Wobbe Index and Gross Calorific Value in European networks

Analysis of ranges and variability

1. Background

As a continuation of mandate M400 and supported by the conclusions of the 29th Madrid forum, CEN continues working on finding an EU agreement for a Wobbe Index band, including elaborating on the possibility of regional bands.

With that aim, CEN Sector Forum[1] Gas working group "Pre-normative study of H-gas quality parameter" is conducting a study on the impact of H-gas quality parameters not yet or insufficiently specified in EN16726:2015 ('Gas infrastructure – Quality of gas – Group H') on the whole gas supply chain. The analysis will be undertaken on the basis of technical evidence.

As part of the preparatory work, CEN SFGas WG has arranged a survey to collect Wobbe index (WI) and (upon request of some end users) the gross calorific value (GCV) measured data from gas system operators and end users. In this context, ENTSOG has offered to collect input from its members.

The survey results will be used as basis to decide on possible Wobbe Index scenarios[2].

In addition, this document proposes an analysis methodology for the data collected by ENTSOG with the view of facilitating the choice of potential Wobbe Index ranges and related parameters (among others, the variability).

2. Scope

The survey on which this report is based was limited to GCV and WI. The data was provided by ENTSOG members on a voluntary basis covering different types of gases and network points with a special focus on transmission system exit points. Both points with high variability and low variability of gas quality as reasonably determined by the TSO have been included.

[1] A Sector Forum is a platform aiming at facilitating the exchange of information between the different stakeholders, coordinating and identifying the standardization needs in a specific field of CEN work.

[2] Scenario in this context is meant as description of a set of boundary conditions, which will be assessed for consequences on the whole gas chain

The survey period was agreed from 1 January 2015 to 31 December 2016. Hourly data was welcomed but TSOs were asked to provide data with 15 minutes resolution when available.

3. Disclaimer

This report was prepared in a professional and workmanlike manner by ENTSOG on the basis of information collected and compiled by ENTSOG. It contains ENTSOG own analysis based upon this information. All content is provided "as is" without any warranty of any kind as to the completeness, accuracy, fitness for any particular purpose or any use of results based on this information and ENTSOG hereby expressly disclaims all warranties and representations, whether express or implied, including without limitation, warranties or representations of merchantability or fitness for a particular purpose. ENTSOG is not liable for any consequence resulting from the reliance and/or the use of any information hereby provided. The reader in its capacity as professional individual or entity shall be responsible for seeking to verify the accurate and relevant information needed for its own assessment and decision and shall be responsible for use of the document or any part of it for any purpose other than that for which it is intended.

4. Methodology and indicators

For each data set (or point) the following calculations were carried out:

- Summary statistics: maximum, minimum, 95 and 5 percentiles, average and standard deviations.
- Frequency distribution of values (i.e. the probability of finding a given value within the time series)
- Amplitude of variation probability for different time periods (e.g. how frequently a variation of 2 MJ/m3 is found within a 24 hour period).
- Maximum amplitude of variation per period (e.g. what is the maximum variation ever registered for a 30 day period).

For the last two indicators the following periods were considered:

- 15 min when the TSO provided data in such resolution.
- Hour, meaning a single measurement (hourly resolution) or every set of 4 adjacent values (15 min resolutions).
- Day, meaning every set of 24 adjacent hours (e.g. 7h-7h, 8h-8h, 9h-9h,….).
- Month, meaning every set of 30 adjacent days (e.g. 1 Jan – 30 Jan, 2 Jan – 31 Jan, …)
- 6-month, meaning every set of 180 adjacent days

It should be noted that for producing any of the figures within this report, daily, monthly and 6-monthly values were never averaged. Instead, for given time period (e.g. day) all the measurements were considered as a whole (e.g. 24 values for hourly resolution or 96 values for 15 min resolution).

5. Summary of participation

	Points
Belgium	9
Denmark	8
France	8
Germany	25
Hungary	14
Ireland	4
Italy	15
Netherlands	9
Poland	14
Slovakia	4
Slovenia	3
Spain	10
Ukraine	5
United Kingdom	8
Total	**136**

	Points
Algerian	3
Biomethane	3
LNG	8
Libyan	1
Mix	76
National production	18
Norwegian	4
Russian	23
Total	**136**

In total, input from 17 TSOs across 12 countries was received (Note: introduce the list of participating TSOs).

It shall be taken into account that the "Mix" category represents points that may receive any combination of supply sources. This category can be used at Entry point when applicable, but in general it has been used for exit points.

	Points
Biomethane injection	3
City gate	55
EU import point	11
Industrial - combustion	3
Industrial - non combustion	3
Interconnection point	27
LNG terminal	7
Power generation	4
Production point	6
Transit	14
UGS (underground storage)	3
Total	**136**

	Points
15 min	37
hourly	99
Total	**136**

It shall be recognised that the results of the present report might be influenced by the selection of the points.

6. Wobbe Index ranges

6.1. By country

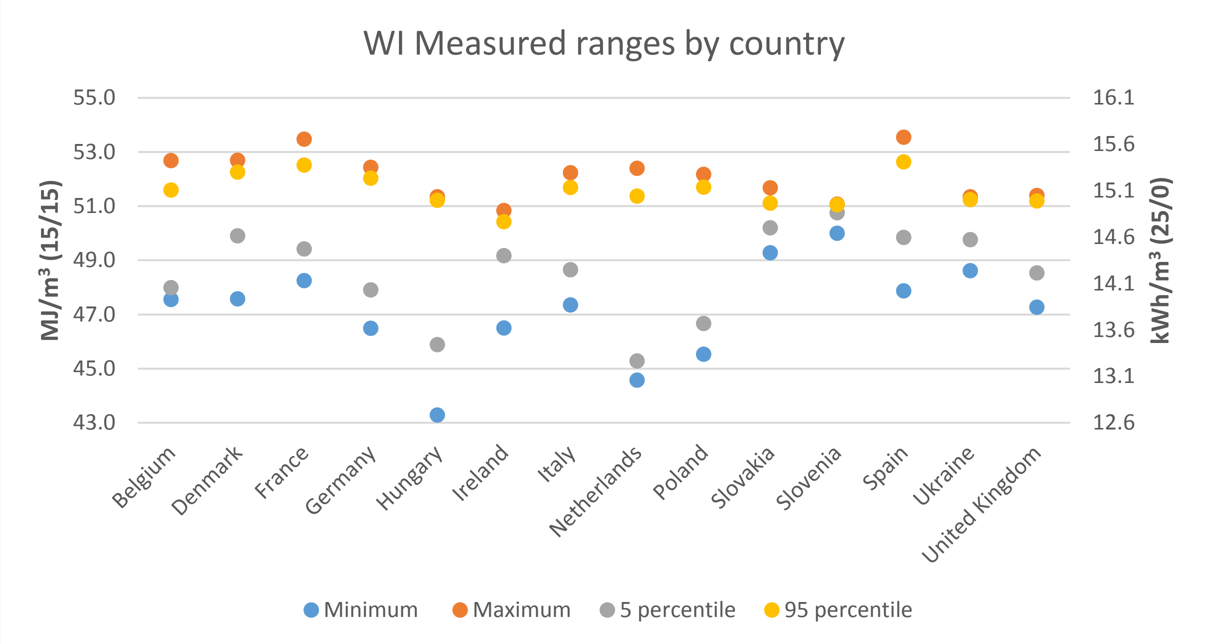

Figure 1

The graph above shows WI range information by country. For a given country, the maximum value represents the highest maximum of all datasets, same applies for 95 percentile; similarly, the minimum value represents the lowest minimum of all datasets, same applies for 5 percentile.

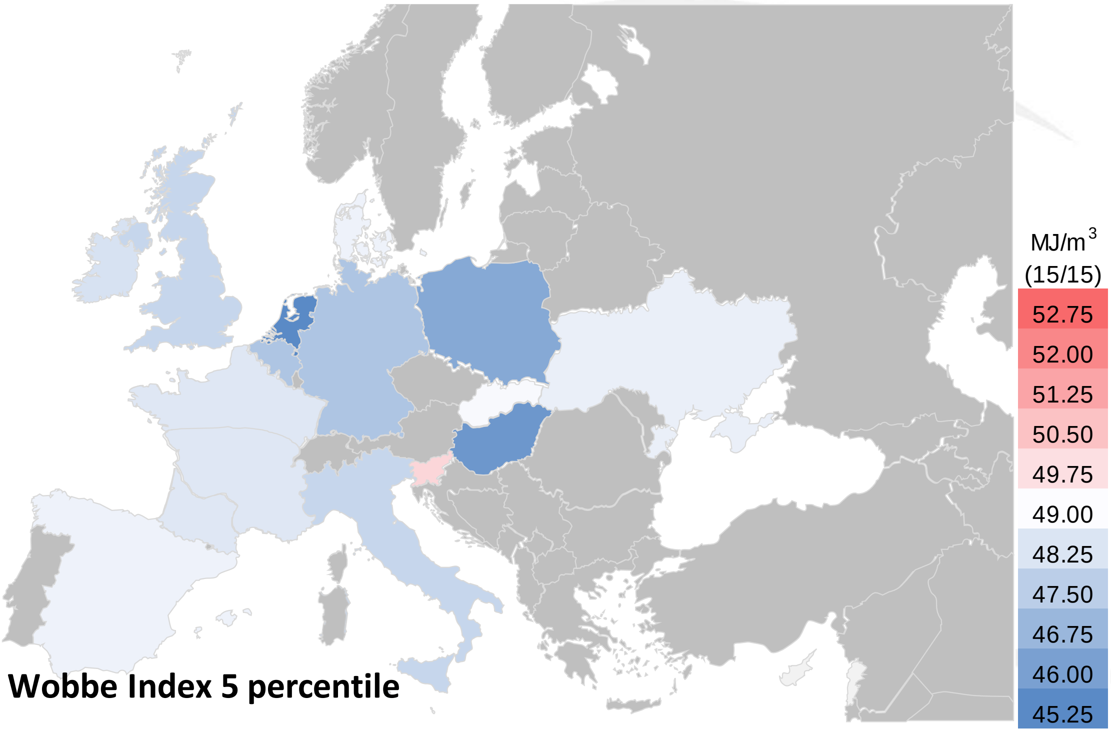

Figure 2

In the map above, the darker the blue is, the lower the Wobbe Index 5 percentile is.

