The European Association of Internal Combustion Engine Manufacturers

EUROMOT

POSITION PAPER

30 May 2011

2011 YEARS Promoting Engine in Society

Gas Quality Aspects for Reciprocating Gas Engines

Background

The European Commission has for some time been working on the harmonisation of gas quality in the European gas market. Currently, we still have differences in gas qualities between different Member States. The Commission aims to achieve an integrated European market where gas can flow freely and wants to ensure that every country or transmission system in the EU will accept the same range of gas quality parameters (see Annex I). In this context, GL Noble Denton, on behalf of the European Commission, is investigating the effects of a Europe wide harmonisation of gas quality on gas-fuelled equipment.

On 27 January 2011, a meeting concerning gas quality issues was held in the EUROMOT office in Frankfurt together with GL Noble Denton to discuss how gas quality impacts gas engines. This position paper summarises and expands on some of the most important aspects raised during this meeting.

Introduction

EUROMOT, the association of engine manufacturers in Europe, strongly promotes a secure supply of affordable gas to Europe and supports in principle the harmonisation of gas quality in Europe. However, the engine sector is concerned that introducing gas quality specifications like the EASEE gas specifications (also called EASEE Common Business Practice or EASEE-CBP, see Annex II) could lead to excessive variations in gas quality with negative implications for the operation of gas applications and especially gas engines. For example, lower gas qualities can result in a high variability of the knock resistance of the gas and lead to a reduced performance (or even shut downs), higher fuel consumption and higher emissions of gas engines. Importantly, adapting existing gas engine installations will incur high costs.

Currently, most regions in Europe receive close to constant gas compositions which allow gas engines to be tuned adequately to the relevant gas composition. EUROMOT understands that diminishing European resources of natural gas, intentions to promote gas exchange between member states and worries about security of energy supply as well as the expectation of increased use of shale gas result in the wish among some stakeholders for wider gas quality ranges in the gas grid within Europe.

As an alternative approach the engine sector strongly advocates the concept of proper gas treatment at each point of reception of imported gas in Europe to address these issues (see Figure 1). Excessive amounts of hydrocarbons higher than methane should be stripped off the gas. This valuable by-product can subsequently be delivered to refineries as a feedstock for liquid fuels. Such liquid fuels have a high economical value and are a welcome energy source for engines running on that type of fuel. Upgrading pipeline gas to almost 'Russian' gas quality would in many ways be ideal and yield the best results for running gas equipment such as gas engines.

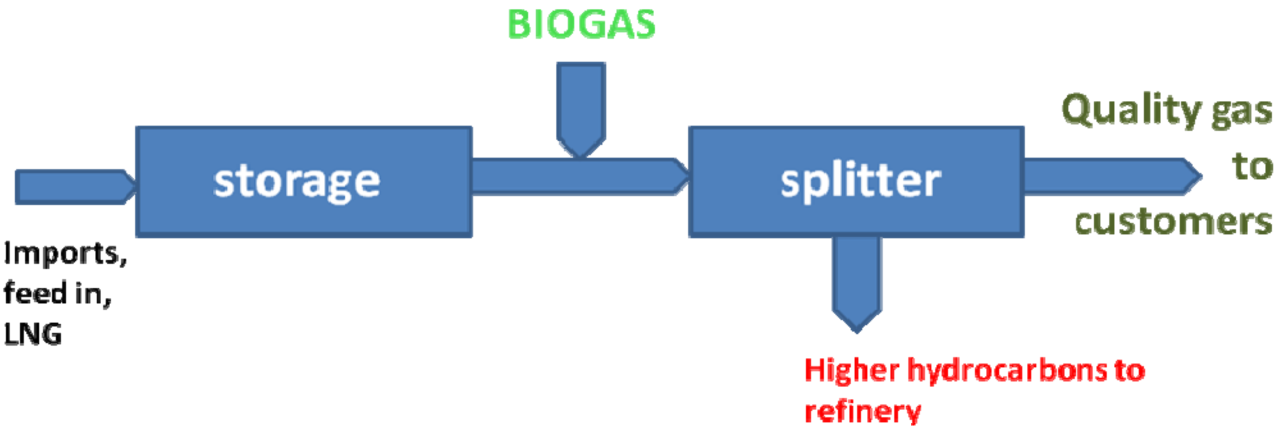


Figure 1: Optimum solution for a secure supply of quality gas within Europe

Furthermore, EUROMOT urges EASEE-gas, gas companies and regulators to take into account further important parameters – such as the Methane Number – when setting gas specifications.

EUROMOT proposes following gas specifications (Table 1: Black colour signifies EASEE-CBP values, green colour signifies EUROMOT positions):

Table 1: EUROMOT proposals for gas specifications

Wobbe Index	**kWh/m3**	**13.6**	**15.81**	**Max. variation of +-2% and providing MN of 80-100**
Methane Number		**80**	**100**	**EASEE CBP gives MN 48 – 102**

Ignitability	Lambda range		2.2	
Laminar Combustion velocity	cm / s	28	32	
Relative density	m3/m3	0.55	0.700	Ensuring the right Wobbe range
O2	mol %	-	0.01	
S	mg/m3	-	5	Introducing Oxi-cat for reducing Form-Aldehyde restricts the S content of the gas
H2S +COS (as S)	mg/m3	-	5	
RSH (as S)	mg/m3	-	0	Preferably no S in odorant
CO2	mol %	-	02. Mai	
H2O DP	OC at 70 bar	-	-8	
HC DP	OC at 1- 70 bar	-	< - 10	To avoid condensation in cooler stretches of gas pipelines
Supply pressure	Bar (gauge pressure)	8	-	Many applications (e.g. engines or turbines) need a higher pressure than domestic applications

Technical implications of low gas qualities

There are many negative consequences of allowing a wide range of gas compositions in the European gas pipeline system. Apart from negative economic consequences, quality variations can induce damage to equipment and end up in unsafe situations. It is very important to note that the Wobbe index is not the only gas quality parameter that affects equipment performance. In addition, the acceptable Wobbe Index range can differ from application to application.

