european network
of transmission system operators
for gas

Winter Review 2016/2017

ENTSOG – A FAIR PARTNER TO ALL!

Contents

Executive Summary

ENTSOG has completed the review of the status of the European gas supply and demand for Winter 2016/2017 (October to March). The Seasonal Reviews aim to provide a deeper understanding of the development of the demand and supply in the previous seasons and the identification of trends that cannot be captured at national or regional level. They also help to build experience and a solid background for the assumptions considered in the Winter Outlook. Such knowledge is also factored in the recurrent TYNDP process in order to ensure consistent and continuous improvement of ENTSOG reports, and will be factored in the ongoing R&D plan. The main findings of this report are:

- **The gas sector managed to cope with last winter extreme cold spell in Europe showing robustness and flexibility and provided the power system with a secure energy source. This report provides some insight, in particular, into the extreme cold event in January 2017 in Europe, complemented by country level insight for: Bulgaria, Romania, Greece, Italy, France, Spain and Belgium.**
- **Seasonal gas demand in Europe was 12.3% higher (+359 TWh) than the previous winter mainly due to the cold spell. Also, peak day consumption reached 25,521 GWh/d, increasing by 5% (+1,195 GWh/d).**
- **The share of gas in the generation of electricity has increased in the last two years from 12% to 20%.**
- **UGS working gas volume utilisation was significantly higher than the one from last winter and the level at the end of season was the lowest of the last six years (26%).**
- **The supplies from Russia, LNG and Algeria were higher than in the previous winter: in particular, Russian imports increased from 32% to 36% (+156 TWh).**
- **National Production was stable compared to Winter 2015/2016.**

Detailed data for the cross-border flows are available on the Transparency Platform[1].

Stakeholders' comments on this seasonal analysis are welcome and would enable ENTSOG to improve its knowledge of seasonal and market dynamics influencing the use of infrastructures. Comments would serve as a basis for the R&D plan and are beneficial to the quality of further reports.

[1] Transparency Platform: https://transparency.entsog.eu/

1. Introduction

This review, as part of the ENTSOG Annual Work Program 2017, is published on a voluntary basis and aims at providing an overview of the demand and supply balance during Winter 2016/2017. The report brings transparency to the internal analysis carried out by ENTSOG for the purpose of developing the seasonal Supply Outlooks and the Union-wide TYNDP, as well as for the ongoing R&D plan.

During Winter 2016/2017, the gas sector contended well with an extreme cold spell. Consequently, a dedicated section of this report analyses the different events which occurred and also provides information about the measures taken and lessons learned.

More generally, the report aims to provide an overview of European trends that could not be captured at national level and to build experience for future reports.

Regarding European dynamics, the report highlights the wide heterogeneity of national demand profiles and supply sources. These differences are linked, among others, to physical rationales such as climate, demand breakdown or producing field flexibility for example.

Overview

The following section highlights specific disruption and market events which occurred during the period between October 2016 and March 2017.

Disruption events

Some occurrences in the European gas market caused fluctuations in the supply and demand balance, the major ones were:

OCTOBER / NOVEMBER

- UK: Injection outage in Rough left the facility with 1.3 Bcm compared with (more than) 3 Bcm in the previous years.
- Norway: supply assets outages in the first half of October and the end of November.

DECEMBER

- UK: Rough outage poses questions for 2017.
- France: outages at the Fos LNG terminal restricted send-out capacity on some days, with a complete halt over 20th-22nd September.

FEBRUARY / MARCH

- Germany: Gas deliveries from Russia via the Opal pipeline fell by around 30%.
- UK: low Rough withdrawals, suffering repeated partial outages.

Market events

Some general gas related topics and information came up or were noticeable. Major ones were:

OCTOBER

- Supply flexibility issues lifted prices in October. Low stock levels in the UK added support.
- French nuclear outages also triggered supply fears and lifted spot gas prices.

NOVEMBER

- Short system on weaker LNG arrivals from Qatar and low storage stock levels in the UK due to the Rough field outage.
- European spot prices showed gains on increased UK imports from the continent.
- Low nuclear availability in France also added a bullish response in European gas markets.

DECEMBER

- Europe pipeline imports hit 263 bcm record in 2016, Russia and North Africa flows posted the higher growths.

JANUARY

- Europe prices were bullish on high demand and the Southern European hubs spiked on lack of LNG. MIBGAS and TRS prices spiked during cold temperatures.
- PSV spot also soared on freezing temperatures.
- Northwest Europe price also set new records in January.

FEBRUARY

- Mild temperatures weigh on European spot prices which came back to normal values.

MARCH

- Europe pipeline imports set a seasonal record this winter increasing 11% over previous winter.
- Pipeline extended its advantage over LNG imports. Russia and North Africa showed the biggest increases.

2. Gas Prices and Quantities at European hubs

The following graphs show the evolution of gas prices in Europe during the Winter 2016/2017:

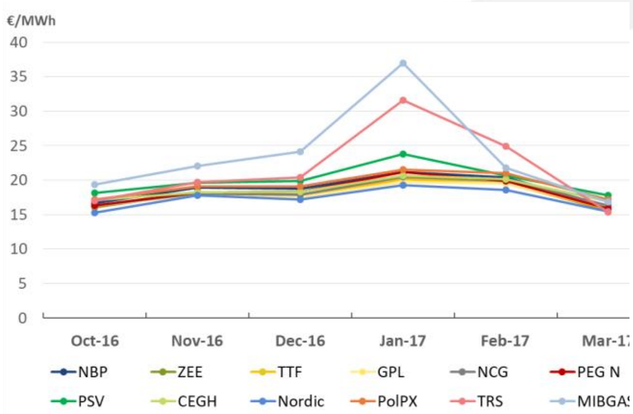

Figure 1 - Day-ahead average prices at European hubs in €/MWh (Source: Bloomberg and MIBGAS).

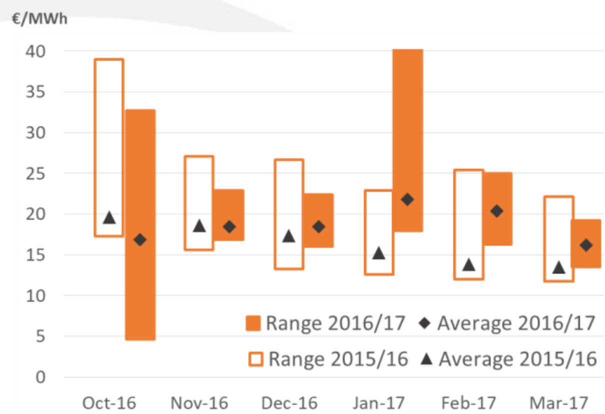

Figure 2 - Ranges and averages of the day-ahead hub prices at European hubs in €/MWh (Source: Bloomberg).

Figure 1 shows the evolution of the day-ahead winter average prices at different European gas hubs and Figure 2 shows the maximum range and average of the day-ahead winter price for the last two winters over all the European hubs.

The average price started the season lower than in the previous winter, between 15 and 25 €/MWh. Nevertheless, the prices in PSV, TRS and MIBGAS reached values close to 40 €/MWh during the cold spell in January 2017. This situation caused a higher maximum price range in winter 2016/2017 than in the previous one. Also, it is important to mention that the ZEE achieved a minimum value of 4.8 €/MWh during October 2016.

As in the previous winter review, price convergence between the different European hubs continued, with the exception of the Italian PSV, the French TRS and Iberian MIBGAS, which were above the other hubs. Meanwhile, all European hubs showed generally a similar trend, meaning that the hubs basically react in the same direction when facing gas-related events.

