GAS QUALITY HARMONISATION IS KEY FOR SECURITY OF SUPPLY AND COMPETITIVENESS OF GAS

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ABSTRACT

Gas quality issues are under scrutiny since more than ten years in Europe as a result of a double evolution. On the one hand, new sources are entering the grids such as LNG's, biomethane or other renewable sources and on the other hand the implementation of the EU internal gas market rules have loosened the control that TSO's and DSOs could had on gas flows and thus on local gas quality variations.

After Marcogaz first proposal for a harmonised Wobbe index range developed in a series of three position papers between 2003 and 2006, the European Commission asked with Standardisation Mandate M/400 on gas quality that the impact of gas quality variations on domestic and commercial appliances be studied in preparation of the preparation of a standard for gas quality for the H group.

CEN/BT WG 197, especially created to manage the phase 1 of Mandate M/400, identified through the GASQUAL project, a number of issues, most of them to be addressed through national policies in order to implement a common range of Wobbe index throughout Europe. Most of the issues identified were discussed in the Gas Quality Pilot Study that aims at building a comprehensive analysis of the national issues in order to facilitate the transfer of best practices and ease the implementation of a wide Wobbe index range.

At the time the Gas quality standard elaborated by CEN is under public enquiry, this presentation aims at highlighting the main issues identified within the GASQUAL project, and how the implementation of the common proposed Wobbe index range may impact the current national rules and practices and the benefits of establishing a wide specification.

It will also highlight the need for a close and constructive partnership between all stakeholders of the gas value chain in order to ensure that gas will still be a player in tomorrow's energy landscape.

CONTEXT

The topic of gas quality harmonisation has been on the European agenda since about 12 years. During the development of the EASEE-gas Common Business Practice on gas Quality[i], Marcogaz developed through a series of two position papers[ii] a proposal for the harmonisation of combustion parameters in Europe. The basis for this proposal was that, as domestic appliances could not be able to tolerate wide variation in natural gas quality without endangering the public, gas quality has to be maintained within defined limits. These limits are currently set nationally and reflect the type, age and condition of the appliance population present within each country. Since 1993 all European appliances are required to comply with the 1990 Gas Appliance Directive 90/396/CEE – 2009/142/EC ("GAD") and are supposed to be able to tolerate the same range in gas quality, wider than those generally set nationally. The performance of modern, GAD-compliant, appliances should therefore provide the basis for a common European gas quality specification.

These bases are illustrated in Figure 1 where the blue triangles are representing the limits of the national Wobbe index ranges and the black dots the Wobbe indexes of gases typically distributed in the relevant countries.

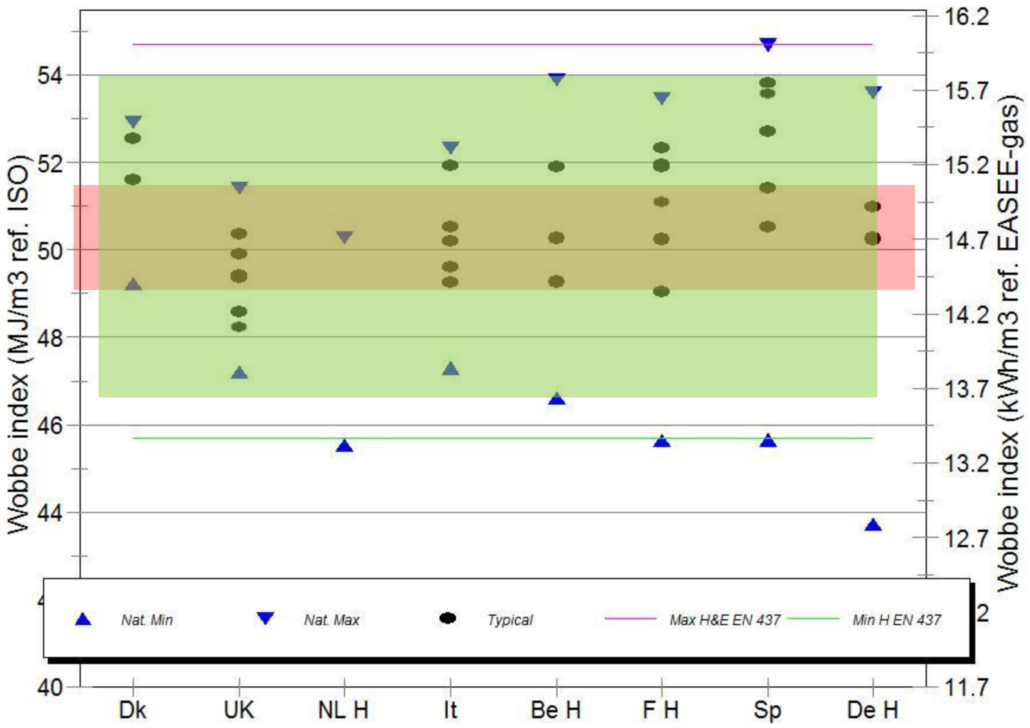

Figure 1: National Wobbe index ranges and typically distributed gases (Marcogaz 2003)

Harmonisation taking into account only the common band of Wobbe indexes (red rectangle) would exclude most of the gases distributed. However if one considers that post GAD appliances are similar all around Europe, then these appliances are able to burn at least the range of gases included in the green rectangle as they are using all these gases in various location.