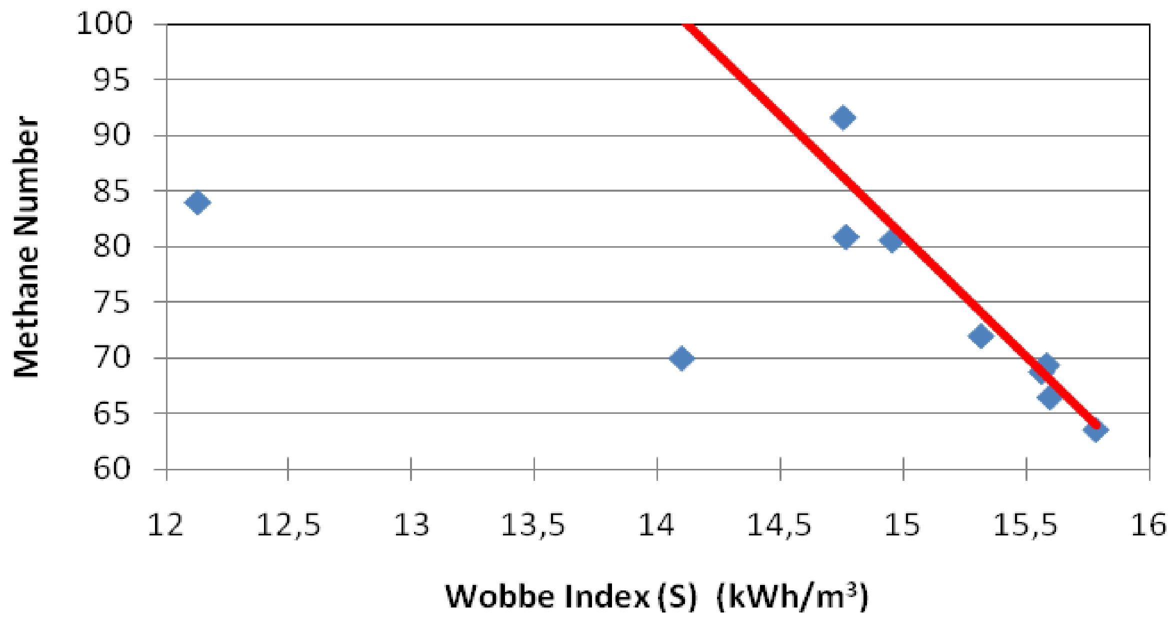
Unfortunately, EASEE-gas has not taken into account gas properties that are of importance for a safe, efficient and clean application of natural gas in applications such as reciprocating gas engines and gas turbines. Gas properties that have been omitted include combustion velocity/flame speed, ignition/ flammability limits, knock resistance and energy content of the gas. Changes in flame speed and ignitability have an immediate effect on combustion stability and emissions. Reference 5 gives the results of investigations by the gas industry itself about the ignition limits and laminar flame speed depending upon the composition of gases. It appears that higher hydrocarbons burn faster than methane while their ignition range expressed in air-to-fuel ratio is narrower. It is also well known that ballasting of gases with inert gases such as CO_2 and N_2 reduces flame speed as well as ignition range. Changes in composition therefore affect the phasing of the combustion process in the engine cylinders. Moreover, higher fractions of higher hydrocarbons as well as more inert gases reduce the acceptable air-to-fuel ratio. That further increases the tendency to knocking and the NOx emissions. Furthermore, a low dew point, for water as well as hydrocarbons, is crucial for an undisturbed performance of gas-fuelled equipment. In many cases, gas supply lines at the premises of customers are subjected to an ambient temperature that can be much lower than the -2 °C which are defined by EASEE-gas for the hydrocarbon dew point. The Joule-Kelvin effect causes a temperature drop of approximately 0.5 K per bar pressure drop in a pressure reducing station. Formation of liquids in the supply lines and subsequent inflow into the appliance is destructive for engines as well as gas turbines and therefore dangerous for operators.

EASEE-CBP defines a Wobbe Index range, based on the higher heating value, between 13.60 and 15.81 kWh/m3 which equals 48.69 to 56.92 MJ/m3. This range goes well beyond most current national limits and practical gas supply values. Variations in Wobbe index induce variations in air-to-fuel ratio λ of gas-fired equipment if no corrections in the mixture preparation device are taken. That applies for nearly all gas-fuelled appliances, including domestic boilers, burners, gas engines and gas turbines. The air-to-fuel ratio with respect to a stoichiometric mixture varies inversely proportional with the Wobbe index. If the uncontrolled λ value is 2.0 for a Wobbe index of 13.60 kWh/m3, λ will change to 1.71 if the Wobbe increases to 15.81 MJ/m3. Likewise, if the Wobbe index changes from 15.81 kWh/m3 to 13.60 kWh/m3, an initial λ of 2.0 will change to λ = 2.32. In the first case, the combustion process will become much hotter resulting in excessive NOx production. Moreover, the overheating will lead to damage, possible ending up in a dangerous situation. In the second case, the flame will be too lean and extinguish, again resulting in a dangerous situation with possibly exhaust system explosions. EUROMOT is of the strong opinion that the Wobbe range as defined by EASEE-gas is too broad to be acceptable for gas engines and many other applications.

