Gas
Transmission

GMaP Gas Quality Knowledge Share

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Introduction and Overview

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Introducing the gas quality knowledge share

The Gas Markets Plan (GMaP), is an output initiative from the Future of Gas programme. It aims to facilitate the energy transition, whilst also continuing to drive consumer value in a collaborative and collegiate way over the 2 to 10-year time horizon.

A key benefit of the GMaP is that it provides a platform to share information on topics where the industry have highlighted that additional clarity would be useful.

In this first 'knowledge share' we have looked at the topic of **gas quality**. Gas quality and its associated rules and regulations are of paramount importance for the safe delivery and consumption of gas in homes and businesses across the UK today.

Gas quality isn't just an important topic today. It has a vital role to play in facilitating the introduction of low carbon gases and supporting the energy transition for the future.

We hope you find this guide concise and easy to follow, we want this information to be accessible for new customers wishing to enter the gas market.

If you have questions, or any thoughts on how we can improve this document please email us at:

Box.FOGForum@nationalgrid.com

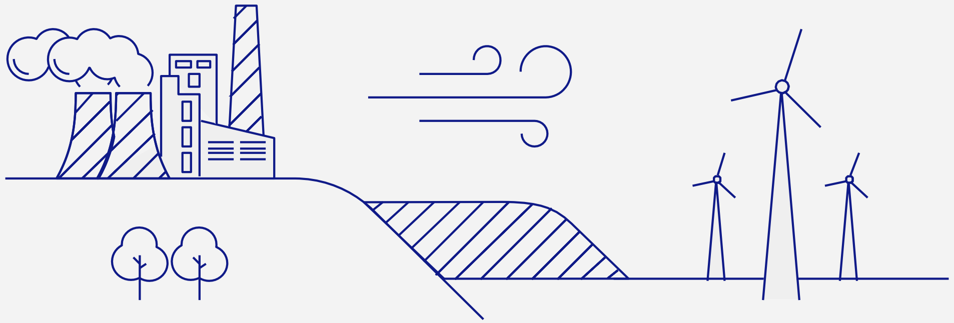
Gas quality
Important now

Natural gas is a vital energy source that millions of people in the UK rely on everyday.

Natural gas is used to generate electricity, powers our industry and heats our homes and workplaces.

The most common form of natural gas used in the UK is predominantly made up of **methane**.

However, natural gas is not a uniform entity. Different factors impact the composition and the amount of energy each molecule releases.



The composition of gas has a direct influence on the amount of energy supplied, used and billed on.

Gas requires stringent legislation and constant monitoring to ensure safe supply and utilisation to protect end consumers.

In 2018:

22m gas customers in the UK

85% of households are using gas for heat

Gas quality
Important in the future

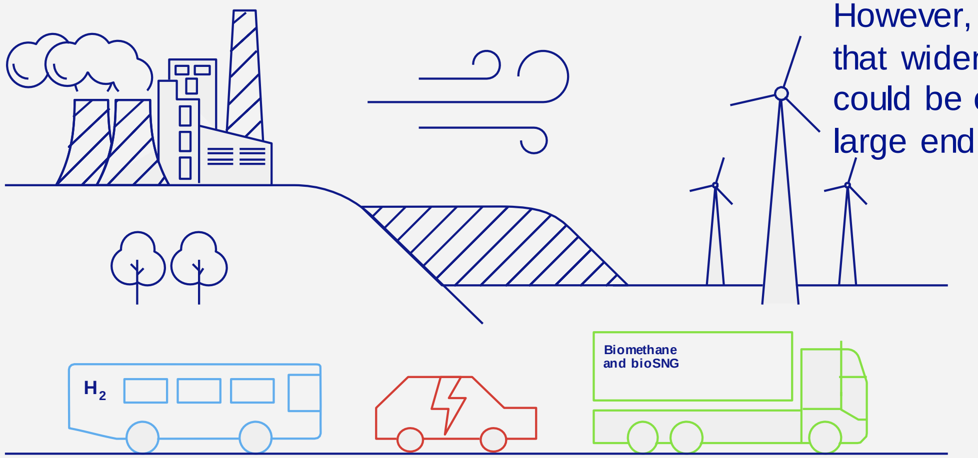
The introduction of low carbon gases to the energy mix could help meet legally binding policy targets in a cost effective manner.

Facilitating this transition will need changes to legislation to remove restrictions on the types of gas that can enter the UK networks.

With the UK having an increasing dependence on imported gas supplies, there is the potential that expanding the allowed composition of gas entering the network, could have positive impacts:

- By maximising the amount of gas recoverable from UK Continental Shelf (UKCS) it has knock on UK wide economic benefits.
- By improving the competitiveness of the UK gas market for global Liquid Natural Gas (LNG) due to reduced processing costs.
- Facilitating the decarbonisation of gas networks to achieve net zero.

However, it is important to highlight that widening the gas specifications could be challenging for certain large end users.



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Gas Quality Technical Information

What is natural gas and where does it come from?

In its most basic form natural gas is a colourless odourless compound made up from chemical substances with different characteristics.

