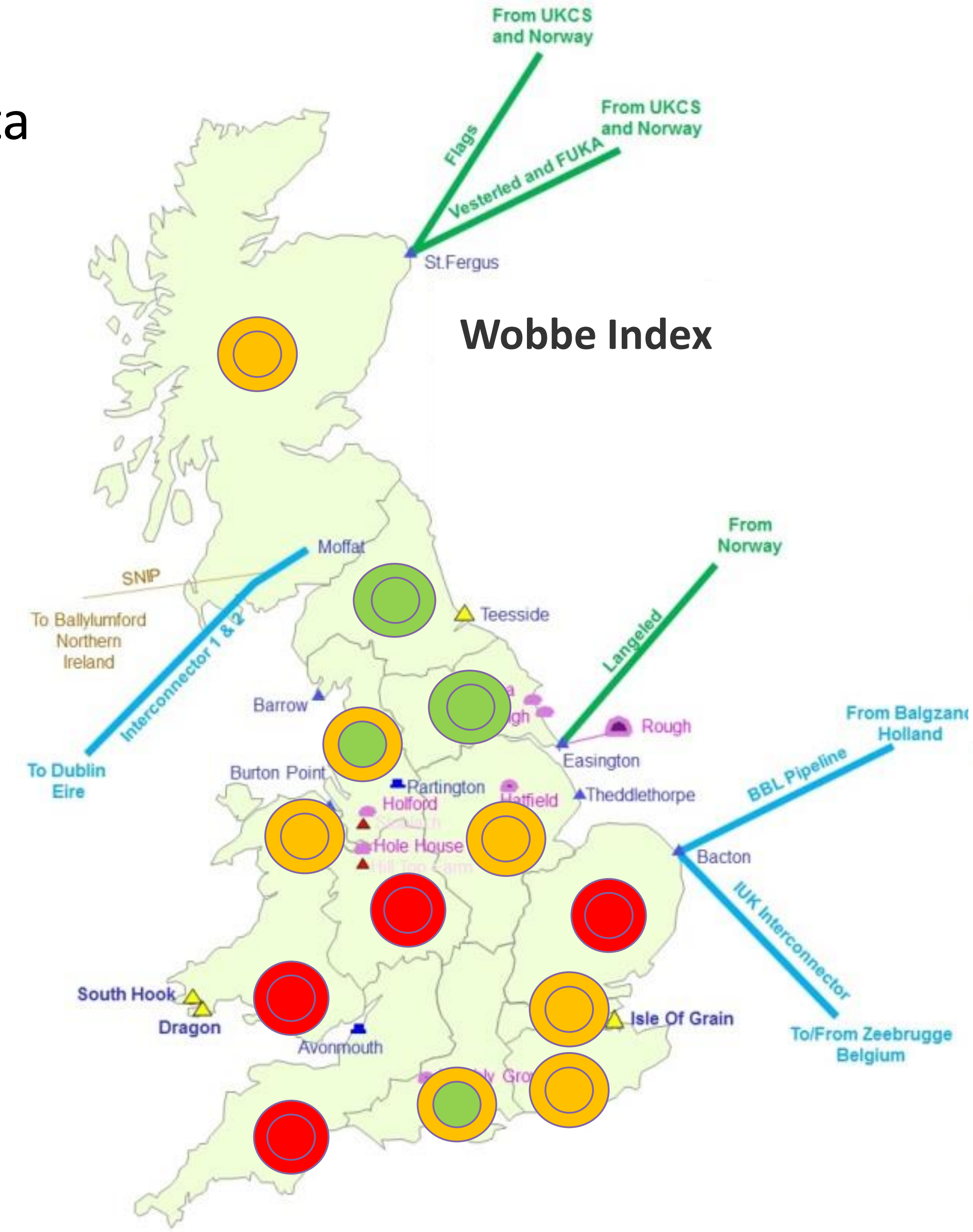
# Gas Quality Data for 2019

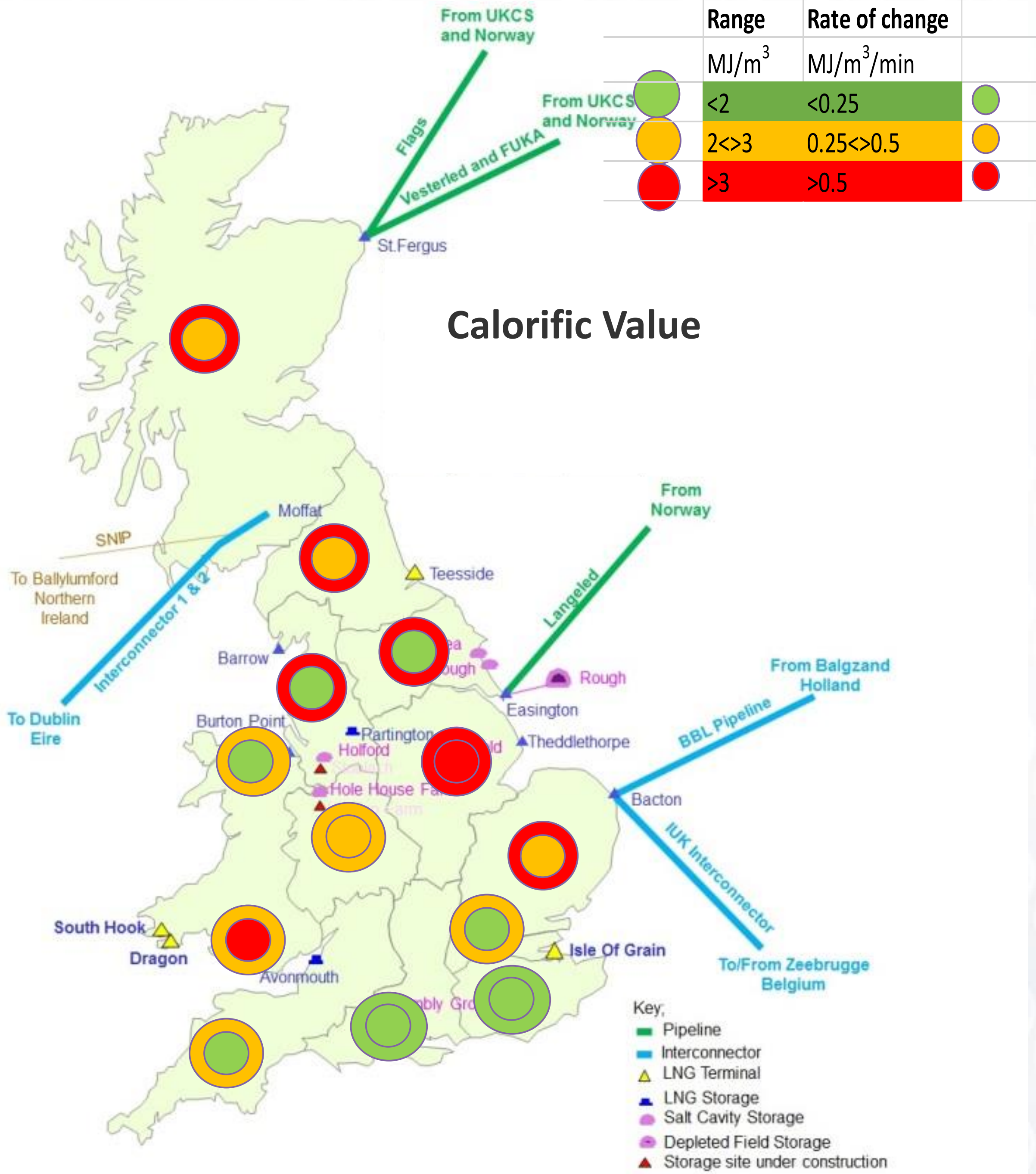
## Ranges and locations of rapid changes vary