Figure 2 illustrates that the Wobbe Index is by no means a proper measure for the knock resistance of gaseous fuels. As soon as inert gases such as N_2 and CO_2 are present in a fuel gas, large deviations from the red line representing fuel gases without inert gases occur.[1]

[1] The Methane Number of the gases in Figure 1 have been determined with the Wärtsilä method with the addition that the nitrogen concentration has been removed from the gas composition. The hydrocarbon concentrations have been corrected after the taking away of nitrogen so that their combined concentrations equate to 100% again.

Figure 2: Example of Methane Number versus Wobbe Index for some gases to be imported and exchanged in Europe.



Explanation: The gas depicted furthest to the left of Figure 2 is Groningen gas.

In addition, Table 2 shows that even gases without inert gases and a constant Wobbe index can have serious deviations in knock resistance. The data are for gases with a maximum Wobbe Index of 15.81. Although the examples given in Table 2 are not based on 'natural' natural gases, in contrast with those in Figure 2, it proves that the approach of the EASEE-CBP, which only sets limits on the Wobbe Index range, can lead to unintended and possibly dangerous results. For example, the EASEE-CBP would allow gas shippers to use butane to increase the Wobbe index of Russian gas – with potentially detrimental effects on the gas user's equipment.

Table 2: Example that a constant Wobbe Index of 15.81 kWh/m^3 for gases with only alkanes can result in large deviations in knock resistance (Methane Number)

CH4	C2H6	C3H8	C4H10	C5H12	***Wobbe***	*Hs*	*Hi*	*d*	*ρ*	***MN***
%	%	%	%	%	**kWh/m3**	MJ/m3	MJ/m3		kg/m3	
79.15	20.85				**15.81**	46.13	41.78	0.657	0.849	**69**
89.37		10.63			**15.81**	46.20	41.84	0.659	0.852	**65**
92.87			7.13		**15.81**	46.22	41.86	0.660	0.853	**57**

Worryingly, a study by MVV[2] finds that in a number of European countries the quality of imported Liquefied Natural Gas exceeds even the already wide range of the EASEE-CBP Wobbe Index values (see figure 2). A gas with a Wobbe Index of 16.3 kWh/m3 – this corresponds with a maximum Methane Number of approximately 50 – will be completely unsuitable for natural-gas-fuelled engines, especially if you consider that the performance of a gas engine already starts decreasing significantly below a Methane Number of 80.

Furthermore, it is important to note that gas engines as well as gas turbines cannot accept a sudden stepwise change in Wobbe Index from 13.0 kWh/m3 to 16.3 kWh/m3 and vice versa. For example in Belgium, the legally acceptable Wobbe Index limits, as given by a Royal Decree, lie between 14.1 and 15.55 kWh/m3. However, in a presentation from 2010 the local gas supplier Distrigas admits that industry cannot accept a Wobbe Index variation range larger than +/- 4% of the average value. For this reason, Distrigas in practice supplies gas in the Wobbe range between 14.4 and 15.1 kWh/m3[3]. Nevertheless, a wide range of the legal limits are a real threat for gas customers, as the gas supplier cannot be held legally responsible for damages done through deviations outside the 'usual' Wobbe range if the deviations are still within the legally defined range.

The development of better equipment which can accept much wider ranges of gas compositions may be desirable. However, there are physical limitations: as of today, the development of equipment for automatic acceptance of a wide range of gas compositions without special adjustment for composition variations was unsuccessful, notwithstanding decades-long research by the gas supplying industry itself. Furthermore, even if such equipment could be developed, one has to expect that such equipment would be more expensive and would still have a permanently lower performance due to physical limitations.

Gas Treatment at Point of Reception

The engine sector therefore advocates the concept of proper gas treatment at each point of reception of imported gas in Europe to guarantee a stable and good gas quality supply. Such gas treatment, as shown in Figure 3, is common practice in the European gas industry. In the gas treatment plants excessive amounts of hydrocarbons higher than methane are stripped off the gas. This valuable by-product can subsequently be delivered to refineries as a feedstock for liquid fuels. Such liquid fuels have a high economical value and are a welcome energy source for engines running on that type of fuel.

[2] 'Study on Interoperability of LNG Facilities and Interchangeability of Gas and Advice on the Opportunity to Set-up an Action Plan for the Promotion of LNG Chain Investments', FINAL REPORT May 2008

[3] In another example from the Netherlands, Gasunie maintains a Wobbe Index between 12.1 and 12.4 kWh/m3 for their low-calorific gas to avoid problem with gas-fuelled equipment.