The most common form of natural gas used in the UK is predominantly made up of **methane**. However it also contains a range of other compounds (see figure 1).

Natural gas arrives into UK from many different sources, such as offshore gas fields in the North Sea, direct pipelines from countries such as Norway, Belgium and the Netherlands, and globally from large LNG tankers.

Once the gas arrives onshore, the National Transmission System (NTS) and Distribution Networks (DNs) transport it to the different end users (power stations, industrial users, businesses and homes) that use it.

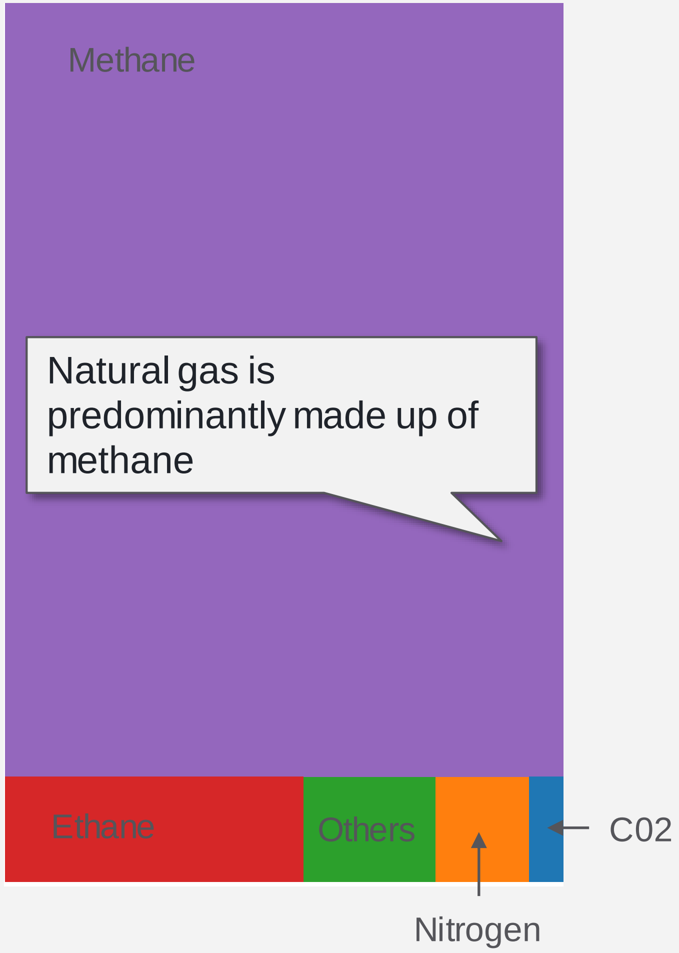
There are two commonly used terms related to the make up of natural gas. These are:

Gas composition which is the specific chemical make-up of the gas mixture and

Gas quality which refers to the physical and chemical properties of the gas, when it changes states (i.e. when it releases energy).

The two terms are directly related to each other. The composition of a molecule of gas will have a direct impact on the amount of energy it releases.

Figure 1: Indicative gas composition



Important gas quality terms

There are a number of key technical terms that are important to understand when discussing gas quality.

The following slides, will give an overview of the terms calorific value, specific gravity and Wobbe index.

They will also show an illustrative example of how these specific gas quality terms interact and what impact this has on the gas allowed into the UK.

Calorific Value (CV)

Calorific Value is the amount of **energy** that a given quantity of gas releases during combustion. Calorific Value is usually quoted in megajoules per cubic metre (MJ/m3).

Specific Gravity (SG) or Relative Density

Specific Gravity is a ratio of density of a gas compared to the density of air.

The higher the specific gravity of the molecule, the heavier the gas, the more slowly it moves.

Both CV and SG are crucial factors when determining the Wobbe index.

Wobbe Index / Wobbe Number

The Wobbe index defines the amount of heat/energy that an appliance will output within a standard period. It is a measure of the interchangeability of gases and is used to compare the energy output of gases with different compositions.

Regardless of the composition of a gas, if two gases have the same Wobbe index number they will deliver the same amount of energy to the appliance.

There are other key factors that impact the UK approach to gas quality standards. These are outlined in the Gas Safety (Management) Regulation (GS(M)R) and can be found in the HSE guide to GS(M)R[1].

1 https://www.hse.gov.uk/pUbns/priced/l80.pdf

Different type of gas

Spotlight

There are predominantly two types of gas that enters the UK. These are termed "lean" and "rich". In certain circumstances additional processes are required to bring gas in-line with the legal specifications. These processes are referenced below.

"Lean Gas"

Lean gas has a higher concentration of methane and ethane in its composition, which results in lower SG and CV values.

This gas is typically found in the southern North sea, the east Irish sea and via biomethane production.

Where it is not possible to blend gases an additional process of adding propane may be required in order to enrich a lean gas, this process is primarily required at biomethane sites.

The process adds an additional cost to biomethane production along with the environmental implications of adding a fossil fuel into a green process.

