



Position paper on the impact of including methane number in natural gas regulation

GIIGNL has developed a position paper to describe methane number and the possible impact on the LNG market of a future regulation/specification for this parameter which is linked to natural gas quality.

Currently, there are several standards describing calculation methods of natural gas methane number, but there are doubts about their reliability and the results differ from each other. No official regulation which states a minimum value for methane number of natural gas has been identified.

A methane number of 80, as recommended by some organisations in Europe, would endanger the LNG supply to the market, limiting acceptable LNG sources, or would require expensive gas treatment.

In the long term, if there is a market for high methane number natural gas, this may be an opportunity for LNG terminals able to adjust or manage supplies to the desired methane number.

What GIIGNL is

GIIGNL (International Group of LNG Importers) is the worldwide association of LNG importers. Founded in 1971, at the outset of the LNG industry, its membership has grown to 75 companies worldwide, comprising nearly all companies active in LNG imports or in the operation of LNG terminals.

As a non-profit organization, its resources come only from the membership fees.

The association constitutes a forum for exchange of experience among its members, with a view to enhance safety, reliability and efficiency of LNG imports.

From a geographical point of view, GIIGNL members are coming from 25 countries and located in the main three important regions: Americas, 9 members, Asia, 35 and Europe, 31.

LNG as a transportation fuel

Natural gas has been used during decades as a fuel for vehicles. According to recent statistics from NGVA [2], in June 2013 there were in the world more than seventeen and a half million of natural gas vehicles, including more than sixteen million light duty ones.

In recent years, the concerns on environmental issues (CO₂, NO_x and particle emissions), diversification of fuel sources and high oil prices have promoted the use of natural gas as a fuel for any type of transportation mode.

According to forecasts from US EIA [3], natural gas as a fuel for transportation will grow at an annual average rate of 11.9 % from 2011 to 2040, although this will represent only a 3.3 % of natural gas consumption in USA at the end of this period (no available consumption statistics for the rest of the world).

In this context, LNG is seen as the perfect choice for heavy transport: trucks, trains & ships, because it allows a higher energy density compared to the traditional CNG (almost double), as can be seen in Figure 1 [4], although lower than other fossil fuels.

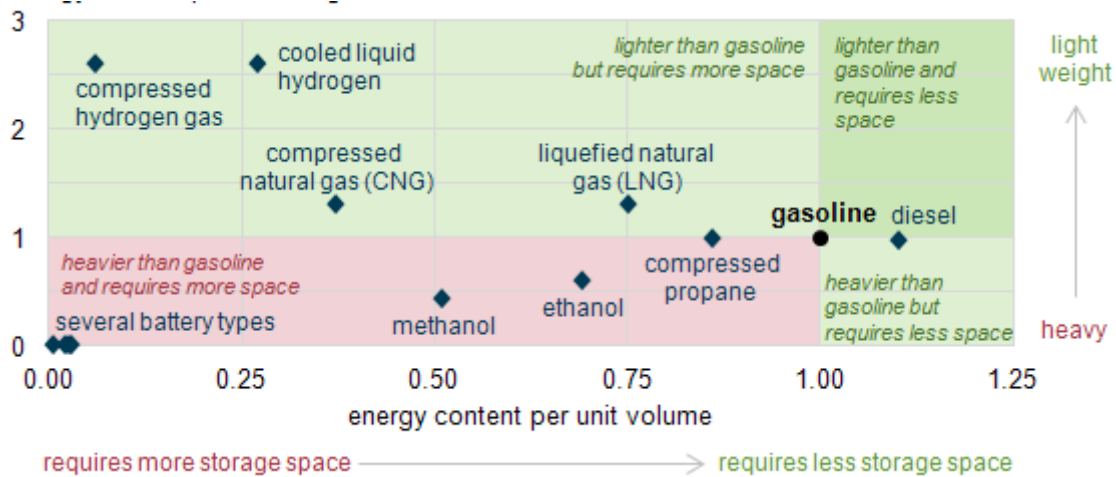


Figure 1.- Energy density comparison of several transportation fuels (gasoline = 1).
 Source: US EIA, <http://www.eia.gov/todayinenergy/detail.cfm?id=14451>.

With the increased use of natural gas as a fuel, other properties of this, apart from the traditional ones (calorific value, Wobbe Index, ...) are starting to be considered for their importance for internal combustion engines. The main one is methane number. This affects not only the mobility sector but also some gas applications using internal combustion engines.

One should keep in mind that, whatever the property to be considered, this one evolves with time, due to LNG ageing.