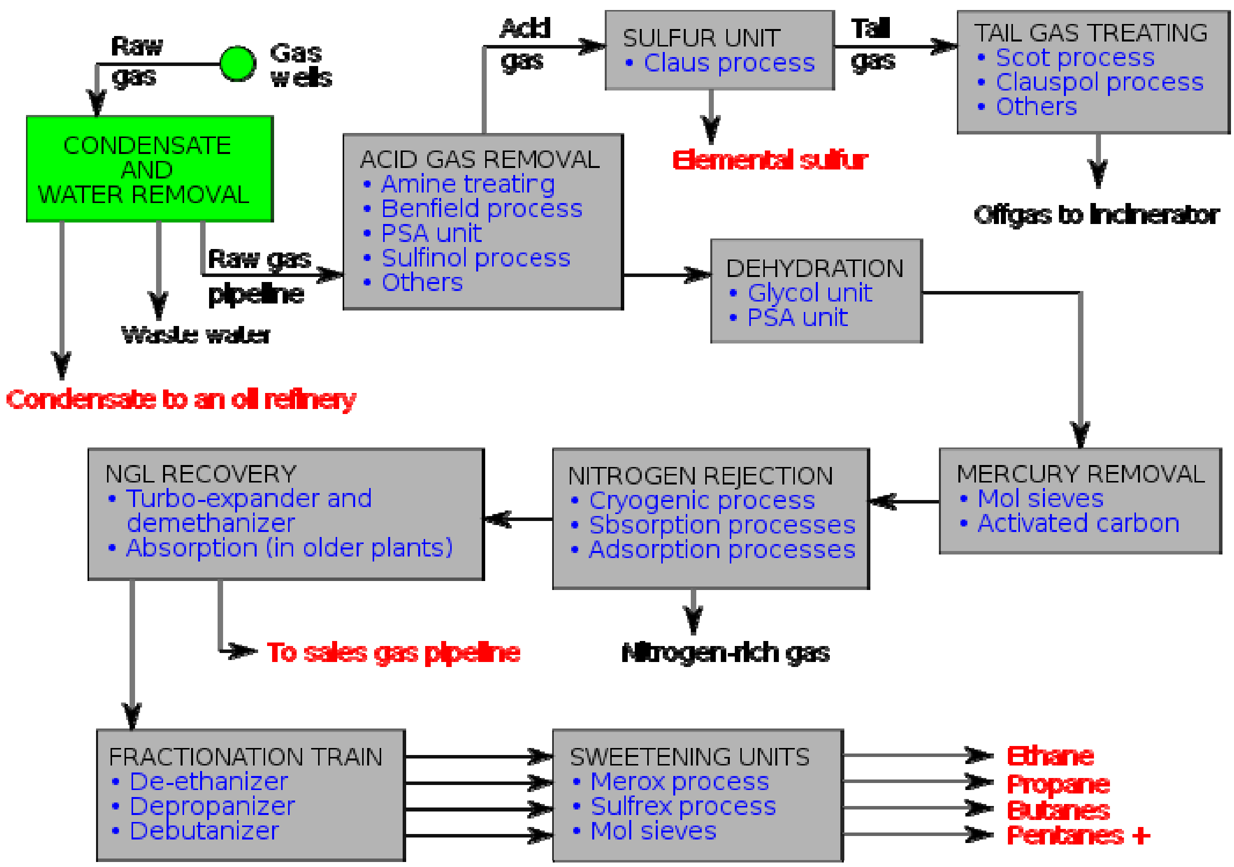


Figure 3: The standard gas treatment process for turning wellhead gas into pipeline gas

Figure 4 shows, the relative costs of re-gasification at LNG reception terminals are comparatively low. Upgrading the gas, e.g. LNG, to acceptable specifications by introducing an additional train for removing some of the higher hydrocarbons will not excessively increase the costs of the final gas. In addition, most LNG terminals are situated close to refineries where the higher hydro-carbons will be welcomed as a valuable feedstock. Studies revealed that adapting the household appliances in the UK to a wider Wobbe range would have additional costs of 8 billion GB£ compared to derichment of the gas.