Figure 3 shows the evolution of the total traded quantities at the different European gas hubs during winter 2016/2017. In terms of trading quantities, the highest level has been reached at the TTF at around 2,400 TWh in March 2017, however NBP has only reached around 1,600 TWh in February and March 2017 (in the last winter NBP reached 2,200 TWh in January 2016).

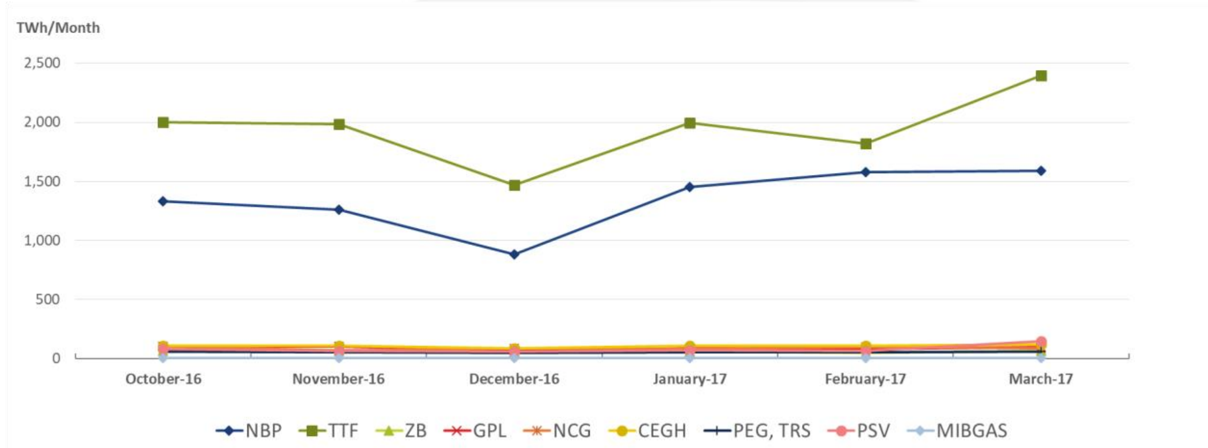

Figure 3 - Total traded quantities at European gas hubs in TWh/month[2] (Source: Platts).

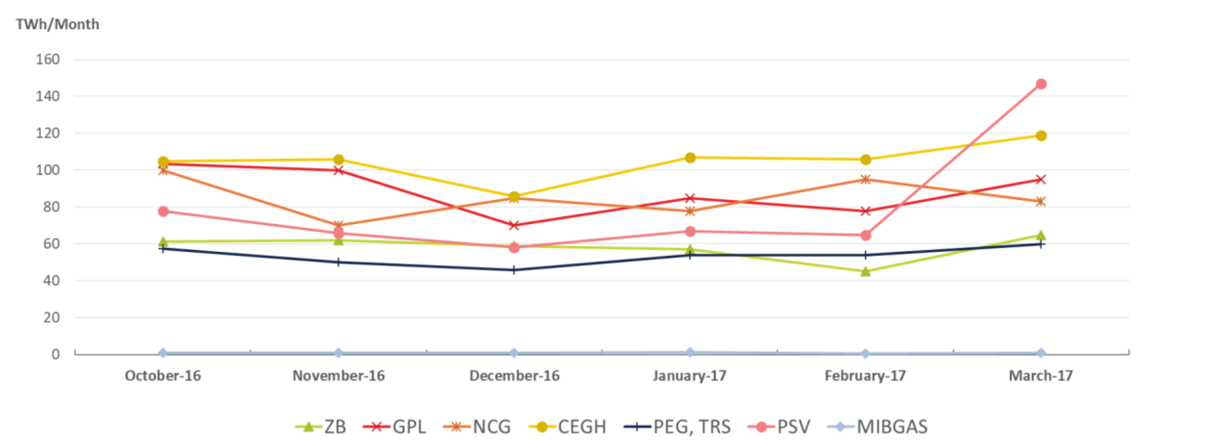

Figure 4 - Zoom on total traded quantities at European gas hubs (except TTF and NBP) in TWh/month (Source: Platts).

Except for those two hubs, maximum traded quantities were still far behind and ranged between 60 TWh for the PEGs and 147 TWh for the PSV hub (except MIBGAS with a maximum value of 1.24 TWh) as is showed in Figure 4. Only NBP and TTF hubs showed a quite big fluctuation in trading quantities throughout all of the winter period.

[2] Total traded quantities means the sum of all energy units (here in the unit of TWh) which have been traded at a hub in the specific month regardless the underlying product.

Figure 5 and Figure 6 show the evolution of the churn rate between the different European gas hubs for the Winter 2016/2017[3]. As seen for the total traded volumes at the hubs, the gap between the NBP and TTF and the rest of the European gas hubs was relatively important implying more trading action at these two hubs in accordance with total traded volumes (Figures 3 and 4).

In the case of German GPL, French PEG, TRS and Italian PSV the values were always lower than 3, similar values to the previous winter. Only NBP and TTF hubs showed high values of liquidity.

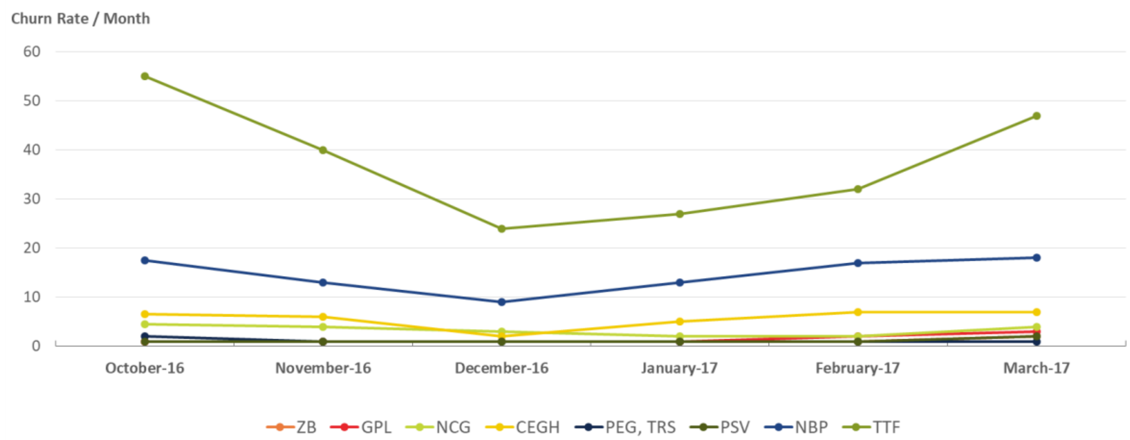

Figure 5 - Evolution of the churn rate per month for the different European gas hubs in the Winter 2016/2017 (Source: Platts)[4].