This proposal raised a number of concerns presented in Marcogaz third position paper[iii]. Essentially these concerns pointed out that difference in installation and maintenance practices at national level may lead to non-uniform performances of the GAD compliant gas appliances, implying that the premises of Marcogaz proposal, e.g. all GAD compliant appliances are similar and thus each one can use all the gases currently in use, may be undermined. A second objection was that certification being done on new products may not reflect the long term behaviour of appliances, and thus safety margins shall be provisioned between the limit of the certification range and the actually distributed range of gases.

Standardisation Mandate M/400 was given by the European Commission, its first phase dedicated to evaluate these concerns. This first phase was conducted under the responsibility of CEN BT WG 197 by the GASQUAL[1] consortium. At the time when this mandate is close to completion with the end of the public enquiry on prEN 16726[iv], one can only note that that the current proposal for Wobbe index range in this draft European Standard, namely from 46.44 to 54 MJ/m^3[2] is the same as the one of EASEE-gas CBP and very close to Marcogaz proposal made in its second position paper although strong reservations have been made against the use of this range during the elaboration of the standard.

Thus this paper intends to present the interest of harmonising the Wobbe index range in Europe on such a wide basis and tries to explicit the main reservations against its use and provides answer to those.

INTEREST OF USING A WIDE RANGE OF WOBBE INDEX

In order to have access to natural gas supplies at a competitive cost, Europe shall accommodate rather different gas qualities, including rich LNG's. It shall also be able to use renewable gases without putting an extra cost for treatment or LPG enrichment if natural gas wants to be a player in the energy transition. This calls for a wide range of Wobbe index to be acceptable all around EU as local limitation would mean a fragmentation of the gas market putting some regions under the dependence of a limited number of suppliers.

About the limits

Europe is importing two thirds of its supplies[v] from non EU countries, including Norway that represents 22% of the gas used in the European Union. Gas imported as LNG represented in 2012 about 13% of EU supplies, in decline from the previous years because of the strong competition on the global market, mainly from Japan. Although future Europe gas consumption is today rather difficult to forecast, the IEA expectation is that by 2035 Europe will import 85 % of its supplies. Furthermore the European agenda calls for the increasing use of renewable resources, which means an increasing role for biomethane within the gas industry.

Figure 2, presents in a Wobbe index vs. relative density graph, the position of typical gases distributed in Europe, such as LNG's in light blue, pipeline natural gases in dark blue and three typical biomethane in green with respective methane content of 97, 96 and 95 %, 2% nitrogen, the balance being CO_2. The different lines represent:

- The methane-propane and methane-nitrogen binary mixtures representing the practical limits for natural gases without hydrogen injection (solid black lines).
- prEN 16726 Wobbe range limits (dashed red lines).
- Constant GCV gases in this Wobbe index vs. relative density representation with GCV's going from 36 to 44 MJ/m^3 by steps of 2 MJ/m^3 (dashed black lines).

As it can be seen, natural gases are generally on the upper part of the range, LNG's in light blue being close to the methane-propane mixtures line due to their very small content of inert gases. Although only LNG's are presenting a Wobbe index above 53 MJ/m^3, to put the higher limit around this value would be very detrimental in practice for two reasons.

Firstly, when assessing the compliance of the gases entering their network, infrastructure operators are using instrumentation with a total uncertainty of about 0.5%, which means that the Wobbe indexes measured in

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[1] *GASQUAL Website: http://www.gasqual.eu/*

[2] *In this document energy is expressed in the following reference conditions: 15°C, 15°C, 1013.25 hPa.*

the field are known within ±250 J/m^3. Thus to avoid dispute about compliance, operators will tend to avoid presenting gases within 0.5 MJ/m^3 of the limit value. To decrease the higher Wobbe limit will ultimately mean that in practices more than half the current LNG's would have to be treated before entering the networks.

Secondly and as mentioned above, the market for LNG is currently in Asia where rich gases are in demand. In Japan LNG's are introduce in the network at a constant GCV of 42.6 MJ/m^3, which leads to Wobbe indexes around 53-54 MJ/m^3. Leaner LNG's are enriched by LPG's which is very costly and thus the preference of the Japanese market is toward the richest LNG's. Thus it is reasonable to expect that the design of new liquefaction plants will try to fit this high Wobbe index specification. To introduce a European specification that does not accommodate those gases would further decrease the competitiveness of LNG's on the EU market.