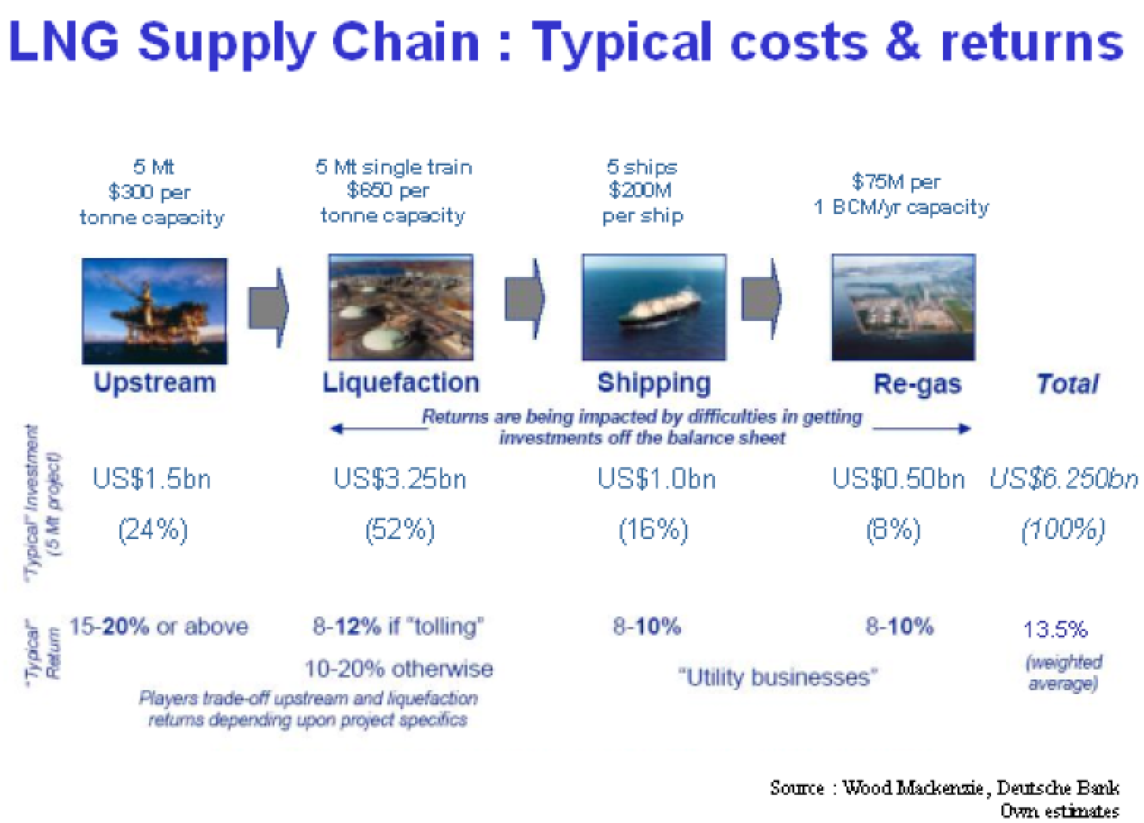


Figure 4: Typical costs distribution in the LNG supply chain.

Methods for gas treatment

As a method for creating an adequate gas quality, the engine sector prefers removal of part of the higher hydrocarbons to other proposals such as ballasting with CO2 or ballasting with N2. Nitrogen does not help to improve the knock resistance while both CO2 and N2 affect the flame speed and the ignitability in a negative way. In addition, CO2 tends to decrease fuel efficiency because of its thermodynamic properties. Ballasting with air is excluded because of the limit for oxygen in the gas. Please also recall that higher hydrocarbons stripped from excessively rich gases are also valuable as feedstock. Any existing legal impediments and limitations regarding the trading of such higher hydrocarbons should be altered to allow free trade of these products.

Gas Quality

Experts[4] estimate that by the year 2030, Russia and Norway will be the major gas suppliers for the Europe Union, followed by Algeria and Qatar. Russia will be by far the largest supplier, with a volume seven times higher than Norway. For this reason, EUROMOT recommends to use Russian and Norwegian gas as benchmark for the gas quality of European grid. The average Wobbe Index of Russian gas is 14.75 kWh/m3 and its Methane Number is 91.6. The average Wobbe Index of Norwegian gas is 14.77 kWh/m3 and its methane number is 80.9.

[4] See MVV Study on Interoperability of LNG Facilities and Interchangeability of Gas and Advice on the Opportunity to Set-up an Action Plan for the Promotion of LNG Chain Investments', FINAL REPORT May 2008

The engine sector could accept a Wobbe range between 14.00 and 15.00 kWh/m3, or a Wobbe Index range of approximately +/- 3 % around the average value. This equals the Wobbe Index range existing today in the UK. In the Netherlands, Gasunie/GTS maintains a Wobbe variation range of +/- 1 %. An obvious reason for this is to guarantee the safety of the customers.

A further restriction on any blending actions is that inert gas ballasting with nitrogen has to be restricted to a maximum of 2.5% in order to obtain a Wobbe Index below 15.00 kWh/m3. This may be necessary if the Wobbe Index of the gas with the inert gases removed exceeds 15.00 kWh/m3. This limit is important, as if a Wobbe Index of 15 kWh/m3 is reached by e.g. adding 4% nitrogen, the Methane Number can drop to 65. Such low Methane Numbers severely impact the engine performance for the worse.

From a gas-transport system point of view, the +/- 8% range in Wobbe Index with a maximum Wobbe of 15.81 kWh/m3 as proposed by EASEE-gas may be acceptable. For most gas applications this range is much too broad.

In addition, a safe dew point, for water as well as hydrocarbons, is crucial for an undisturbed engine performance.

A useful definition of interchangeability could be the one provided by the NGC+ group[5]:

"The ability to substitute one gaseous fuel for another in a combustion application without materially changing operational safety, efficiency, performance or materially increasing air pollutant emissions".

[5] A technical working group set up by some US industry stakeholders to address gas interoperability issues.

Table 3: Some examples of gas compositions leading to an acceptable Wobbe Index range for gas engines.

C1	C2	C3	C4	inerts	Wobbe	MN
%	%	%	%	%	kWh/m3	-
92	4	0.8	0.5	2.3	14.7	81
98	0.6	0.3	0.2	0.9	14.6	92
91	6.7	0.6	0.2	1.5	15.0	80
86	3	1	0.5	9.5	14.0	80

Table 3 gives some examples of possible gas compositions leading to Wobbe numbers below 15 kWh/m3 and suitable for gas engines. The presence of nitrogen in fuel gas should not change the proposed ratio between the hydrocarbons. Nitrogen does not help to improve the knock resistance of fuels although it lowers the Wobbe index.