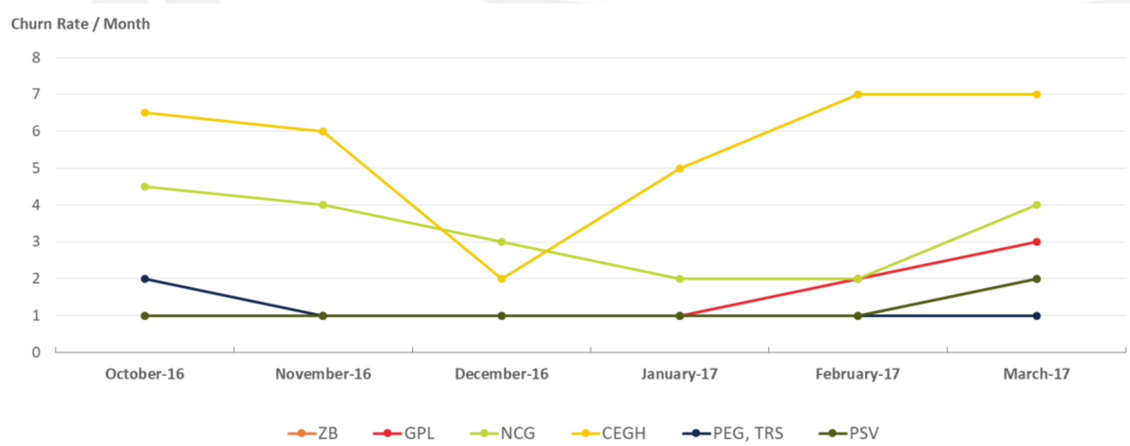

Figure 6 - Zoom on evolution of the churn rate per month for the different European gas hubs (except TTF and NBP) in the Winter 2016/2017 (Source: Platts).

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[3] The churn rate is the ratio between traded volumes and physical gas flows through a gas hub.

[4] The churn rate of MIBGAS is not shown because data are not available.

3. Demand

3.1. European seasonal gas demand

The gas demand in Winter 2016/2017 was higher (3,286 TWh) compared to the previous winter (2,927 TWh). All months (except March), the maximum and minimum values and the average daily demand was higher, especially in November and December. Temperatures for this winter were much lower than in Winter 2015/2016. Figure 7 shows the range and the daily monthly average for total demand in EU and a comparison with the previous winter.

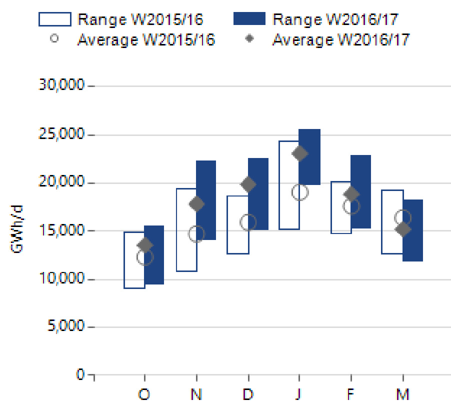


Figure 7 - Total gas demand. Winter 2015/2016 vs Winter 2016/2017.

Figures 8 and 9 show the demand range and monthly average when split into Final Demand (Residential, Commercial and Industrial) or Power Generation sectors, for the countries where the demand breakdown is available. Residential, Commercial and Industrial sector represented 80% out of 2,639 TWh.

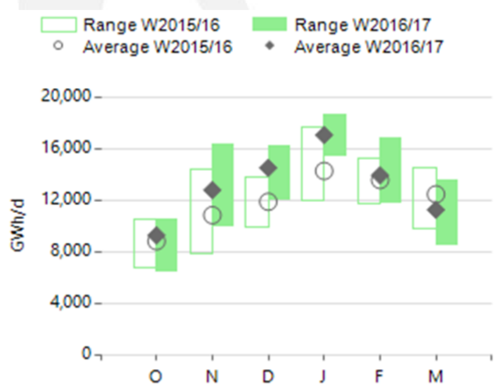


Figure 8 - Final gas demand. Winter 2015/2016 vs Winter 2016/2017. (*)

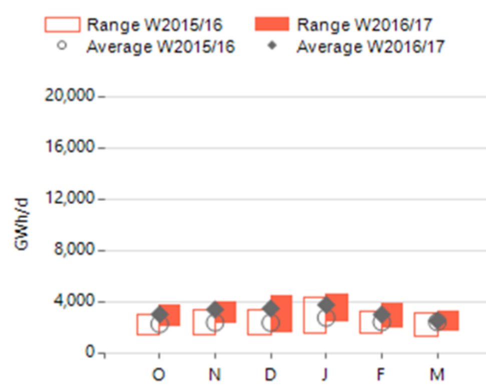


Figure 9 - Power generation gas demand. Winter 2015/2016 vs Winter 2016/2017. (*)

(*) These graphs refer to the countries for which demand breakdown is available (Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, FYROM, Netherlands, Portugal, Sweden, Slovenia, Slovakia and United Kingdom).

3.2. Electricity power generation from gas

In Winter 2016/2017 continued the growth of the generation of electricity from gas. Compared to the previous winter, the power generated with gas in 2016/2017 increased 7.5%. This generation increased for second year in a row, whereas coal and other sources reduced in general terms.

This is despite the increase in gas prices as coal overall remained a more economical option.

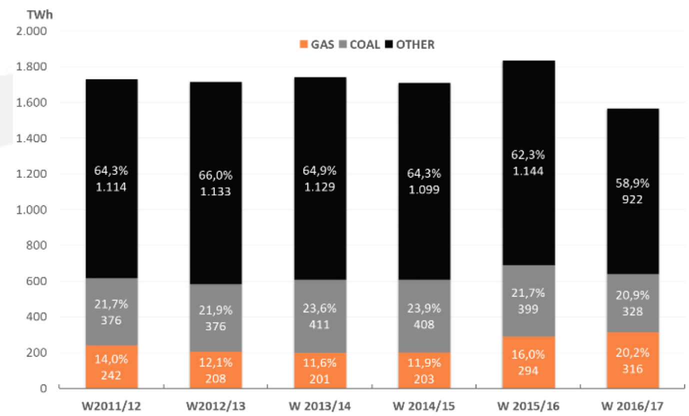


Figure 10 - Gas, coal and other sources in the electricity mix. Winters 2011-17. (Source: own elaboration based on data from ENTSO-E).

Figure 11 shows the evolution of the minimum and maximum month ahead clean spark spread[5] (gas) and clean dark spread[6] (coal) of the previous winters[7]. Until 2014, market conditions for power generation from coal and gas were quite divergent, showing stable high maximums and minimum spreads at around zero for coal. In contrast, since 2014, both maximum and minimum spreads for gas showed an upward trend reaching the spread range of coal. This convergence was almost achieved in Winter 2016/2017 were the range of clean spark spread and clean dark spread are quite similar. Generally, these spreads are driven by the respective input prices for gas and coal, the price of CO_2 allowances and the power prices in the different countries.

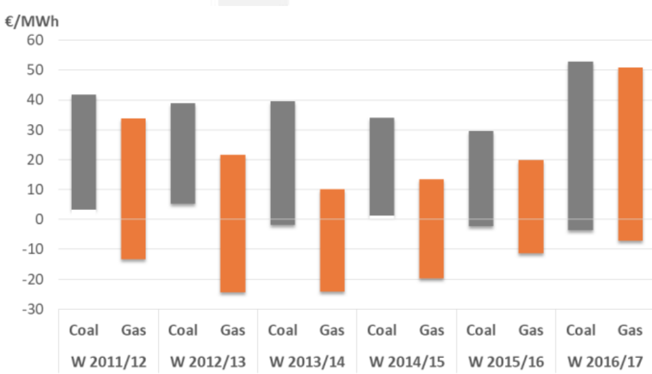


Figure 11 - Range of clean dark vs. clean spark spread over the season in €/MWh. Winters 2001-17. (Source: own elaboration based on data provided by Bloomberg).

