european network
of transmission system operators
for gas

GAS QUALITY OUTLOOK

2024

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1 INTRODUCTION

Article 18 of the network code on interoperability and data exchange rules (Commission Regulation (EU) 2015/703) requires ENTSOG to publish, alongside the TYNDP, a long-term gas quality monitoring outlook (Gas Quality Outlook – GQO) for transmission systems in order to identify the potential trends of gas quality parameters and respective potential variability within the next 10 years.

The GQO shall cover at least the gross calorific value (GCV) and the Wobbe Index (WI), produce forecasts for different regions and be consistent and aligned with the TYNDP considering existing and new supply sources, based on reference gas quality values from previous years when available. For each region, forecasts are illustrated by charts that provide ranges within which the parameters are likely to evolve.

This publication represents the fifth edition of the Gas Quality Outlook. As the previous edition, this document includes synthetic methane in the production scenarios.

Identical to the TYNDP 2020 and TYNDP 2022 exercise, the influence of hydrogen on GCV and WI is also included in this gas quality outlook. One of the main improvements in this edition is the analysis of hydrogen blends impact for all the regions considered in the study and the inclusion of different scenarios for share of hydrogen blends. This report only provides initial assessments of the possible quantities of renewable, decarbonised and low-carbon gases. In this respect, the report does not prejudice the technical feasibility of injecting the projected quantities of such gases into the gas systems as this subject is still under investigation – and does therefore not constitute any legal responsibility on ENTSOG in this matter.

2 METHODOLOGY

The GQO is produced with a probabilistic approach based on a statistical characterisation of historical WI and GCV data supplied by TSOs for each different supply source. In the Input data subsection, a graphical representation of the used values for all the sources included in the study can be found.

The flow volumes for each assessed region/corridor presented in this document are derived upon the Dual Gas Model (DGM) simulation results[1]. The results asses the resilience of the European natural gas system under the analysed infrastructure levels – Low natural gas infrastructure level in combination with PCI/PMI hydrogen level[2] – for the reference weather years 2030 and 2040.

The integrated gas network is mapped in line with a scenario that follows the National Energy and Climate Plans and is considered central to the TYNDP 2024 (National Trends+ or NT+[3]). Demand, indigenous production for natural gas, synthetic methane and biomethane, and supply potential for this scenario are based on figures collected from the TSOs, translating the latest policy and market driven developments as discussed at national level.

1 All information about the legal background, assumptions, modelling tools, and methodologies can be found in the **TYNDP 2024 Hydrogen and Natural Gas System Assessment Methodology (Annex D3)**

2 Detailed information about the project collection and infrastructure levels is provided in the **TYNDP 2024 Draft Infrastructure Report**

3 Detailed information is provided in the **TYNDP 2024 scenarios**.

In addition, natural gas demand for power generation, hydrogen demand, and electrolytic hydrogen production is incorporated. These values are derived from the Dual Hydrogen/Electricity Model (DHEM) simulation results as part of the modelling of the electricity and hydrogen infrastructures.

The supply configuration applied in the Dual Gas Model (DGM) is designed to minimise the use of Russian natural gas. In line with this assumption, the DGM simulation results indicate that Russian pipeline supply does not contribute to the overall supply mix.

Note: the results presented here are derived from the output flows of the simulations which represent one possible optimized solution based on the defined assumptions.

The underlying mathematical model is built on the following assumptions:

- The supply corridors and regions are defined like the regional groupings that develop the GRIPs[4]:
  - South corridor: FR, ES, PT
  - South-North corridor: DE, BE, FR, IT, CH, LU
  - North-West corridor[5]: SE, DK, DE, NL, BE, LU, FR, UK, IE
  - Baltic Energy Market Interconnection Plan (BEMIP) corridor: DK, SE, FI, PL, EE, LT, LV
  - Central Eastern Europe (CEE) corridor: DE, PL, CZ, SK, AT, HU, HR, RO, BG
  - Southern Corridor: IT, AT, SI, SK, HU, HR, RO, BG, GR
- The actual use of supply considered in 2030 and 2040 simulations is a result of the model taking into account the maximum supply potentials. More detailed explanation can be found in the Annex D3 to the TYNDP 2024[6].
- WI and GCV have only been collected at entry points to the EU transmission network and indigenous production points.
- For each supply source, the probability distributions of GCV and WI are derived from the historical data and they are assumed to be representative for the future developments of that source.
- Gas quality parameters per identified supply source are assumed to follow a normal probability distribution.
- L-gas has not been considered for different reasons:
  - L-gas is expected to continue declining in contribution, and no cross-border flows from the Netherlands to Belgium, France, and Germany are anticipated by 2030.
  - The underlying network model does not make a distinction between L-gas and H-gas production in the Netherlands.
- Biomethane and synthetic methane gas quality is assumed to lie within a common range for all production plants, irrespectively of the country where they are located.
- LNG is grouped as a single gas quality range, under the assumption that the same range of qualities can reach any terminal in Europe. The range used for the simulation is based on measured values from re-gasified LNG in different LNG terminals in the EU.
- Indigenous production data of natural gas have been aggregated per country, contrary to biomethane and synthetic methane.
- Hydrogen flows in blends simulations are considered as high purity (100 %) hydrogen.
- For those countries with natural gas production that are not listed in the input data section, a generic probability distribution has been assumed for their national production based on default values. The NP range is built considering the highest and the lowest values across all indigenous production data.
- A Low natural gas infrastructure level in combination with PCI/PMI hydrogen is considered in the analysis[7].
- Supply and gas quality figures are combined by means of Monte Carlo simulation.

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4 https://www.eugastsogrip.eu/

5 For the North West corridor, the 2020 edition of GRIPs has been considered in this study to keep consistency with previous GQO editions

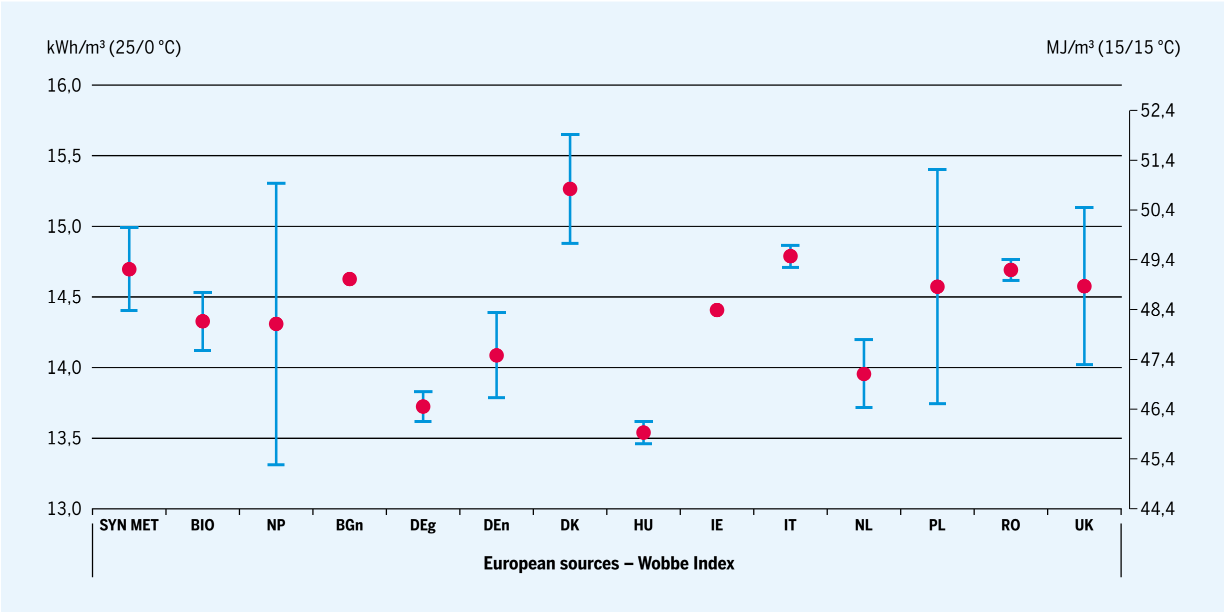
6 See **TYNDP 2024 Hydrogen and Natural Gas System Assessment Methodology (Annex D3)**

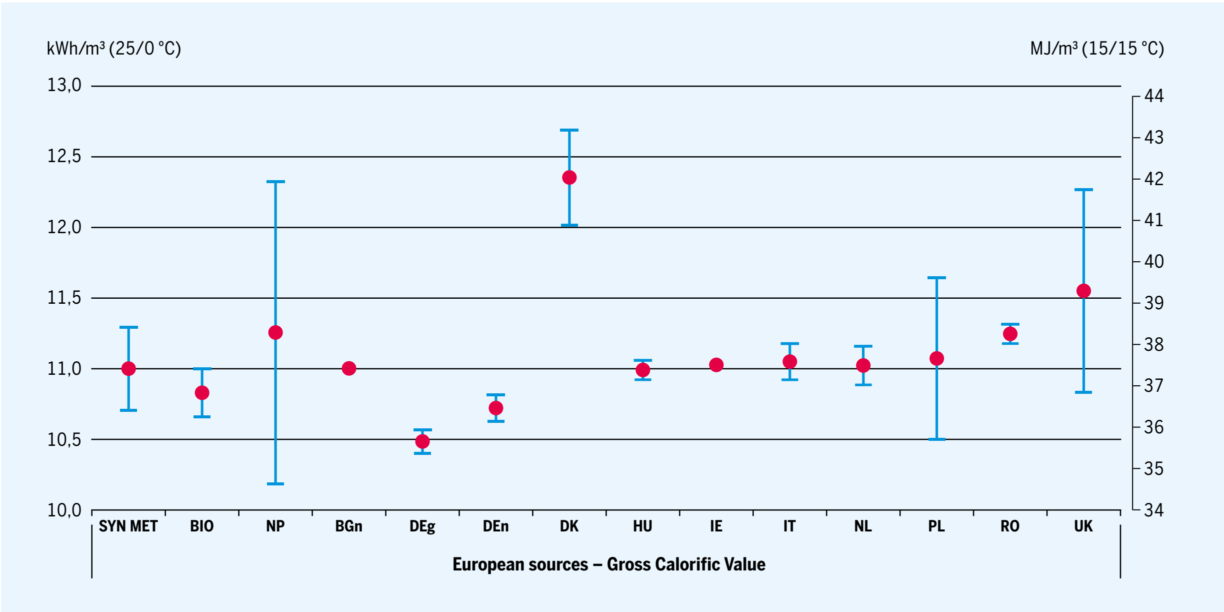
7 More information on infrastructure development levels are available in the **TYNDP 2024 Draft Infrastructure report**