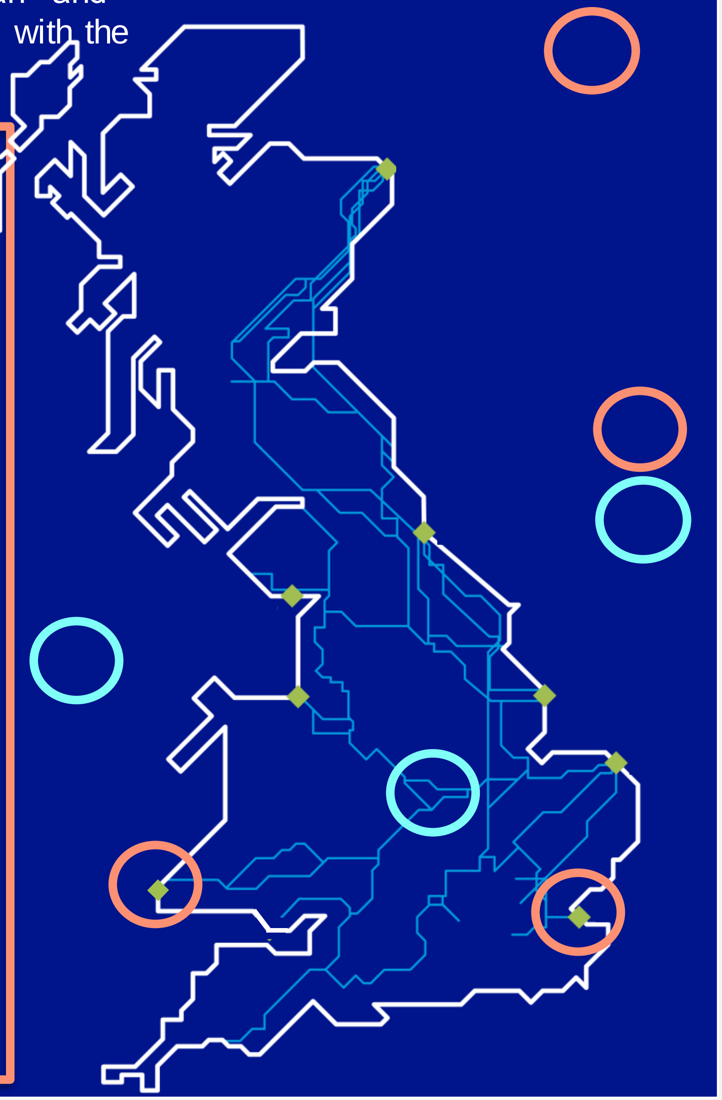
"Rich Gas"

Rich gas has a higher concentration of propane and butane which results in higher SG and CV values.

This type of gas is found in the northern North sea area, and via LNG imports

There are circumstances where rich gas is required to be made leaner. In this process nitrogen an inert gas is added to dilute the rich gas. This process has a financial cost.

For LNG that is procured on the global market, this additional cost, combined with other EU markets having wider gas quality specifications has a market attractiveness implication for the UK.



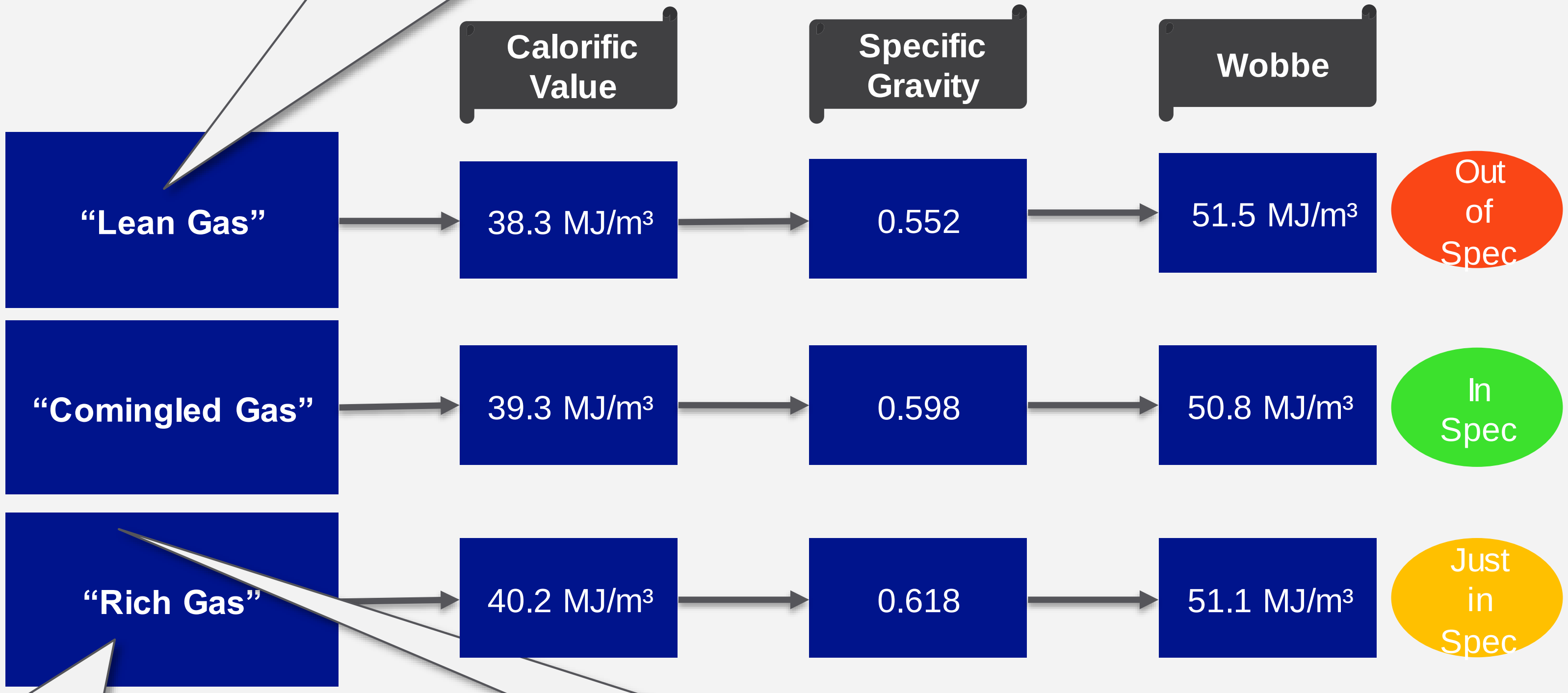
Illustrative example of how CV and SG impact Wobbe