[5] The clean spark spread is the difference between the price received by a generator for electricity produced and the cost of the natural gas needed to produce that electricity, including any carbon costs. The formula applied is:

*Clean Spark Spread = Price of Electricity - [(Price of Gas) * (Heat Rate)] – Carbon Price*

[6] The clean dark spread follows the same methodology as the clean spark spread but applies to coal rather than gas.

[7] This graph represents data for the following countries: Germany, United Kingdom, Netherlands, Italy, Spain, France and Czech Republic. Even though there are European countries missing, it could generally give information on the European market conditions for power generation from coal and gas seen in the previous winters. Data retrieved from Bloomberg.

In absolute terms, the electricity produced from gas was 316 TWh_e in Winter 2016/2017, representing 20% of the generation mix with an increment of 4%, whereas the coal presents a reduction of 1% compared with the previous winter. On the other hand, as shown in the graphs below, the share of fossil fuels in the power generation increased to 42%.

Non-fossil fuels do not show large variations from the previous year, only with reductions from Hydro (-2%).

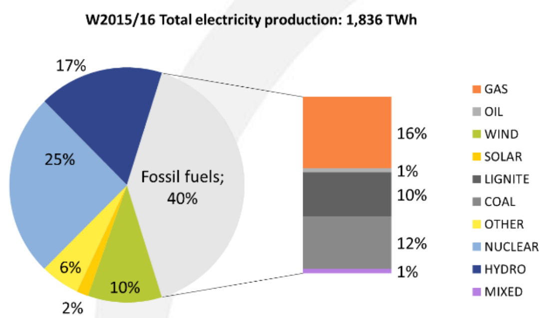


Figure 12 - Electricity generation mix. Winter 2015/2016.

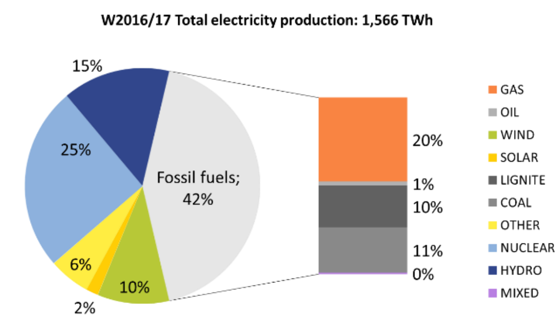


Figure 13 - Electricity generation mix. Winter 2016/2017.

Source: own elaboration based on data from ENTSO-E in 2017.

3.3. Winter demand evolution 2011-2017

The demand for the winter 2016-2017 was higher than in Winter 2015/2016. The growth was a significant 12.3%, meaning it was the third consecutive increase in the total demand and achieved similar values to those seen in winter 2012/2013.

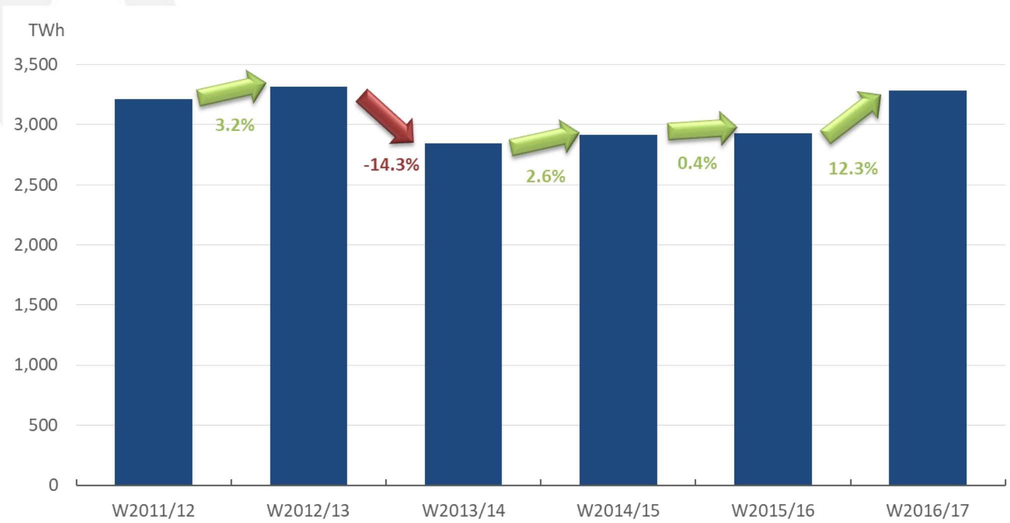


Figure 14 - Total consumption of natural gas. Winters 2011-2017.

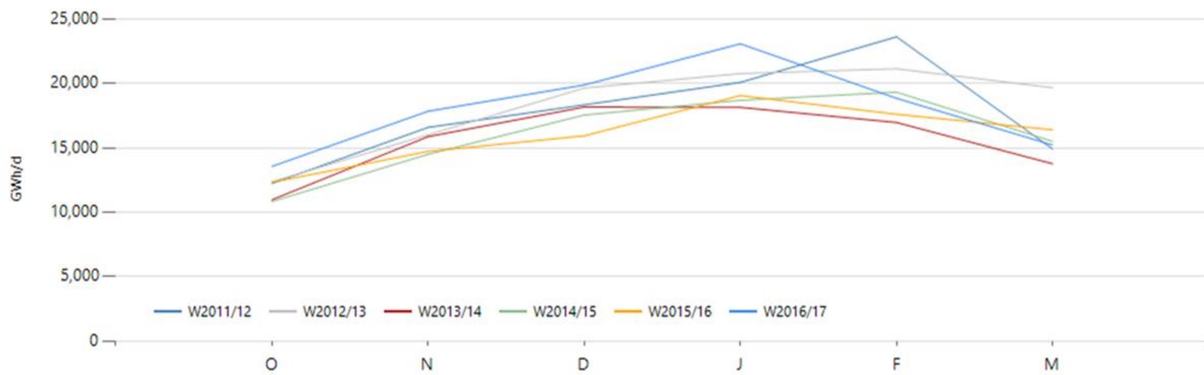


Figure 15 - Daily average of monthly gas demand. Winter 2011/2017.

Figure 15 shows the daily average demand for each month in every winter since 2011. The largest daily average demand occurred in February 2012 (23,624 GWh/d), and this winter achieved a similar value (23,077 GWh/d), due to the cold spell that EU faced during January 2017.

As shown below, by sector - for the countries where the demand breakdown is available - demand for power generation increased for the second time in a row in the last six winters.

Figure 16 - Final gas consumption (residential, commercial and industrial). Winters 2011-2017. (*)

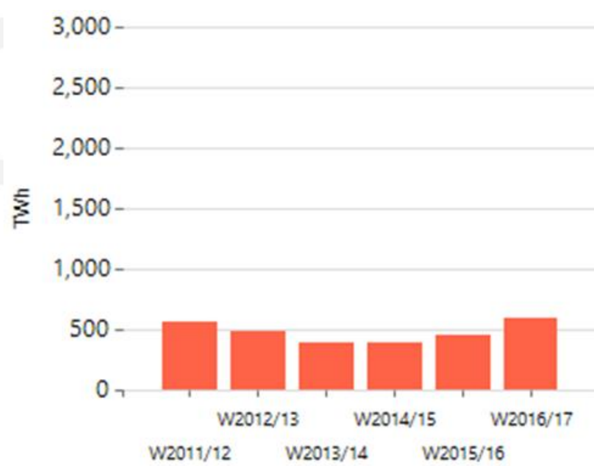


Figure 17 - Gas consumption for power generation. Winters 2011-2017. (*)

** These graphs refer to the countries for which demand breakdown is available (Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, FYROM, Netherlands, Portugal, Sweden, Slovenia, Slovakia and United Kingdom). In years and countries where the data breakdown has not been provided, then demand forms part of Residential, Commercial and Industrial.*

Country detail

As in Winter 2016/2017, all countries except three (Estonia, Finland and Sweden) had significant positive variances, related to the cold spell during January 2017.