What methane number is

Methane number is the measure of resistance of fuel gases to engine knock, as well known as detonation.

Detonation is produced by the auto-ignition of the fuel/air mixture ahead of the propagating flame, this phenomenon produces some shock waves that could lead to serious loss of power (efficiency) and damage to the engine. It is similar to the octane number for petrol engines. The loss of efficiency could be about 2 % [5].

Methane number calculation

Unlike other natural gas properties, methane number is not a thermodynamic property of gas, so no equations of state can be used to calculate it from its composition.

Methane number is assigned to natural gas based upon operation in a *knock testing unit* at the same standard knock intensity. The references used are:

- Pure methane is assigned as the knock resistant reference fuel with a methane number of 100.
- Pure hydrogen is used as the knock sensitive reference fuel with a methane number of 0.

Several empirical models have been developed based on experimental measurements of methane number of different artificial natural gases. Some of these models are:

- Calculation of methane number from motor octane number. Based on an experimental work carried out by the Gas Research Institute (USA), two different models were developed [6] & [7]:
 - Linear Correlation method
 - Hydrogen/Carbon (H/C) Ratio method
- AVL method. Method, developed in 1970s, to calculate the methane number based on experimental measures of different gas mixtures [8].
- Different AVL method implementations: the AVL method has been implemented in some software packages developed by different companies which produce slightly different results: E.on-GasCalc, DGC, GL Noble Denton GasVLE,
- Engine manufacturer methods. Manufacturers have developed their own methods fitting their engines: MWM, Wärsilä, Caterpillar,

As it can be seen, many methods to calculate methane number exist but there are several issues regarding them:

- All are based on experimental measurements in synthetic gases where only hydrocarbons up to C₄ were used. To consider higher hydrocarbons, they are usually added to C₄ fraction in different ways.
- Only in the development of some methods were used H₂, CO₂ or SH₂, so if these are not included in the model it is not possible to take them into account. This is not critical for LNG.
- The results of the different models are different from each other, as can be seen in Figure 2 for some of them. This difference can be higher than 5 depending on the LNG composition (origin) and with no clear trend amongst them in the results.

Finally, it is worth to say that, nowadays, there are several investigations under way with the aim of getting better models to calculate Methane number.

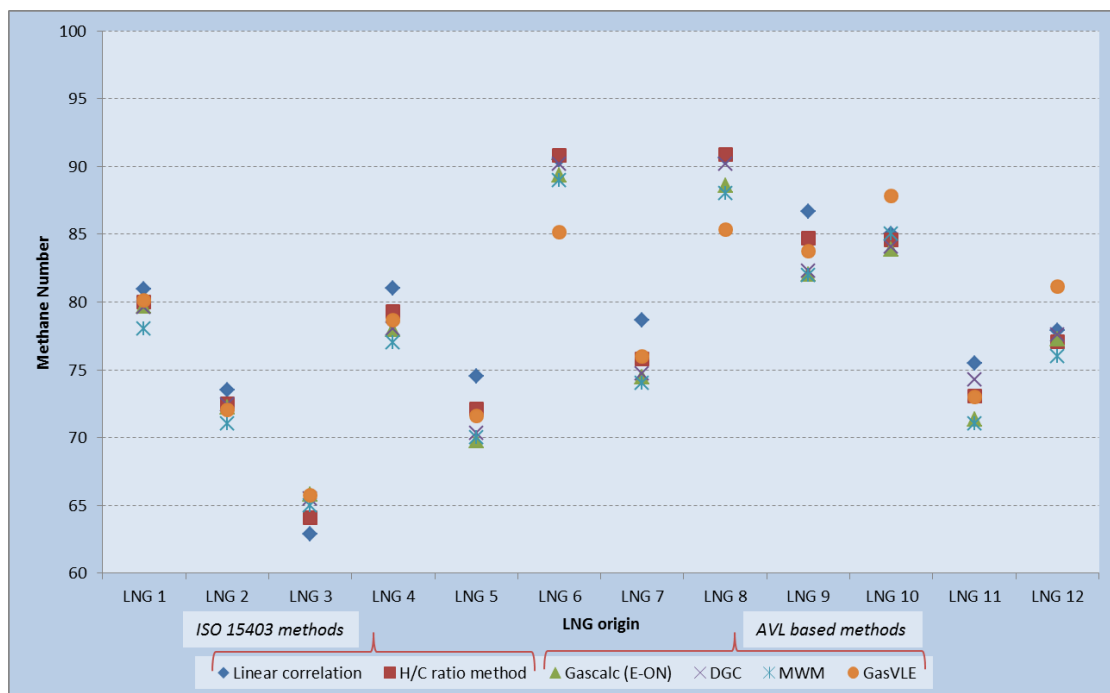


Figure 2.- Methane number for LNG from various sources according to different calculation methods.