2.1 INPUT DATA

The average WI and GCV values used as input for the simulations are represented in the figures below. The error bars, also shown in the graphs, represent a range within which 95 % of the values fall. The WI and GCV values are expressed in kWh/m³ (25/0 °C) on the left axis while in MJ/m³ (15/15) on the right axis. The figures below illustrate the WI and GCV of the European sources: national production of natural gas, biomethane and synthetic methane.

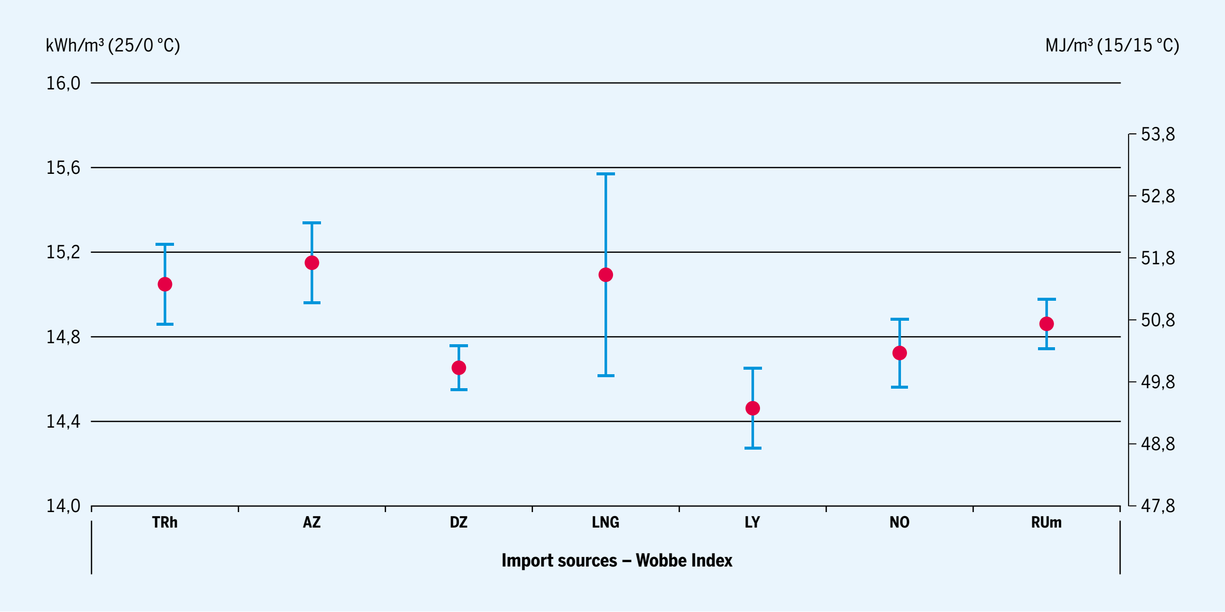
Except for the countries indicated in the graphs below, a default value of WI and GCV is considered for countries with natural gas production, indicated as NP (National Production) in the graphs below.

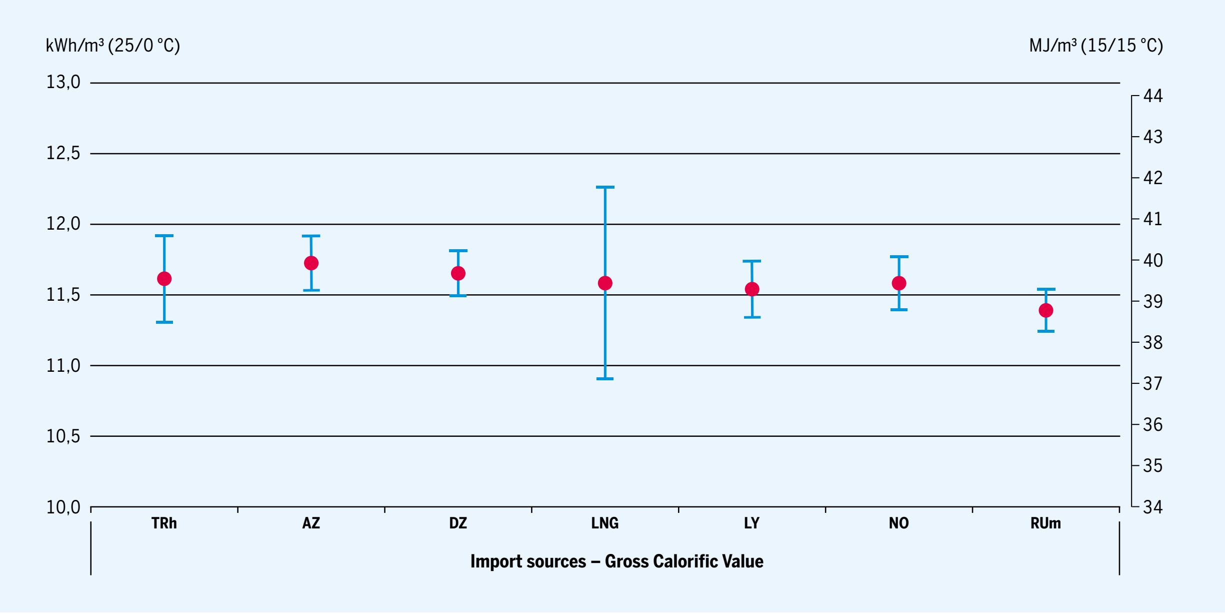




The figures below represent WI and GCV for the import sources considered in the current Gas Quality Outlook.

Russian pipeline supply does not contribute to the overall supply mix considered in this analysis. Nevertheless, the combustion characteristics of Russian gas are presented in the graph for comparative purposes with other supply sources.



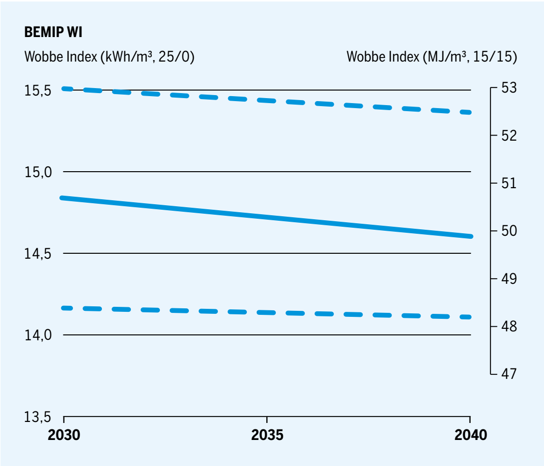


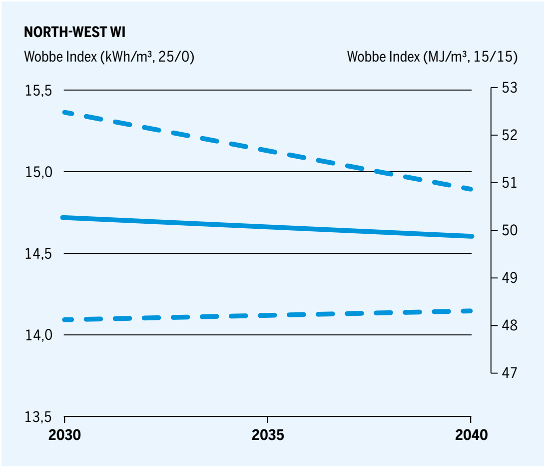
3 RESULTS

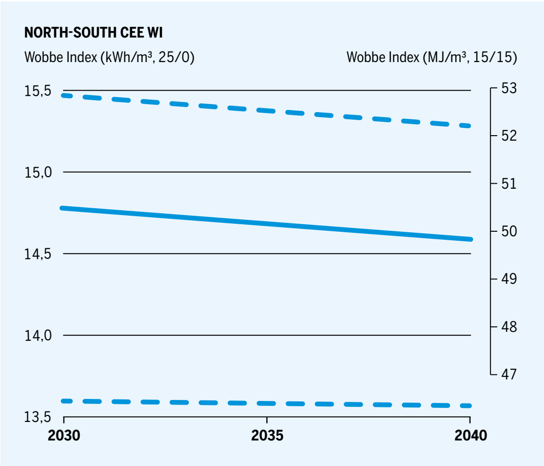
In order to identify trends in WI and GCV, simulations were carried out to identify, for each region, the median (50 percentile) of the resulting probability distribution of WI and GCV in 2030 and 2040.