It is also interesting to highlight the high increase in demand on FYROM (91.64%), Croatia (43.66%), Greece (34.14%) and Portugal (31.61%). In Greece and in Portugal, these increases happened mainly in January and February, also as a consequence, by cold spell. However, in the case of FYROM and Croatia, the increments continued during the entire winter.

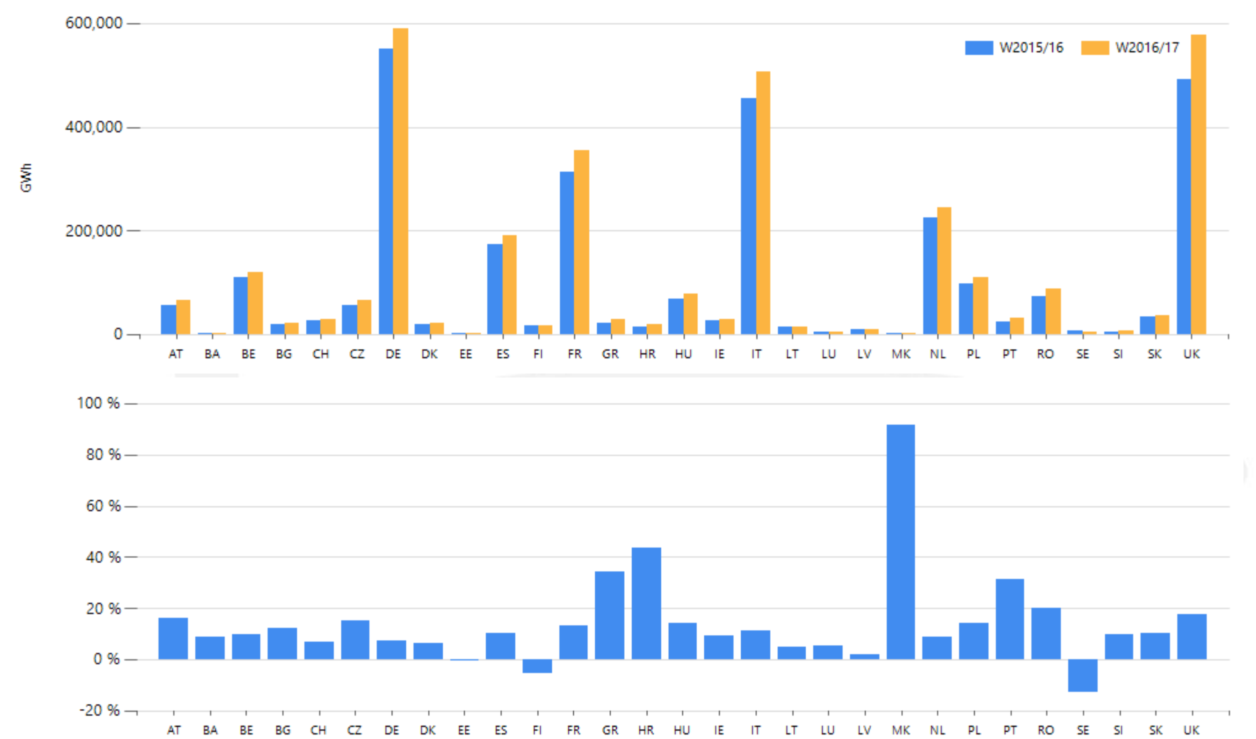


Figure 18 – Total winter demand and variation. Winter 2016/2017 vs. Winter 2015/2016. Country detail.

3.4. Peak demand 2016/2017

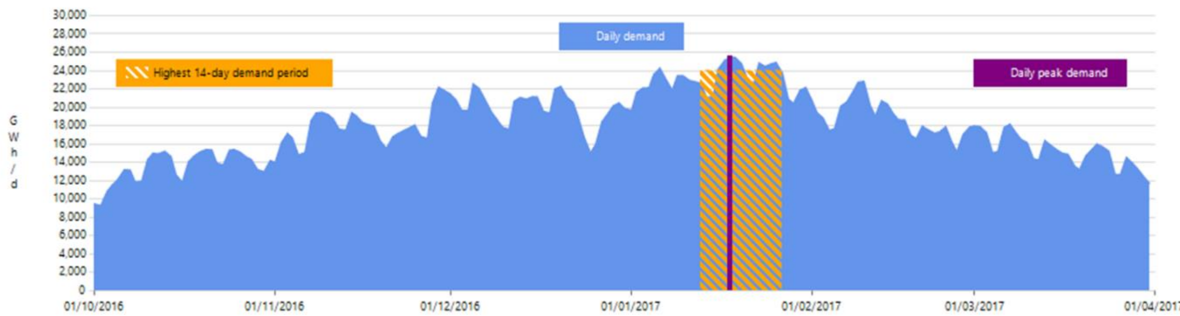


Figure 19 - Total demand daily profile. Winter 2016/2017.

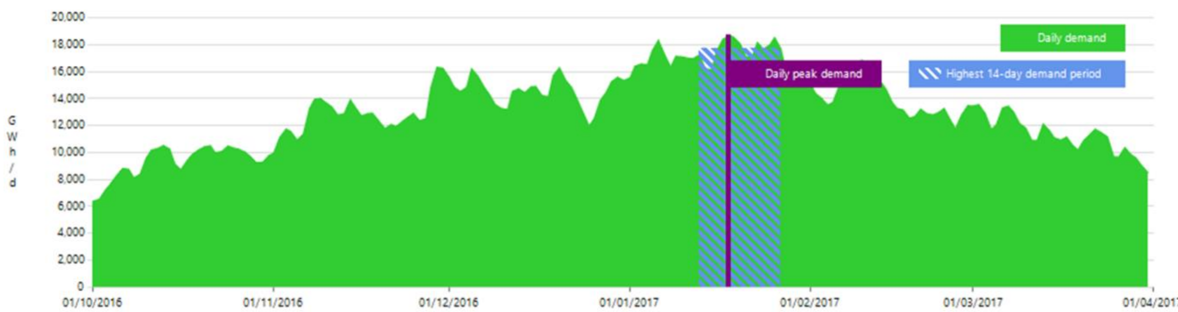


Figure 20 – Final demand (residential, commercial and industrial) daily profile. Winter 2016/2017. (*)

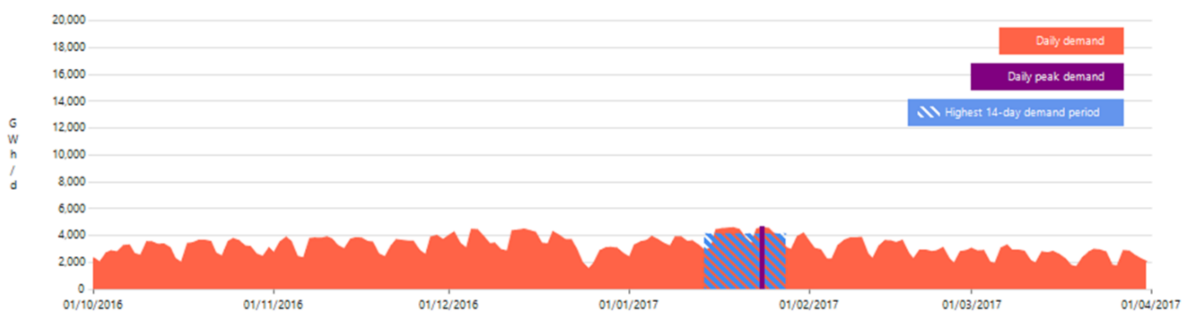


Figure 21 - Power generation demand daily profile. Winter 2016/2017. (*)

(*) These graphs refer to the countries for which demand breakdown is available (Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, FYROM, Netherlands, Portugal, Sweden, Slovenia, Slovakia and United Kingdom).