– No location can be guaranteed constant gas quality

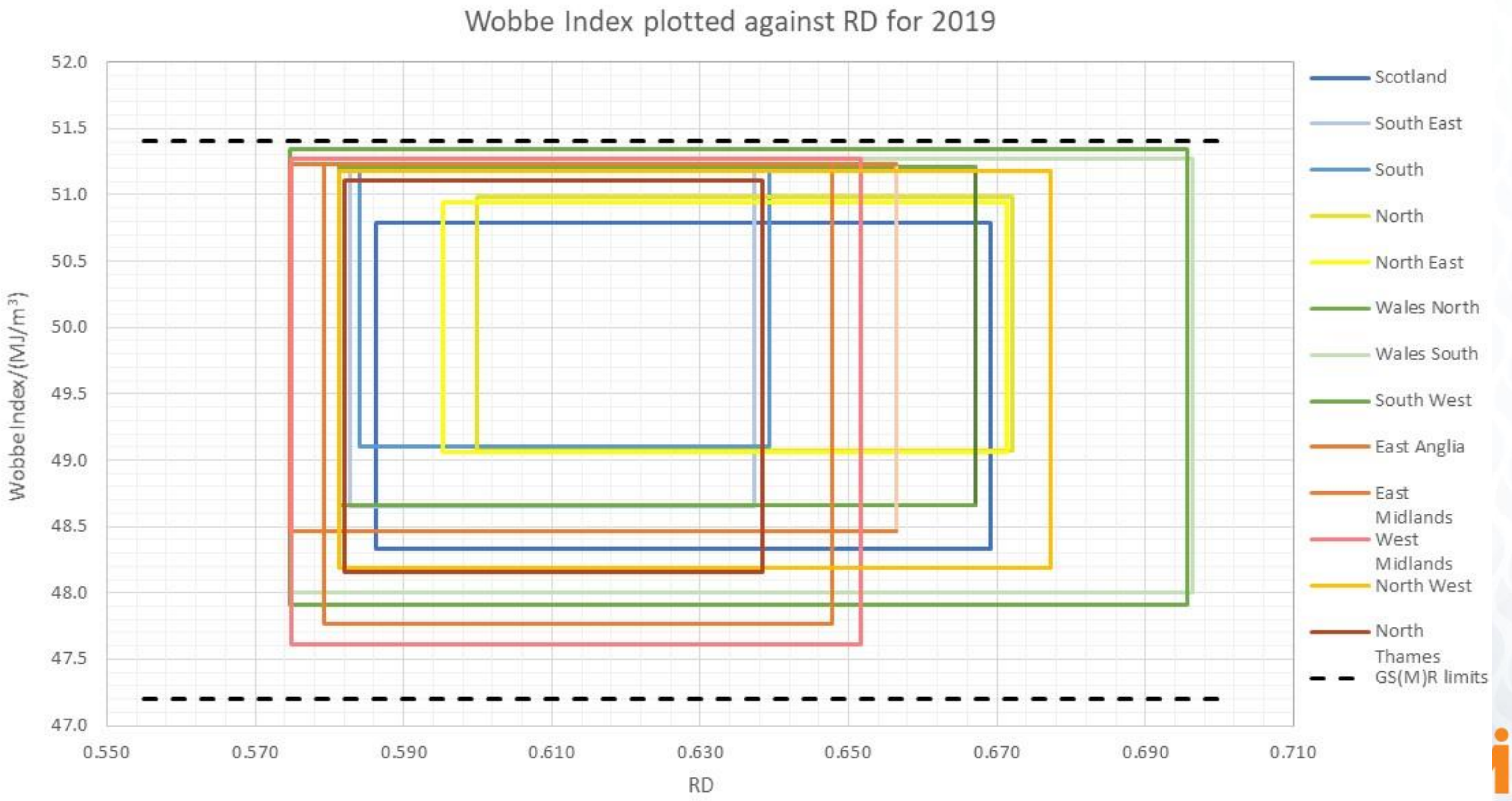
| Range of Wobbe Index and calorific value shown as outer circle | Units | Rate of change in Wobbe Index and calorific value shown as inner circle | Units |
|---|---|---|---|
| <2 | MJ/$m^3$ | <0.25 | MJ/$m^3$/min |
| 2≤>3 | MJ/$m^3$ | 0.25≤>0.5 | MJ/$m^3$/min |
| ≥3 | MJ/$m^3$ | ≥0.5 | MJ/$m^3$/min |