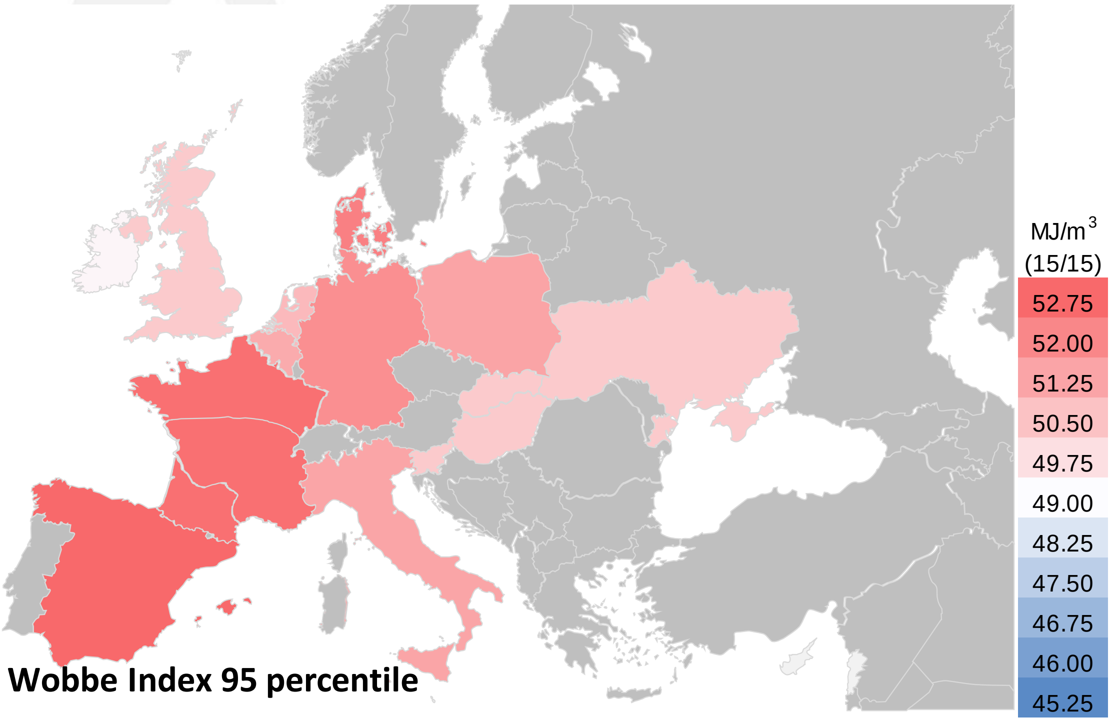

Figure 3

In the map above, the darker the red is the higher the Wobbe Index 95 percentile is.

6.2. By source

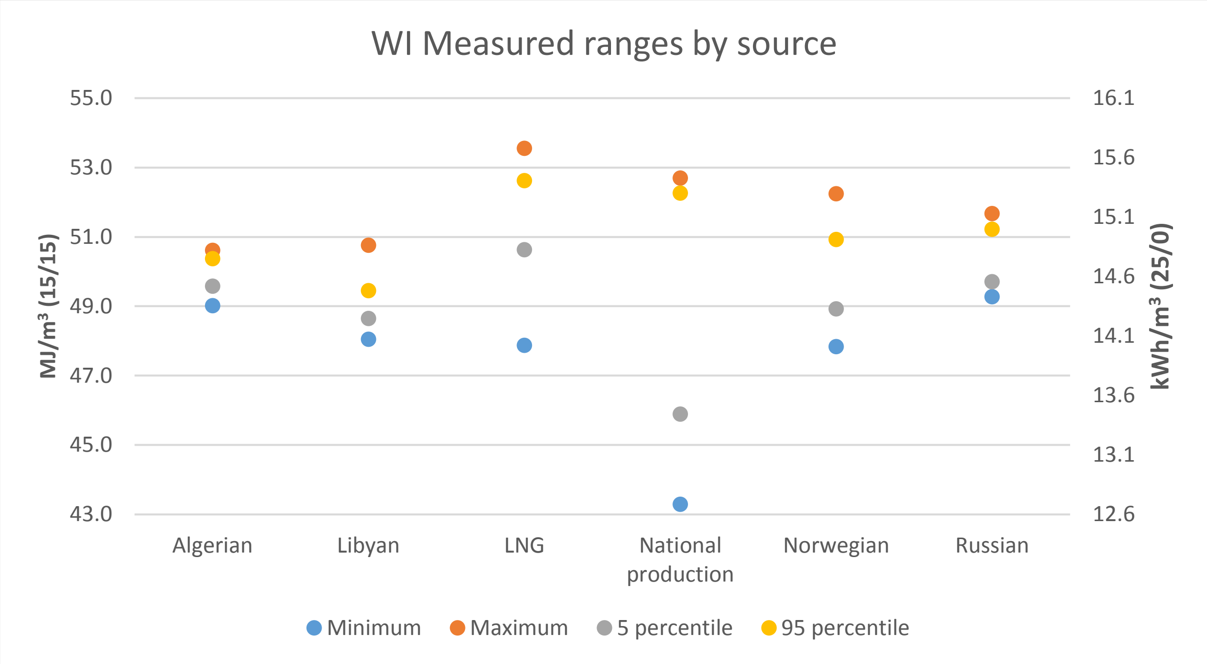

Figure 4

The graph above shows WI range information by type of gas. For a given type, the maximum value represents the highest maximum of all datasets, same applies for the 95 percentile; similarly, the minimum value represents the lowest minimum of all datasets, same applies for the 5 percentile.

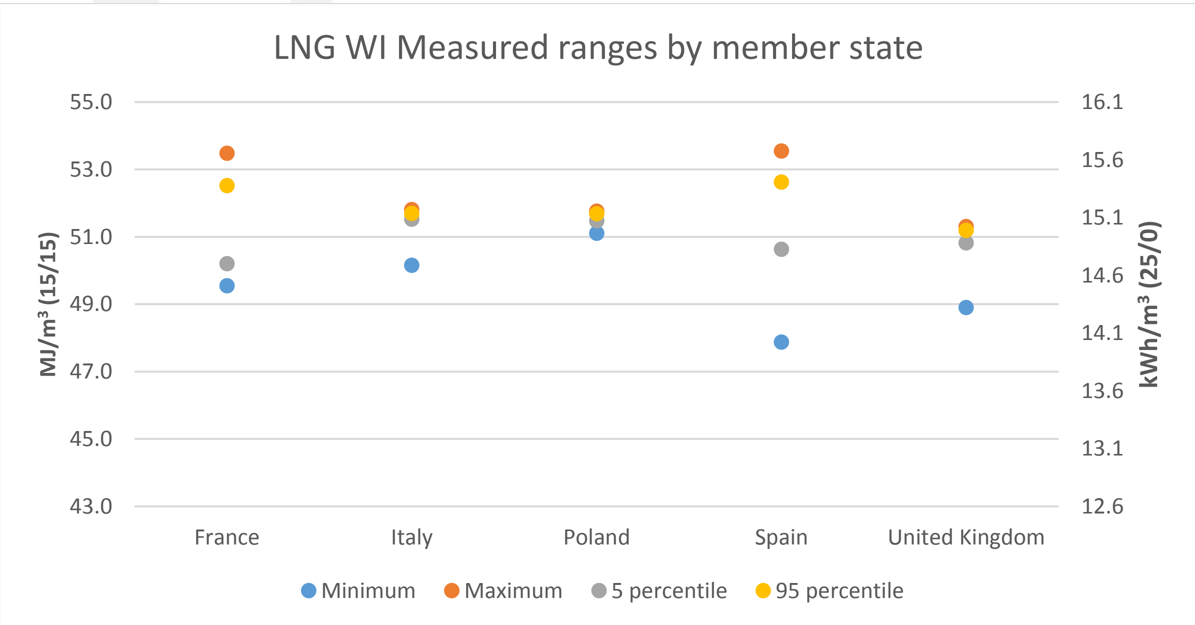

Figure 5

The graph above shows LNG WI range information by country. For a given country, the maximum value represents the highest maximum of all datasets, same applies for 95 percentile; similarly, the minimum value represents the lowest minimum of all datasets, same applies for 5 percentile.

It should be noted that LNG values correspond to send out point of terminals. Therefore, the WI range of the LNG received by cargo may differ. In addition, the relatively low degree of utilisation of LNG terminals across Europe in the last two years, which is the period of the survey, may influence the results.

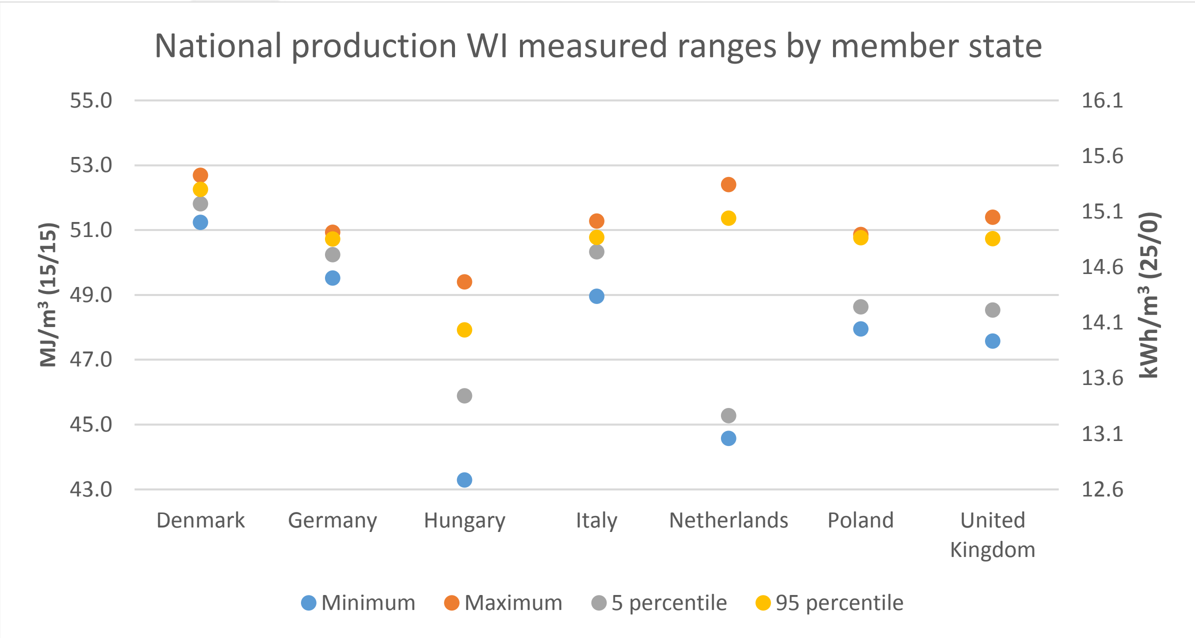

Figure 6

The graph above shows WI range information for conventional national production by member state. For a given member state, the maximum value represents the highest maximum of all datasets, same applies for 95 percentile; similarly, the minimum value represents the lowest minimum of all datasets, same applies for 5 percentile.

It should be noted that datasets from Ireland correspond to a mixture of imports and national production.

For more information on gas quality inputs to the EU, please refer to the long-term gas quality monitoring outlook of ENTSOG.