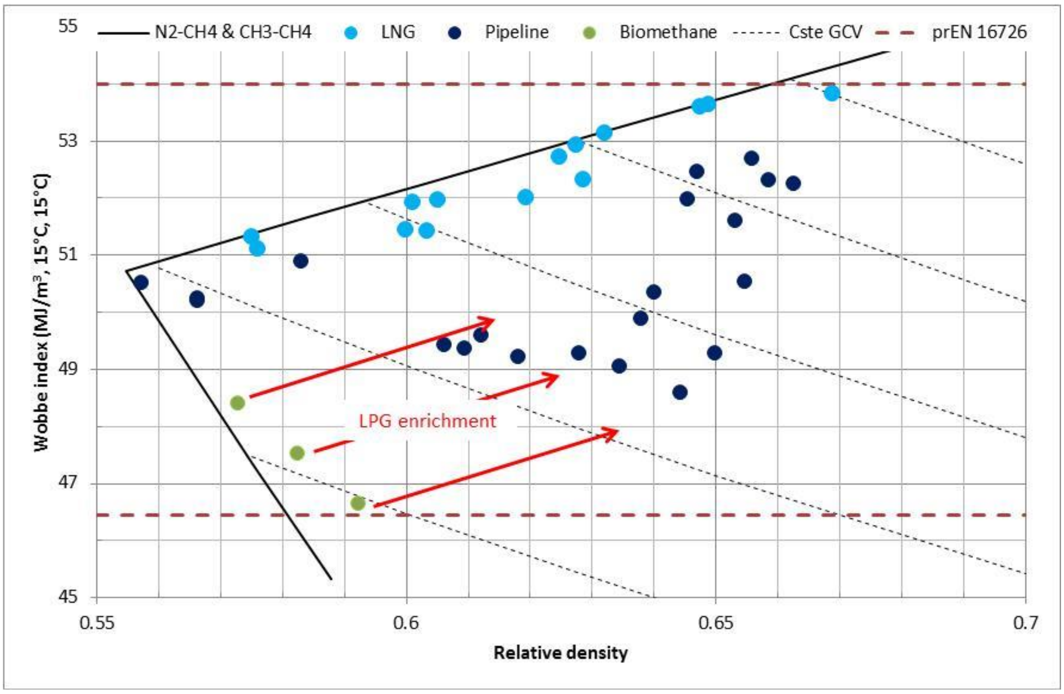

Figure 2: Position of different gas type.

Although there are currently no natural gases supply in the lower part of the Wobe index range proposed in prEN 16726, the will to increase the share of renewable gases in the European supply portfolio calls for keeping a lower limit as low as possible. Most of the biomethane currently entering the networks are coming from anaerobic fermentation of biomass that leads to a raw biogas composed essentially of methane and CO_2. As presented in Figure 2, to make it compliant with the proposed specification the biogases need purification to at least 95% methane unless the gas is enriched with LPG. Although this is a practice that is in use in some countries, it is costly and decreases the environmental interest of biomethane injection.

To push up this lower limit would mean increased purification costs and/or more LPG injection and may be impossible to reach for existing injection installation designed for the current national requirements in a number of European countries.

About variations within the limits

The European gas system has been organised around four main supplies, Russian gas with Wobbe indexes around 51 MJ/m^3 coming from the East, Norwegian gases with Wobbe indexes around 52 MJ/m^3 coming from the North, LNG's with usually higher Wobbe indexes entering through the South West and leaner UK gases that have an influence around Belgian borders since the end of the 1990's (see Figure 3). According to their position on the main supply routes, some European countries or regions have historically been using only one type of supply, leading to a very stable gas quality with time. In other regions, especially in Belgium and

France, where different supplies may be distributed, local gas quality changes according to the supply demand pattern and fluctuations are the rule.

The increasing interconnections of the European network, the development of new infrastructures that will bring LNG in places where it was never seen and the development of spot contracts in place of long term contracts mean that the European supply pattern is more and more complex. Thus the zone of influence of each kind of supply will increase and fluctuate meaning more overlapping between supplies and thus more area where gas quality is likely to fluctuate. Preventing such evolution would mean that borders are set within the European gas system defining regions that would use a limited part of the overall Wobbe range and that treatment facilities would be installed at each of this border to adapt the gases whenever necessary.