14- day peak period	Jan. 14th to Jan. 27th 2017	**Peak day**	18/01/2017
Average 14-day demand	23,999 GWh/d	**Peak demand**	25,521 GWh/d

Peak demand was reached mid-January 2017 during the cold spell, in the heart of the 14-day peak period. Likewise, the peak demand for final demand and for power generation was reached during the cold spell in January 2017. In the case of the 14-day period for final demand and power generation consumption, both are coincident and also during cold spell.

3.5. Peak demand evolution 2011-2017

Both 14-days demand and peak day demand increased during last year. In the first case, the increase reached 15% compared to last year and for the peak demand it was 5% higher than the previous winter.

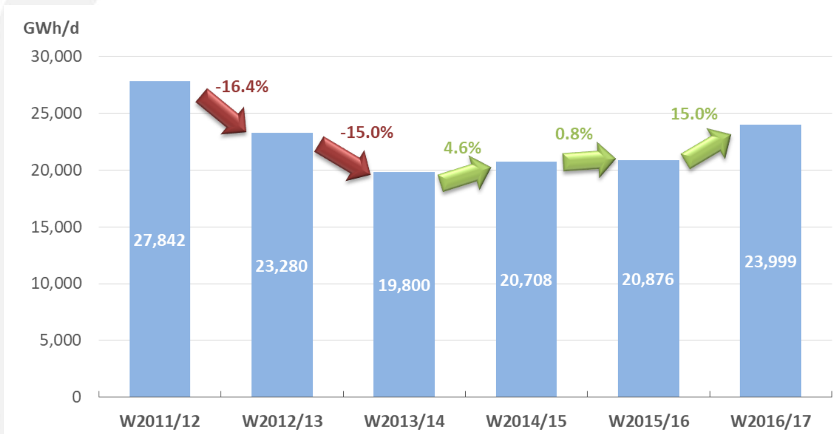


Figure 22 - Average daily demand for highest 14-day demand period. Winters 2011-2017.

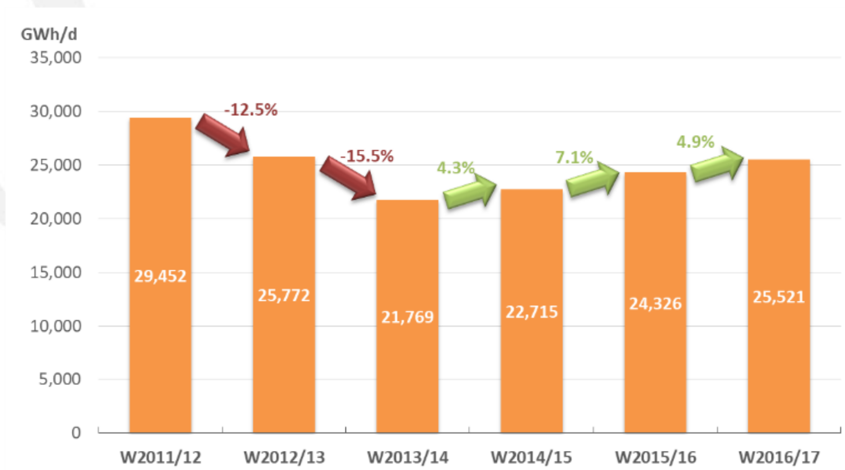


Figure 23 - Daily peak demand. Winters 2011-2017.

The charts below show a comparison between the high demand periods for the last two winters where a greater level of detail is available on the split between gas demand for power generation and for residential, commercial and industrial. It is important to mention that the total value of these graphs is lower than the previous figures because the information of the split is not available for all countries.

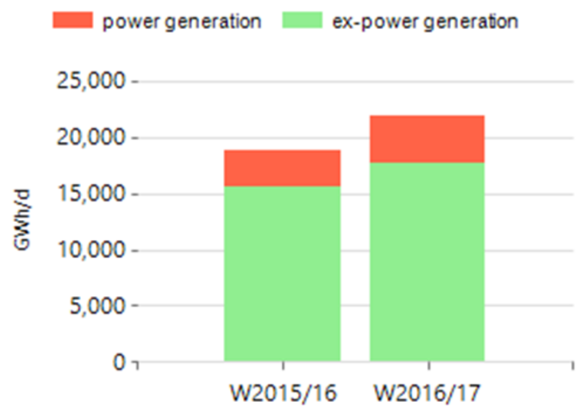


Figure 24 - Average daily demand for highest 14-day demand period split (*).

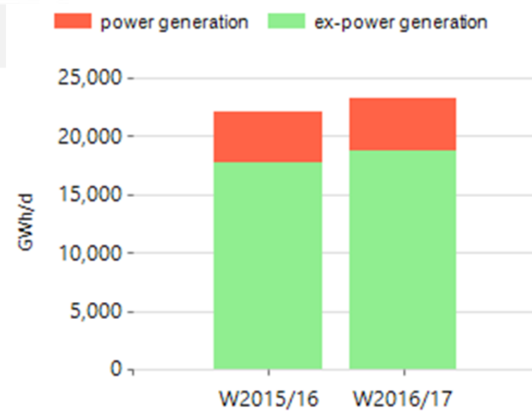


Figure 25 - Daily peak demand split (*).

(*) These graphs refer to the countries for which demand breakdown is available (Belgium, Czech Republic, Germany, Denmark, Estonia, Croatia, Finland, France, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, FYROM, Netherlands, Portugal, Slovakia, Slovenia, Spain, Sweden and United Kingdom).

> **Seasonal modulation**

The pattern followed by winter demand is strongly linked to the climatic conditions, like the presence of cold snaps or particularly mild conditions in one or several months during the winter.

The graph below shows the deviation of the monthly average demand from the winter average for each of the last six winters.

In this winter, the cold spell during January 2017 shows an increase of around 28% in comparison to the winter average. Nevertheless, the higher increment occurred in February 2012 by 34.5%.

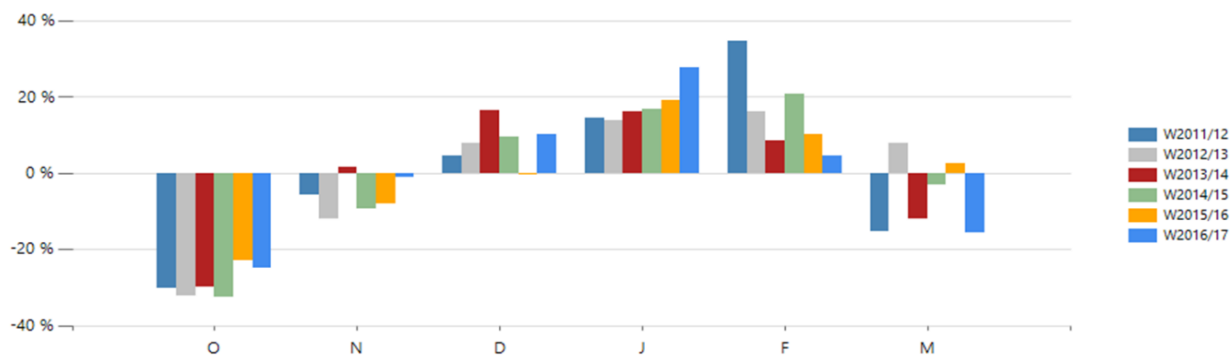


Figure 26 - Winter modulation 2011-2017.

