International Gas Union Research Conference 2011

PHYSICAL PROPERTIES OF LNG AND COMPARISON WITH EUROPEAN PIPELINE GASES

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This paper analyses LNG properties of the world LNG market and compares them with European pipeline gases. The target is to analyse which LNG qualities can be regasificated and fed directly to the natural gas pipeline network without any processing. The target is also to find LNG qualities that can be used as ferry and ship fuel.

Background

The focus is mainly on the Finnish natural gas use in Finland, where natural gas has been used since 1973. All natural gas used in Finland has been delivered from Russia. The gas has been so called Siberian gas, which methane content is about 98 mol-%. This means that it is not possible to use all LNG qualities available in the general market.

Natural gas has been used in Finland mainly for energy and power production and for industry purposes. Natural gas consumption is annually about 45 TWh, which consist 10 % of the total energy consumption. There are only 3000 kilometers of transmission and distribution pipelines in Finland.

The target to reach lower exhaust emissions and lower fuel consumption requires finding better energy solutions than used earlier. This means the use of natural gas for the traffic purposes. Alternatives are CNG (compressed natural gas) and LNG (liquefied natural gas).

At this moment there are very high targets to use LNG as ferry and ship fuel. Emission limits on Baltic Sea are highly regulated after 2015. Sulfur limit of fuel must be less than 0,1 %. Also regulations for NOx-limitation mean that only with LNG these targets can be reached with the existing technology.

Programs have been regulated in order to analyse which kind of LNG qualities can be imported for the ferry and ship fuel and for regasification and feeding to natural gas pipeline. And as mentioned earlier, without LNG processing.

Wobbe index

Wobbe index of gas is the most important figure for analysing the gas quality or to determine, which gases are suitable to be used for natural gas distribution. Also heat value and relative density of gas are important, but they are components of wobbe value calculation as follows:

$$Wo = \frac{Gross\ Calorific\ Value}{\sqrt{d}}$$

Where d is relative density and

$$d = \frac{\rho\ gas}{\rho\ air}$$

and where p_{gas} is density of natural gas and p_{air} is density of air.

Figure 1 shows wobbe indexes and gross calorific values of the most well-known LNG producers. It is remarkable that the heat value is gross calorific value (upper value) and wobbe indexes have been calculated from that. Both values in the picture mean that the temperature in normal condition is 0 ^{o}C and absolute pressure is 1,01325 bar. In some countries the temperature of gas in normal condition has been determined as 15 ^{o}C or 20 ^{o}C.