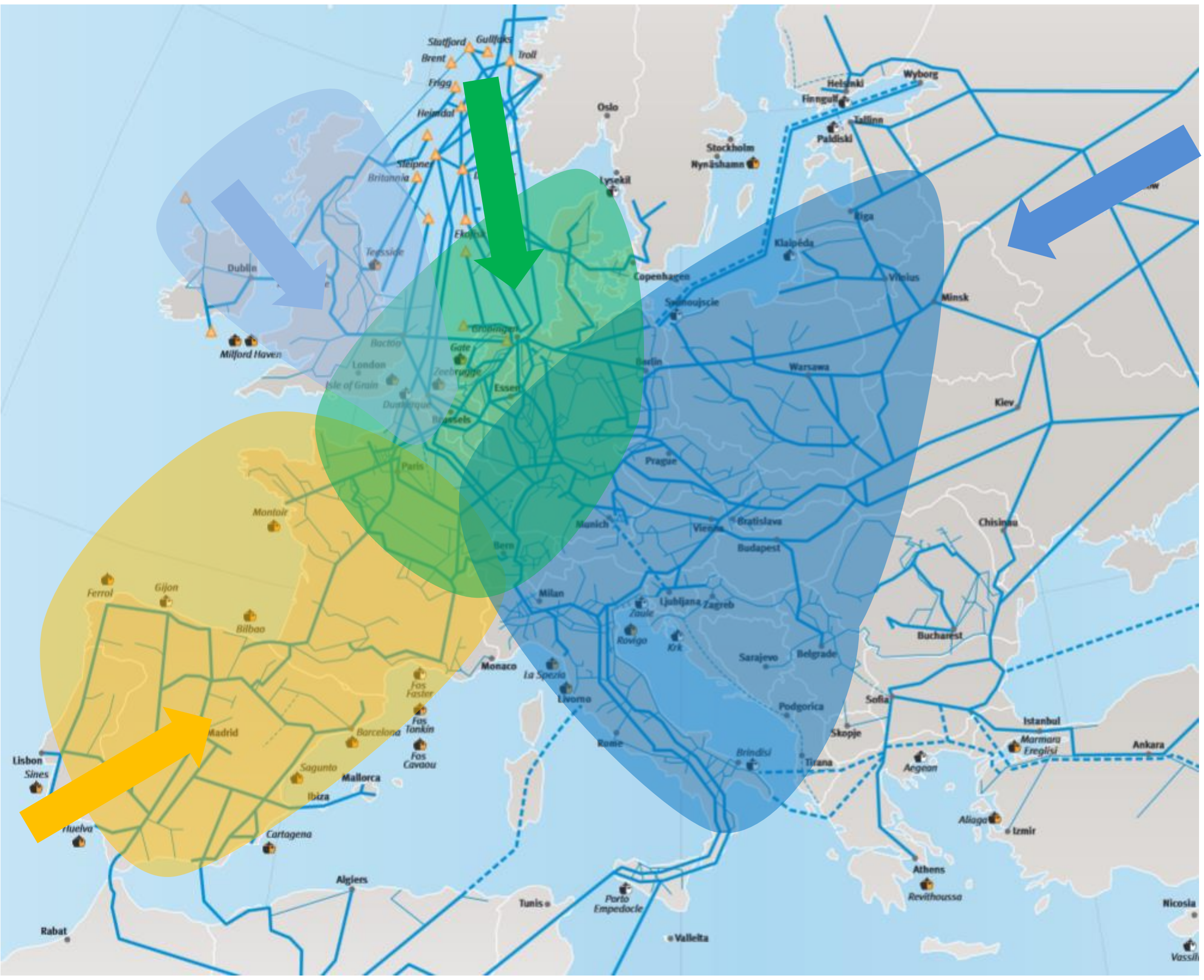

Figure 3: Schematic of the main EU supply routes and influence.

Such a solution would divide the European market into several small ones, each dependant on one or two supply that would compromise both the competition and the security of supply of each region.

FACTORS NARROWING THE ACCEPTABLE RANGE OF WOBBE

Safety issues

The bulk of the work done during the GASQUAL[vi] project was to evaluate the impact of gas quality variations on the safe behaviour of GAD certified appliances. To this end about one hundred domestic appliances have been tested. The results obtained were interpreted to check how far from nominal behaviour the appliances were operating in terms of safety when using gases with Wobbe indexes changing on all the range as defined in EN 437. Furthermore, as it was deemed that most issues would be observed with high Wobbe indexes, the testing range went higher than the existing limits in order to ensure a comprehensive knowledge of the issues at this end of range.