ENGINE SPECIFIC REMARKS

Higher hydrocarbons than methane have a much lower knock resistance than methane. A higher Wobbe index means a higher amount of higher hydrocarbons resulting in a decreasing knock resistance. Even with a constant Wobbe index, the knock resistance of a gas can show large variations of up to 20 points in so-called Methane Number. The gas engine sector uses the Methane Number to determine the knock resistance of gaseous fuels and it is very important that the specifications of gaseous fuels should contain the Methane Number as an extra parameter.[5]

Knocking combustion can lead to a complete destruction of an engine, with the inherent safety issues. Other important quantities for all gas applications are ignitability and flame speed. Those properties have not yet been considered in the proposed gas specifications, but they are crucial for modern clean burning gas applications, ranging again from modern household appliances to gas engines and gas turbines. Changes in flame speed and ignitability have an immediate effect on burner stability and emissions.

Some installed engines have engine management devices that are able to control the air-to-fuel ratio within certain limits. Such systems are required to compensate for changes in ambient pressure and temperature as well as air humidity in order to keep the emissions within legal limits. However, these control systems have not been designed to compensate for the large Wobbe index variations proposed by EASEE-gas (+/-8%). Consequently, the ultimate accuracy of the air-to-fuel ratio will decrease.

[5] In this connection it should be noted that the so-called “AVL methodology” to determine the Methane Number – and still generally used by gas companies – is outdated. The “AVL methodology” was developed for stoichiometric engines which nowadays can be regarded as an (almost) obsolete technology. For the purpose of defining gas specifications the Methane Number should be determined according to the latest state-of-the art.

Also part of the engine installations has been equipped with knock detection and protection devices. Such systems cannot protect the engines against large stepwise variations in gas composition leading to richer and less knock-resistant mixtures.

Estimated costs for adapting the engines

With the proposed wide Wobbe range, decreased knock resistance and changes in combustion velocity, the engines without engine management systems have to be equipped with control systems. Even if such control systems are installed, it will be difficult to cope with stepwise changes in composition caused by plug flow. In many cases, such systems have to be especially developed for a certain engine type since they currently do not exist. This is especially problematic for engines that are no longer available on the market. For some obsolete engine types, the development costs per engine can be up to € 50,000. Existing control systems might costs some € 10,000 per engine[6].

In many cases, the compression ratio of the engines has to be adapted to accommodate the poorer gas quality. That can also involve adapting the turbocharger and the camshaft timing. The costs connected with such changes can vary between 80 €/kW and 300 €/kW, depending upon the size of the engine (Figure 5). There are two tendencies in the conversion costs. Changing a smaller engine is more expensive per kW than a large engine having the same running speed, although the absolute costs are naturally higher for a large engine. However, for engines with a lower running speed, relatively more material is required to produce the same output as a machine with a higher running speed. It will be clear that the costs of adapting engines smaller than 250 kW will be excessive.

[6] Estimates by Jacob Klimstra Consultancy

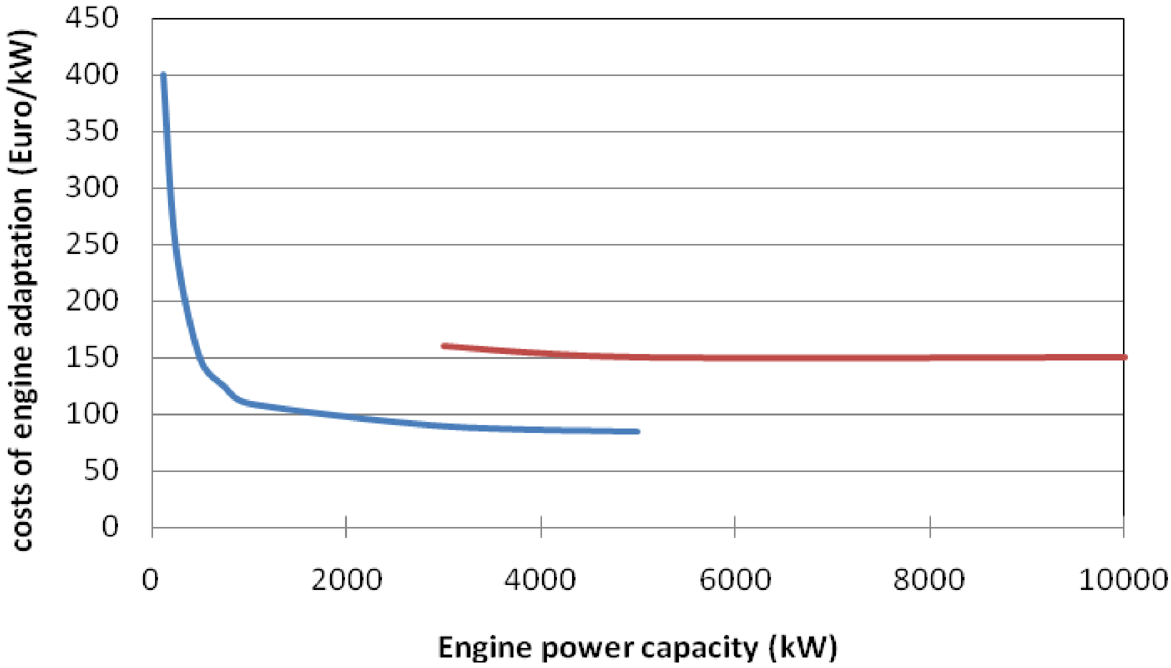


Figure 5: Estimated average specific costs to adapt gas engines to the proposed lower quality gas[1]

EUROMOT estimates that for at least 20% of installed engines adapting them to lower gas quality is economically not feasible e.g. because the type in question has been taken out of production, the factory has been closed down or the engine is relatively unique. It is important to note that these cost estimates do not take into account of the loss in financial returns of operators of the installation. Not producing contractually agreed electricity during an optimistic time span of two weeks can consume the profits of a whole year.