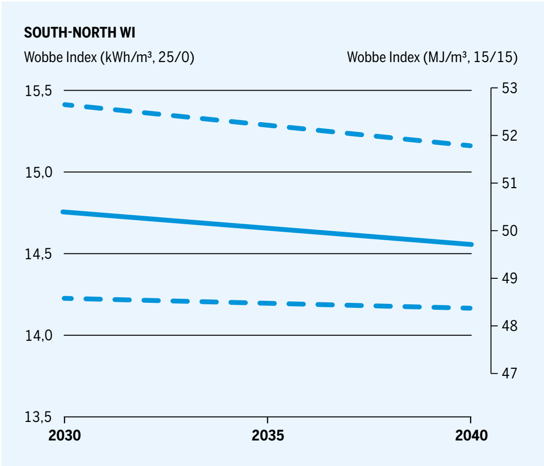
The figures illustrated in the current section show the median of the resulting probability distribution. The variability of gas quality parameters is depicted with dashed lines representing 2.5 and 97.5 percentiles, respectively on the bottom and the top of the figures. Those percentiles indicate the values below which 2,5 % and 97,5 % of the data fall, providing an indication of the range of WI and GCV most likely to be observed.

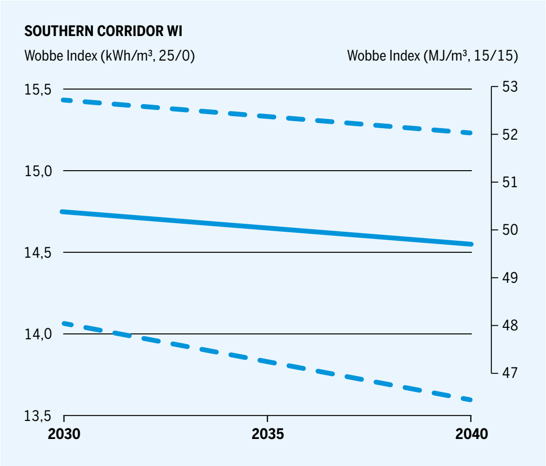
3.1 WOBBE INDEX OVERVIEW

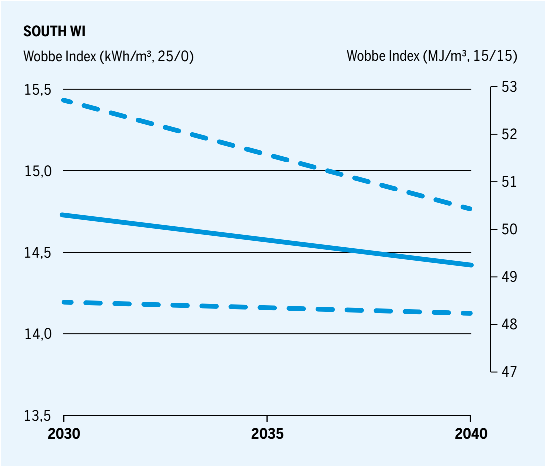












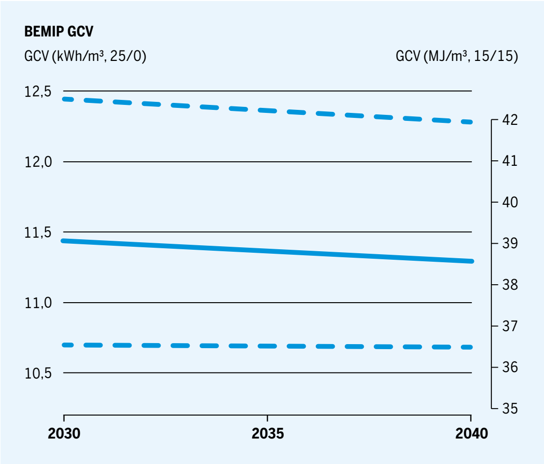
As it's possible to observe in the plots, all the regions present a decrease in both median values and 97.5 percentile of Wobbe Index from 2030 to 2040. This trend from 2030 to 2040 results from the model assumption that prioritizes pipeline gas over LNG, combined with a decrease in gas demand in 2040. Since LNG generally has a higher WI value than most other supply sources, a reduced share of LNG in the 2040 supply mix leads to lower overall WI values.

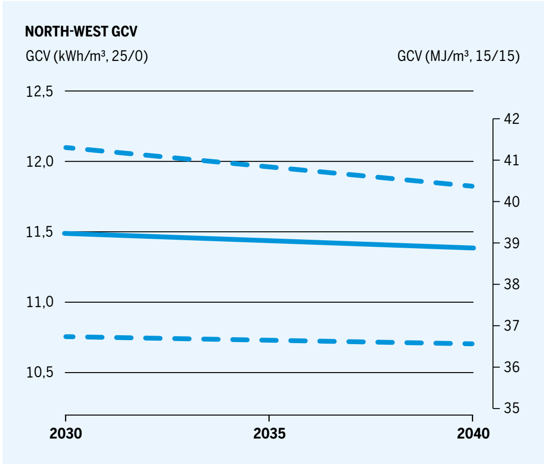
The decrease in WI is more pronounced in regions with a high share of biomethane, like the South region.

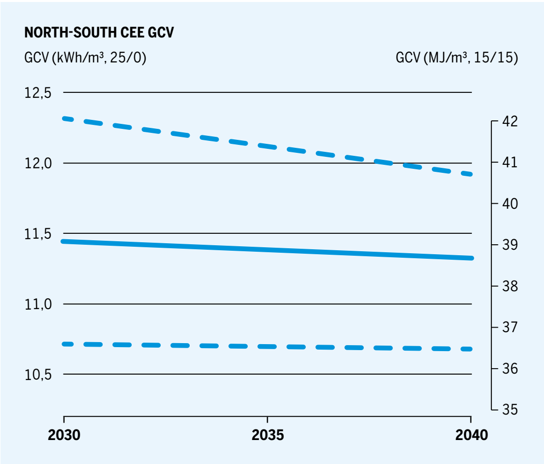
Looking at the percentiles, the more pronounced variations in the 2.5th and 97.5th percentiles (dashed lines in the graphs above) from 2030 to 2040 are observed in regions where most of the supply sources in the 2040 mix have a narrow variability range (blue bars in the Input data plots), such as biomethane, Norwegian gas and Algerian gas.

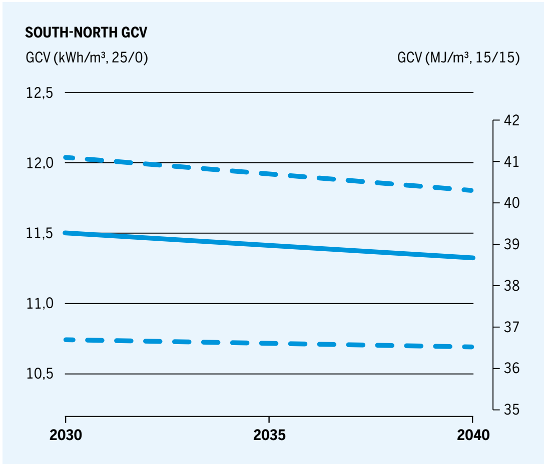
These sources are typical of regions like South, North-West and South-North, where a decrease in 97,5 percentile and/or increase of 2.5 percentile is observed. A large decrease of the 2.5th percentile (dashed line on the bottom of the plots) occurs in the Southern Corridor, where low values of 2.5 percentile can be attributed to the natural gas production in Hungary, whose share in the region increases from 2030 to 2040. For this reason, the WI range in the Southern corridor expands from 2030 to 2040, in contrast to the other regions.

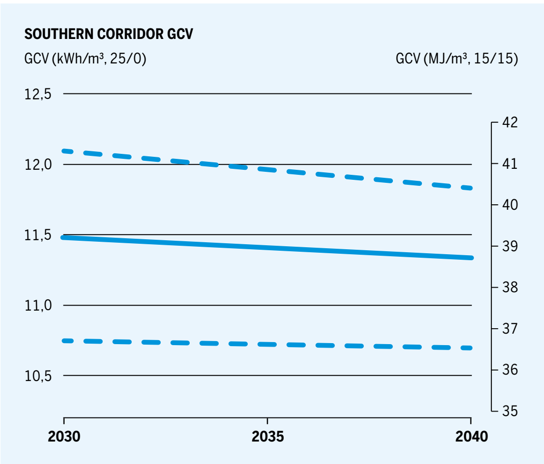
3.2 GCV OVERVIEW

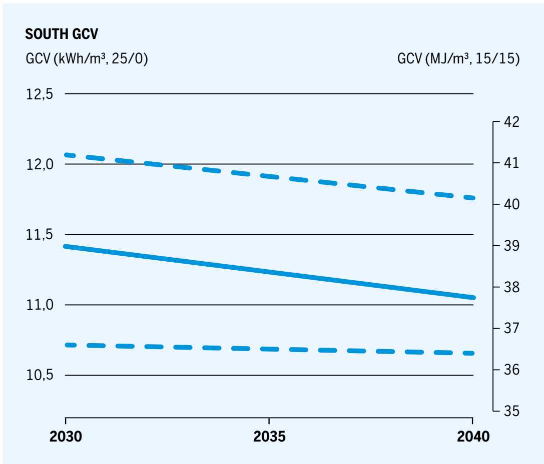












As for WI, also GCV median and 97.5 percentile decrease in all the regions while the 2.5th percentile remains quite stable. The decrease in median GCV is highly pronounced in the South region due to the high share of biomethane.