To allow for a quick understanding of the work done, the results were summarised by a colour code:

- Green means that the appliance tested is presenting a similar behaviour as the one observed with the reference gas (G 20 e.g. pure methane). Same level of CO_{DAF}[3] without any safety issue with the Wobbe index considered. For such appliances Wobbe index variations have no impact on safety.
- Orange means that the appliance tested presents an increase of CO emissions with the Wobbe index considered when compared with G 20. It generally corresponds to a CO_{DAF} level between 500 and 1 000 ppm. The maximum admissible level for compliance with the product standards **under reference conditions** being 1 000 ppm, an appliance in the orange zone is still presenting **safety performances acceptable for normal use**. For these reasons the impact of Wobbe variations is deemed moderate for those appliances within the orange zone.
- Red means that the appliance tested presents a strong increase of CO emission when using the Wobbe index considered, generally above 1 000 ppm, or operational problems such as noise or no cold start. The Wobbe index variations impact is thus qualified as high.

The results obtained are presented in the graphs below:

- Figure 4 gives overall picture including the influence of voltage variations, pressure variations and field adjustment.
- Figure 5 presents the same picture without the influence of pressure variations or field adjustment.

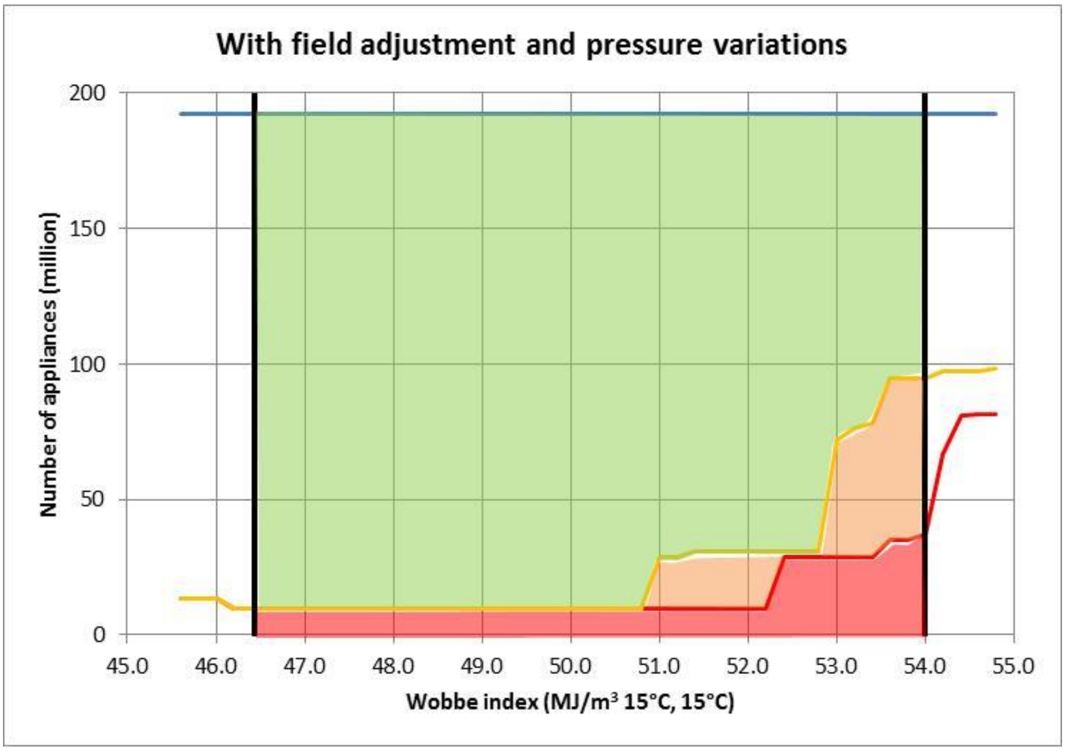

Figure 4: Impact of Wobbe variations on Domestic GAD compliant appliances (GASQUAL)

[3] *CO_{DAF} indicates that the CO concentration measured in the combustion products have been corrected to dry air free combustion products.*