# 2019 data

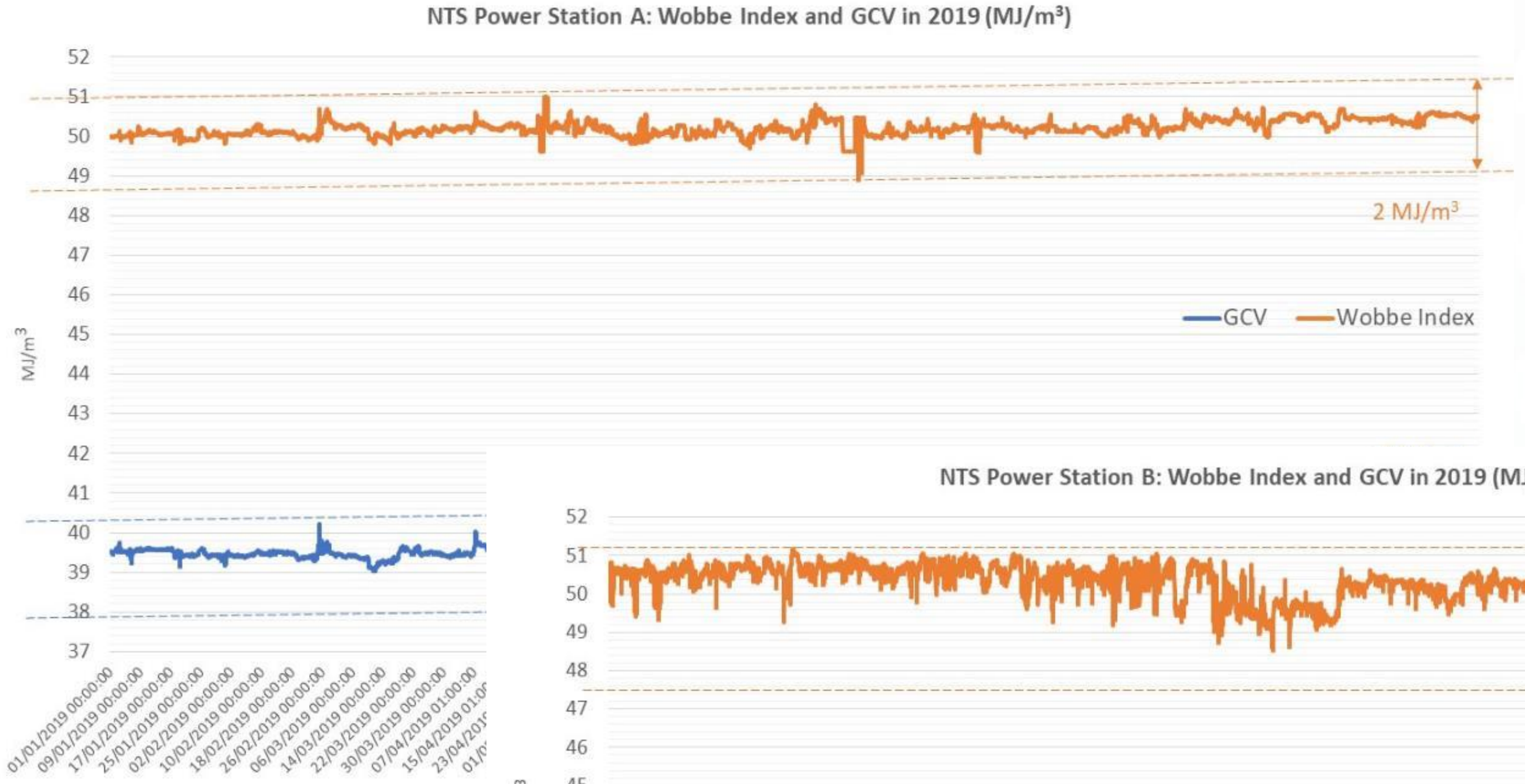


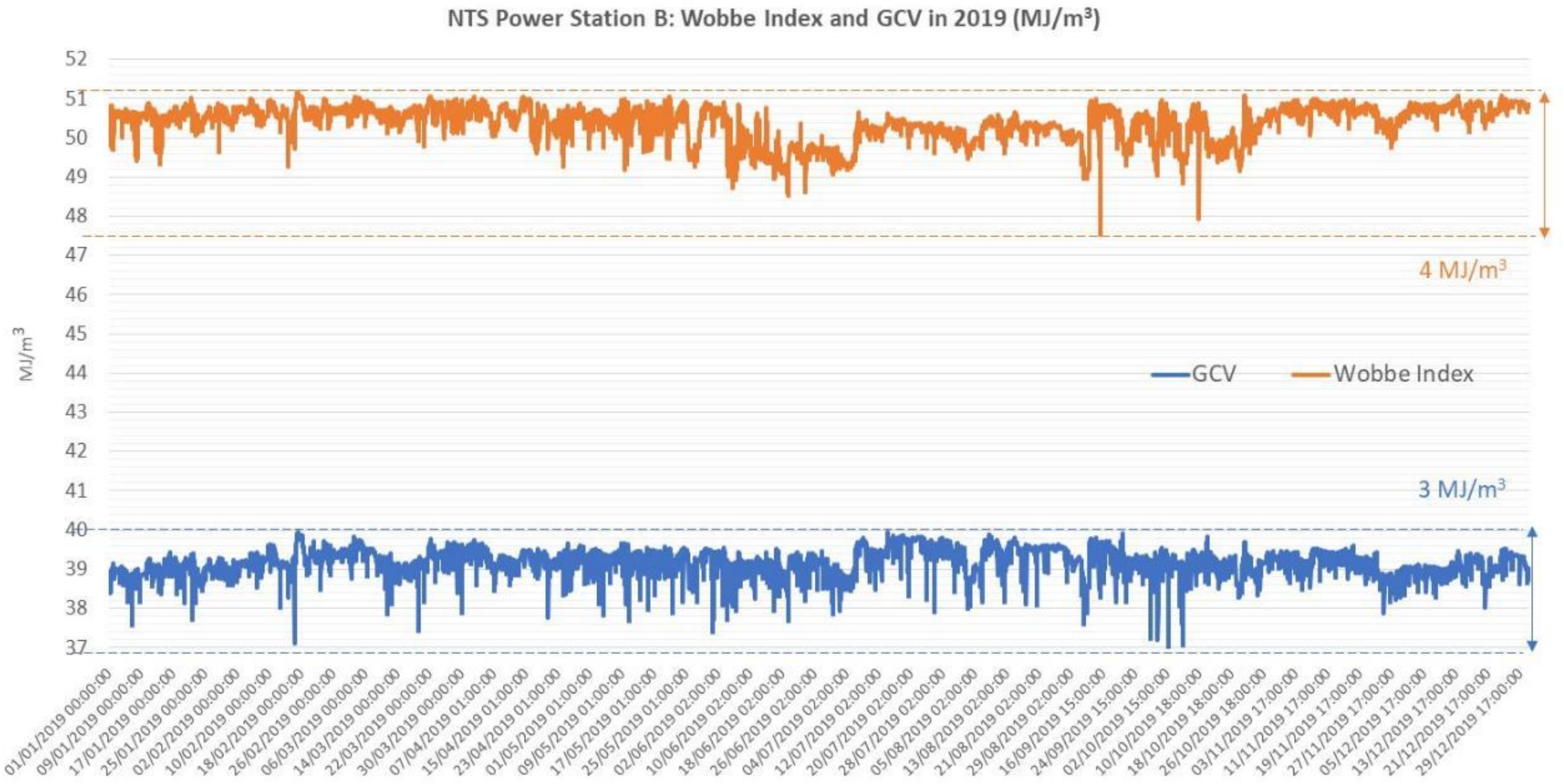




| | Range | Rate of change | |
|---|---|---|---|
| | $MJ/m^3$ | $MJ/m^3/min$ | |
| | <2 | <0.25 | |
| | 2<>3 | 0.25<>0.5 | |
| | >3 | >0.5 | |


Wobbe Index plotted against RD for 2019
52.0
51.5
51.0
50.5
50.0
49.5
49.0
48.5
48.0
47.5
47.0
Wobbe Index/(MJ/m3)
0.550
0.570
0.590
0.610
0.630
0.650
0.670
0.690
0.710
RD
Scotland
South East
South
North
North East
Wales North
Wales South
South West
East Anglia
East Midlands
West Midlands
North West
North Thames
GS(M)R limits

Two power stations connected to NTS in 2019

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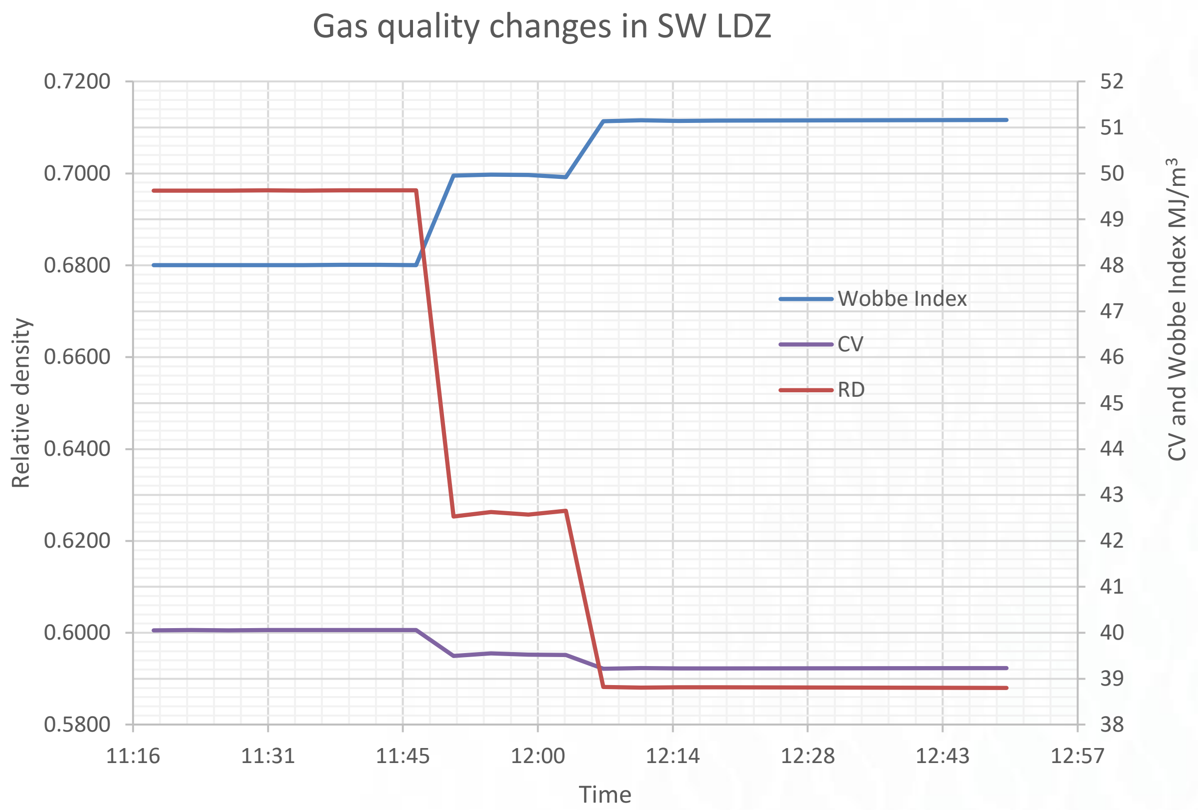
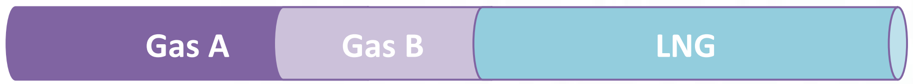



LNG unballasted 51.7 MJ/m$^3$
LNG ballasted 51.1 MJ/m$^3$




| Gas | Methane | Ethane | Propane | Butane | C5+ | $CO_2$ | $N_2$ |
|---|---|---|---|---|---|---|---|
| A | 80.50 | 7.00 | 3.00 | 1.00 | 0.50 | 3.40 | 4.50 |
| B | 89.55 | 5.40 | 1.50 | 0.43 | 0.12 | 1.60 | 1.40 |
| LNG | 93.10 | 6.07 | 0.03 | 0.00 | 0 | 0 | 0.80 |

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# Impact of Wobbe Index changes

| I&C Application | Gas Property | Current GS(M)R limits | | Upper WI Limit 52.85 MJ/m$^3$ | |
|---|---|---|---|---|---|
| | | **Fluctuation up to 3 MJ/m$^3$** | **Mitigation** | **Fluctuation up to 4.4 MJ/m$^3$** | **Mitigation** |
| Power Generation | WI and combustion properties | | Control systems | | Control systems |
| Gas Engines | WI, MN & combustion properties | | Control systems | | Control systems |
| Industrial Applications | CV & combustion properties | Burner set up mid-range WI<br>Burner set up at limit WI | Gas quality measurement at burner setup | Burner set up mid-range WI<br>Burner set up at limit WI | Gas quality measurement at burner setup |
| Boilers | WI | Burner set up mid-range WI<br>Burner set up at limit WI | Gas quality measurement at burner setup | Burner set up mid-range WI<br>Burner set up at limit WI | Gas quality measurement at burner setup |
| Storage | CV (commercial) | Status quo | | For dry low NOx gas-fired compression | Control systems |
| NTS compressors | Gas composition | Status quo | | For dry low NOx gas-fired compression | Control systems |
| Chemical Feedstock | Gas composition | | | Information still required | |
| Control and measurement system suppliers | | Know-how and equipment available | | | |

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# Widening the Wobbe Index: Gas Quality Variations and Industrial & Commercial Customers Case for Change