6.3. By type of point

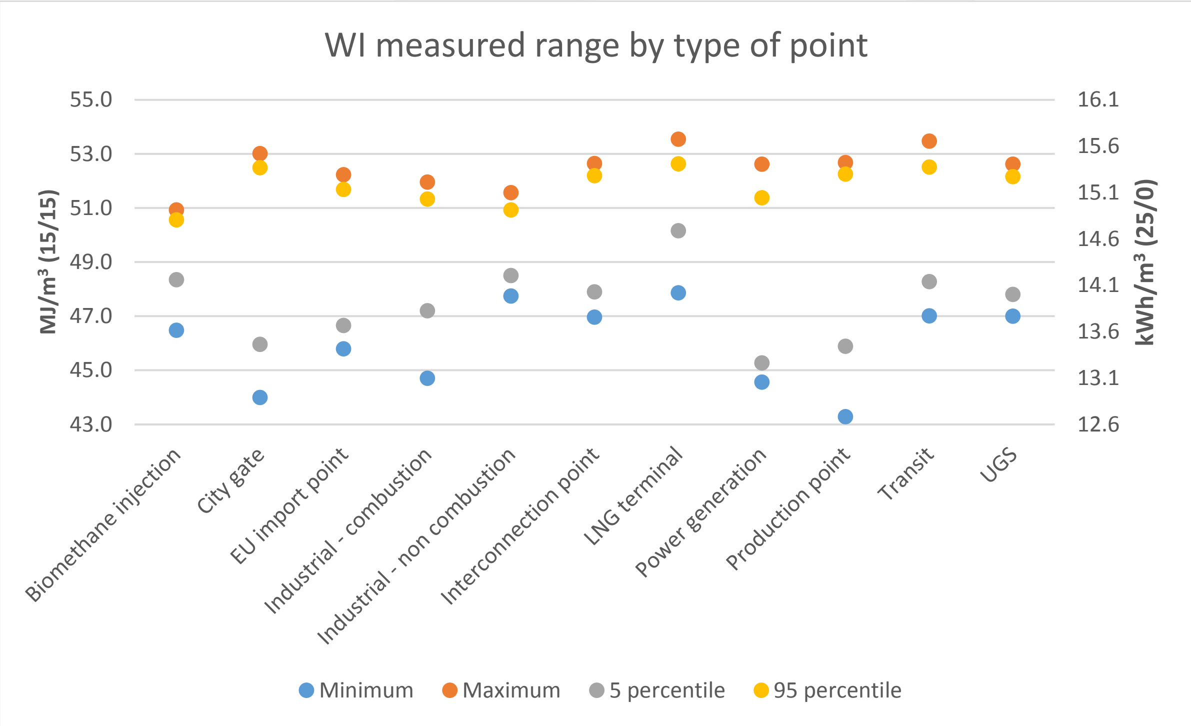

Figure 7

The graph above shows WI range information by type of point. For a given type, the maximum value represents the highest maximum of all datasets, same applies for 95 percentile; similarly, the minimum value represents the lowest minimum of all datasets, same applies for 5 percentile.

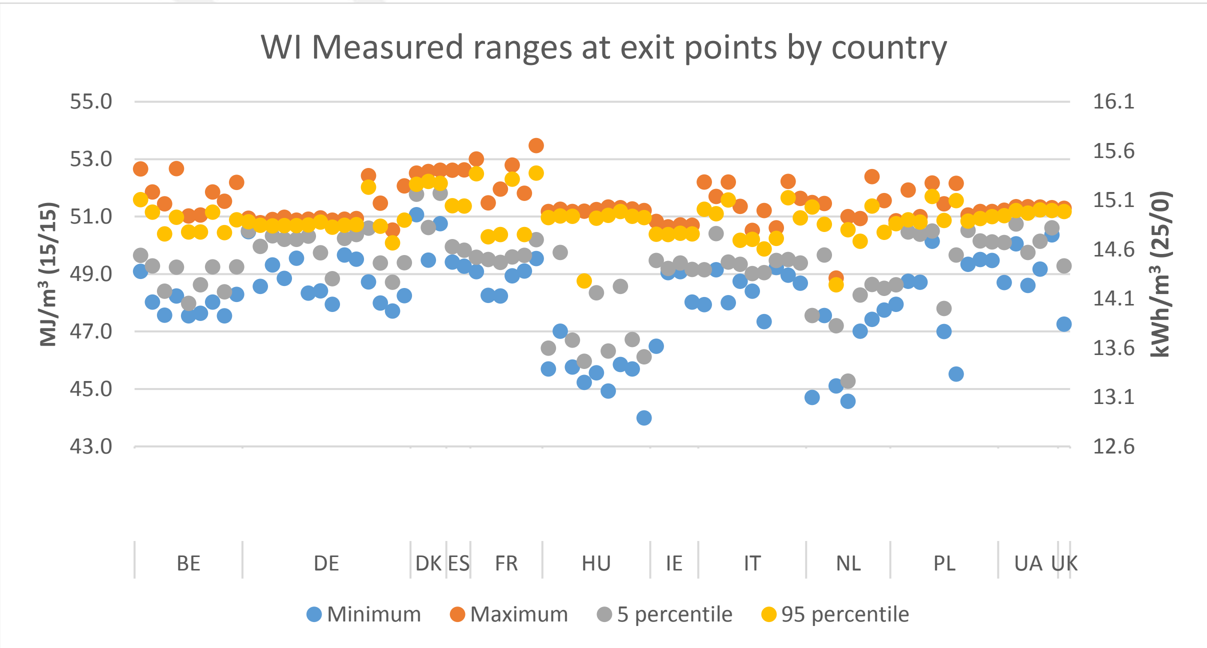

Figure 8

The graph above shows WI ranges for exit points (city gates, industrial consumers, power generation, transit and UGS point types) grouped by regions (NUTS3 level, which is normally the province or county).

7. Wobbe Index frequency distribution

7.1. By source

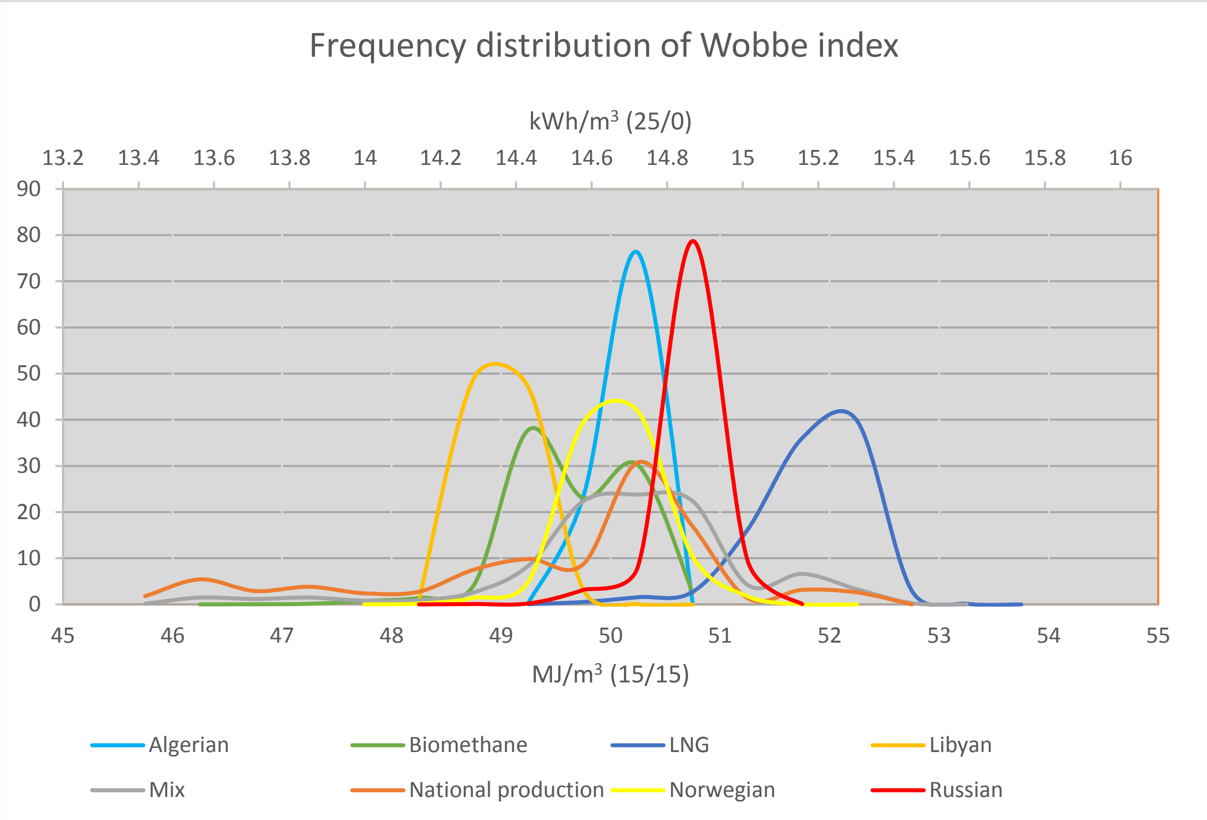

Figure 9

The graph above shows the frequency distribution of WI values for different supply sources.

While several sources are characterized by a narrow WI range (Algerian, Russian, Libyan ...), their average values are different. In addition, other sources are characterized by a much wider WI range (national production, biomethane ...). As a consequence, the WI range of the gas that is distributed in Europe[3] (see "Mix" category) corresponds roughly to the wide EASEE-gas range (46,46 → 54 MJ/m³).

[3] For the points studied in this report

The following graphs illustrate the relative Wobbe Index frequencies by country. Attention shall be paid to the fact that the following figures have been obtained by averaging all points within a country without taking into account flows.