Figure 26 shows the monthly variation between the maximum and minimum daily demand. When comparing Winter 2016/17 with the five previous winters, the ranges shown are very narrow. Figure 27 shows the average daily demand for each month of the winters.

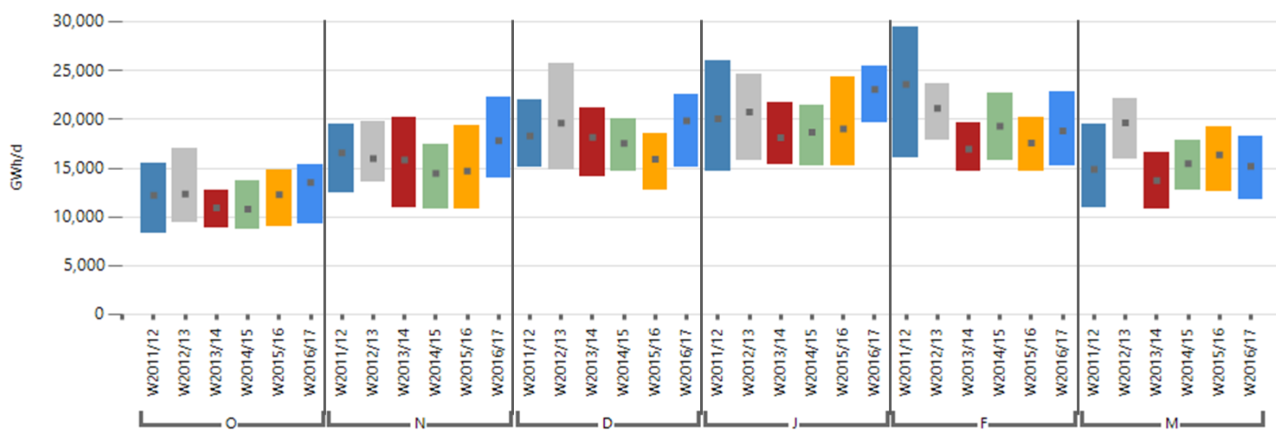


Figure 27 - Monthly demand ranges and average daily demand for each month. Winters 2011-2017.

> Country detail

In the same way that the seasonal demand increased across Europe in Winter 2016/17, several countries experienced a variation over 20% in the peak consumption: FYROM +50%, Bosnia Herzegovina +45%, Greece +33%, Portugal +30%, Switzerland +28%, Croatia 25%, Slovenia 25% and Austria +22%.

On the other hand, there were seven countries that their peak consumption this winter was lower than the previous one: Estonia -23%, Finland -19%, Sweden -12%, Lithuania -5%, Denmark -4%, Latvia -2% and Luxembourg -0.5%.

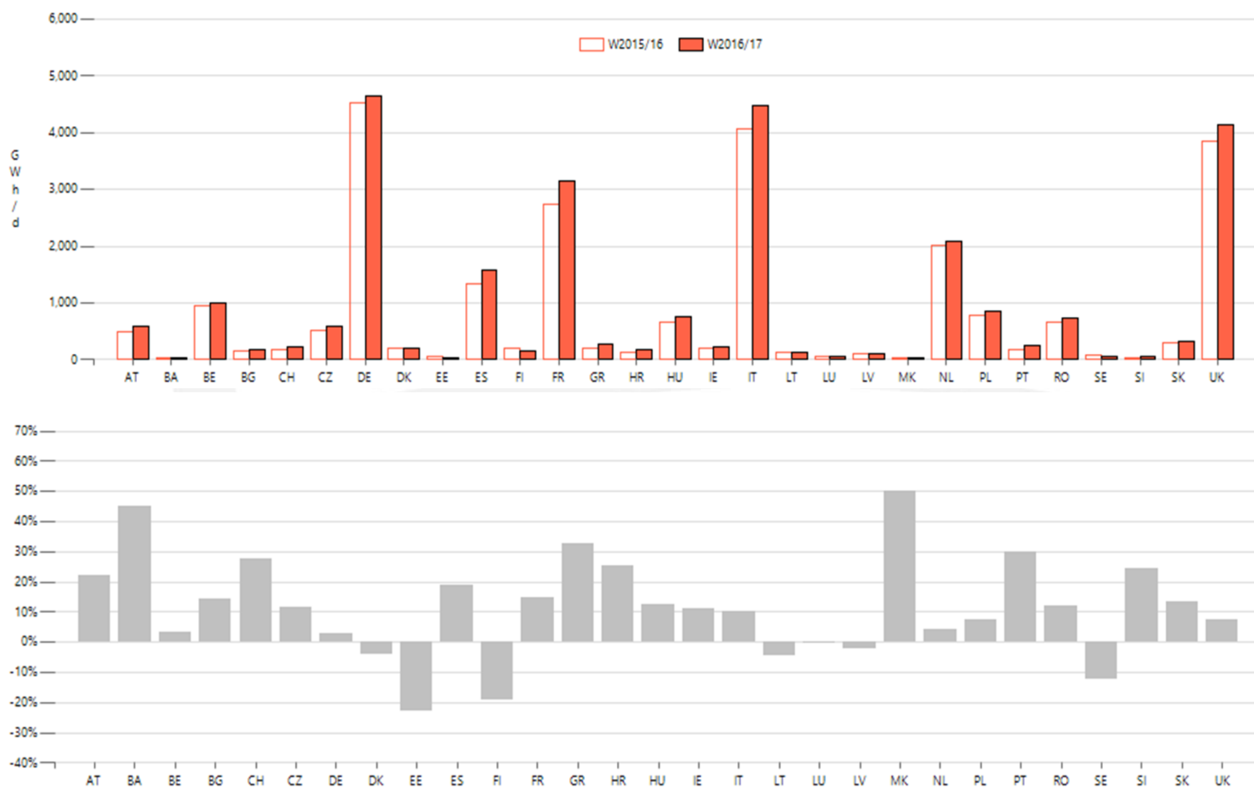


Figure 28 - Daily peak demand and variation. Winter 2016/2017 vs. 2015/2016.

As presented in Figure 29, most of the countries show an increase of the 14-day high demand compared to last winter, in line with the seasonal demand and peak day consumption. Only six countries reduced its 14-day demand (the same countries that reduced their peak consumption except Luxembourg that presents an increase of around 10.5%).