Methane number in regulations and standards

Regarding standards, some of them made reference to methane number and the calculation method to be used: ISO 15403-1 [6], ISO/TR 22302 [7] and DIN 51624:2008-02 [9].

In ISO 15403-1 and ISO/TR 22302, two methods (GRI calculation ones) are described, in an *annex for informative purpose in the first one*, and a reference to the existence of AVL method is done, but stating that it is a proprietary and confidential method. In the standard there is not any indication about a recommended methane number for natural gas.

In DIN 51624 is fixed a minimum methane number of 70 calculated using AVL method [8].

On the other hand, a natural gas quality harmonization process is currently in progress in the European Union, under Mandate M/400 from the European Commission to CEN [10]. As a consequence of this process, CEN is developing a natural gas quality standard, prEn 16726 [11], and methane number is one of the requirements included.

Behind the inclusion of methane number as a gas quality parameter it is the position of European engine manufacturers (Euromot) which are pushing for including a value of methane number as high as possible in order to avoid malfunction of internal combustion engines and to increase their efficiency. Euromot recommends including 80 as a minimum value of methane number [12].

The draft standard prEn 16726, submitted for public enquiry beginning May 2014, fixes a methane number value of 65. For calculating methane number of natural gas a *normative annex* defining the method to use has been added to the standard. The method proposed is the one developed by engine manufacturer MWM (based on AVL with some modification to consider more accurately C₄₊ hydrocarbon).

In parallel to the natural gas harmonisation process, the European Union has launched the quality harmonization process for biomethane¹, Mandate M/475 from European Commission to CEN [13]. The standard under development by CEN is divided in two parts: one for quality of biomethane injected into natural gas grids, prEN 16723-1 [14] and one for biomethane *and natural gas* used as a fuel for vehicles, prEN 16723-2 [15]. In the last one, two gas qualities regarding methane number are defined: Grade X, MN = 65 and Grade Y, MN = 80.

So at this moment, it can be confirmed that there are developments at the European level. The aim behind the mentioned European standard development is that in the medium term the entire natural gas transported by European pipelines should fulfil the quality specification. If a natural gas is outside this specification, some treatment should be done at the entry point to adjust quality, if possible, or this gas could be rejected.

In any case, no official regulation which states a minimum value for methane number of natural gas has been identified.

Methane number of LNG supplies

Figure 3 shows the relationship between Wobbe Index (25/0 reference condition) and methane number of LNG from different liquefaction sites. The results are based on GIIGNL 2013 average LNG composition data, with MWM [11] calculation method for methane number.

Figure 3 shows the following:

- There is a relation between Wobbe Index and methane number, the richer/heavier the LNG, the lower the methane number.

¹ *Biomethane*: gas comprising principally methane, obtained from either upgrading of biogas or methanation of biosyngas.

Biogas: gas comprising principally methane and carbon dioxide, obtained from the anaerobic digestion of biomass.

Biosyngas: gas comprising principally carbon monoxide and hydrogen, obtained from gasification of biomass.

- If methane number of natural gas is fixed at 65, nearly all the commercial LNG supplies will fulfil the requirement.
- If methane number of natural gas is fixed at 80, a great number of LNG supplies will not fulfil the requirement.