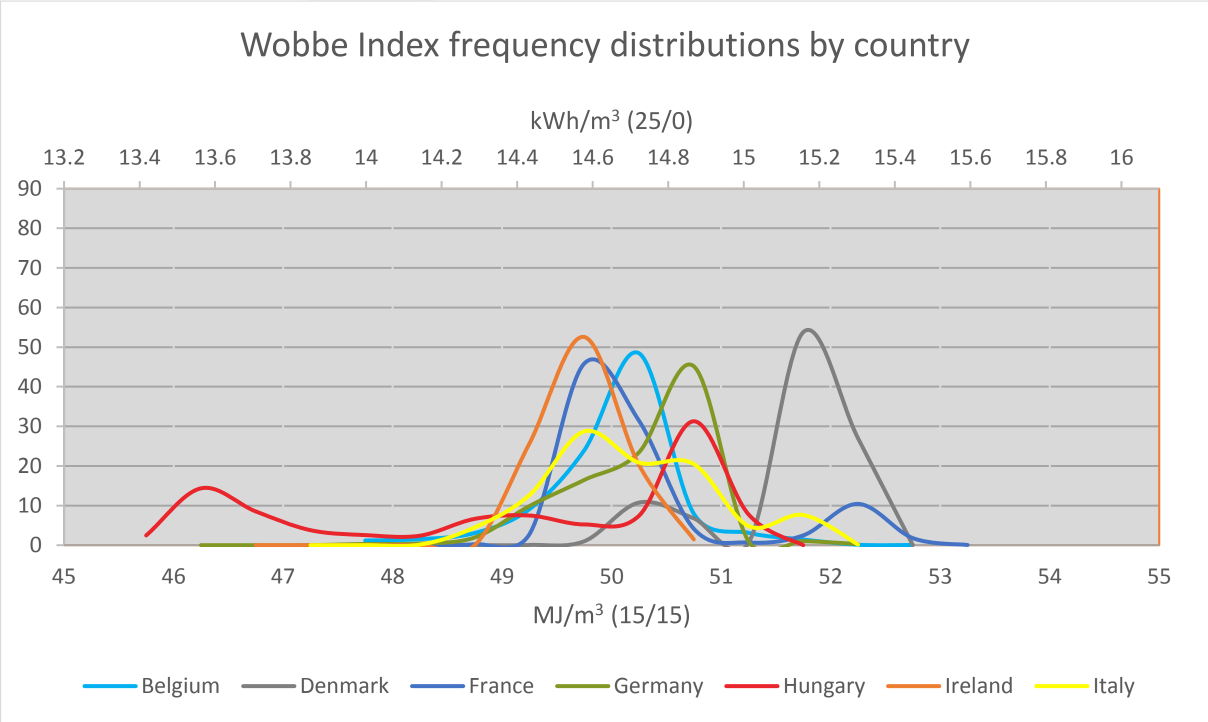

Figure 10

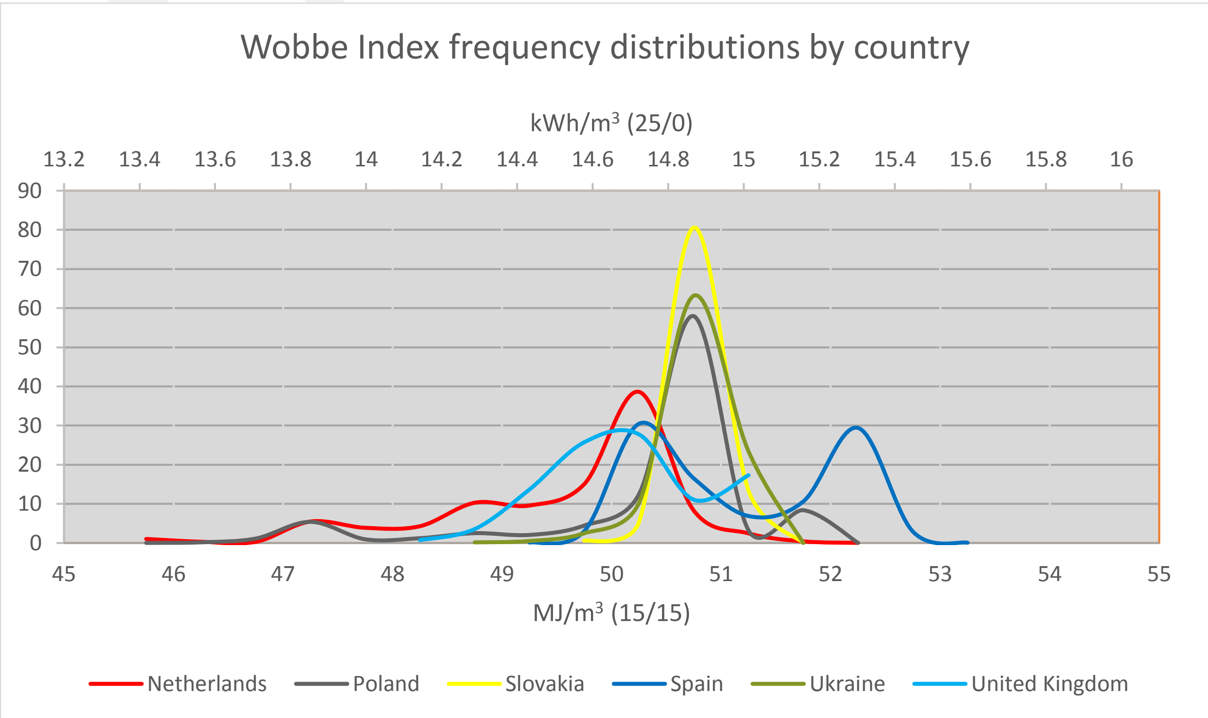

Figure 11

8. Wobbe Index variability

8.1. By source

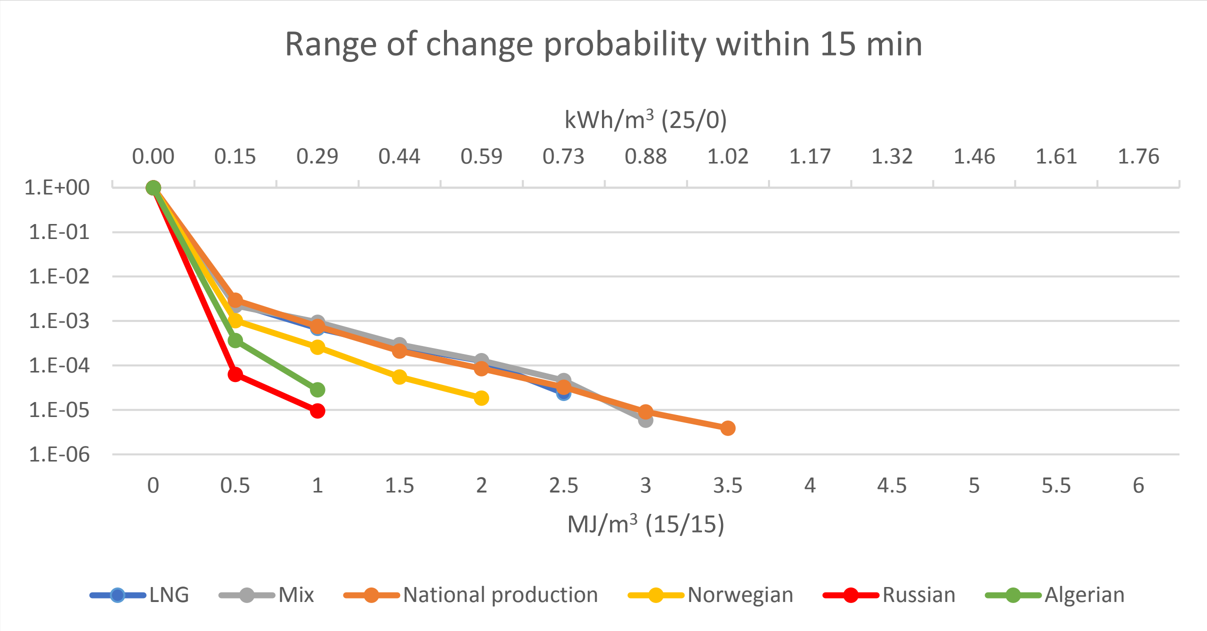

Figure 12

The graph above shows the probability of different step changes in a period of 15 minutes (data from FR, IE, NL, SK and UK). The probability has been calculated by dividing the number of changes that are bigger than a given threshold (e.g., 0.5 MJ/m3) by the total number of registered measurements. For example, the probability of seeing a change of 0.5 MJ/m3 in 15 min for points supplied with Russian gas is less than 0.01%. When a data series stops at a given point (e.g., Russian stopping at 1 MJ/m3), it means that no changes greater than the next threshold (e.g., 1.5 MJ/m3) have been observed. In general the more the curve is extended to the right, the wider the variations are. The higher the curve, the more frequent the variations are.

Alternatively the graph below shows the probability as individually computed for every single point (only those reported with 15 min resolution data). This analysis shows for example that only 2 points out of 29 registered changes greater than 3 MJ/m3 in a 15 min period.

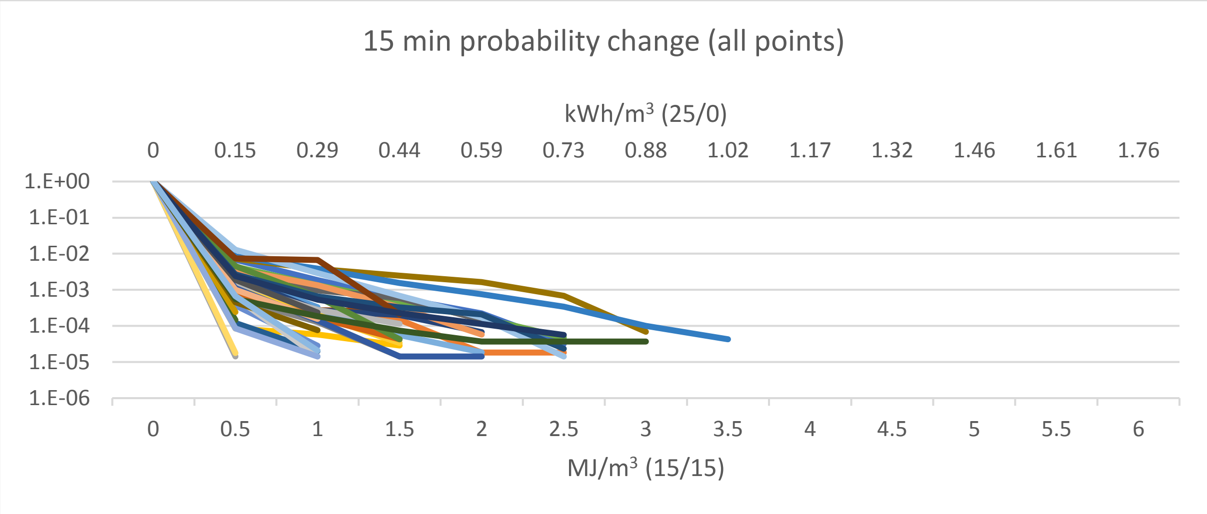

Figure 13

8.2. By period

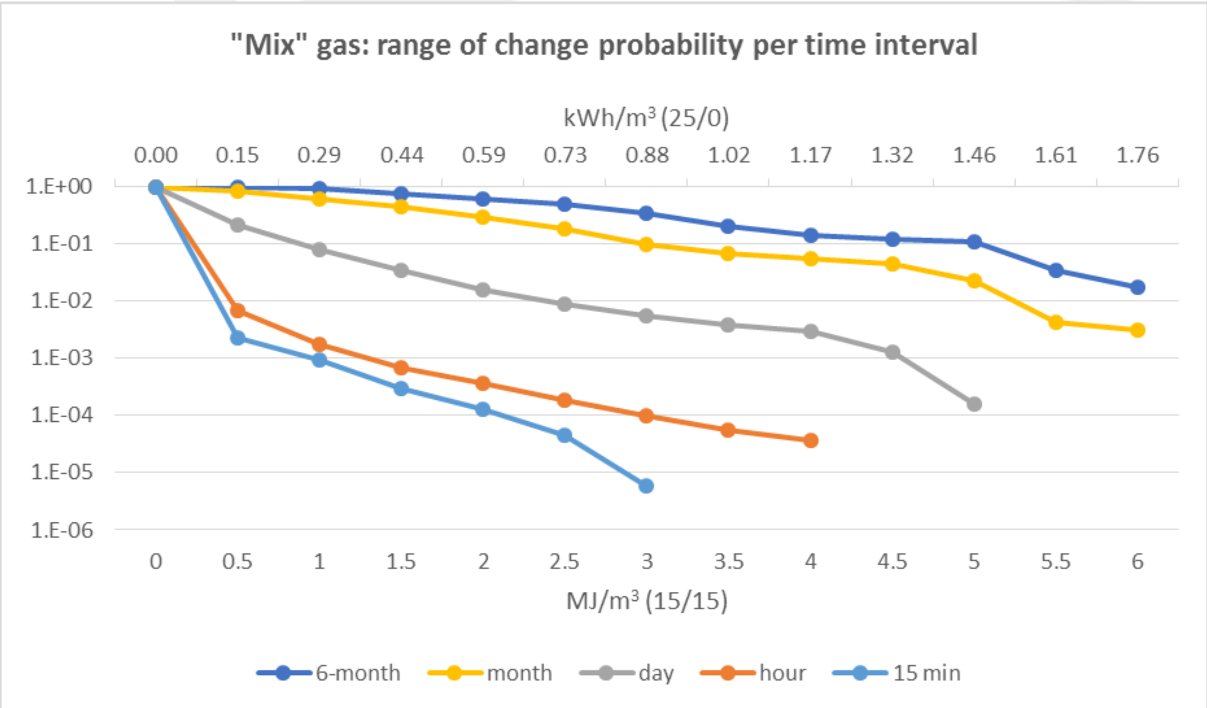

Figure 14

The graph above illustrates how the probability of a given change increases with time. For example, in this case, for points receiving different gas mixes, while there are no records of daily changes greater than 5.5 MJ/m3, that threshold may be trespassed if a period of one month is considered.