## Q&A

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ena energynetworks association

# Network Safety

Dave Lander, Dave Lander Consulting

# Overview

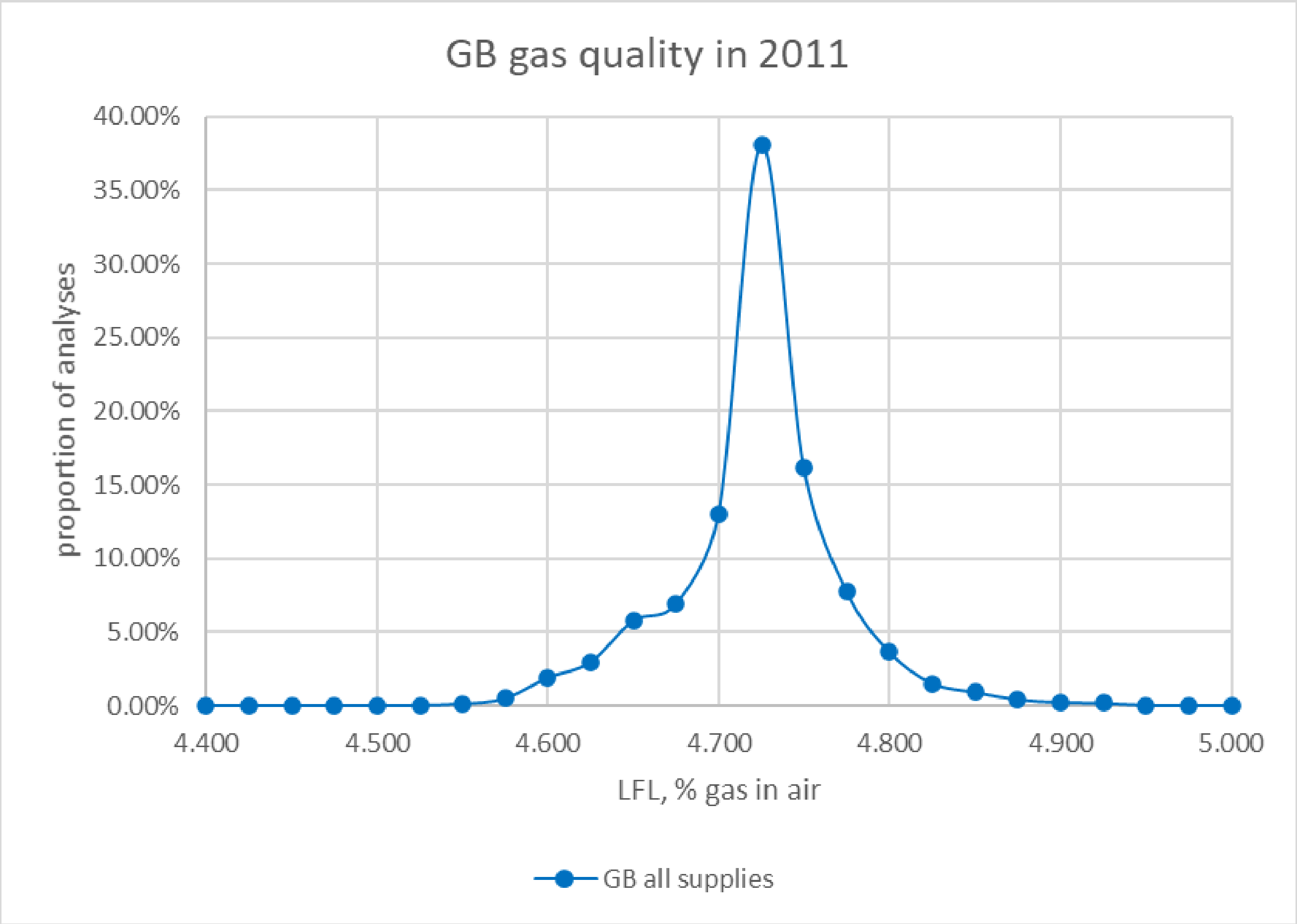
- **Flammability limits**
  – Would hazardous area limits and procedures for gas escapes need to be re-visited if WI limits were changed?
- **Pipeline fracture propagation**
  – Would risk of fracture propagation increase if WI limits were changed?

# Flammability limits

- **Would hazardous area limits and gas escape procedures need to be revisited if the WI limits are changed?**
  - Principally governed by the flammability/explosion limits of natural gas being conveyed
  - For many IGEM standards the lower and upper flammability limits are taken to be 5% and 15% gas in air
  - In practice, the flammability limits vary considerably…
  - …and have probably never been these values