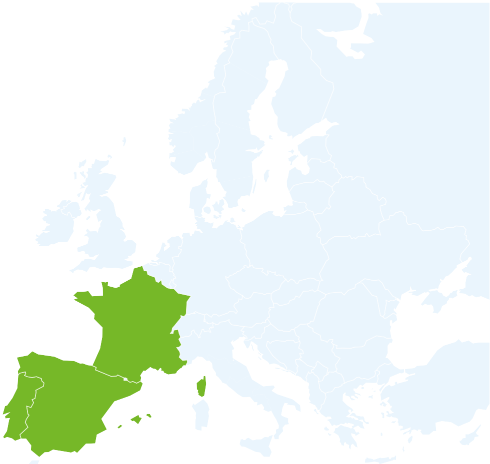
The decrease in 97.5th percentile combined with a stable 2.5th percentile from 2030 to 2040 results in a narrowing of the GCV range for all the considered regions.

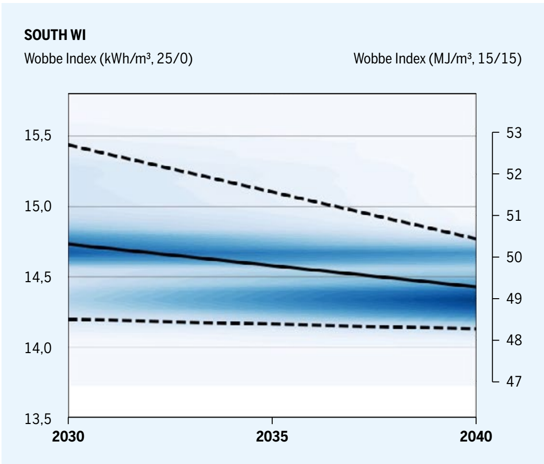
3.3 PROBABILITY DISTRUBUTION OF WOBBE INDEX AND GROSS CALORIFIC VALUE IN 2030 AND 2040

In the sections below, the trends of WI and GCV are presented with a surface plot illustrating the probability distribution of different gas qualities over time. The darker the area, the higher the probability. These plots highlight that the probability distribution of the output does not follow a normal distribution even if all input sources are assumed to do so.

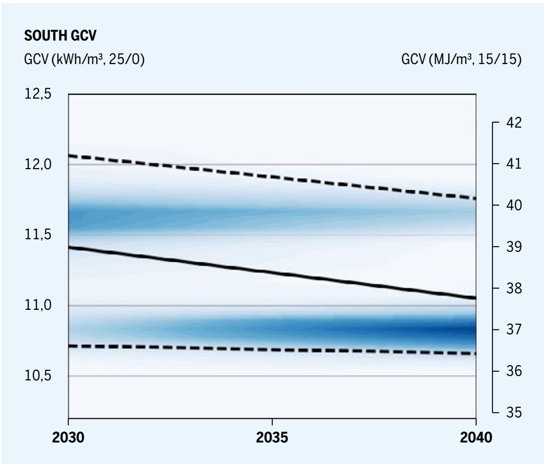
For a given region and time horizon, the range of gas quality can be described between the two extreme percentiles. The width and intensity (probability) of each band comes as a result of the gas quality parameters of the supply sources and their relative contribution to satisfy the forecasted gas demand. In other words, the probability distributions are projected to vary depending on the correlation of forces between supply corridors.

3.3.1 SOUTH REGION: ES, FR, PT





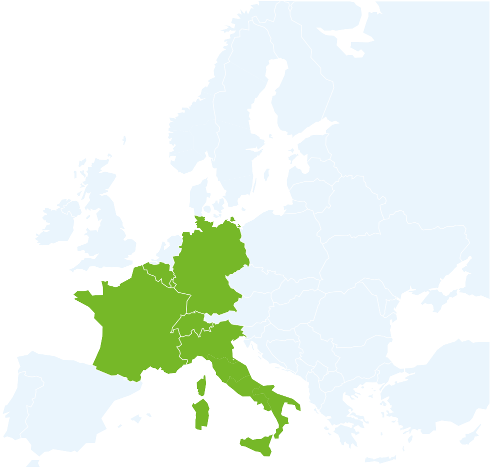
In this region, both WI and GCV ranges tighten from 2030 to 2040. This trend can be attributed to the reduction in LNG share in 2040 (due to prioritization of pipeline gas and decreased demand in 2040), coupled with a significant increase in biomethane.

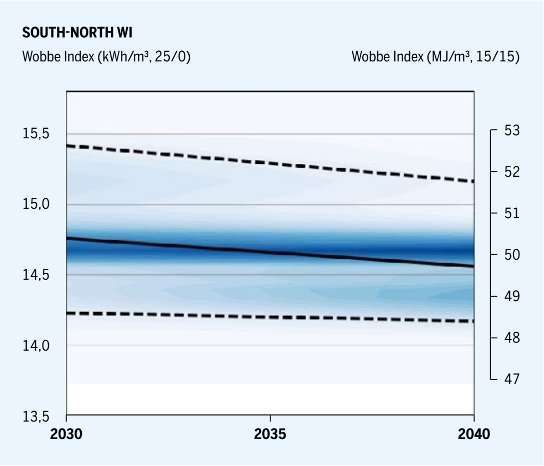


Concerning the WI and GCV probability distributions, it is possible to observe two clusters of Gas Quality (blue areas in the Figures):

- One area around WI values of 14,7 kWh/m³ and GCV of 11.6 kWh/m³, which can be attributed to Norwegian and Algerian gas, whose share is high in 2030 but decreases in 2040.
- Another area centred around WI of 14,3 kWh/m³ and GCV of 10,8 kWh/m³ corresponding to biomethane which represents a significant share of the South region's supply in 2040.

3.3.2 SOUTH-NORTH REGION: BE, CH, DE, FR, LU, IT

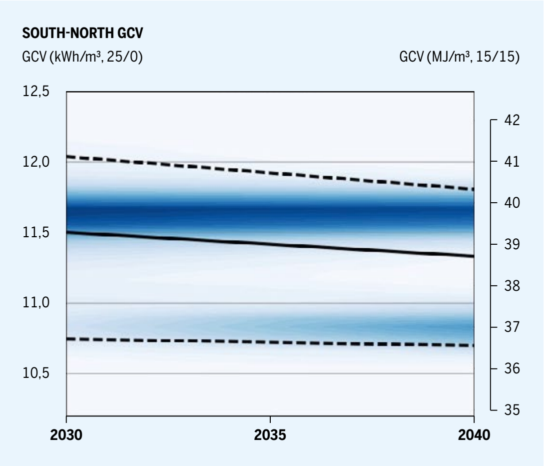




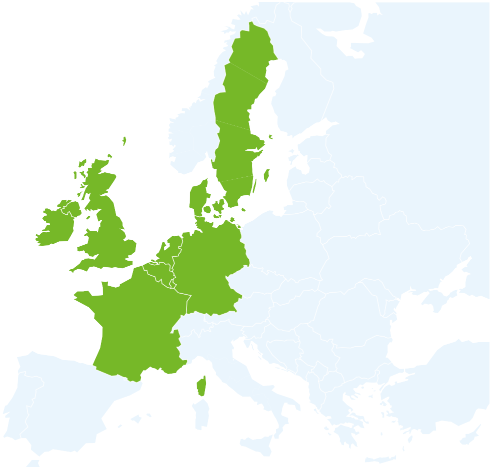
By examining the probability distribution surface plots it is possible to observe that the highest probability density centres around 14,7 kWh/m³ for WI and 11,6 kWh/m³ for GCV, reflecting the consistent share of supplies from Norway and Algeria, which are high in 2030 and remain significant in 2040. Biomethane increase in 2040 can be observed in the lighter blue region appearing in 2040.

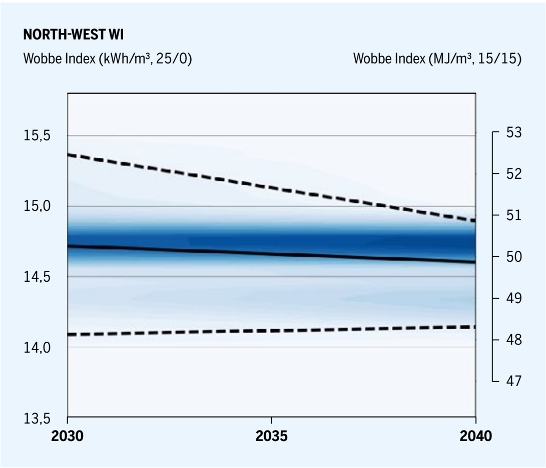
A distinct cluster of WI values exceeding 15 kWh/m³ is observable in 2030 due to the presence of LNG.

This cluster is not visible in the GCV plot due to the similar GCV values of LNG, Norwegian and Algerian gas.