The graphs in the following pages illustrate the same phenomenon for the different gas types. In general, they will show more stable behaviour than mixes, which are typically distributed to end users, and which are combining several sources.

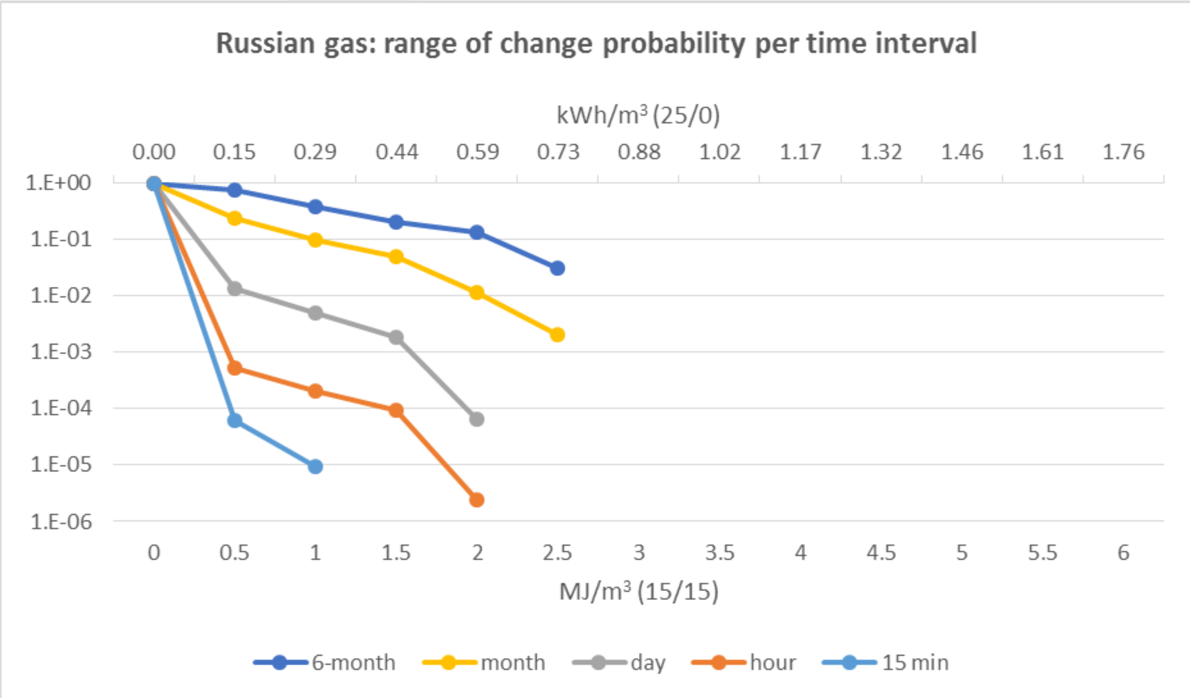

Figure 15

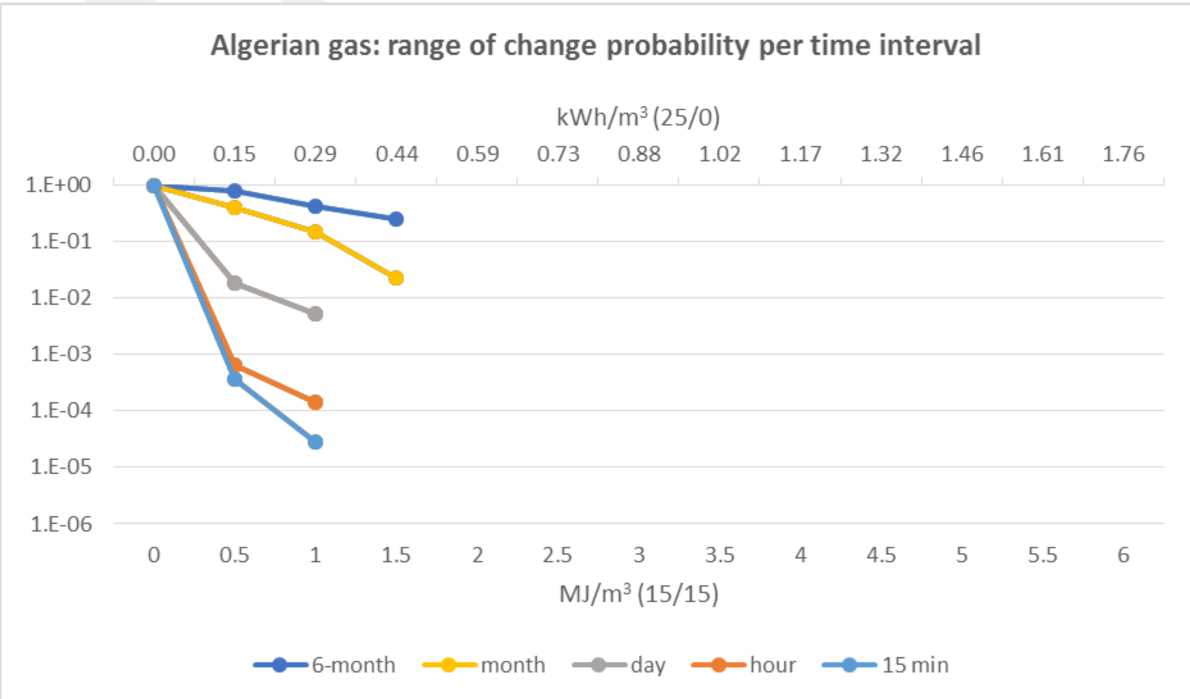

Figure 16

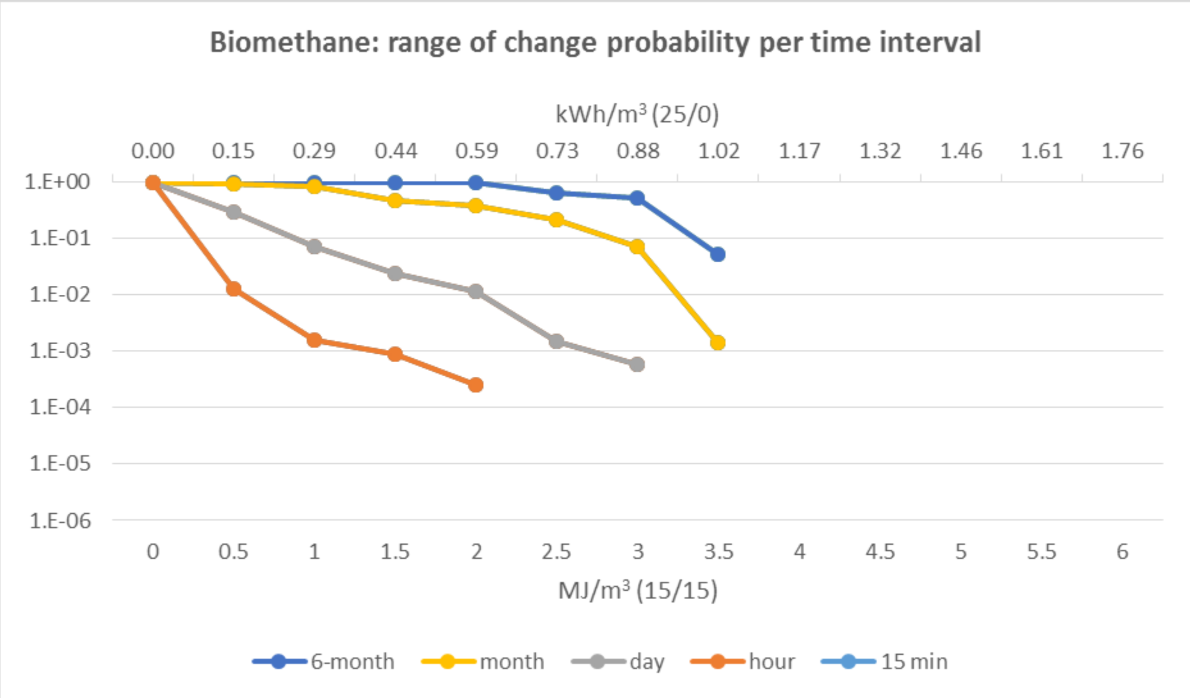

Figure 17

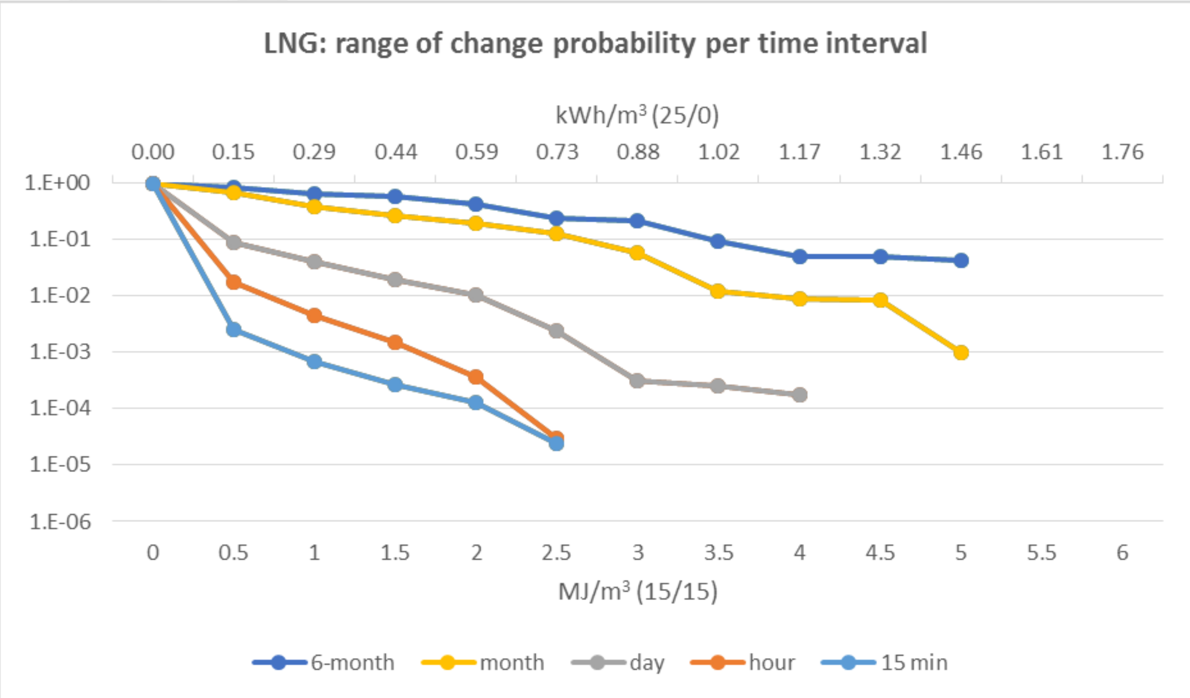

Figure 18

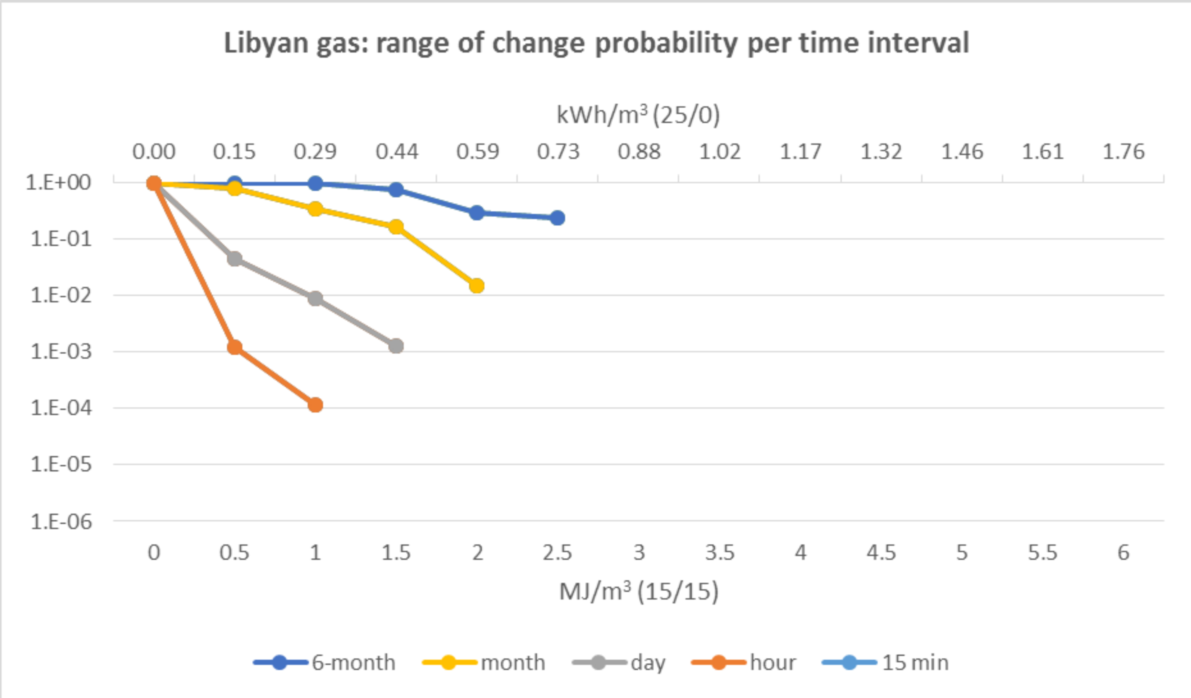

Figure 19