The following illustrative example, shows the relationship between calorific value, specific gravity and Wobbe, and how it impacts whether a gas is in an acceptable safety range.

The calculation to derive the Wobbe figure is CV divided by $\sqrt{SG}$.

Allowed Wobbe range is $47.20 MJ/m^3$ to $51.41 MJ/m^3$

"Lean gas", contains a low concentration of larger molecules which causes a lower CV and specific gravity, which results in it falling out of the allowed Wobbe range



"Rich gas", contains more larger molecules which causes a higher CV and specific gravity, nearly resulting it to fall out of the allowed Wobbe range

"Comingled gas", contains a blend of rich and lean gas to produce a CV and SG values which allow it to comply with the allowed Wobbe range.

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Gas Quality Regulations & Agreements

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Gas quality, billing & ‘capping’

Gas quality plays a fundamental role in how end users are billed.

Most GB domestic customers and industrial customers are billed on the basis of a daily **CV average** for their specific charging zone applied to the volume of gas consumed. This is called the **Flow Weighted Average Calorific Value** (FWACV).

There are currently 13 FWACV charging zones in Great Britain.

The rules relating to this process are setout in law via the Gas (Calculation of Thermal Energy) Regulations (CoTER).

In order to stop the end user being unfairly penalised by the averaging process (i.e. paying for excessive amount of energy they haven’t used), CoTER introduces the concept of **CV ‘Capping’.**

This means that there is a cap on what a CV for a charging zone can be.

The energy of the gas that physically enters a charging zone is called the **Measured Energy**, whilst the energy of the gas billed on the FWACV is called the **Billed Energy**. The difference between the two energy values is called **CV Shrinkage.**

National Grid have responsibility for the procurement of CV Shrinkage. Therefore National Grid are incentivised to try and ensure the CV of the gas entering a zone is as uniform as possible.

However, the introduction of embedded biomethane sites within a charging zones means that not all the gas that flows into a charging zone can be monitored by National Grid.

This regulatory requirement reduces the potential of end users cross subsidising other end users within a specific charging zone.

Please see the supporting information for a worked example of how a charging zones billing CV is calculated.

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Biomethane production and target calorific values

Spotlight

Biomethane is produced through a process of anaerobic digestion of organic waste. Biomethane sites can connect to the NTS, or directly into a distribution network.

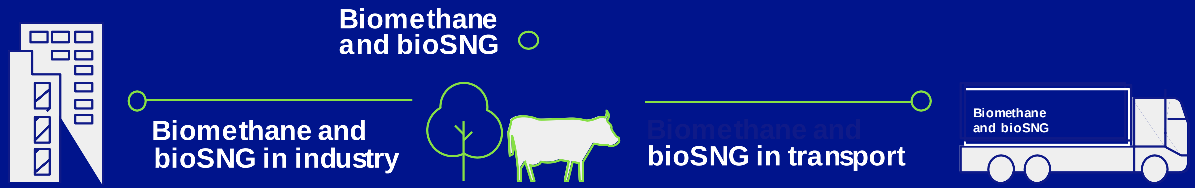
Sites that directly connect into a distribution network need to be taken into account for the purposes of producing a billing CV.

Biomethane traditionally produces a leaner lower CV gas, which if left unchecked would most likely cause ‘capping’ of the FWACV.

Therefore the DNs set a **Target CV** for the biomethane sites to aim to meet. The target CV is more aligned with those expected CVs entering from the NTS.