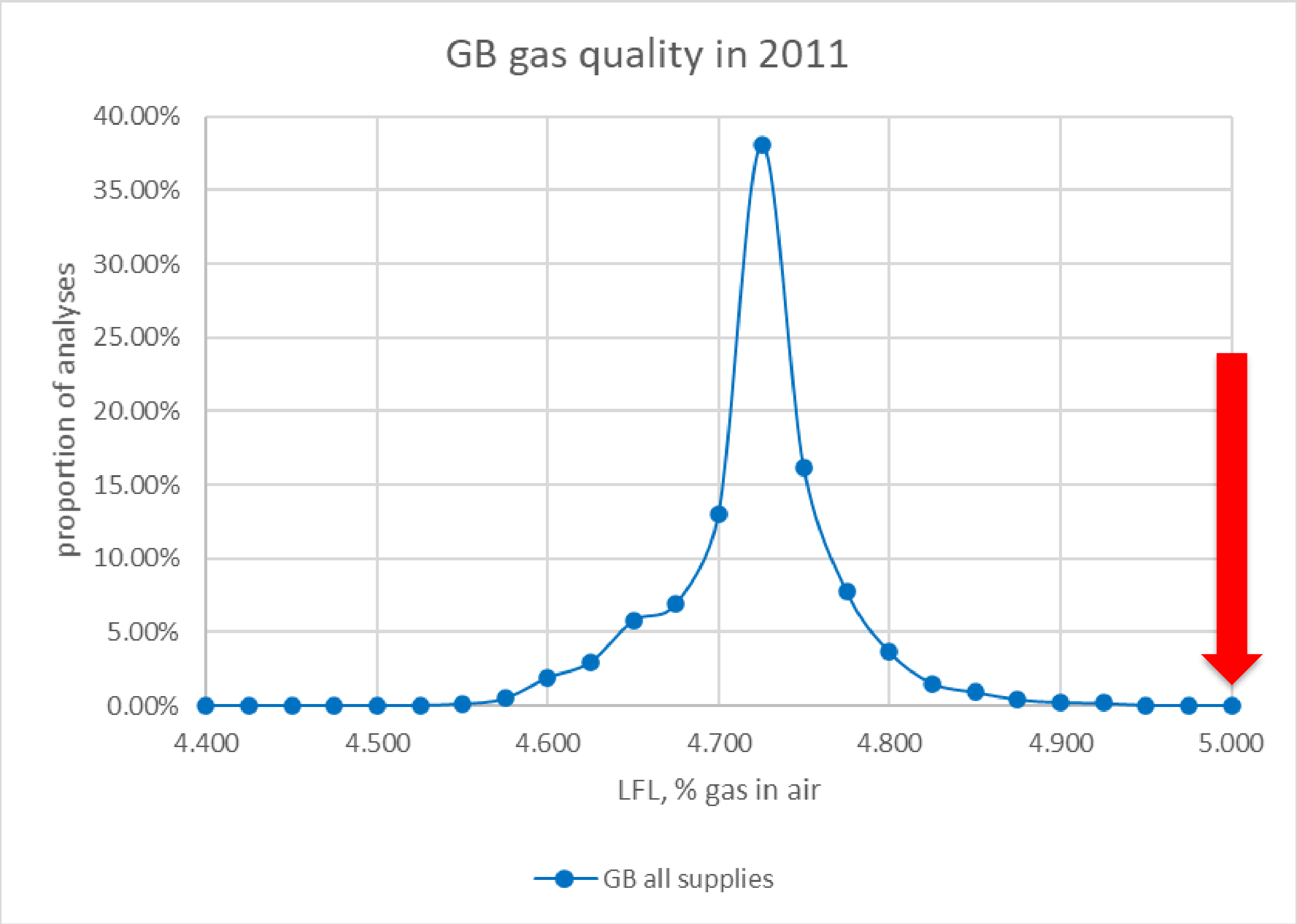
# Current UK gas quality varies widely

- **LFL varies from 4.5% - 4.9%**



# Current UK gas quality varies widely

- LFL varies from 4.5% - 4.9%
- "Traditional" LFL is 5%

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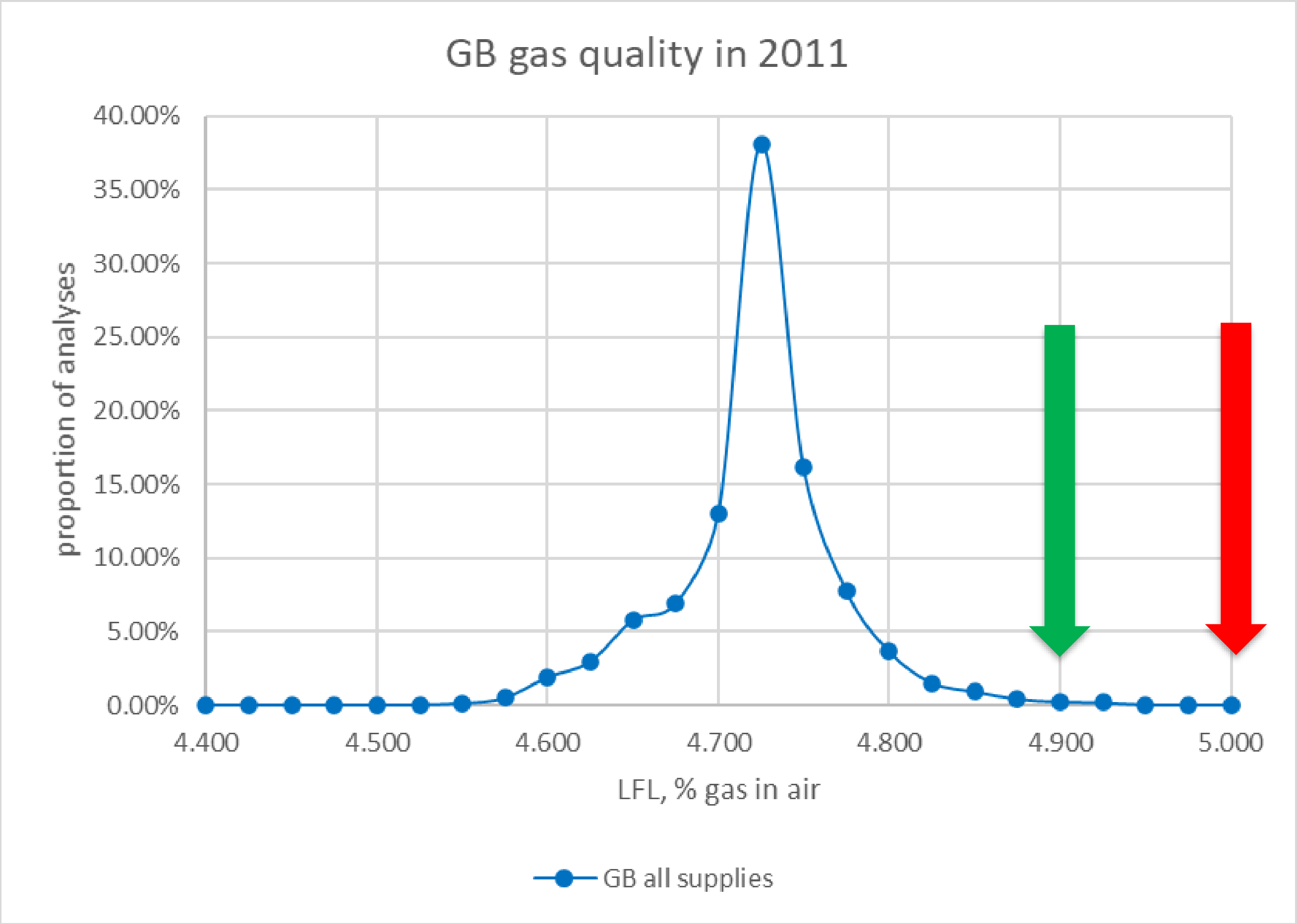
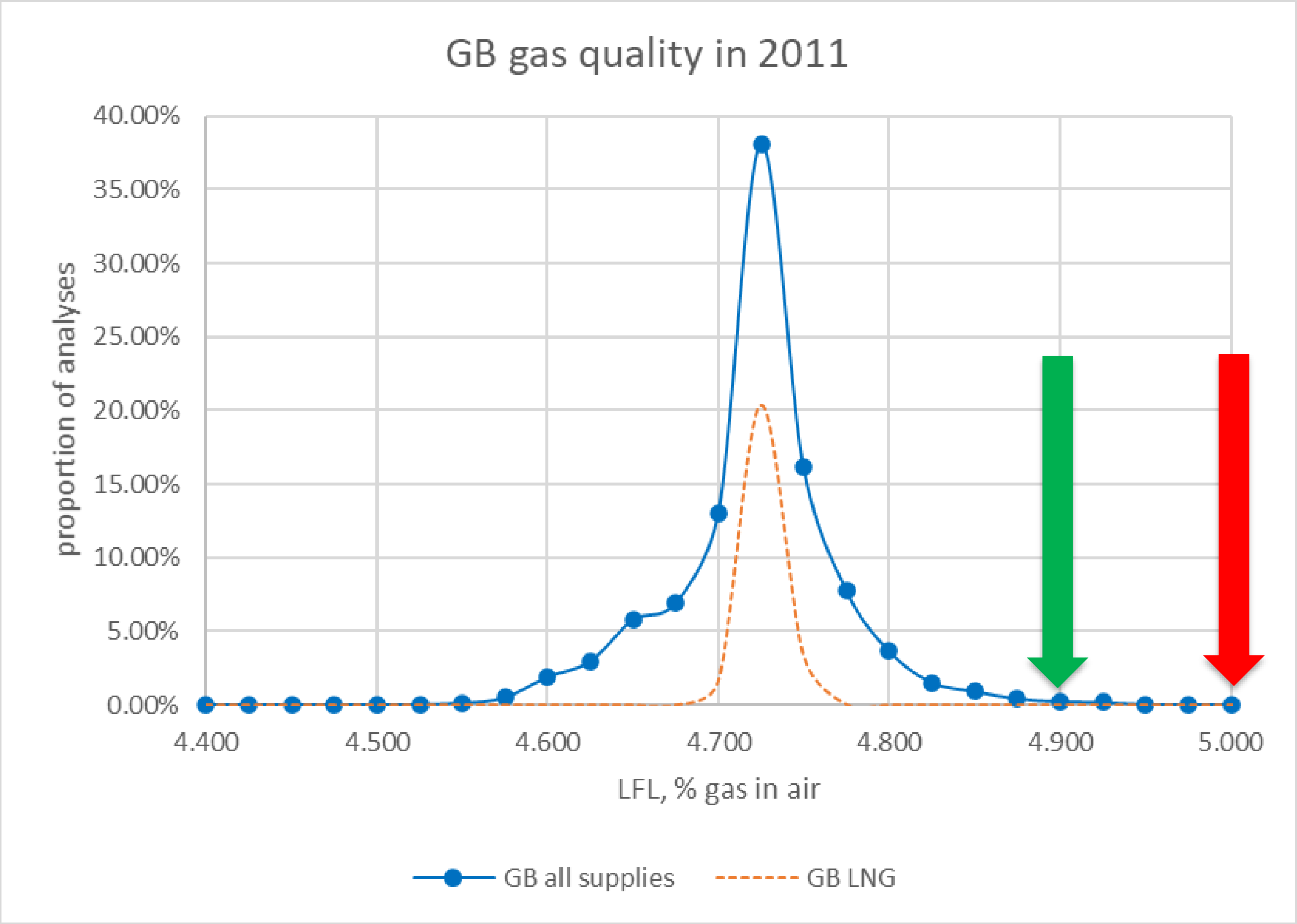
# Current UK gas quality varies widely

- LFL varies from 4.5% - 4.9%
- “Traditional” LFL is 5%
- Mean Bacton Gas is 4.9%



# Current UK gas quality varies widely

- LFL varies from 4.5% - 4.9%
- "Traditional" LFL is 5%
- Mean Bacton Gas is 4.9%
- Current GB LNG varies from 4.64 – 4.96%