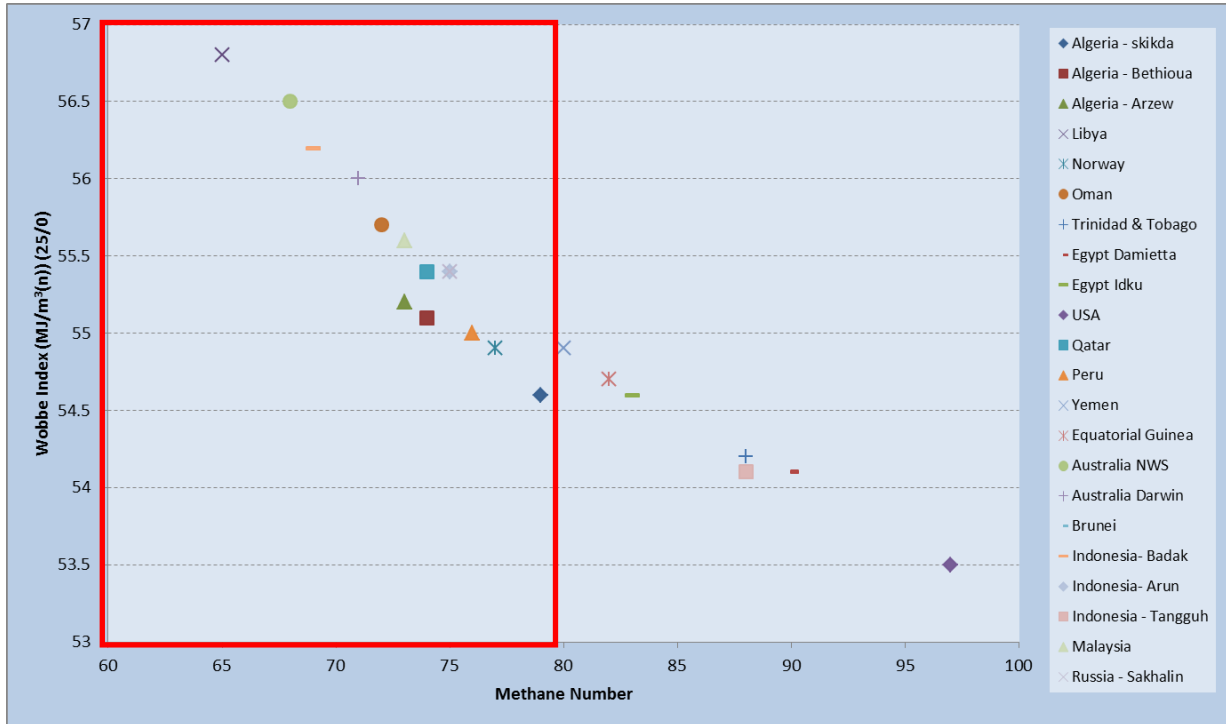


Figure 3.- Methane number vs Wobbe Index (25/0) of LNG from different supplier (based on average composition for 2013 [1] and MWM calculation method [11]).

Effect on LNG supplies worldwide

Figure 4 shows the methane number of most of the LNG supplies worldwide, including the relationship to the amount unloaded, represented by the diameter of the circles (based on GIIGNL’s 2013 LNG average composition and export data [1]). The methane number is calculated with the MWM method [11].

Some remarks to the figure. Due to the available information on the amount of exported vs LNG quality data for Algeria, Australia and Indonesia, the methane number assigned is the most unfavourable for the first two and the medium of the three export sites for Indonesia. For Egypt, the data for Idku terminal has been used.

In the following table is shown the percentage of LNG trade affected in function of the methane number defined, for a global trade production of 231.5 Mt (data from Abu-Dhabi and Angola not available) [1].

Methane number	LNG trade below MN (Mt)	LNG trade affected (%)
65	0	0%
70	7.01	3%
75	151.74	66%
80	204.55	88%

As can be seen, if a methane number higher than 80 is requested for using LNG as a transportation fuel, 88 % of world trade production should be treated. On the other hand, the affected trade production below 70 could be higher than the 3 % shown, because, due to a lack of precise export data, the exported amounts from Australia NWS and Indonesia Badak have been included with the other national supplies.

This risk in supplies has already been analysed by Gas Infrastructure Europe (association of European infrastructure operators) [5].