This process requires the addition of propane and has costs and environmental implications for the biomethane site.

National Grid have **no control** over the CV of the gas entering the charging zones from a embedded biomethane site. Any CV Shrinkage these sites cause is still captured via the existing CV Shrinkage mechanism.



Gas quality regulations

Safety is of absolute paramount importance to operation, delivery and utilisation of gas due to its combustible nature.

To operate the gas system safely and reliably the delivery of gas has to be within certain pre-determined limits as set out in legislation and contractually.

Key documents are GS(M)R and specific Network Entry Agreements (NEAs) underpinned by the Uniform Network Code (UNC).

Gas Safety (Management) Regulation

What is GS(M)R? GS(M)R was introduced as a statutory instrument, to ensure the safe use and management of the flow of gas through the gas network in Great Britain.

GS(M)R applies to the transportation of natural gas through pipes to domestic and other consumers.

Why is GS(M)R important? It places strict limits on the quality of gas entering the network, and an obligation on transporters to only convey gas in their networks that conforms to these limits.

Future of GS(M)R? There is currently an industry wide review of GS(M)R being undertaken by IGEM which hopes to remove the specification from primarily legislation and expand some of the current parameters.

Gas quality agreements

There are a number of contractual entry and exit agreements which determine the types of gas allowed to be input to or off taken from the network, such as Network Entry Agreements (NEAs).

What are NEAs? These are operational agreements between the transporter and the delivery facility operator which define the technical arrangements, including the gas quality limits at a specific entry point onto the system.

Storage Connection Agreements (SCA) and Interconnection Agreements (IA) also cover gas quality specifications for those types of specific sites.

Directly connected entry sites to the distribution networks have connection agreements called 'LDZ System Entry Agreements'.

Why are agreements important? These agreements cover other gas quality limits in addition to GS(M)R specific components. They aim to ensure the safe running of the system.

To change a gas quality parameter within an NEA normally requires an **enabling UNC** modification (as detailed in section I of the Transportation Principal Document in the UNC).

This ensures UNC market participants have the ability to engage in the process and highlight any potential impacts.

See the support information indicative specifications

Gas quality and the European Union

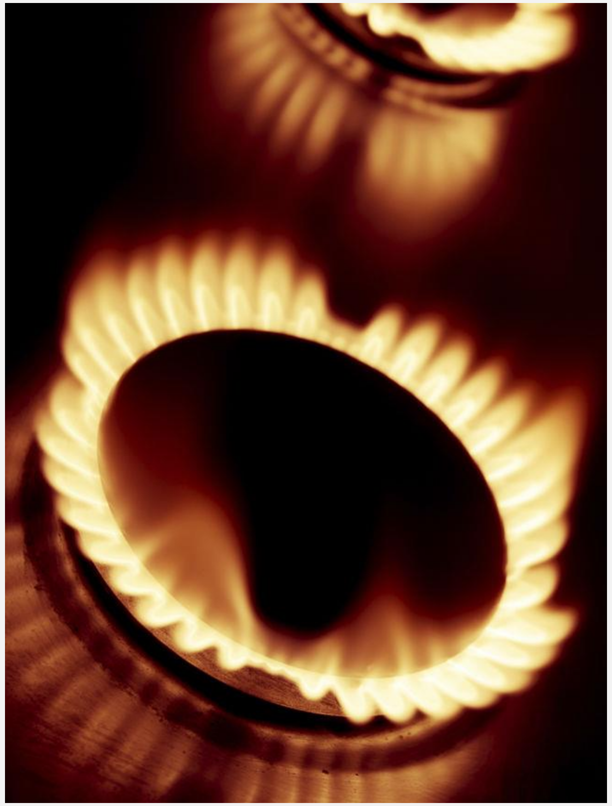
Since 2007, the European body for Standardisation (CEN), has been working to produce a gas quality standard for the whole of Europe.

In 2015 CEN published **EN 16726** which established ranges for a number of gas quality properties, including carbon dioxide and oxygen.

However, the adoption of this standard in individual countries is voluntary because there is currently no legal framework that bind member states to comply with it.

It was not possible for member states to agree on a harmonised range for Wobbe index.

CEN has continued to work on proposals for Wobbe index which and these are expected to conclude in 2020.



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Gas Quality Industry Impacts

How gas quality impacts transporters

Gas transporters are legally obligated not to convey any gas in their networks that does not conform to the GS(M)R specifications.

The National Grid Control Room constantly monitors gas quality at all entry points against limits defined in each Network Entry Agreement.

If a GS(M)R parameter is breached by a terminal, the flow can be curtailed to try and prevent that gas reaching the NTS

The National Grid Control Room also monitors the CV of gas entering charging zones from the NTS to try to minimise the differential between billed and measured energy, which results in CV Shrinkage.