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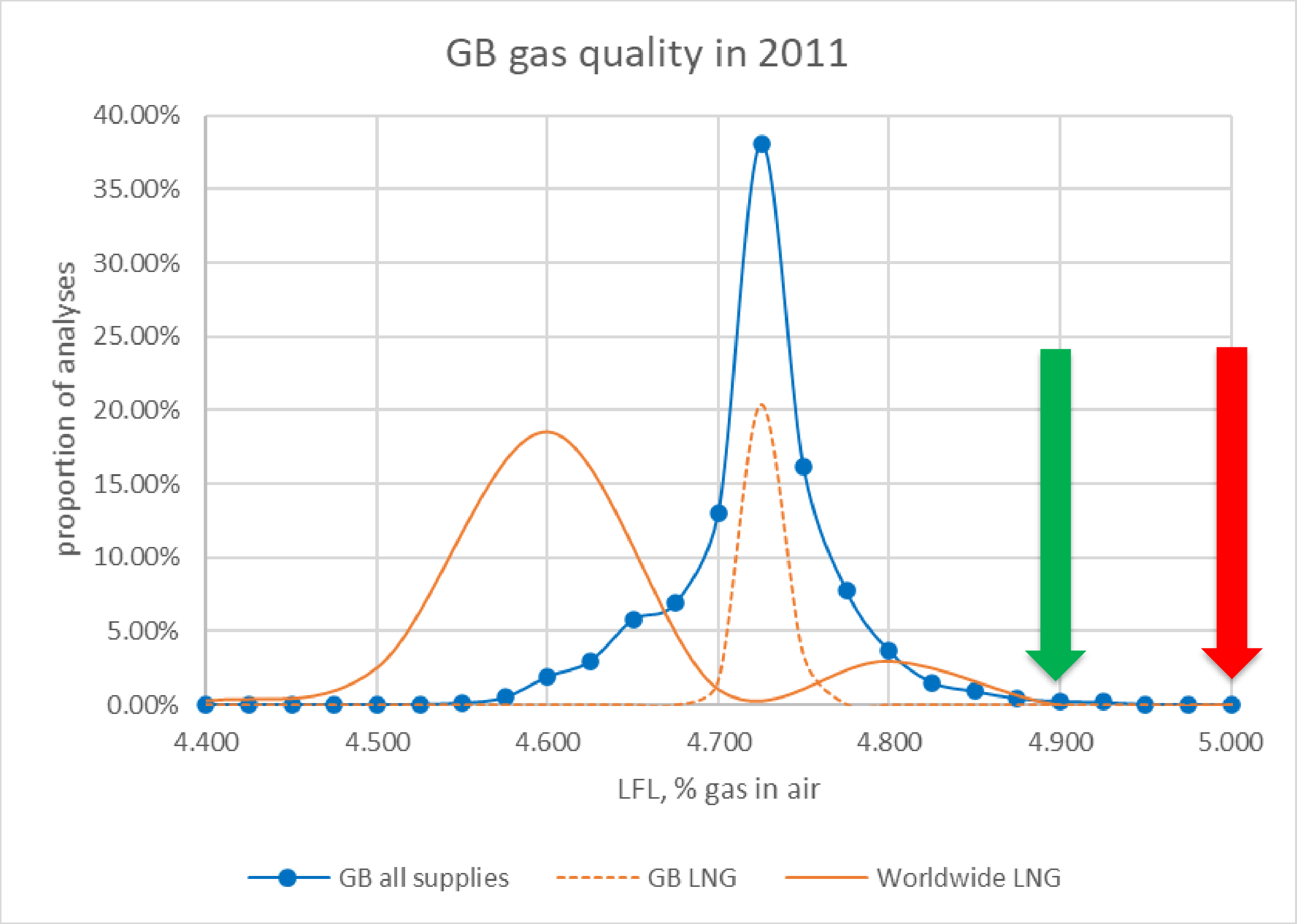
# Current UK gas quality varies widely

- **LFL varies from 4.5% - 4.9%**
- **"Traditional" LFL is 5%**
- **Mean Bacton Gas is 4.9%**
- **Current GB LNG varies from 4.64 – 4.96%**
- **Worldwide LNG varies widely**

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# Ballasting high WI gases (LNGs)

- **Ballasting tends not to significantly affect LFL**
  - Ballasting to reduce WI by 1 MJ/m3 increases LFL by 0.07 % gas in air

| Source | WI MJ/m3 | LFL %gas |
|---|---|---|
| Grain | 52.19 | 4.54 |
| Grain, ballasted | 51.25 | 4.61 |
| Qatar heavy/rich | 52.42 | 4.53 |
| Oman | 52.99 | 4.42 |
| Australia NSW | 53.48 | 4.34 |

# Criterion for IGEM safety standards

- **Often consider impacts at 20% of the LFL**
  - 1 % gas in air (based on "traditional" LFL)
- **Mean Bacton gas is also used as the basis for IGEM standards**
  - LFL is 4.9 % gas in air

# Current UK operations

- **Safety margin is not 80% (100-20%)**
  - 78 % to 79 % gas for current UK gas quality
  - 79.6 % gas for Mean Bacton Gas
  - 77 % to 78 % gas for LNGs in the table

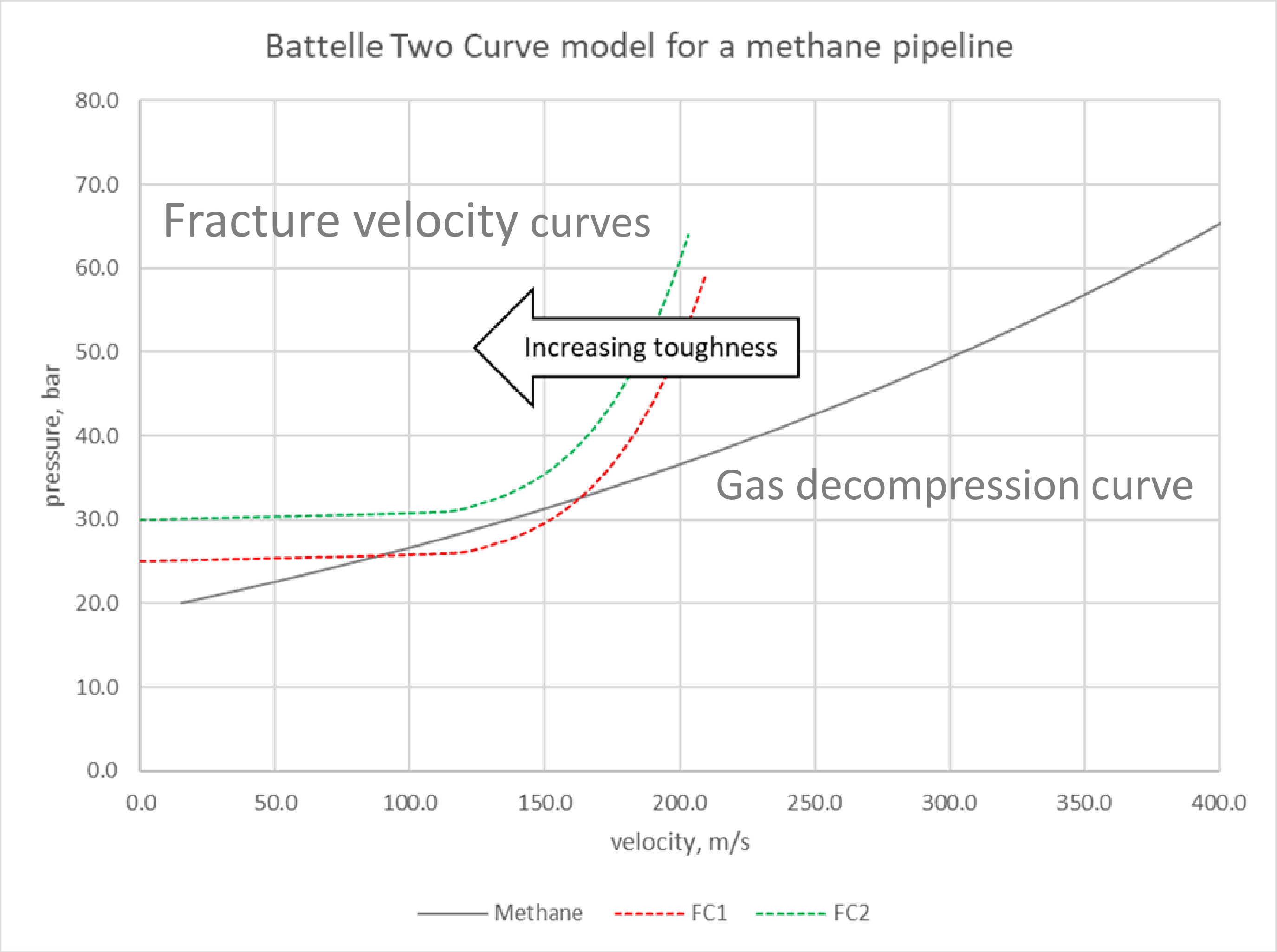
# Pipeline fracture propagation

- **Would risk of fracture propagation increase if WI limits were changed?**
  - High strength steels are generally preferred for gas transmission pipelines
    - Reduced construction costs and higher capacity (pressure) offsets the higher materials cost
  - Ability of such steels to arrest a propagating ductile fracture
    - generally caused by outside forces, such as mechanical damage, soil movement, etc.