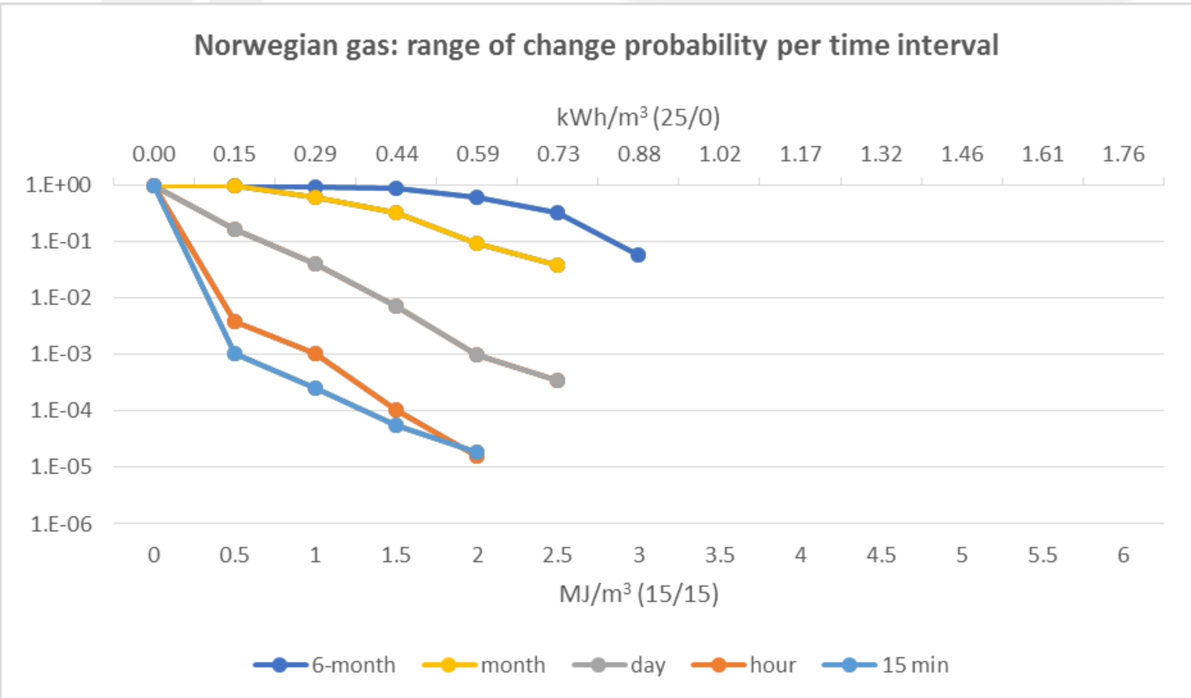

Figure 20

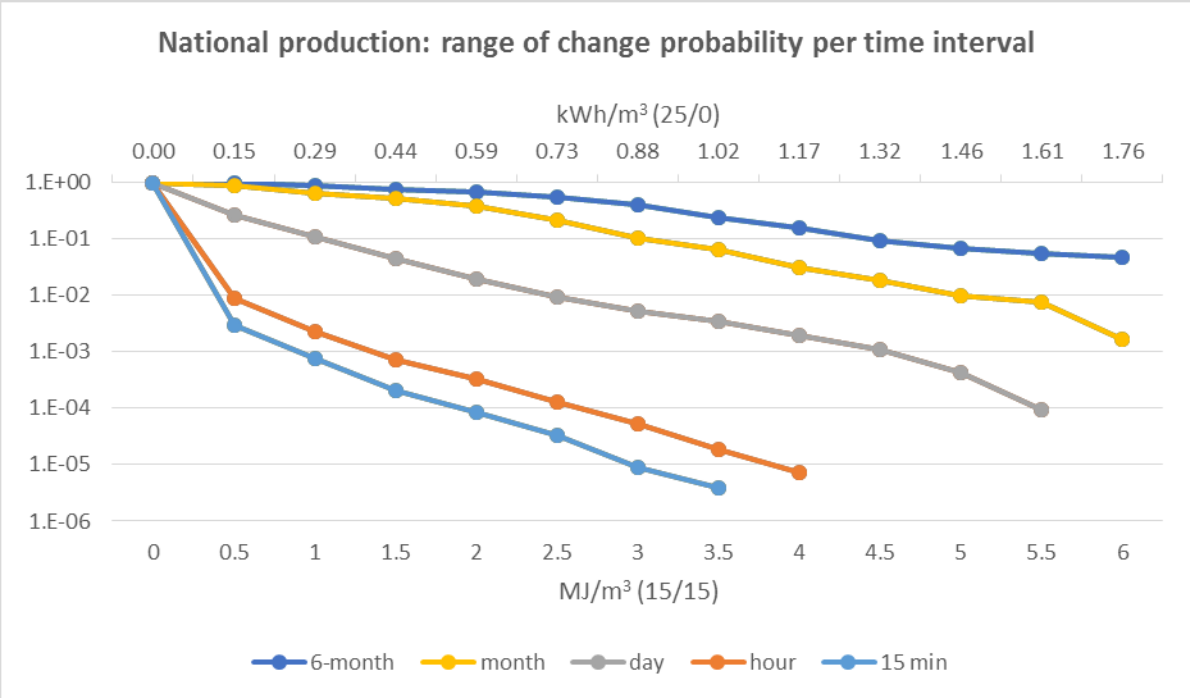

Figure 21

The graph below presents a summary of the maximum ranges of change that have been observed among all points, categorised by period and supply source.

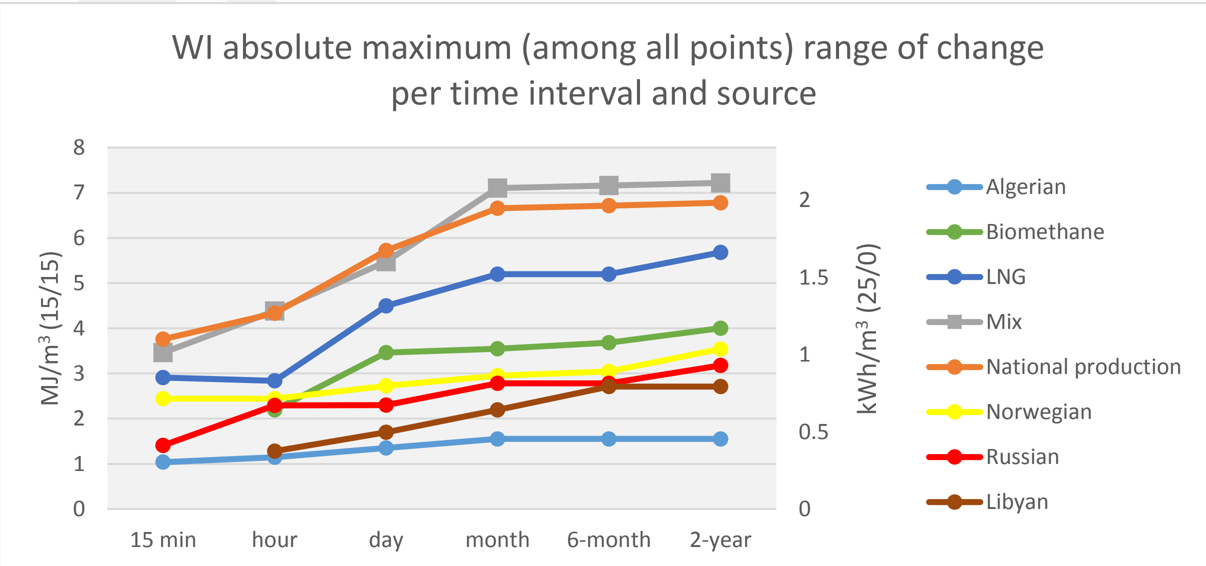

Figure 22

Remarkably, only 3 types of gases (Russian, Libyan and Algerian) remain within a 3 MJ/m3 range for the 2 years. Norwegian gas may trespass that threshold on monthly periods while LNG and biomethane may do it within a day.