Distribution Network Control Rooms also monitor the gas entering their network ensuring those entry sites that directly flow onto the Distribution Network provide gas that meets legal requirements

How gas quality impacts shippers

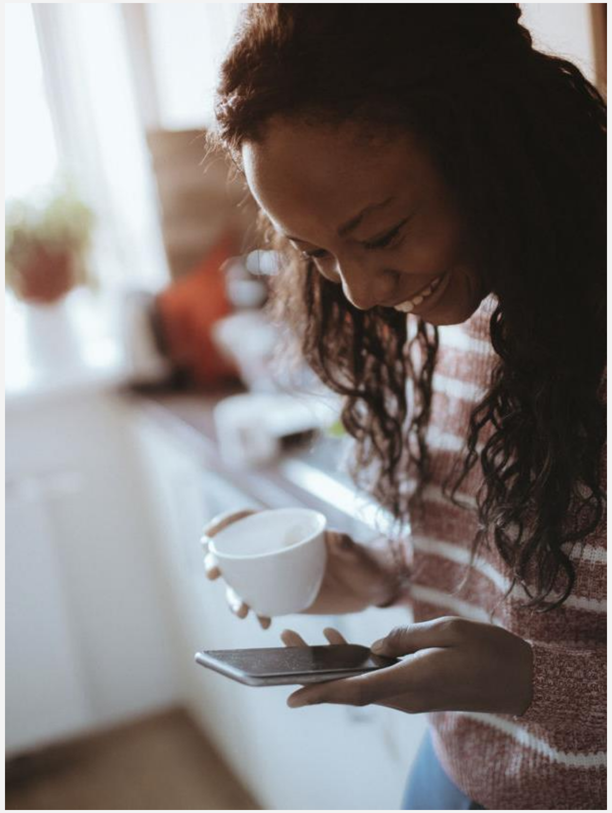
GB Shippers could be impacted by gas quality specifications in a range of ways depending on their commercial positions:

Entry: If an entry delivery facility operator delivers off specification gas and is curtailed that would impact a shipper. It would leave them with a shortfall of gas on their entry portfolio, which would require the shipper to procure additional gas from alternative sources or potentially face an energy imbalance charge.

Exit: If gas is taken of the system outside the quality range, a plant operator may refuse the gas causing a shipper imbalance on their exit side. In a worst case, this could cause plant damage, leading to an extended outage and loss of transportation revenue for the Shipper.

Shippers could be impacted by a number of high level gas quality developments, including:

- The cost and competitiveness of LNG entering the UK market.
- Maximising recovery of UKCS reserves
- Encouraging further biomethane development and supply.
- Facilitating the introduction of hydrogen and other low carbon gas on the network.



How gas quality impacts end users

Changing the gas quality ranges would have different impacts on different types of end users.

It is important to understand the potential **challenges** these end users may face if gas quality ranges are changed

Gas fired power stations: These users require limited rates of changes in CV and Wobbe. Onsite equipment is tuned to operate within a Wobbe band to maximise efficiency and minimise emissions. Significant and rapid gas quality fluctuations could impact on revenues and component life span.

Industrial users: These users traditionally have a strong focus on plant efficiency to drive positive economic outcomes. Certain industrial users are more sensitive to changes in gas quality than others, so consistency of gas quality could minimise excess costs for these users

Underground Storage: Storage sites are potentially sensitive to changes in carbon dioxide and oxygen levels as the additional moisture could cause corrosion and site damage.

Domestic users: Domestic appliances are typically less sensitive to fluctuations in gas quality. These appliances are covered by Gas Appliance Regulation (GAR).

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The Future of Gas Quality

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Gas quality, future opportunities and net zero

Low carbon gases can play a significant role in enabling the energy transition to meet the net zero target in an economical and efficient way.

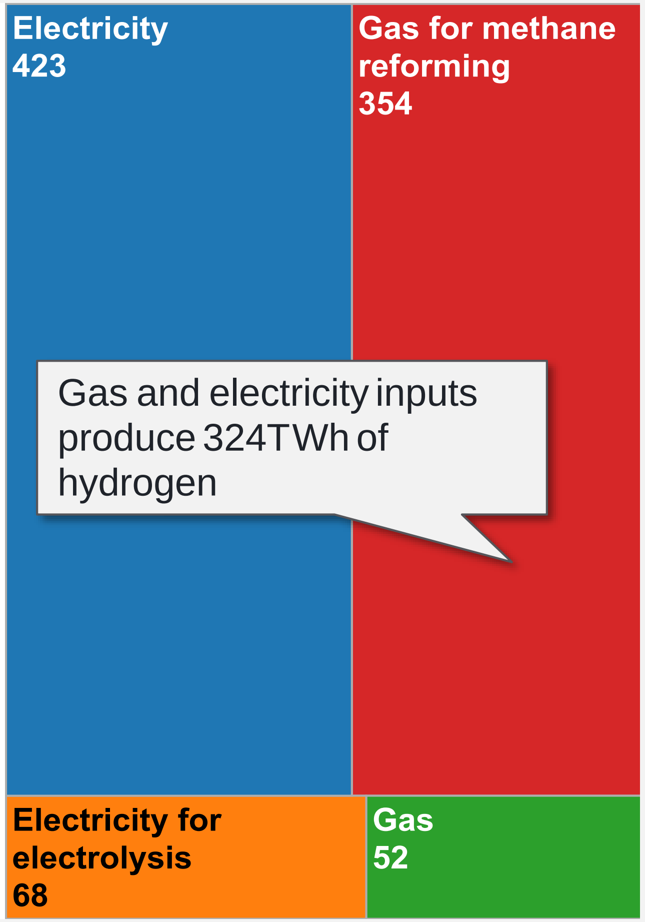
This was highlighted in National Grid's 2019 Future Energy Scenarios Net Zero sensitivity, where in 2050 47% of energy utilised in the sensitivity was for the creation of Hydrogen