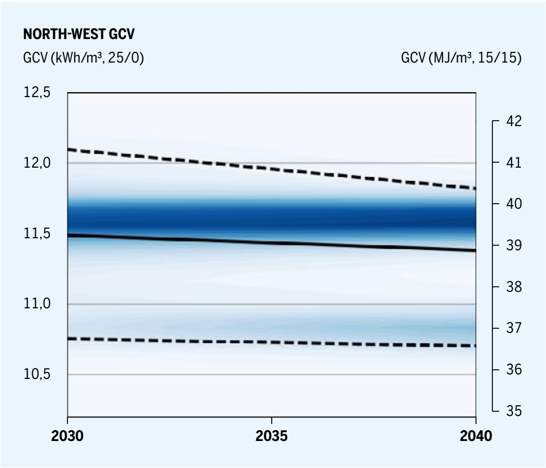


3.3.3 NORTH-WEST REGION: SE, DK, DE, NL, BE, LU, FR, UK, IE

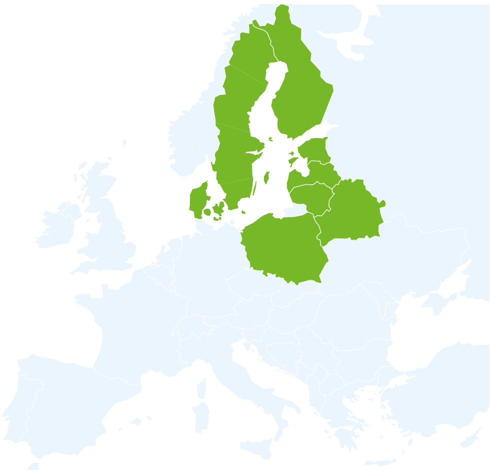


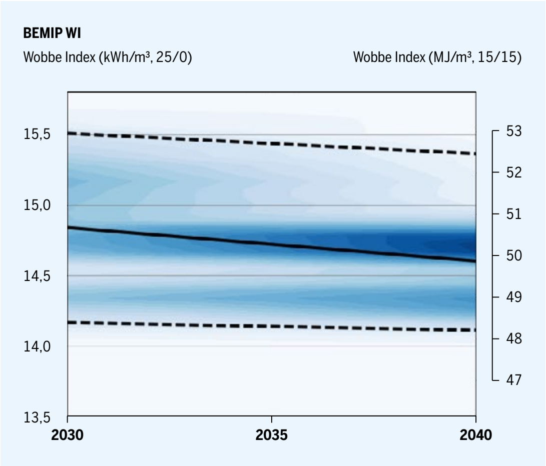


For the North-West region, the median values of WI and GCV slightly decrease from 2030 to 2040. The dark blue area in both GCV and WI plots indicates that the main supply source for North-West region is Norwegian gas. The share of biomethane is higher in 2040 compared to 2030.



3.3.4 BEMIP REGION: DK, SE, FI, PL EE, LT, LV

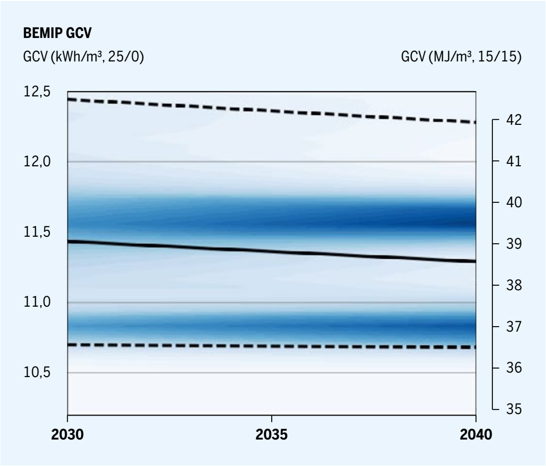




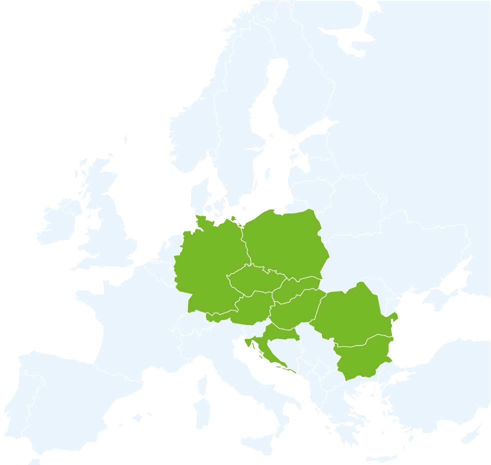
From 2030 to 2040, the WI and GCV median decreases and the WI and GCV ranges become slightly narrower.

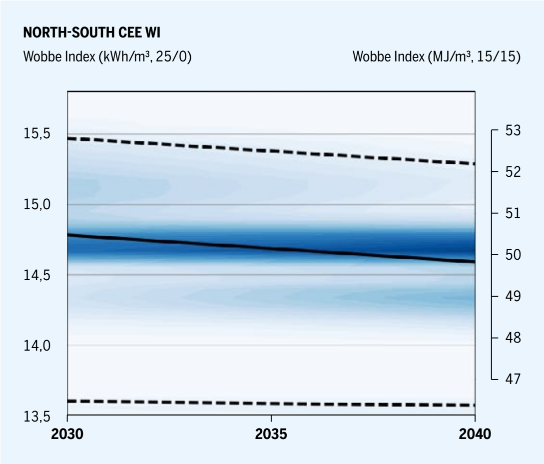
For WI, the presence of a cluster around 15,3 kWh/m³ in 2030 is due to the high share of LNG in the region, coupled to a discrete share of Danish production. This cluster disappears in 2040 where the highest probability density concentrates around WI values of 14,7 kWh/m³ typical of Norwegian gas.

Biomethane, which represents a relatively high share of gas supply already in 2030, increases in 2040 where the blue area becomes darker due to the high renewable production in Poland and Denmark.



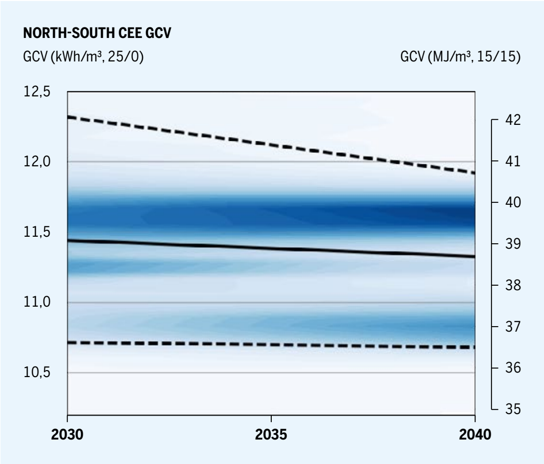
3.3.5 CEE: DE, PL, CZ, SK, AT, HU, HR, RO, BG



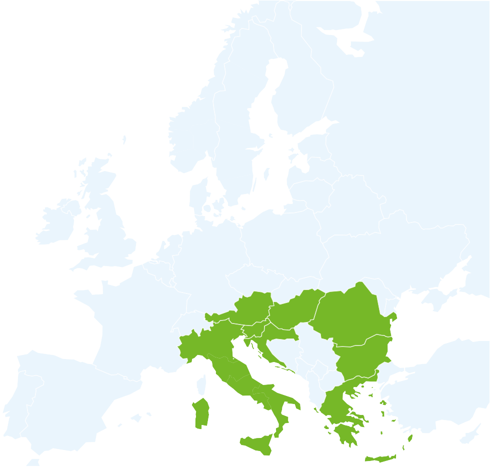


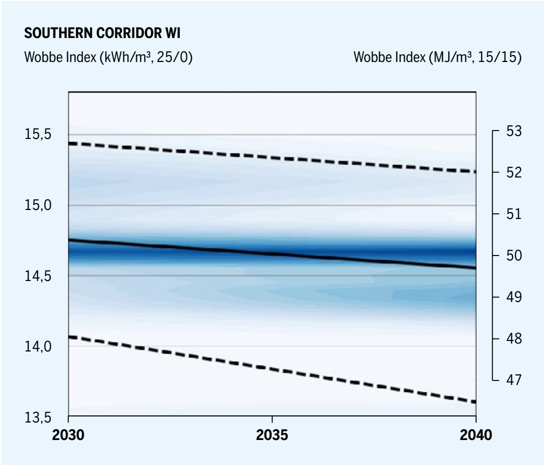
The trend of WI and GCV in this region is very similar to the one observed in the BEMIP region, in the previous section. Indeed, this region is characterized by an increase in Norwegian gas over LNG from 2030 to 2040.

Romanian production also contributes to the main WI cluster. Its impact is more evident in the GCV plot, corresponding to the blue cluster around GCV values of 11,2 kWh/m³.



3.3.6 SOUTHERN CORRIDOR: IT, AT, SI, SK, HU, HR, RO, BG, GR



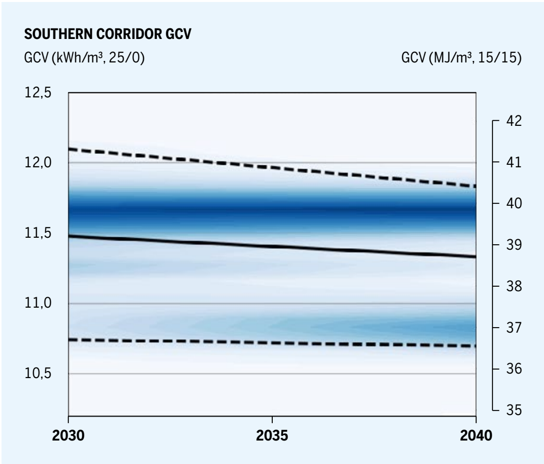


Simulations show that the WI range expands from 2030 to 2040, while the GCV range narrows over the same period. This can be attributed to the presence of Hungarian gas in this region, characterized by an average WI of 13,5 kW/m³ (lower than the average WI of biomethane) and an average GCV of 11,0 kW/m³ (higher than biomethane).

Also in this region, a pocket of high-WI gas can be observed in 2030, linked to LNG imports.

The highest probability density of WI and GCV in the Southern corridor indicates a supply of gases from different sources, particularly Algeria and Libya.

In the GCV plot, a cluster appears around GCV of 11,2 kWh/m³ which represents natural gas production from Romania.