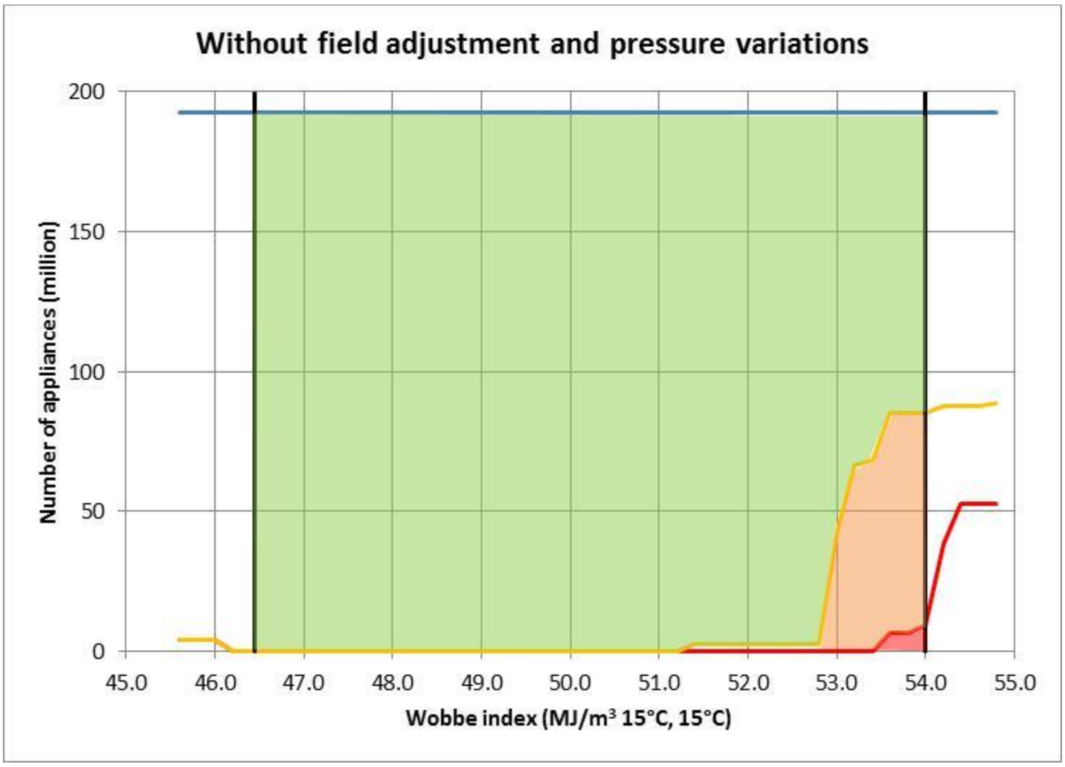

Figure 5: Impact of Wobbe variations on Domestic GAD compliant appliances without pressure variation or field adjustment (GASQUAL)

The differences in Figure 4 and Figure 5 illustrate the major influence of supply pressure and field adjustment.

Supply pressure, when the appliance is not equipped with a pressure regulator, modifies the gas flow rate. Consequently, some appliances that were not impacted by Wobbe index variations when supply pressure was stable are impacted with high Wobbe indexes when the supply pressure reaches its maximum value for testing, 25 mbar, because of the non-linearity of the CO increase with load.

However, supply pressure variations depend on the way gas is distributed. In countries where medium pressure networks (100 mbar to 4 bar) are in use, each service line is equipped with a pressure regulator that will keep the pressure at its nominal value. The tolerance of such pressure regulator means that a supply pressure above 23 mbar at the entrance of the service line is a maximum without a fault that generally leads to a shut down. Thus supply pressure variations are not an issue. In countries were low pressure network (20 mbar) are widespread, pressure fluctuations can arise from one end of the network to the other end. Consequently a significant number of appliances can be supplied at non nominal pressure. Furthermore in some countries, regulation prohibits the use of an internal pressure regulator in the appliances whereas in others their use is compulsory, enabling the compensation of some effects of supply pressure variations.

Thus the influence of supply pressure has to be evaluated on a country to country basis. For instance instantaneous water heaters, falling under product standard EN 26, are very sensitive to the influence of supply pressure. With a supply pressure of 25 mbar a moderate impact is observed as soon as 51 MJ/m^3 and a high impact above 52 MJ/m^3. A cursory analysis of the situation may lead to the conclusion that distributing gases with Wobbe indexes above 52 MJ/m^3 is dangerous on a normal basis. However, when supplied at nominal pressure, a moderate impact is observed only above 53 MJ/m^3 and a high impact needs more than 55 MJ/m^3, above the limits of the H group. Furthermore, GASQUAL market survey indicated that the main market for these appliances is in Spain and Portugal where most gases distributed are falling in the 52 – 54 MJ/m^3 range without any safety issue related to their use. This illustrates the need to consider GASQUAL testing results in light of the actual situation in the field.

Adjustment procedures are referring to the fact that during installation or maintenance of appliances, air gas ratio is tuned to obtain the optimum performances in terms of efficiency and NO_x emissions. These performances are typically the ones that have been measured under reference conditions during certification. There are also the bases for the labelling under the so called ECOdesign Directive[vii]. This operation is not possible with appliances fitted with an atmospheric burner, only for those equipped with an air blown burner. Thus, on the domestic market it concerns only condensing boilers and boilers equipped with forced draught burners. On the non-domestic market it may concern the majority of the boilers and air heaters.

As demonstrated by GASQUAL results and illustrated by a recent experience in Denmark presented in appendix 5 of CEN BT WG 197 final report, although adjusting the air gas ratio to the reference value with the distributed gas may give the best performances at the time of adjustment, it may also prevent any change of gas quality. On the other hand the GASQUAL project has demonstrated that appliances retaining their factory setting on the reference gas, G20, are able to use safely all the gases in the H range. The counter part is that, when the Wobbe index of the distributed gas is higher than that of the reference gas, the appliance efficiency and the NO_x emissions are increased, Wobbe index gases below the reference gas leading to lower efficiency and lower NO_x emissions.