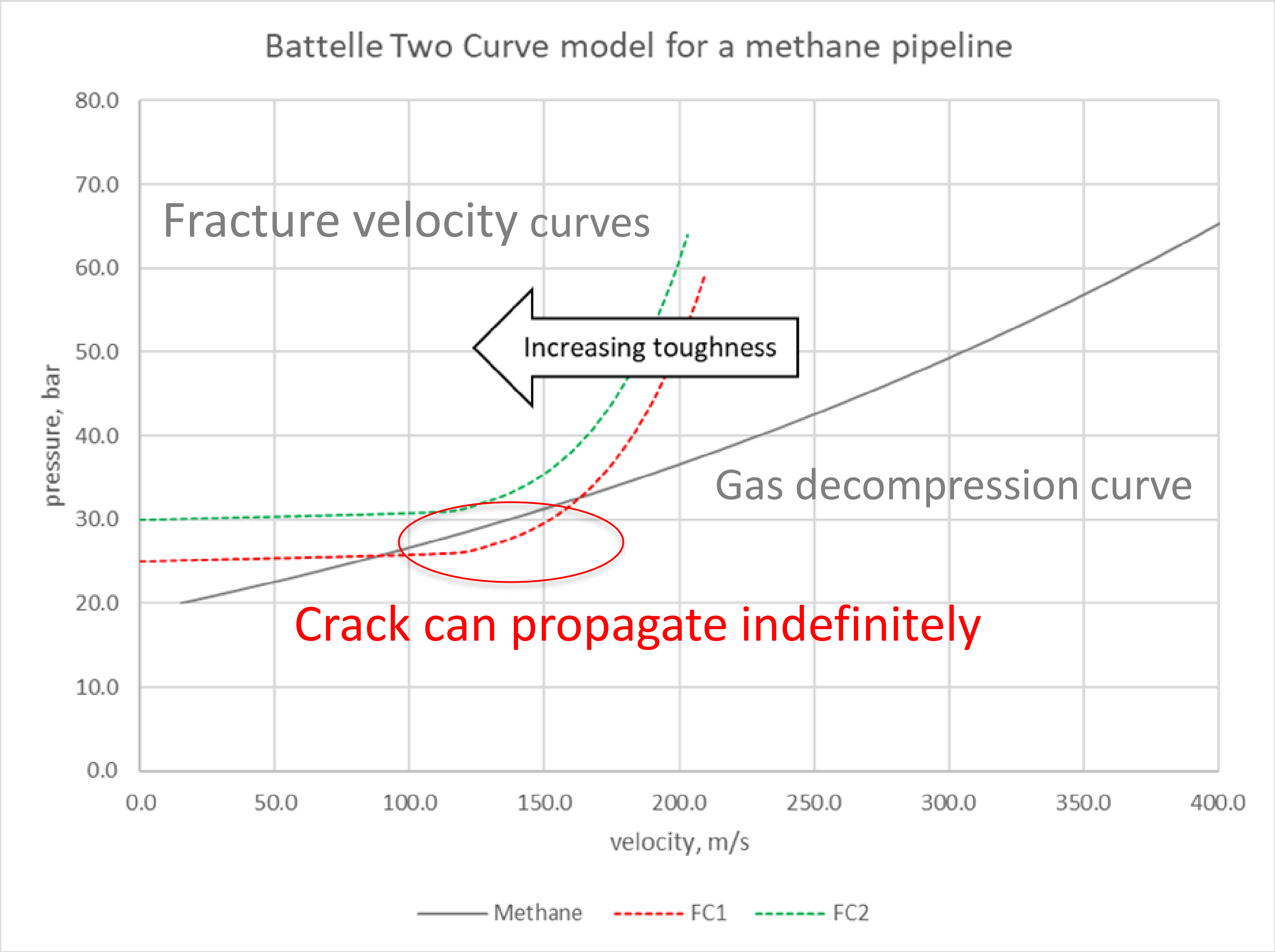
# Assessment of risk

- **Battelle Two Curve (BTC) approach**
  - Used by operators to show that fractures will not propagate beyond a small number of pipe joints
  - Compare the fluid decompression wave velocity and the crack propagation velocity
    - If fluid decompression velocity is larger than the crack velocity the crack tip stress will decrease and the crack will arrest