Gas mixes and national production will have higher variations in any time frame, even overcoming 7 MJ/m3 within a month. Notably, even if each supply source has a quite stable gas quality, the variations in output quality can be wider and faster than the variations on the sources due to comingling or changes in sources of supply to a particular (exit) point.

Below the same analysis is carried out for all input and exit points separately. It can be observed that while variations at nearly all entry points are within 4 MJ/m3, on exit points, where mixes are distributed, the situation is quite different with much wider short and long-term variations.

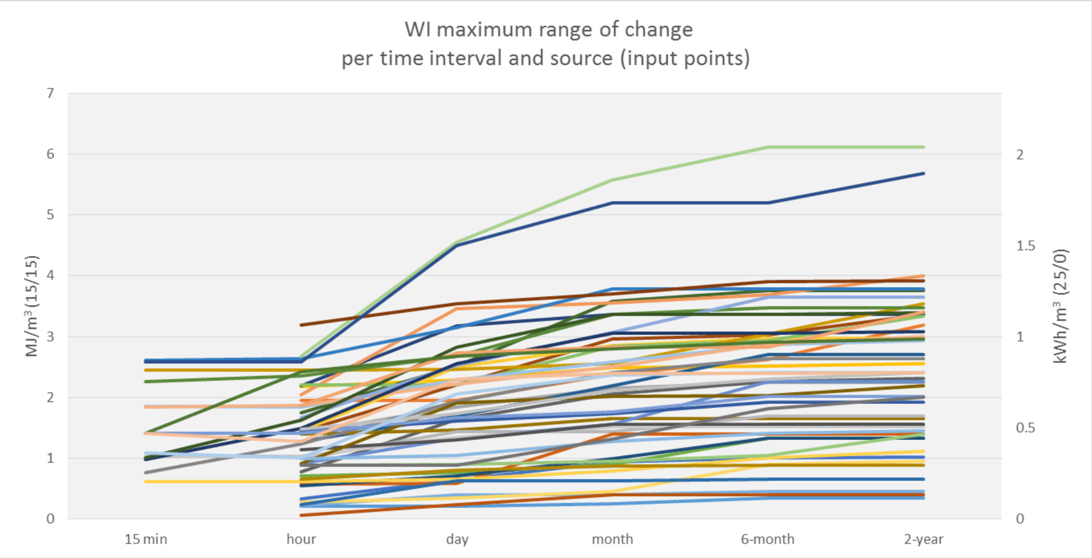

Figure 23

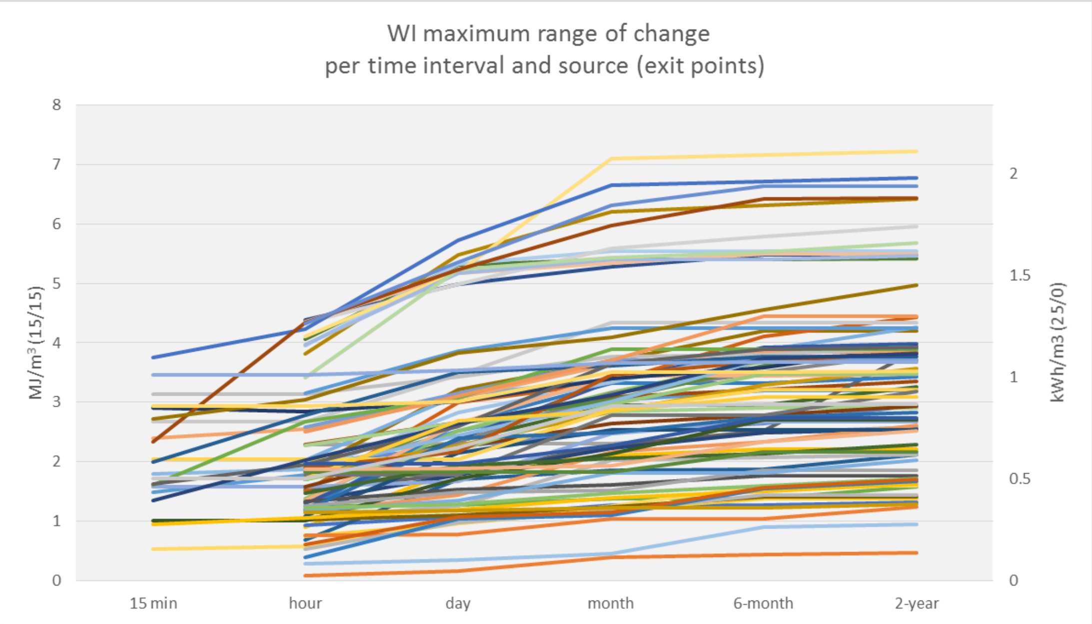

Figure 24

9. Gross Calorific Value

As the main topic under consideration in the standardisation work of CEN is Wobbe Index, the analysis of GCV has been done on a higher level. This is justified on the fact that, generally, WI presents greater amplitude of variation.

9.1. By country

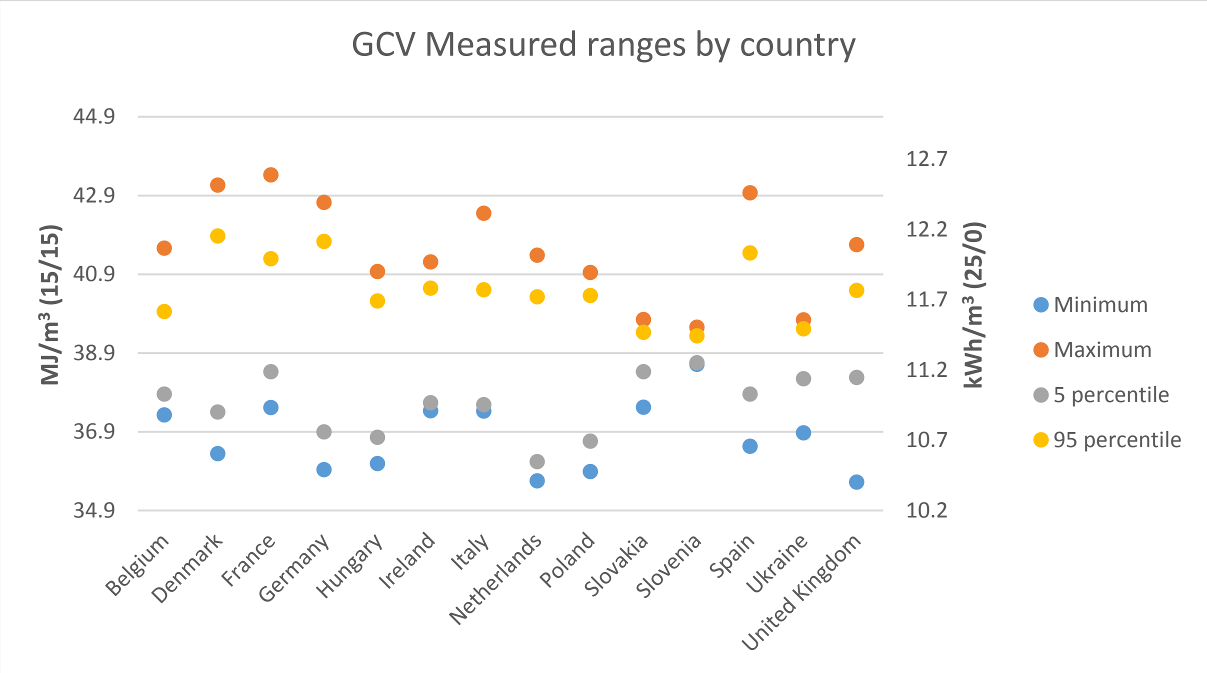

Figure 25

The graph above shows GCV range information by country. For a given type, the maximum value represents the highest maximum of all datasets, same applies for the 95 percentile; similarly, the minimum value represents the lowest minimum of all datasets, same applies for the 5 percentile.

The graphs on 8.2 and 8.3 follow the same approach.