These evolutions of efficiency and NO_x emissions to air gas ratio variations are well documented[viii] and do not depend solely on the Wobbe index of the gas distributed. For instance the ambient condition (temperature, pressure and humidity) between summer and winter conditions lead to air gas ratio variations of a balanced flue boiler of the same magnitude as Wobbe index variations on the full H range.

This means that in a situation where gas quality variations shall not be excluded any adjustment shall be made taking provision of these potential variations. Fluctuations of Wobbe index will not degrade the overall performances of the appliances, as the variations in efficiency and NO_x emissions will averaged to the ones observed with the average Wobbe index of the gas distributed.

In particular, for GAD compliant appliances in application of article 2.2 of the Directive, member states have declared that normal gas quality variations are within the ranges as presented in Figure 6.

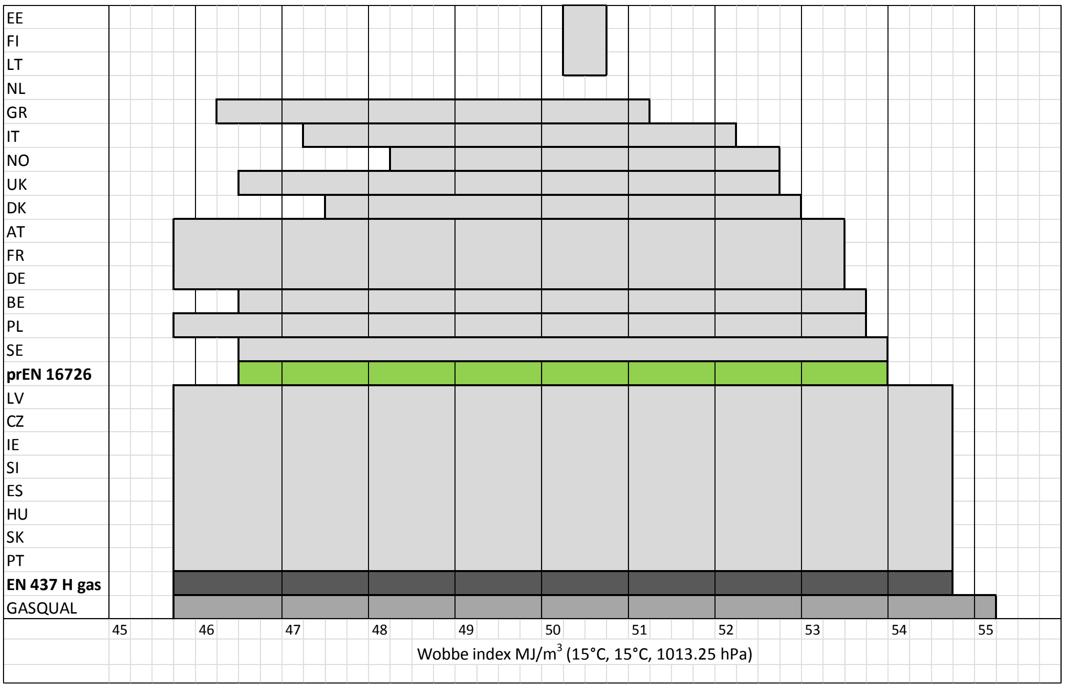

Figure 6: Normal variations of gas quality for gases within the H group according to declaration of Member States (Data CEN BT WG 197).

According to the Gas Appliances Directive, appliances normally used and normally installed and maintained shall fulfil the essential safety requirements of the Directive when used with the range of gas that has been declared by the Member state. Gas quality variations within the national declared ranges are normally not controlled, meaning that fluctuations covering the entire declared range are possible, if gases covering the entire declared range are entering the network. Frequency of the fluctuations depends on the supply demand pattern variations that alter the physical balance of the network. It is clear that the range proposed in prEN 16726 is very similar than the ones in most EU countries. In a dozen of countries, the introduction of such a range in place of the current declaration would lead to marginal changes or a reduction of the normal range. Would this situation bring safety issues with the current installed appliances, one should conclude that operational or safety issues already exist within the national framework.

This conclusion as been achieved at least in Denmark as the introduction of a gas in the lower end of the declared range has led to operational issues with appliances adjusted on the usual gas quality. This prompted the Danish gas industry to readjust all appliances to the reference factory setting (G 20) in order to be able to tolerate gas quality variations. This re-adjustment is done during the routine maintenance of the appliances with a very low marginal cost and the Danish industry expect that by 3 years all the population of existing appliances will be corrected.