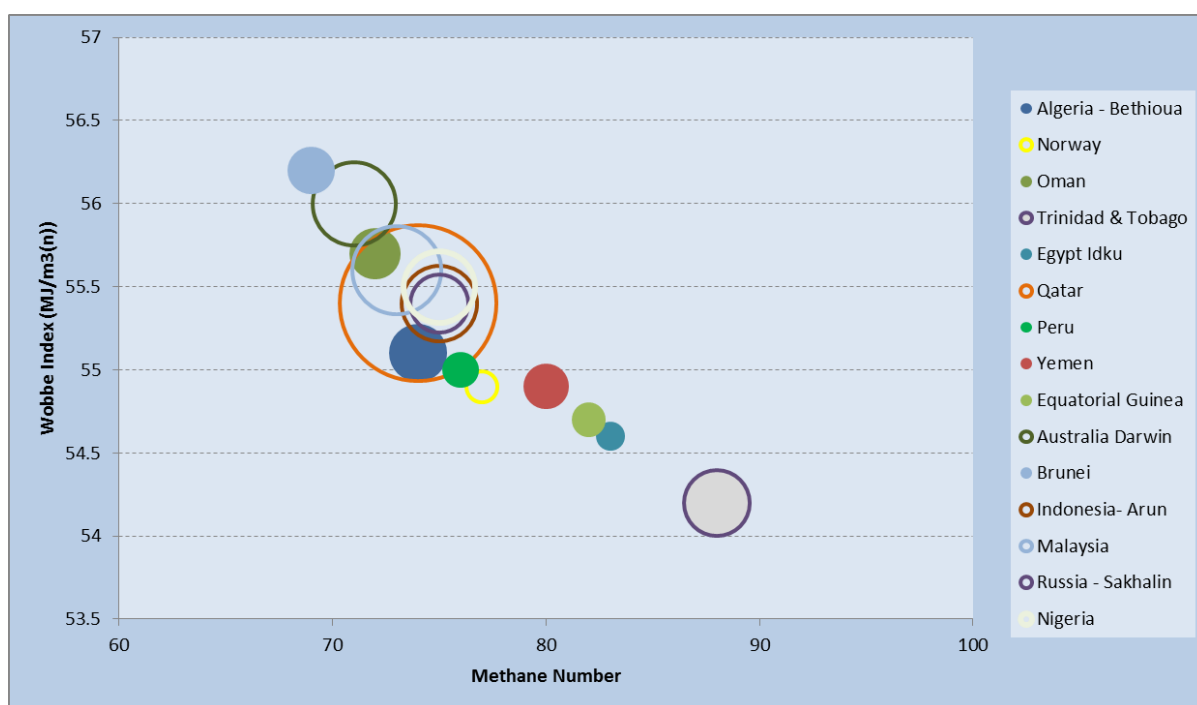


Figure 4.- Methane number vs Wobbe Index (25/0) of LNG from different countries and amounts exported worldwide (based on average composition for 2013 [1] and MWM calculation method [11]).

Adjusting the methane number of natural gas/LNG

Adjusting the methane number of natural gas is not an easy task for Import LNG Terminals.

In contrast to the adjustment of calorific value or Wobbe Index of natural gas, where adding nitrogen or LPG could be enough, the only way to increase the methane number is by removing heavy hydrocarbons from LNG.

Some European terminals originally had fractionation units to separate heavy hydrocarbons from LNG, but these were dismantled more than 20 years ago because the LNG received fulfilled national regulations and the amount of heavy components was so low (due to changes in liquefaction processes at export sites) that it was not profitable to operate them.

Another option for supplying markets setting a high methane number, is to manage the LNG supplies with the desired methane number. This requires there to be sufficient tanks at the terminal to do this, a regular supply of this type of LNG and the existence of a national regulation allowing this kind of service.

Position of GIIGNL

A methane number of 80, as recommended by some organisations in Europe, would endanger the LNG supply to the market, limiting acceptable LNG sources, or would require expensive gas treatment just for the benefit the NGVs - a small, albeit growing, sector of the market.

Including methane number in the standards and/or regulations requires an agreed, public and reliable method/model for determination. It is not clear if such a method/model exists at this moment. On the other hand, most of the current methods have been developed based on tests which do not take into account the presence of hydrocarbons heavier than butane.

Additionally, although this affects to the whole natural gas market, a high methane number will limit or will prevent the addition of hydrogen into the gas grid, which it is seen, in the medium/long term, as a promising method for using surplus of renewable power/energy and a way of greening natural gas.

As a consequence of the above mentioned arguments there are reasons for not including the methane number in Regulations and Standards. However, if it is to be included then the maximum number in the standard needs to be 65, in order to ensure security of supply and access of LNG to the markets.

In addition, an agreed, public and reliable method for its determination should be a prerequisite for standardization.

In the long term, if there is a market for natural gas with a high methane number, this may be an opportunity for LNG terminals able to adjust or manage supplies to the desired methane number.

References

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Acronyms

AVL: *Anstalt für Verbrennungskraftmaschinen List*

EC: European Commission

CEN: European Committee for Standardization

CNG: Compressed Natural Gas

DGC: Danish Gas Center

EOS: Equation Of State

Euromot: European Association of Internal Combustion Engine Manufacturers

GIE: Gas Infrastructure Europe

GIIGNL: International Group of LNG Importers

GRI: Gas Research Institute

ISO: International Organization for Standardization

LNG: Liquefied Natural Gas

LPG: Liquefied Petroleum Gas

NGL: Natural Gas Liquids

NGV: Natural Gas Vehicle

NGVA: Natural Gas Vehicle Association

US EIA: United States Energy Information Agency