3.4 HYDROGEN SHOWCASE: INFLUENCE OF H_2 BLENDS ON WI AND GCV

In this report, the influence of hydrogen injected into the gas grids is considered, and the impact on WI and GCV in the upcoming years is analysed.

When H_2 is blended with natural gas, WI and GCV of the blend decrease compared to natural gas alone. To evaluate the impact of H_2 on WI and GCV, the same approach as the previous GQO has been used in this study.

The ratio of the combustion parameters, WI and GCV, with H_2 is presented in the graphs below, respectively on the left and on the right. For both the parameters, the influence of hydrogen is approximately linear for concentrations up to 30 % hydrogen in volume. This assumption is made for all the calculations in this outlook, as a hydrogen concentration up to 2 % in volume is considered.

The H_2 concentration considered in this study is limited to 2 % vol. in order to reflect the recent developments in CEN (revised EN16726) and the recent Regulation (EU) 2024/1789. The results shown are built on the TYNDP 2024 National Trends scenario for 2030 and 2040.

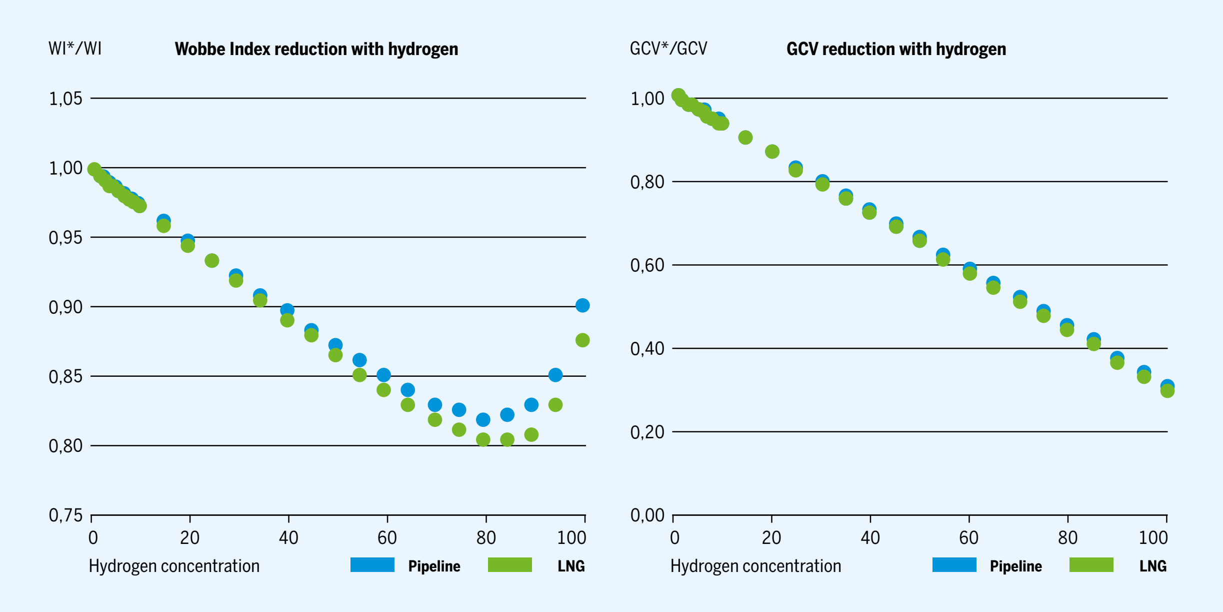
Several cases were analysed and two of those are presented in this report to analyse the impact of two different situations:

A) each supply source consists of 10 % gas blended with hydrogen (at 2 % H_2 concentration) and 90 % unblended.

B) each supply source consists of 50 % of gas blended with hydrogen (at 2 % H_2 concentration) and 50 % unblended gas.

In addition, the hydrogen showcase is built on average yearly data and therefore does not reflects the possible fluctuation in hydrogen injection at operational time scales.

In general terms, both the WI and GCV ranges exhibit trends akin to those observed in the non-blended case. As expected, in case of blends, the median values of both WI and GCV experience a downward shift compared to the non-blended case shown in section 3.5. The influence of H_2 on GCV is notably more pronounced than on WI. In 2040, clusters of lower values of WI and GCV appear due to the high biomethane share in conjunction with H_2 blends.

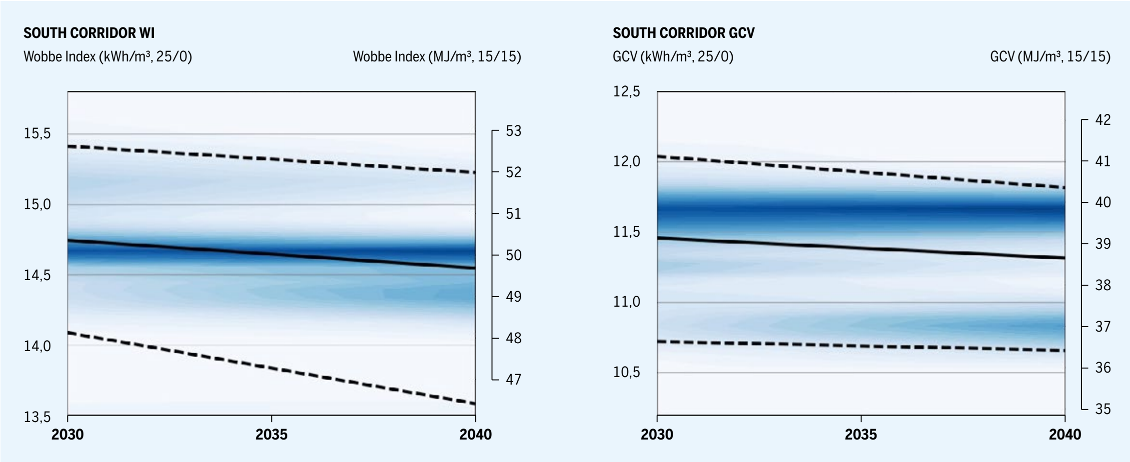


3.4.1 INFLUENCE OF 2 % VOL. HYDROGEN ON WI AND GCV – CASE A (10 % OF SUPPLY SOURCES CONTAIN 2 % H_2)

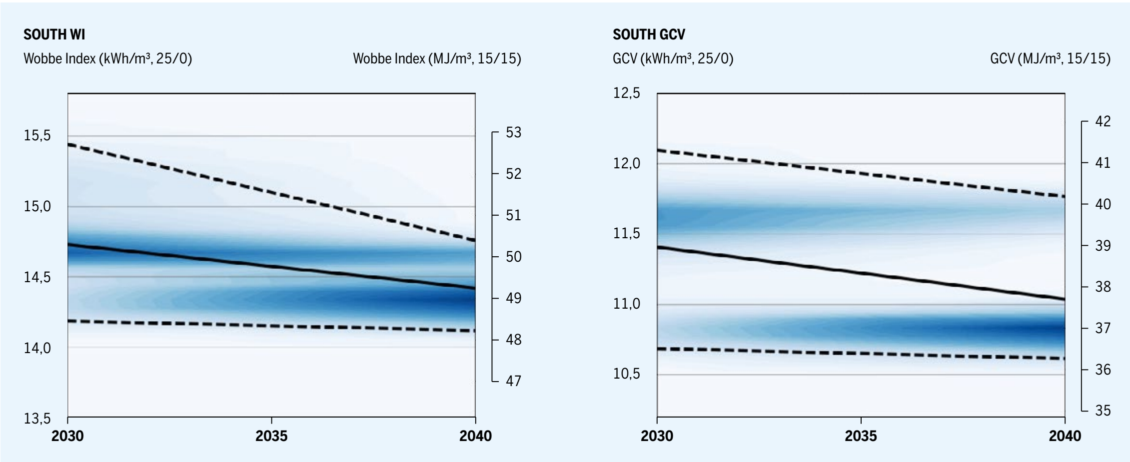
This section presents the influence of hydrogen, at a concentration of 2 % vol., on WI and GCV ranges for all regions. The model assumes that only 10 % of each supply source is blended with H_2.

Given the negligible impact of 2 % H_2 on combustion parameters, the results of the Case A analysis are very similar to those obtained without blending, shown in Section 3.3.