9.2. By source

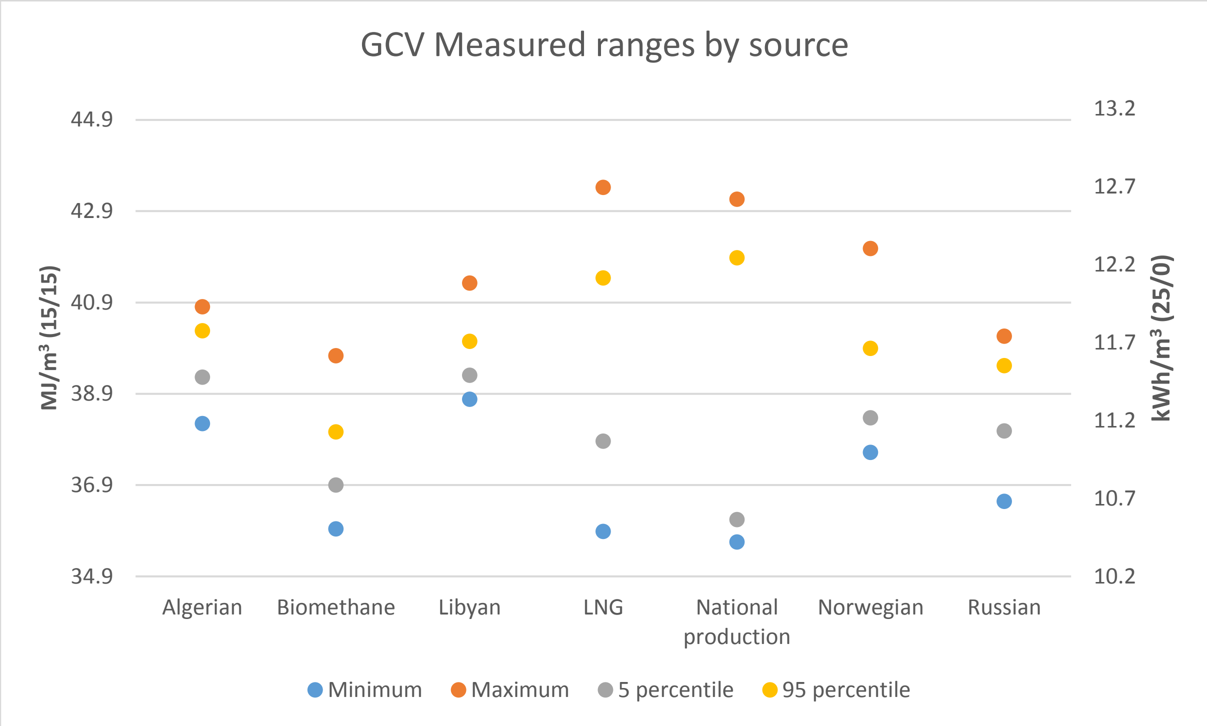

Figure 26

9.3. By type of point

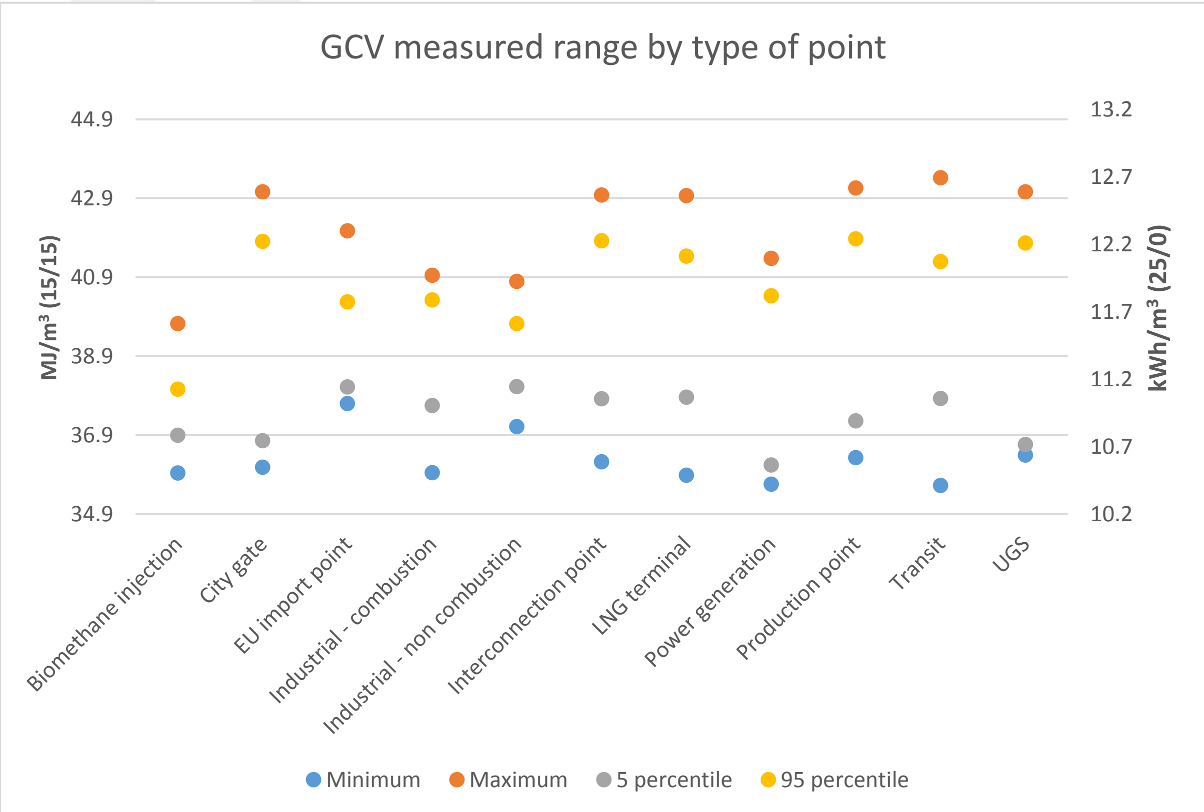

Figure 27

10. GCV frequency distribution

10.1. By source

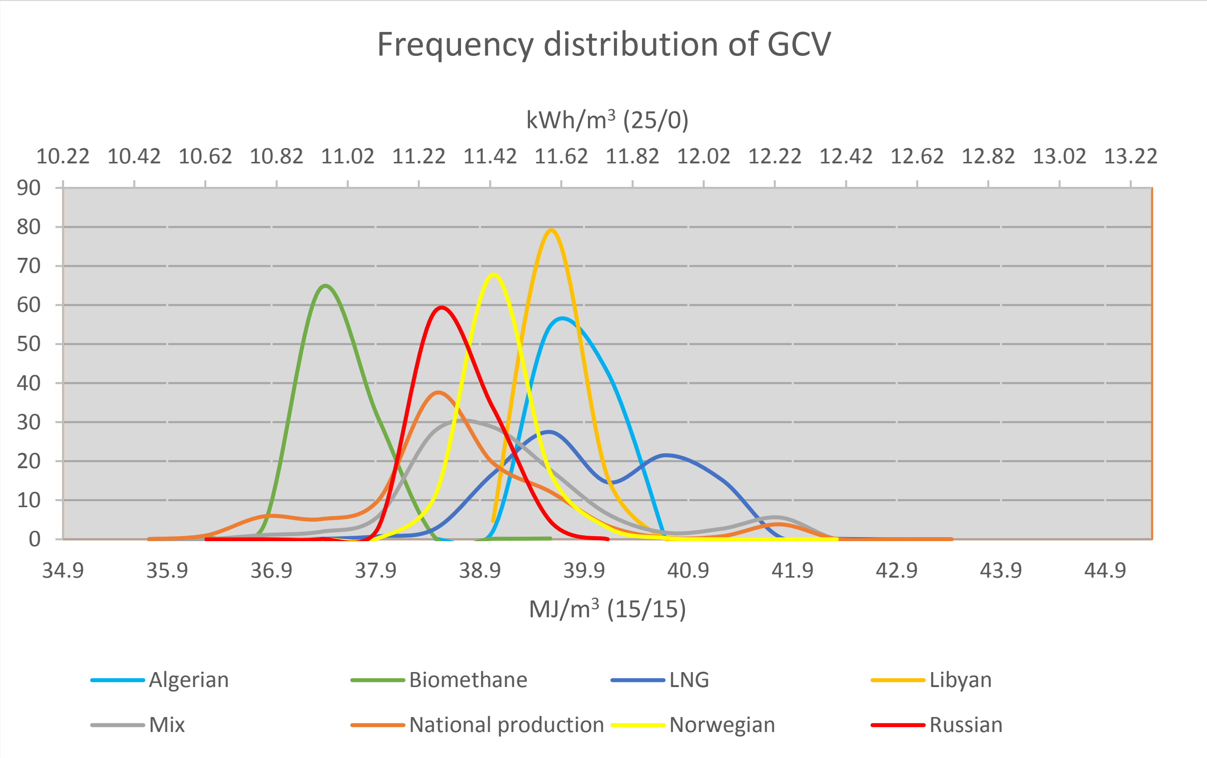

Figure 28

11. GCV variability

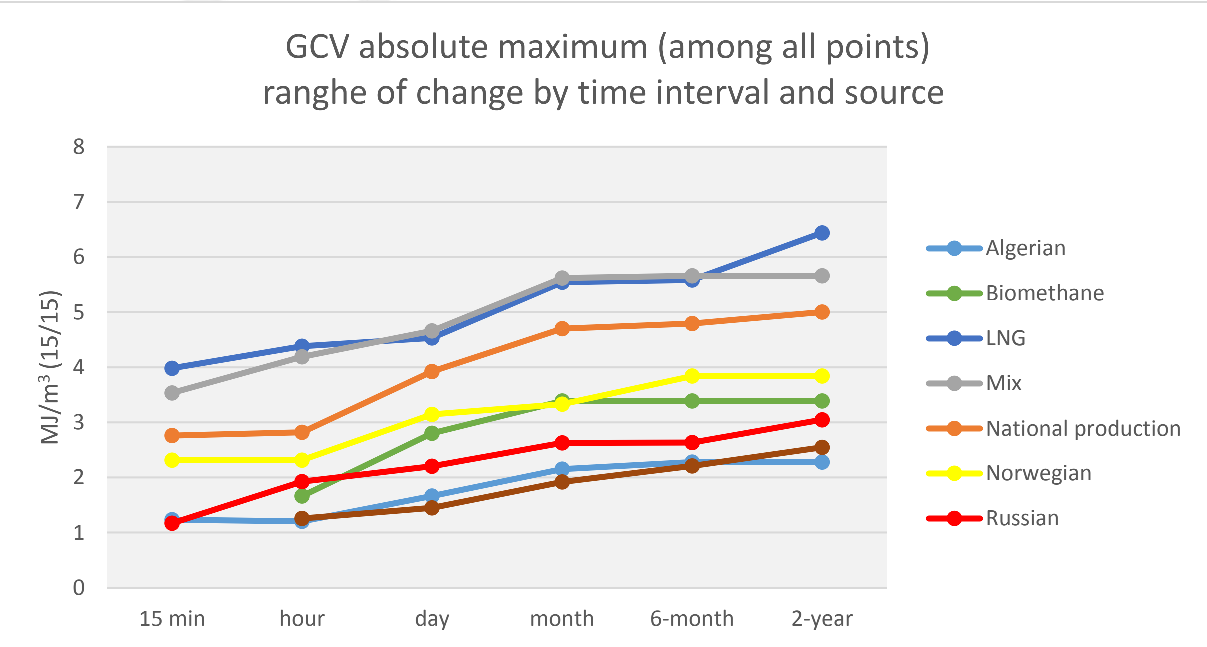

Figure 29

12. Conclusions

- The data in this survey level includes more than 120 data sets from 17 TSOs across 13 countries. Therefore, the study is considered representative for the purposes of gas quality analysis.
- WI ranges arising from the data collected in the survey show a great variety depending on the supply source. That variety is also present at exit points, which are very often supplied with different gas mixes (see Figure 8). While imports to EU may be within a 5 MJ/m^3 range, national production includes extremely low values (below 45.7 MJ/m^3 [4], see Figure 4).
- The probability distribution of WI values in a given point of the network is strongly influenced by the supply source or sources (see Figure 9).
- The amplitude of variation for WI will be significantly wider the longer the period of examination is (see 8.2). Regarding entry points, there is also a strong dependency with respect to the given supply source. Some of the most relevant ones may be able to guarantee a narrow range (3 MJ/m^3) over time but other sources are within a relatively wide range (5 MJ/m^3). On the other hand, indigenous European production appears to be linked to the most extreme variations. Finally, (exit) points supplied with mixes of different gas sources may also be faced with very wide variations (above 6 MJ/m3, see Figure 22).
- GCV ranges present also a wide variety across Europe. Generally speaking the range of change appears to be slightly more restrained with maximums of 6MJ/m3 for the 2 year period (Figure 29).
- Regarding the long term Gas Quality Outlook, the values collected in this survey may be used to update the input ranges assigned to different supply sources. The data gathered for biomethane will be used to consider this source independently from indigenous conventional production.

[4] The lowest value in EN 437: Test gases. Test pressures. Appliance categories.