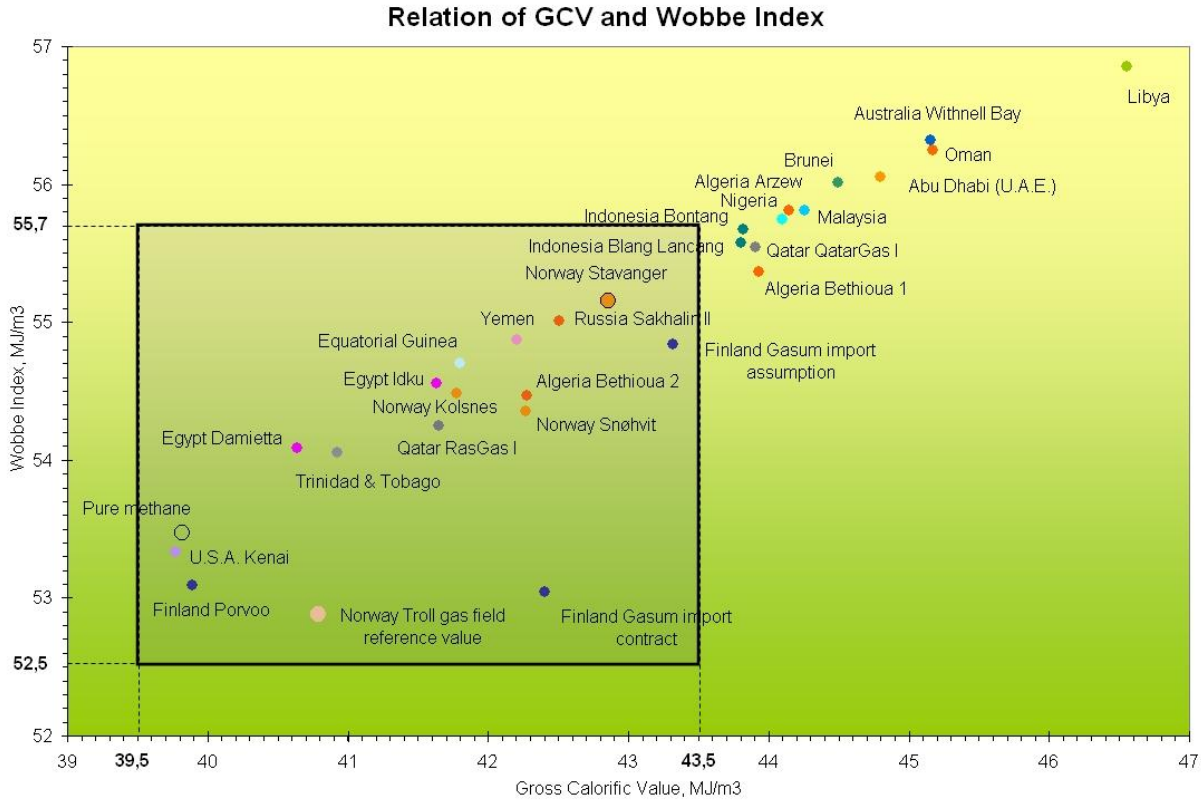

Fig 1 Wobbe indexes and gross calorific value of the most well-known LNG producers.

As the figure 1 shows, the wobbe indexes and gross calorific values are quite different depending on the place where LNG has been produced. Generally in European LNG market is used so called “lean gas”, on the left hand side of the picture. In Asian market, like in Japan or Korea is used so called “rich gas”, on the right hand side of the picture. The rich gas contains ethane, propane or butane also.

Figures 1 and 2 show the “wobbe window”, the limits of the LNG qualities that can be used instead of pure methane reference gas (H-gas in Europe). Window limits are in some countries +/- 4 % or +/- 5 %. These numbers are shown in the figure 2.

If European L-gas is needed, it has to be processed by adding nitrogen to the gas flow in regasification plant. This means that the gross calorific value must be less than 39 MJ/m^3 (Fig 2).

Also LNG for Asian market can be produced by adding heavier hydrocarbons such as ethane or propane to gas flow in order to reach gross calorific value about 44 – 45 MJ/m^3.