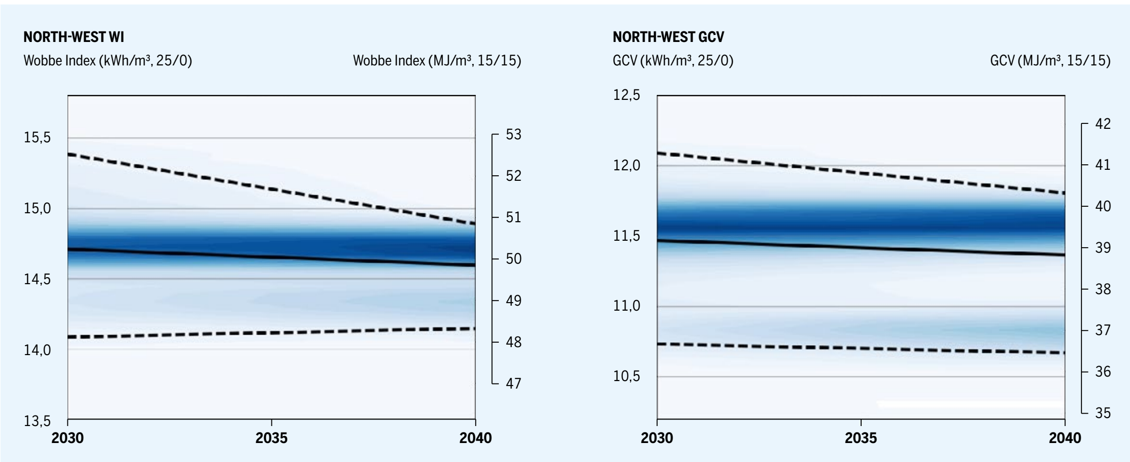
2 % blend with 10 % mix for SOUTHERN CORRIDOR: IT, AT, SI, SK, HU, HR, RO, BG, GR



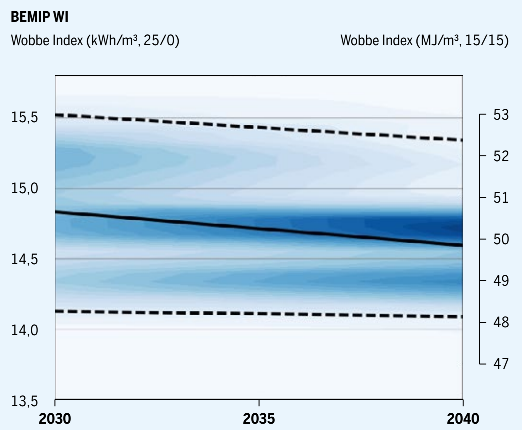
2 % blend with 10 % mix for SOUTH REGION: ES, FR, PT

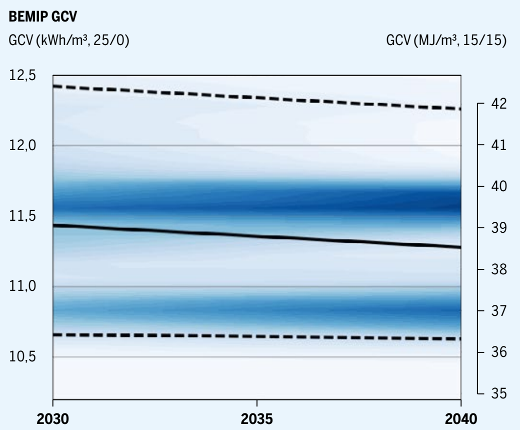


2 % blend with 10 % mix for NORTH-WEST REGION: SE, DK, DE, NL, BE, LU, FR, UK, IE

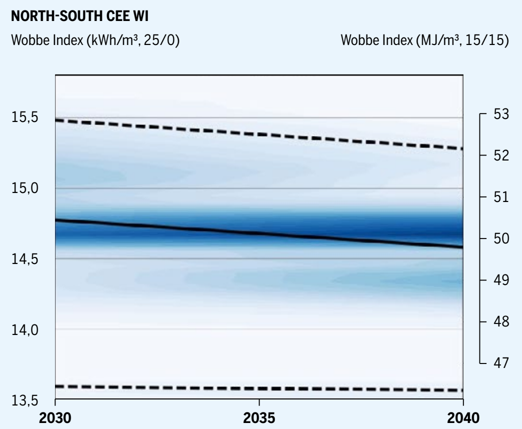


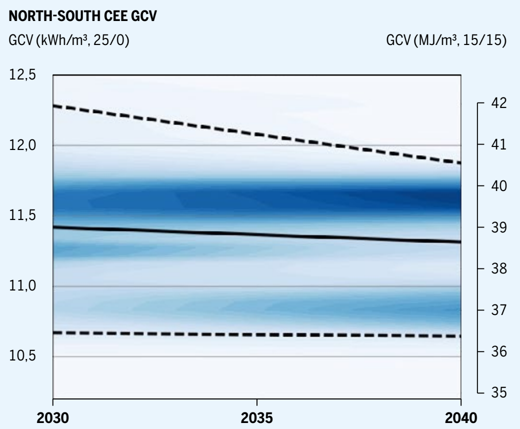
2 % blend with 10 % mix for BEMIP REGION: DK, SE, FI, PL EE, LT, LV



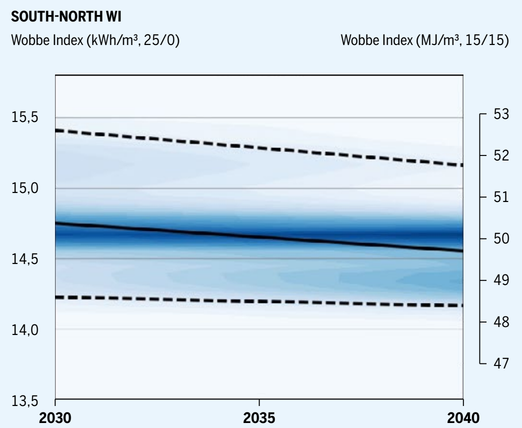


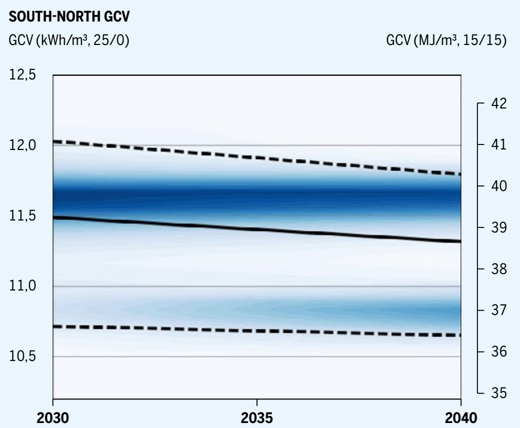
2 % blend with 10 % mix for CEE: DE, PL, CZ, SK, AT, HU, HR, RO, BG





2 % blend with 10 % mix for SOUTH-NORTH REGION: BE, CH, DE, FR, LU, IT



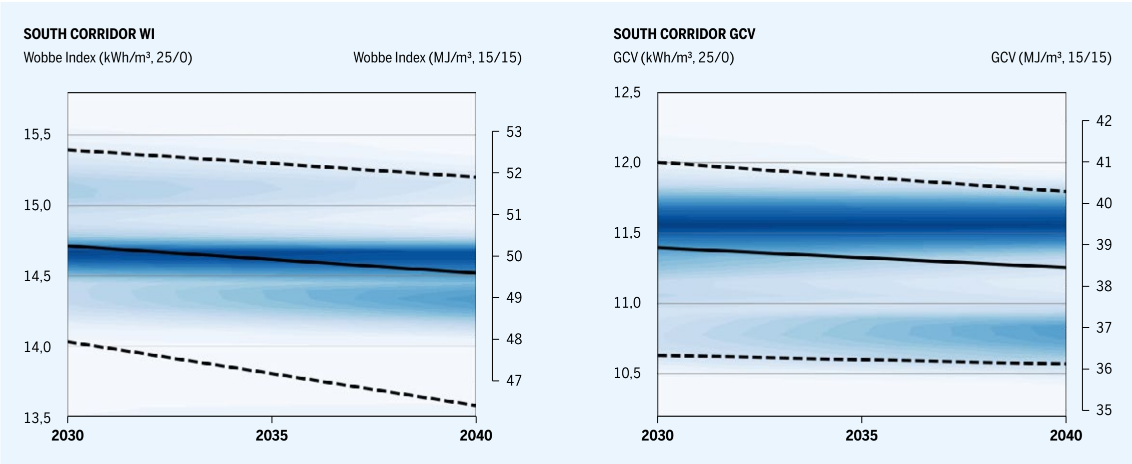


3.4.2 INFLUENCE OF 2 % VOL. HYDROGEN ON WI AND GCV – CASE B (50 % OF SUPPLY SOURCES CONTAIN 2 % H_2)

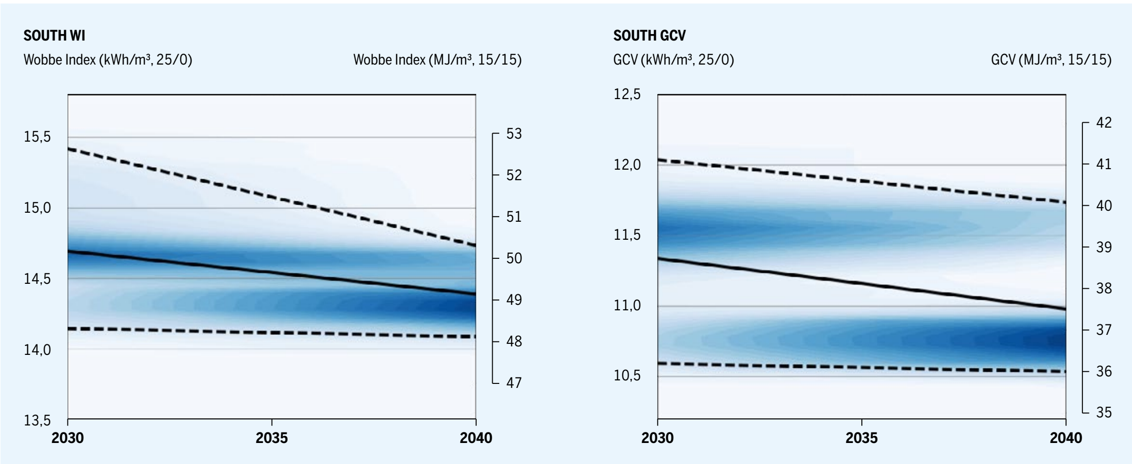
When half of the supply sources contain H_2 blends, with the same concentration of 2 %, the effect of H_2 becomes more noticeable compared to case A.

All plots below show the same overall trend as the case without blends (Section 3.3), however the curves are slightly shifted toward lower WI and GCV values.