Estimated number of engines, installed capacity and capital investments

Policy makers would like to have a complete overview of the number of gas engines installed in Europe, including the extent to which they are equipped with control devices. This number is however not available in absolute terms since often the manufacturers lose sight of the delivered equipment (delivered to packagers, sales to third parties, engine considered obsolete by the owner). However, it is estimated that in The Netherlands alone, a total capacity of 3.7 GW has been installed consisting of about 4500 installations. An estimated 40% of these installations are not equipped with lambda and knock control devices. The estimated capital investment is € 2.8 billion. Denmark has about 1 GW of gas engines installed. Experts estimate the total installed gas engine capacity in Europe at 9 GW. Extrapolating the data from The Netherlands, we end up with € 6.8 billion investment[7].

[7] Source: Jacob-Klimstra-Consultancy

Biogas-fuelled Engines & Engine Emissions Issues

Many biogas-fuelled engines (e.g. at sewage treatment plant) use natural gas as a back-up fuel. For such installations, a high compression ratio is needed to exploit the high knock resistance of biogases. Lowering the compression ratio to accommodate a wide range of poor quality natural gases will substantially deteriorate the economics of biogas fuelled power plants.

Potentially, additional investments in selective catalysts (SCR) for NOx abatement will be required, as controlling the air-to-fuel ratio will be made more difficult by a wide Wobbe range. Furthermore, tuning the engine for a wide Wobbe range might easily result in a increase of average NOx production by a factor two. The specific investment for SCR can vary between € 100/kW and €35/kW, depending upon the size of the engine.[8]

Effects on power capacity, fuel efficiency and CO2

For example, if the effective methane number drops from MN 80 to around 55 this will require a power reduction of up to 15 - 35% depending on engine type and „generation“. That raises the specific capital costs (€cts/kWh) by more than 33% in some cases. In addition, the specific fuel consumption will increase between 4 and 10% depending on engine type.

For some existing engine types in the field, a compression ratio change and timing adjustment could compensate for the power reduction (new engine generations are less affected) to a certain extent anyhow lowering the compression ratio will anyhow result in a fuel consumption penalty in order of 3 %. To be able to maintain the performance as good (compression ratio change, timing adjustments, etc.) as possible (before the methane number drop), a modification to existing engines in the field will result in a additional high investment (see above figure 5). However, this technology is not available for some engine types and will therefore result in a permanent power reduction with fuel penalty.

Every increase in specific fuel consumption will also result in a proportional increase in CO2 emissions. This effect is exacerbated by the fact that higher hydrocarbons produce more CO2 per unit of energy released than methane.

Consequences of a sudden Europe wide widening of the gas quality range for required manpower

Manpower also causes problems. Converting and adapting the large portfolio of installed engines requires a huge amount of working hours. The mechanics and engineers currently employed are fully occupied with daily tasks. Hiring new skilled technical personnel is already difficult these days. Moreover, only temporary jobs can be offered and that does not justify the connected education process. It is expected, based on extrapolation of data from The Netherlands, that at least 1100 man-years are needed for adapting all engines, within a time frame of at least two years.

The need for gas engines for electricity grid balancing

The large-scale introduction of renewable energy sources in Europe means that much more rapidly deployable power has to be available. Only gas engines have the capability to frequently switch on and off without suffering from reduced fuel efficiency and excessive wear. A gas-engine-driven generator can deliver full capacity with high efficiency within 5 minutes after a start command and that is impossible for any other technology. It is

[8] Source: Jacob-Klimstra-Consultancy

expected that the installed capacity of gas engines has to increase drastically with the advent of more renewable power.

Loss in reliability

For a constant gas quality with good knock resistance, gas engines can have a reliability of 99%. However, if the gas quality shows large variations, especially with plug flow, one might expect a substantial reduction in reliability, may be down to 97%. This all depends upon the frequency and extent of the gas quality variations. The reduced reliability can be explained by the fact that sudden external variations are already the main cause of unplanned shutdowns.

Problems with fuel supply measurements

The volumetric calorific value of natural gases can vary between +/- 7% of the average value with the Wobbe range as proposed by EASEE-gas. This means that the gas meter at the customer site becomes a very unreliable meter for the quantity of energy delivered. The financial damage due to incorrect measurement of the energy supplied can be that high that the customer's installation becomes fully uneconomic.

EUROMOT – Frankfurt/M, 2011-05-30

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3 EASEE-gas, 'Common Business Practice', CPB 2005-001/02, Approved version 2008.

4 Michelle Michot Foss, , 'Introduction to LNG', Energy Economics Research, Texas, USA, January 2007.

5 Guidebook to Gas Interchange-ability and Gas Quality, BP/IGU, August 2010.

6 Theo M. Geerssen, 'Physical Properties of Natural Gases', N.V. Nederlandse Gasunie, Groningen, 1988.

ANNEX I

GL Noble Denton was charged with its task according to the following message from Mr.Heinz Hilbrecht. Director of Directorate C, security of supply and energy market of the EC, on February 12, 2010:

As you may know, the European Commission has for some time been working on the harmonisation of gas quality in the European gas market. Currently we still have differences in gas qualities between different Member States. In an integrated European market where gas can flow freely, we cannot accept that the suppliers face the risk that the gas they want to transport across borders is refused by TSOs because it is not the right quality. As markets integrate and sources of gas will penetrate new markets, we need to ensure that every country or transmission system in the EU will accept the same range of gas quality parameters.