However the installation and maintenance procedures are not harmonised within Europe which means that the number of appliances that are adjusted in the field without provision for future gas quality variations is not known and may differ from one country to the next. Thus this issue has to be addressed on a national basis.

Field performances

The existence of requirements on the performances of appliances as measured in the field is often presented as a justification for limiting any gas quality variations. These performances are expressed in different ways, a maximum limit on CO or NO_x emissions or a minimum efficiency to be achieved, but without any provisions to take into account the parameters of influence. For some appliances such as boilers the maximum CO emissions required in some countries in the field (500 ppm) are even below the level acceptable in reference conditions for compliance with the essential safety requirement as stated in the standards harmonised under the Gas Appliance Directive (1000 ppm). This leads to the paradox that an appliance can be certified and sold on the basis of acceptable performances in controlled laboratory conditions but cannot be used as such.

Bigger installations, especially some industrial processes outside the scope of the Gas appliance Directive, shall achieve minimum performances defined by European or national legislation. As mentioned above efficiency and NO_x emissions are changing with changing air gas ratio. Wobbe index is one of the parameter that can influence the air gas ratio and without any control system the performances of a gas burning installation will change with varying Wobbe index.

For such appliances, if the level of performances that is required is too high for being satisfied with the potential air gas ratio variations, compliance with the requirement will then depends on the situation at the time of measurement. This could be addressed by correcting the measurements to bring them back to defined reference conditions but in any case a reflection shall be undertaken in order to achieve a balanced approached between the following factors:

- Field performance requirements in line with the environmental objectives,
- Gas quality fluctuations ensuring security of supply and a fluid gas market,
- Use of affordable technology.

This approach is particularly necessary in countries or region that are currently favoured by stable gas quality supplies and where in consequences the technologies in place may not be able to fulfil the existing requirements with varying gas quality.

This need is particularly illustrated when considering some industrial processes very sensitive to gas quality variations. For instance glass or ceramics oven may not be able to tolerate Wobbe index fluctuation higher than ±2% around the one for which the installation is set. In some countries, such as France, observed Wobbe index variations may reach ±5% at a given location which is unacceptable for those industries. Thus solutions[ix] have been developed to ballast all gases entering the installation to a minimum Wobbe index on which the installation is adjusted. The costs of these solutions, around 1 000 €/month is negligible against that of keeping such low variations on the network fed by supplies of different quality. It is also very low when compared to the energy bill of these type of industry, generally above 200 000 €/month.

CONCLUSION

After more than ten years of debate and hard work, the draft standard prEN 16726, proposes a set of specifications for gases in the H group in Europe, including Wobbe index. The range of Wobbe index defined in this standard encompasses all gases currently distributed in Europe and as such is satisfactory as for the objectives of Mandate M/400.

The work being done on the impact of gas quality variations on GAD appliances have demonstrated that, although some safety or operational issues may be raised if gas quality evolves on the full range of Wobbe index, these issues are not solely dependent on the Wobbe index of the gas but also on factors that are not harmonised on a European basis: installation/maintenance rules, grid pressure control… Thus **the implementation of this range of Wobbe index shall be studied on a national basis** as recommended in the draft standard. During such studies, specific attention shall be given to the frequency of Wobbe index variations.

Furthermore performance levels specified in European or national regulations, because they are required to be measured in the field cannot be achieved without **self-adapting technologies** when gas quality variations are occurring. This calls for establishing a consensus on the adequate balance between performance requirements, flexibility of supply and technology costs.

Finally solutions exist that can allow the more demanding applications to work when connected to a network with changing gas quality. Although these solutions have a cost, this cost is very small when compared to processing all gases entering the network to the very limited range that would fulfil the needs of these specific applications.

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[i] EASEE-gas CBP CBP 2005-001/02.
[ii] Marcogaz WG "Gas Quality" 1st and 2nd position papers on gas quality harmonisation, UTIL-GQ-03-06, February 2003 and UTIL-GQ-03-09, August 2003.
[iii] Marcogaz WG "Gas Quality" 3rd Position paper on gas quality harmonisation, UTIL-GQ-06-08, February 2006.
iv prEN 16726 "Gas infrastructure – Gas quality – Group H".
[v] EUROGAS Statistical report 2013, figures for 2012.
[vi] See CEN BT WG 197 N 310 "Final report". This report and all documentation including individual testing reports are publicly available at http//: http://gqpilot.dgc.eu/
[vii] Directive 2009/125/ EC Ecodesign; Directive 2010/30/EU Energy labelling
[viii] For instance in Marcogaz report "Main effects of gas quality variations on applications", UTIL-GQ-05-04.
[ix] Cordier Rémi, "New appliances and systems for Wobbe Index measuring and regulating in industry.", IGRC 2008, Paris.