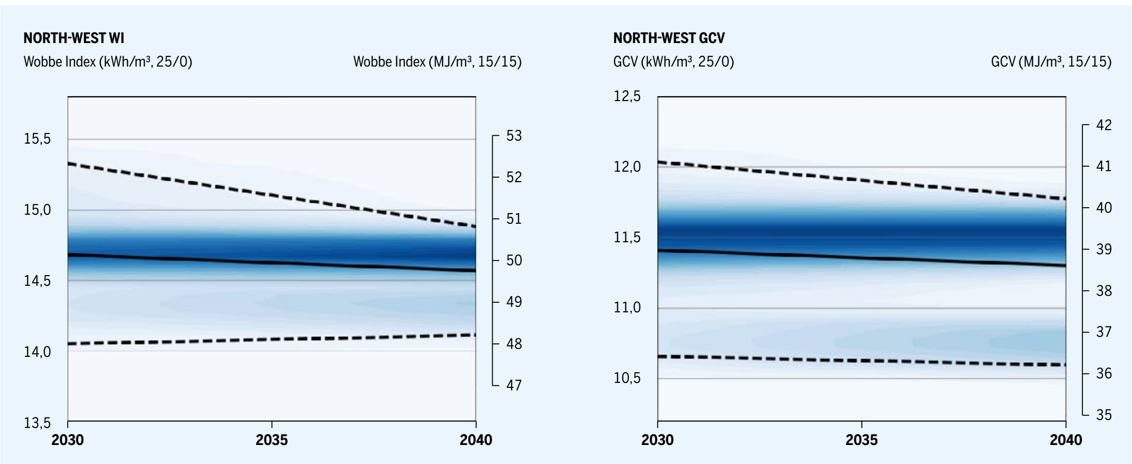
2 % blend with 50 % mix for SOUTHERN CORRIDOR: IT, AT, SI, SK, HU, HR, RO, BG, GR



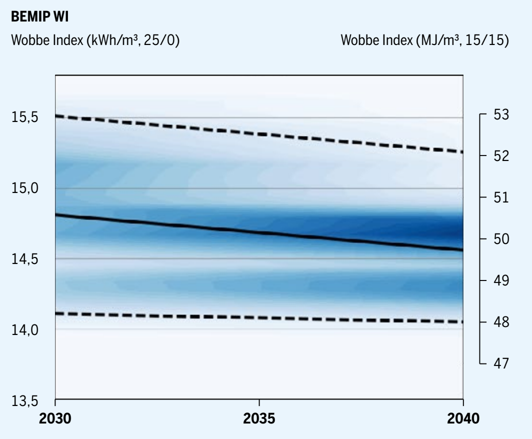
2 % blend with 50 % mix for SOUTH REGION: ES, FR, PT

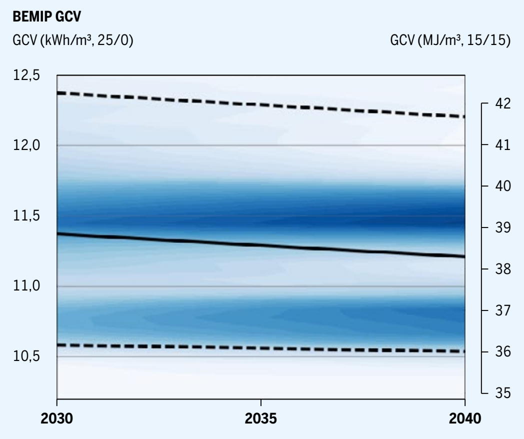


2 % blend with 50 % mix for NORTH-WEST REGION: SE, DK, DE, NL, BE, LU, FR, UK, IE

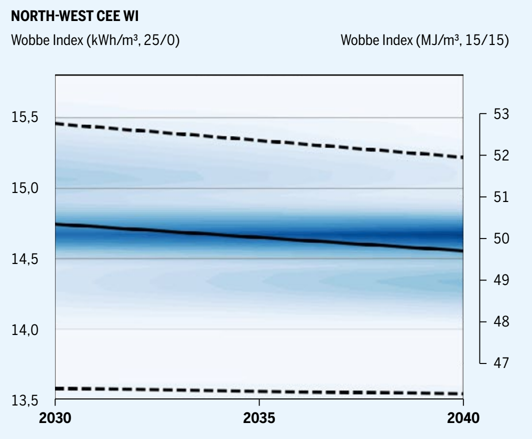


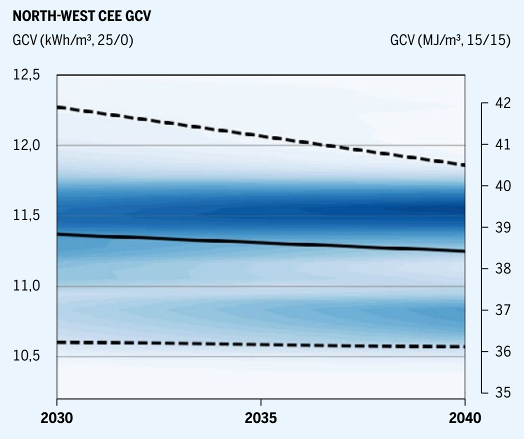
2 % blend with 50 % mix for BEMIP REGION: DK, SE, FI, PL EE, LT, LV



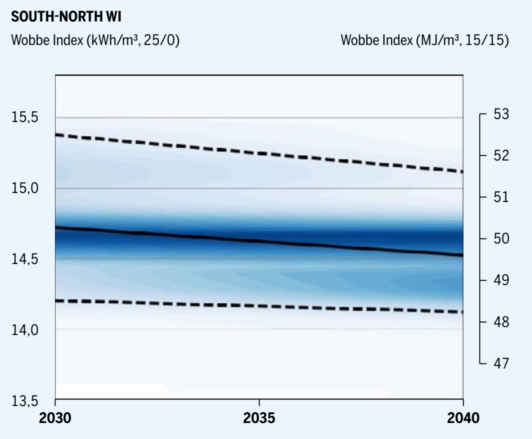


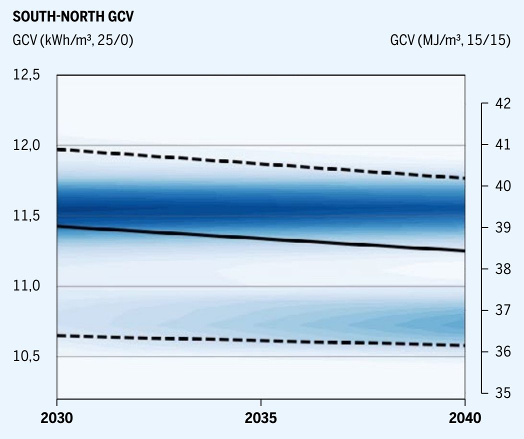
2 % blend with 50 % mix for CEE: DE, PL, CZ, SK, AT, HU, HR, RO, BG





2 % blend with 50 % mix for SOUTH-NORTH REGION: BE, CH, DE, FR, LU, IT






Picture courtesy of terranets bw)

4 CONCLUSIONS

The long-term gas quality monitoring outlook (GQO) presented in this report comes under the request of INT NC Article 18 for transmission systems to identify the potential trends and variability of gas quality parameters within the next 10 years.

The study is based on the TYNDP 2024 models and assumptions. The parameters investigated in the GQO 2024 are the gross calorific value (GCV) and the Wobbe Index (WI). The input data considered for this study were provided by ENTSOG members.

The results of the study should be interpreted in light of the TYNDP 2024 model assumption that prioritizes pipeline gas over LNG, combined with the decrease in demand in 2040. The analysis shows that almost all regions are likely to experience a narrowing range of GCV and WI from 2030 to 2040, due to the increased share of gas from pipelines and biomethane production.

Additionally, the influence of hydrogen blends at a concentration of 2 % vol. on GCV and WI was assessed. Two cases were considered:

- A: 10 % of the gas in the region is blended with 2 % H_2
- B: 50 % of the gas in the region is blended with 2 % H_2.

The results show that small-scale hydrogen blending (case A) has negligible impact on WI and GCV ranges. Higher hydrogen blends in case B lead to a slight decrease in WI and GCV, though trends remain consistent with the case without blending.

LIST OF **ABBREVIATIONS**

ENTSOG	European Network of Transmission System Operators for Gas
EU	European Union
GCV	Gross Calorific Value
GRIP	Gas Regional Investment Plan
GQO	Gas Quality Outlook
H_2	Hydrogen
H-gas	High calorific gas
INT NC	Interoperability and Data Exchange Network Code
L-gas	Low calorific gas
LNG	Liquefied Natural Gas
MWh	Megawatt hour
NECP	National Energy and Climate Plan
NeMo	Network Modelling
NP	National Production
PCI	Project of Common Interest
P2G	Power-to-Gas
REG-703	REGULATION (EU) 2015/703 of 30 April 2015 establishing a network code on interoperability and data exchange rules
SoS	Security of Supply
SYN MET	Synthetic methane
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
Vol.	Volume
WI	Wobbe Index

COUNTRY CODES (ISO)

AL	Albania
AT	Austria
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
BY	Belarus
CH	Switzerland
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
DZ	Algeria
EE	Estonia
ES	Spain
FI	Finland
FR	France
GR	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxembourg
LV	Latvia
LY	Libya
MA	Morocco
ME	Montenegro
MK	Macedonia
MT	Malta
NL	The Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
RU	Russia
SE	Sweden
SI	Slovenia
SK	Slovakia
TM	Turkmenistan
TN	Tunisia
TR	Turkey
UA	Ukraine
UK	United Kingdom

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