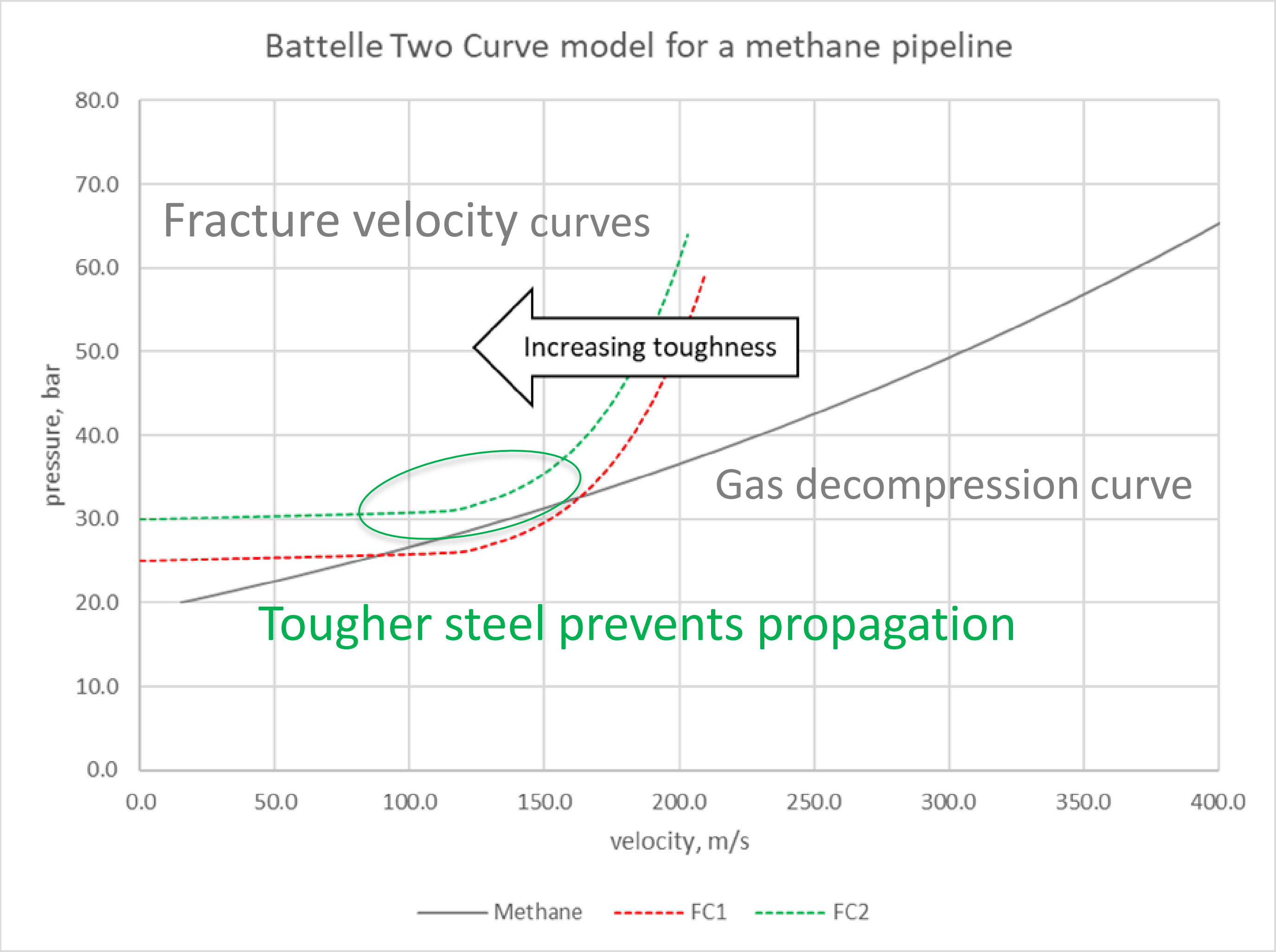
# BTC model – methane pipeline



# BTC model – methane pipeline



# BTC model – methane pipeline

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# For this assessment

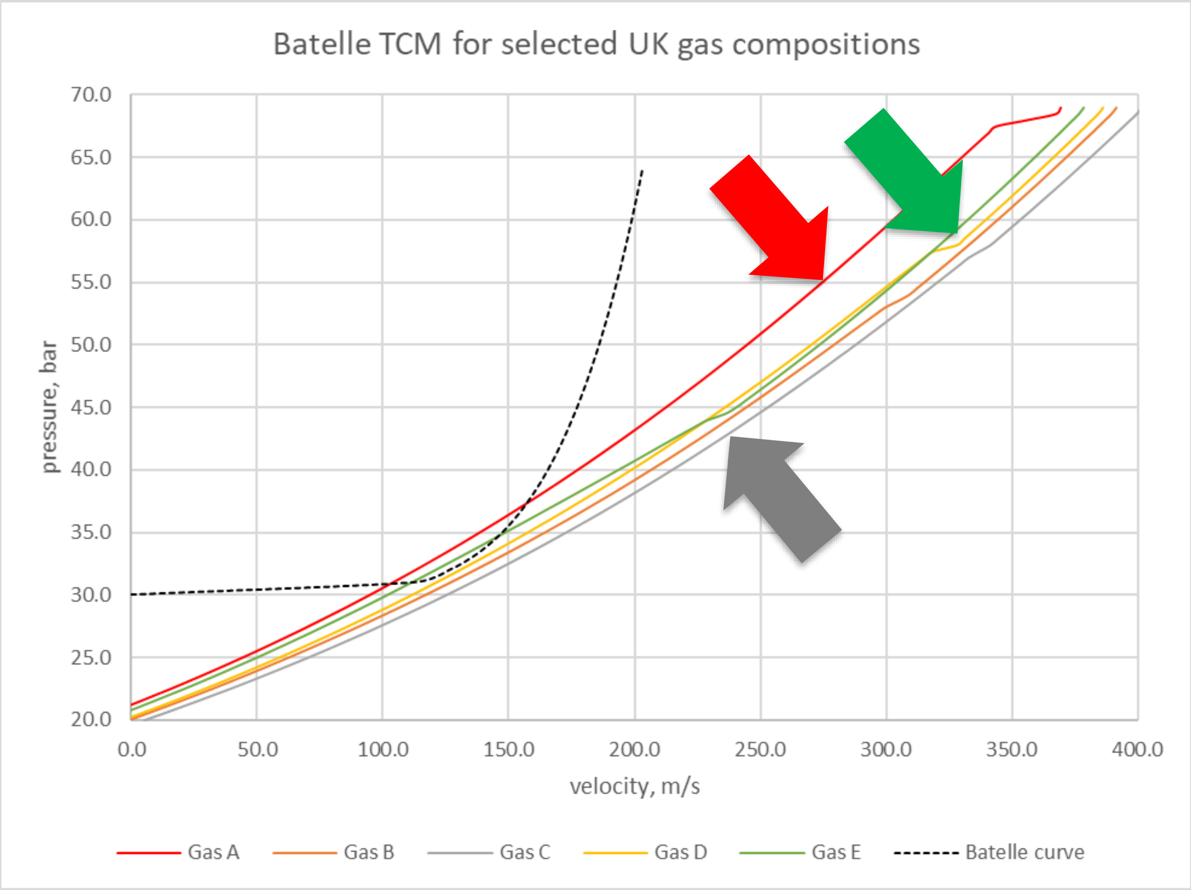
- **Comparison of relative risk posed by differing gases**
  - Examine gas decompression curves for various gas compositions
  - Dependant on thermodynamic properties of the fluid and the starting pressure and temperature on the pipeline at the time of fracture

# Compositions examined

- **Pipeline gases at GB import terminals**
  - Compositions characterised in detail by consortium in 2009
- **LNG**
  - Compositions characterised in the NIC project "Opening up the gas market"
    - Ballasted
    - Unballasted
- **All compositions available in DLC Report DLC180**

# Pipeline gases

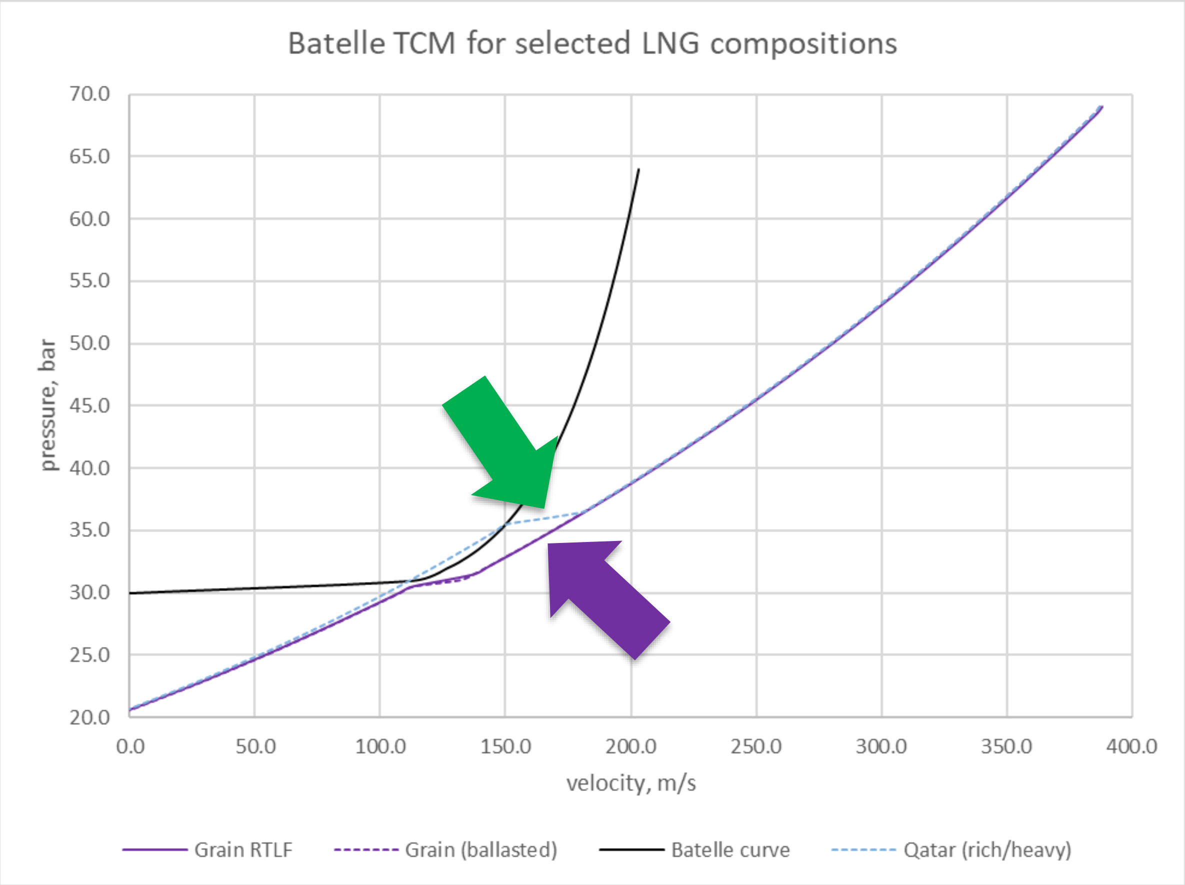
| Gas | Wobbe index, MJ/m3 |
|---|---|
| A | 49.54 |
| B | 48.31 |
| C | 49.45 |
| D | 47.21 |
| E | 50.23 |




Note: Fracture curve is illustrative only!

# LNGs

| Gas | Wobbe index, MJ/m3 |
|---|---|
| Grain | 52.19 |
| Grain (ballasted) | 51.25 |
| Qatar (rich/heavy) | 52.42 |




Note: Fracture curve is illustrative only!

# Summary

- **Flammability limits**
  - Vary widely for existing UK gas
  - LFL was probably never as high as 5%
    - Safety factor is never 80% (ca. 78% for Mean Bacton Gas)
    - Around 77-78% for most unballasted LNGs
- **Pipeline fracture propagation**
  - Not a Wobbe index issue
    - High density gases, exacerbated by hydrocarbon liquid formation
    - Ballasting does not alter the risk
  - Not an obvious parameter to specify that would control risk
    - Existing compliant gases show varying risk
    - Risk is dependant upon pipeline properties and operating conditions
    - Gas transporters should continue to assess their assets for future supplies

# Network Safety

## Q&A

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# Gas Quality Standard Consultation

- A draft of IGEM standard IGEM/GL/10 Gas Quality Specification for Conveyance of Group H Gases of the Second Gas Family is available for comment
- https://www.igem.org.uk/technical-services/comment-on-draft-standards/
- Comment period ends on 30th July

# Thank you

- For more information on Gas Goes Green:
- Visit us https://www.energynetworks.org/gas/futures/gas-goes-green.html
- Contact us GasGoesGreen@energynetworks.org

- For more information on IGEM:
- Visit us https://www.igem.org.uk
- Contact us general@igem.org.uk