We know gas quality standards will need to change, therefore it is vital that an agile and transparent process is developed to change the gas quality standards in an inclusive and customer focused way.

As outlined in the Enabling the Gas Markets Plan document, gas quality will be a key focus area in 2020.

- We will explore and document existing initiatives in the gas quality area.
- We will provide recommendations for future projects, whilst continuing to engage with industry stakeholders to drive consumer value.

Figure 2: Net zero energy demand in 2050



Total energy demand: 896TWh

Hydrogen future?

Hydrogen provides a unique opportunity to decarbonise our heating, transport and industrial processes which would help in reaching the Net Zero target by 2050.

This is because when hydrogen is burnt at source it produces energy and water, without emitting carbon.

The gas industry is currently going through a period of intense innovation in demonstrating the safety and technical feasibility of hydrogen at different blends.

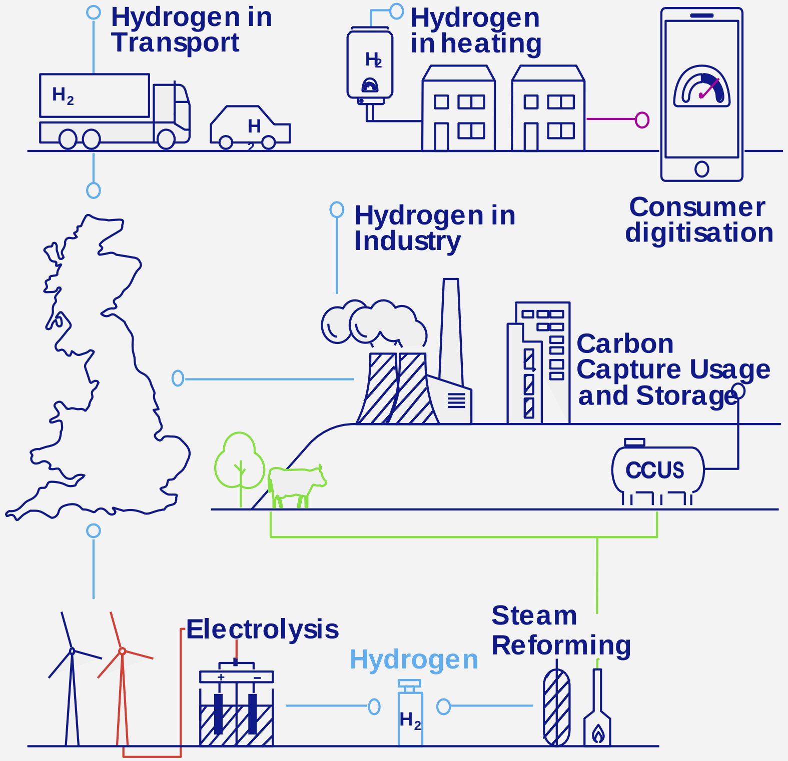
The current amount of hydrogen allowed in the gas composition by law is 0.1% (with exemptions for innovation projects). This is a historical legacy from the move from town gas to North Sea gas.

It is widely expected that this restriction will need to evolve over time, as the technical feasibility of hydrogen is proven.

There are primarily two ways hydrogen could be produced, commonly known as:

Blue Hydrogen: This is where hydrogen is created through industrial processes such as steam methane reformation (SMR), and where the excess carbon emissions created would then be captured, used or stored (CCUS)

Green Hydrogen: This is where hydrogen is created via a process of electrolysis (combination of renewable electricity and water). If renewable electricity is used in this process, then the generation and use of hydrogen is completely carbon free



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Supporting Information

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Flow weighted average calorific value example

The example on the following 2 slides shows how the FWACV is calculated for a charging zone. It has representative calorific values, but with lower volumes and energy for simplicity.

There are two ways gas is supplied to a charging zone, via offtakes from the NTS, or via directly connected sites within a charging zone (typically biomethane sites). For this example the term "offtake" relates to both the above ways gas can enter a charging zone.

Offtakes are designated as either "Directed" or "Non-Directed" by Ofgem. Directed offtakes use the CV of the gas that pass through the on-site equipment, whilst non-direct offtakes have a CV attributed to them from a nearby directed offtake.

Measured: Each directed offtake into a charging zone has a measured volume and a measured CV specific to the gas flow through that offtake during a day. A calculation (1) is then applied to define the measured energy of each offtake.