To that end, the European Commission has issued a mandate to CEN (M/400, attached to this letter), the European Committee for Standardization, to draw up harmonised standards for gas quality in the EU. This mandate consists of two major tasks prior to the definition of standards by CEN. One is the analysis of the effects of changes in gas quality on appliances falling under the Gas Appliance Directive 90/396/EEC. This work was started a year ago by a consortium called GasQual, and managed by CEN.

The other part of the work is an analysis of the costs and benefits of gas quality harmonisation on the whole gas supply chain: from gas producer and consumer to appliance producer and user. This study has been started recently and will be undertaken by GL Industrial Services together with Pöyry Energy Consulting. In order to make their analysis they will need input from all the parties involved in *the gas supply chain, including your organisation and the companies you represent.*

Therefore I would like to ask you and the companies you represent for your cooperation with the European Commission, GL Industrial Services and Pöyry Energy Consulting in the undertaking of the study.

ANNEX II

The CEN activity is a continuation of the work of the EASEE-gas working group that has defined parameters for natural gases to be allowed in the European pipeline system. Common gas-quality parameter values allow interoperability and free trade of natural gas. Important aspects for interchangeability of gases are safe combustion, no damage to pipelines and gas transport installations, no damage to customers' gas installations, cross-border trade. The text in the red frame gives the gas quality parameters and values as defined by the EASEE-gas working group.

The text in the red box states that the Forum of Energy Regulators identified the need for removing **technical** obstacles for interoperability. However, the work carried out by the transmission system operators assembled in EASEE-gas seems to be concentrated on **administratively** widening the allowed Wobbe Index range in Europe. It is commonly known that most gas-fuelled appliances can only accept a limited range in Wobbe Index variations. Too wide a Wobbe range results in loss in fuel efficiency and power capacity, while the emissions will also deteriorate. Next to that, flame stability problems will occur resulting in pulsations and high noise levels. Apparently EASEE-gas did not study the typical sensitivities of gas-fuelled equipment to variations in gas composition, but only considered the legal limits and administrative issues. Fortunately, the EC has now charged GL Noble Denton with investigating the consequences of large variations in gas composition for the users.

The Forum of Energy Regulators (Madrid Forum) identified in 2002 the need for removing technical obstacles for interoperability of different natural gas qualities and asked Gas Transmission Europe (GTE) for a plan.

EASEE-gas undertook this responsibility and set up a specific working group on gas quality.

After 19 meetings over a 2 year period attended by representatives of 14 countries, 6 industry associations and 37 companies, EASEE-gas approved a Common Business Practice (CBP) on February 2005 recommending the values tabled hereunder:

EASEE-GAS — THE GAS QUALITY HARMONISATION COMMON BUSINESS PRACTICE

Approved parameters, values and ranges

Parameter	Unit	Min	Max	Recommended implementation date
WI	kWh/m^3	[13.60]	15.81	1/10/2010
d	m^3/m^3	0.555	0.700	1/10/2010
Total S	mg/m^3	-	30	1/10/2006
H_2S + COS (as S)	mg/m^3	-	5	1/10/2006
RSH (as S)	mg/m^3	-	6	1/10/2006
O_2	mol %	-	[0.01]	1/10/2010
CO_2	mol %	-	2.5	1/10/2006
H_2O DP	°C at 70 bar (a)	-	-8	
HC DP	°C at 1-70 bar (a)	-	-2	1/10/2006

Where:
WI - Gross (Superior) Wobbe Index
d - relative density
S - Total Sulphur
H_2S + COS - Hydrogen sulphide + Carbonyl sulphide
RSH - Mercaptans
O_2 - Oxygen
CO_2 - Carbon dioxide
H_2O DP - Water dew point
HC DP - Hydrocarbon dew point

The energy unit is kWh with a combustion reference temperature of 25 °C, and the volume unit is m^3 at a reference condition of 0°C and 1.01325 bar(a).
EASEE-gas standards are derived from EN437 norm but have subtracted a safety margin to account for ageing and maintenance of gas appliance.

EASEE-gas recommended the implementation of the parameters by 1 October 1st, 2006 but admitted that implementation related to combustion properties (WI, d) and oxygen would not be reasonably feasible before October 1st 2010.

- Upper limit:

  Gas fuel with a WI that exceeds the permitted upper limit for the burner causes incomplete combustion with the formation of CO and soot.

- Range width:

  The wider the permitted WI range accommodated for the design of a burner, the lower the efficiency and the higher the NO_x emissions resulting from the combustion.

EUROMOT is the European Association of Internal Combustion Engine Manufacturers. It is committed to promoting the central role of the IC engine in modern society, reflects the importance of advanced technologies to sustain economic growth without endangering the global environment and communicates the assets of IC engine power to regulators worldwide. For more than 20 years it has been supporting its members, consisting of national associations and companies from all over Europe and abroad, by providing expertise and up-to-date information and by campaigning on their behalf for internationally aligned legislation.

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