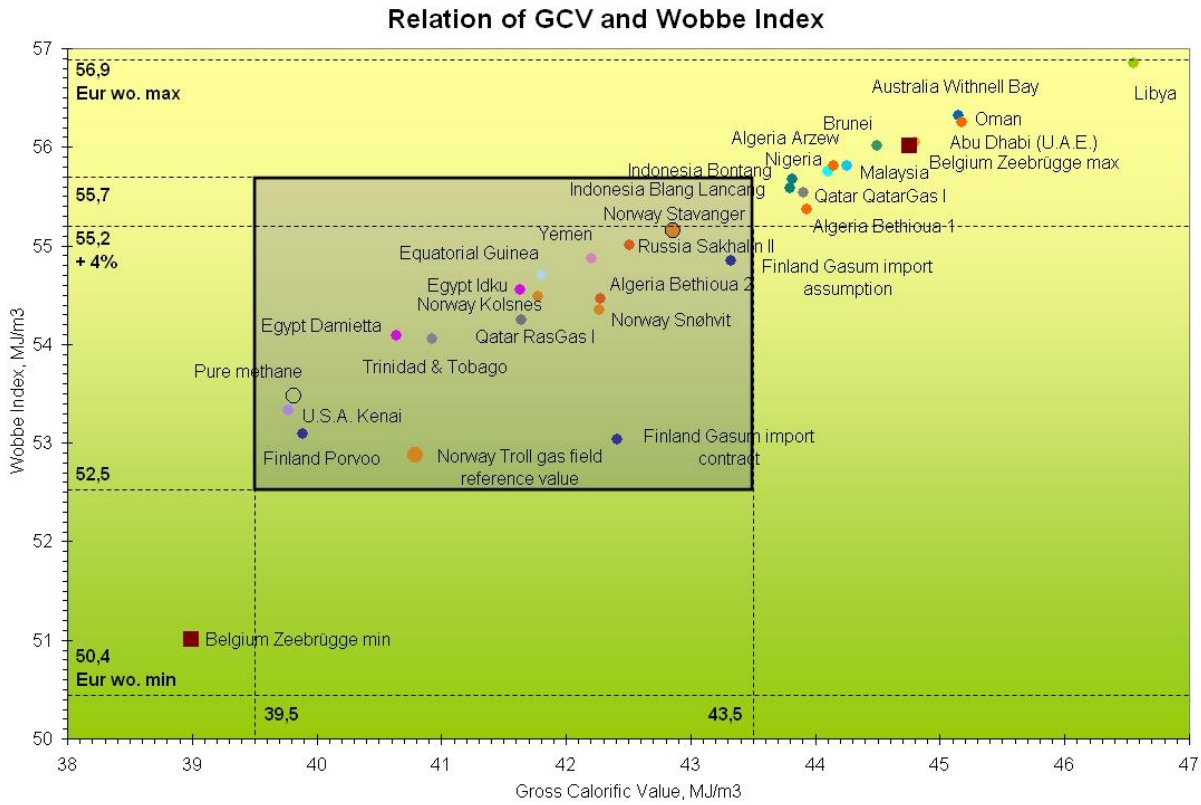

Fig 2 Wobbe indexes and gross calorific values with different wobbe windows

Figure 2 shows the limits of wobbe indexes generally in European natural gas market. Wobbe minimum value is 50,4 MJ/m^3 (14,00 kWh/ m^3) and maximum value 56,9 MJ/m^3 (15,81 kWh/m^3). All cubic meters are 0 ^{o}C and absolute pressure 1,01325 bar. These wobbe limits are said in European EASEE-gas publication “Harmonisation of Natural Gas Quality”. It is very important and remarkable that these wobbe limits are not the same ones that can be used in the certified typetesting of gas appliances. The wobbe window there is much more narrow.

Some countries accept many kind of LNG qualities (liquid densities and wobbe numbers) because they have many storage tanks and they have possibilities to mix gas flows as they like. The spot market of LNG add these needs in the future.

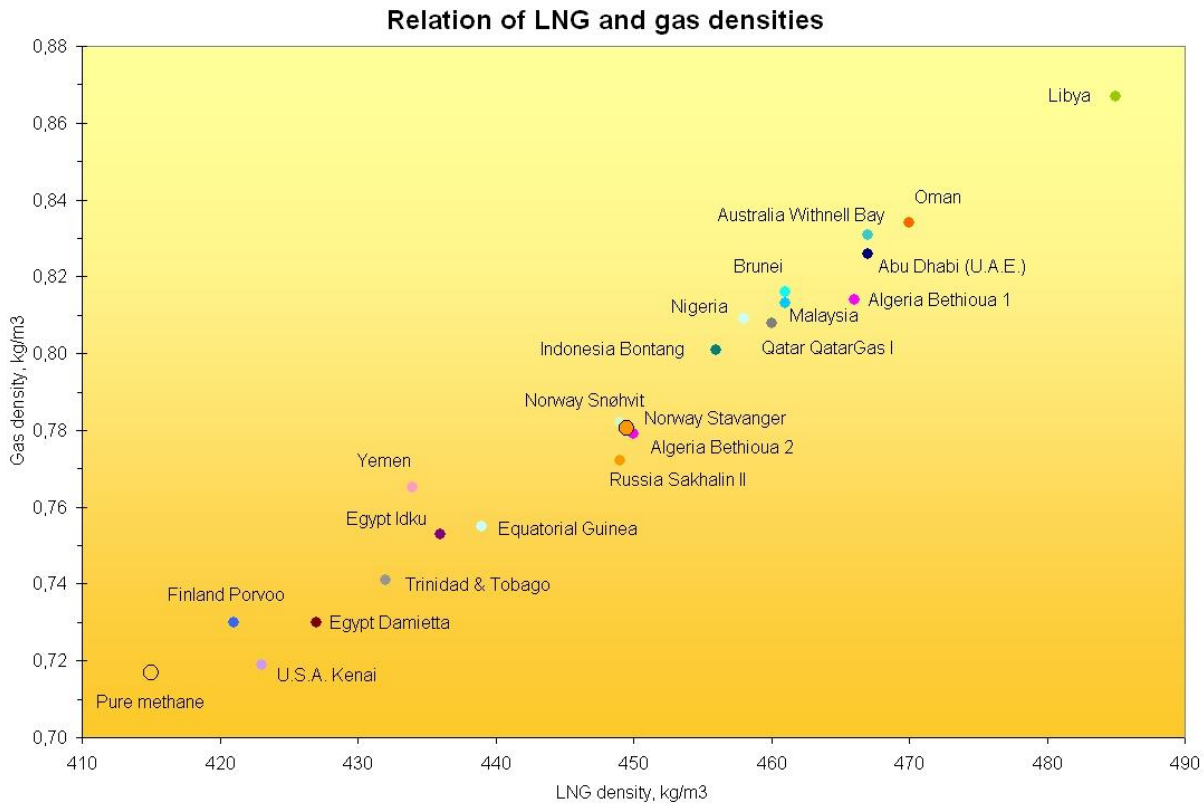

Fig 3 Natural gas density and LNG (liquid) density.

Figure 3 shows LNG density (kg/m^3) at the boiling temperature and regasified natural gas density (kg/m^3) at normal condition (temperature 0 ^{o}C at 1,01325 bar absolute). LNG density is lot of depending where LNG is produced, or how much heavier hydrocarbons are with methane.

Gas powered engines accept LNG qualities quite widely, much more critical is the general gas distribution.

Also rollover of LNG storage tank will limit the use of LNG if the density varies very widely.