Billed: The total volume for the charging area (e.g. 8,500*) and the total energy for a charging area (e.g. 93,528**) is then calculated (2) to define an 'uncapped' CV (e.g. 39.6***). The maximum daily CV average for the charging area permitted by the regulations is equal to 1.0 MJ/m³ above the lowest measured daily CV average of the inputs into the charging area.

Hence, in the example below instead of a 39.6 Billed CV, a 'Capped' Billed CV of 39.4 is applied which is 1.0 MJ/m³ above the lowest measured CV of 38.4. The difference is called CV Shrinkage (e.g.500****) which National Grid takes responsibility to procure.

Flow weighted average calorific value example continued

Offtake / Direct Connect	Measured Volume (m³)	Measured CV (MJ/m³)	Measured Energy (kWh)	Billed CV (MJ/m³)	Billing Energy (kWh)	CV Shrinkage (kWh)
A	500	38.4	5,333	39.4	5,472	-139
B	4000	39.2	43,556	39.4	43,778	-222
C	3000	40.1	33,417	39.4	32,833	583
D	1000	40.4	11,222	39.4	10,944	278
	8500*	38.4	93,528**		93,028	500****

LOWEST SOURCE CV:	38.4
CHARGING ZONE CV (UNCAPPED):	39.6***
CHARGING ZONE CV (CAPPED):	39.4

Calculation 1	Volume x CV / 3.6 = Energy
Calculation 2	Energy / Volume x 3.6 = CV

Gas ten year statement & gas quality

For entry agreements to the NTS National Grid provides an indicative specification that is usually acceptable at most locations in its Gas Ten Year Statement (GTYS). This specification encompasses, but it is not limited to, the statutory requirements set out in the GS(M)R.

The Gas Ten Year Statement 2019 document can be found here

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Table 1: Gas quality specification

Parameter	Quality requirement
Hydrogen Sulphide	Not more than 5 mg/m3
Total Sulphur	Not more than 50 mg/m3
Hydrogen	Not more than 0.1% (molar)
*Oxygen	Not more than 0.001% (molar)
Hydrocarbon dewpoint	Not more than -2° C at any pressure up to 85 barg
Water dewpoint	Not more than -10° C at 85 barg
Wobbe Number (real gross dry)	The Wobbe number shall be in the range 47.20 to 51.41 MJ/m^3
Incomplete combustion factor (ICF)	Not more than 0.48
Soot index (SI)	Not more than 0.60
*Carbon dioxide	Not more than 2.5% (molar)
Containments	The gas shall not contain solid, liquid or gaseous material that might interfere with the integrity or operation of pipes or any gas appliance, within the meaning of regulation 2(1) of the Gas Safety (Installation and Use) Regulations 1998, that a consumer could reasonably be expected to operate.
Organo halides	Not more than 1.5 mg/m^3
Radioactivity	Not more than 5 becquerels/g
Odour	Gas delivered shall have no odour that might contravene any statutory obligation. The odourisation requirements in GS(M)R do not apply where the gas is at a pressure above 7 barg.
Pressure	The delivery pressure shall be the pressure required to deliver natural gas at the delivery point into our entry facility at any time, taking into account the back pressure of our system at the delivery point, which will vary from time to time. The entry pressure shall not exceed the maximum operating pressure at the delivery point
Delivery Temperature	Between 1° C and 38° C

*Requests for higher limits will be considered

GS(M)R Schedule 3, Part 1

The following table shows the ranges and characteristics of allowed gas in the UK.

Table 2: GS(M)R Schedule 3, Part A specification

Content or Characteristic	Value
hydrogen sulphide content	≤5 mg/m3;
total sulphur content (including H2S)	≤50 mg/m3;
hydrogen content	≤0.1% (molar);
oxygen content	≤0.2% (molar);
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 1994 Regulations) which a consumer could reasonably be expected to operate;
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 1994 Regulations) which a consumer could reasonably be expected to operate;
WN	(i)≤51.41 MJ/m3, and (ii) ≥47.20 MJ/m3;
ICF	≤0.48
SI	≤0.60

Glossary

Abbreviation	Name	Abbreviation	Name
CCUS	Carbon Capture, Usage and Storage	IGEM	Institution of Gas Engineers and Management
CO2	Carbon Dioxide	LDZ	Local Distribution Zone
CoTER	Calculation of Thermal Energy Regulations	LNG	Liquid Natural Gas
CV	Calorific Value	NEA	Network Entry Agreements
DNs	Distribution Networks	NTS	National Transmission System
FES	National Grid's Future Energy Scenarios	SCA	Storage Connection Agreement
FWACV	Flow Weighted Average Calorific Value	SG	Specific Gravity
GMaP	Gas Markets Plan	SMR	Stream Methane Reformation
GS(M)R	Gas Safety Management Regulations	TPD	Transportation Principle Document (part of the UNC)
GTYS	National Grid's Gas Ten Year Statement	UK	United Kingdom
HSE	Health and Safety Executive	UKCS	UK Continental Shelf
IA	Interconnection Agreement	UNC	Uniform Network Code

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