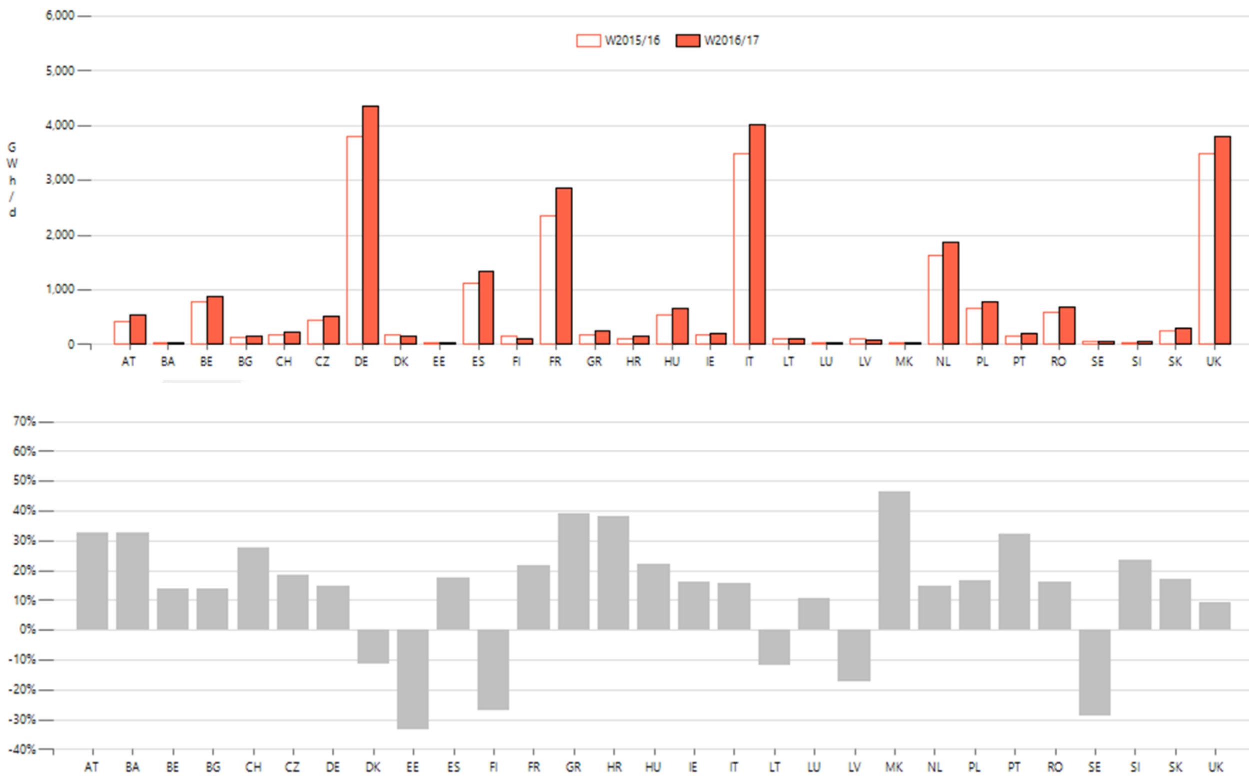


Figure 29 - Average 14-d demand and variation. Winter 2016/2017 vs. 2015/2016.

The following graph shows the minimum, maximum and average daily demand during Winter 2016/17, as well as the daily maximum and minimum demand of the last six winters (not include W16/17) per country:

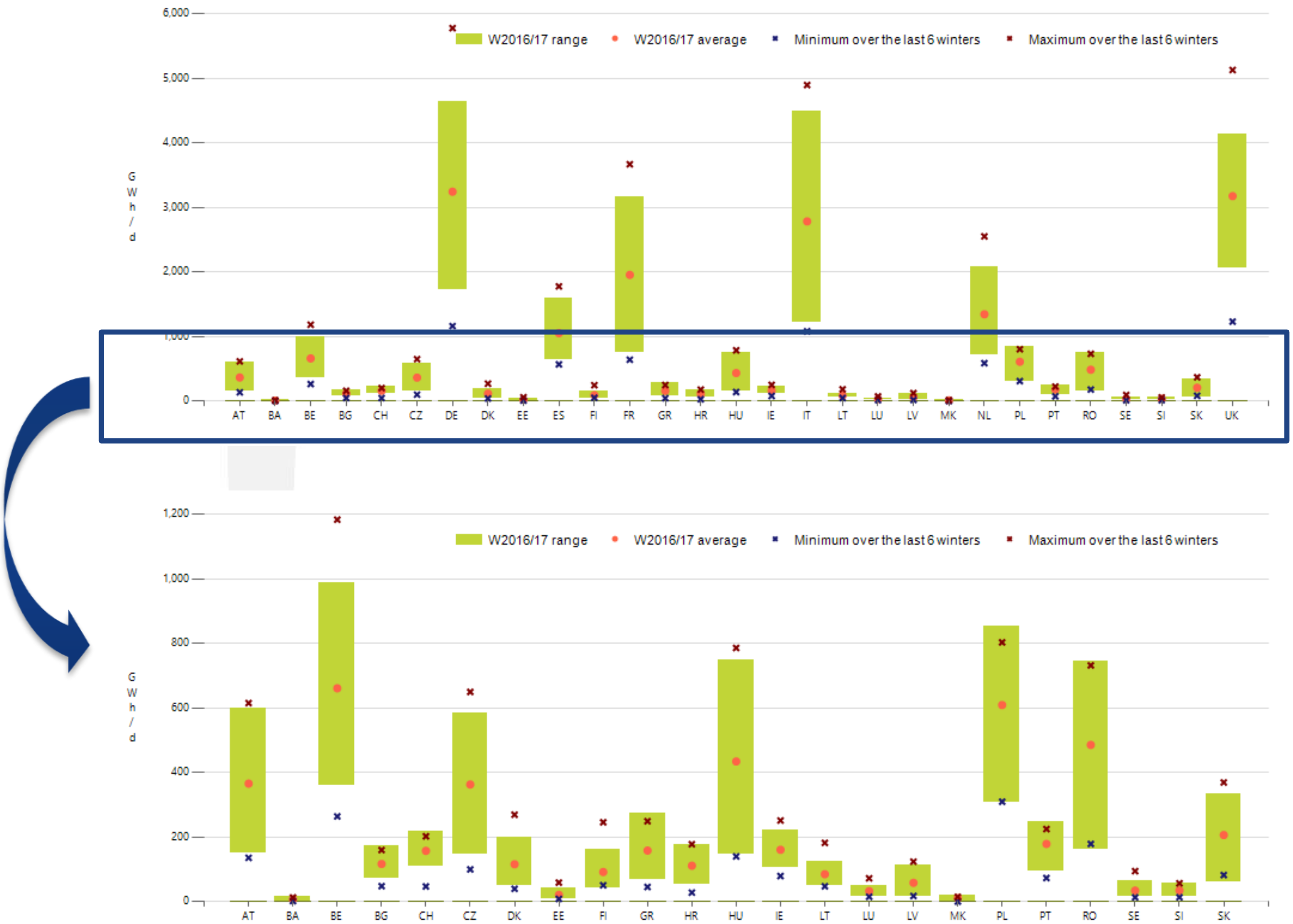


Figure 30 - Winter maximum, minimum and average demand.

In this graph, we could observe that for some countries as Greece, Romania, Bulgaria, Portugal or Switzerland, the highest daily demand in W16/17 is higher than the maximum demand over the six previous winters.

Simultaneity

In order to measure the simultaneity between the peak days in different countries, the "Un-simultaneous Peak" is described as the sum of the peak day demands of the individual countries having occurred un-simultaneously, defining:

- The European Peak Simultaneity (EPS)
  - EPS = European Peak Demand / Un-simultaneous Peak (%)
- The simultaneity of an individual country in the European peak day (CPS)
  - CPS = Country demand on the European peak day/Country peak demand (%)

So defined, the European peak simultaneity during the peak day on 18th January 2017, was 94%, a value below to average of 96% seen over the previous 5 winters.

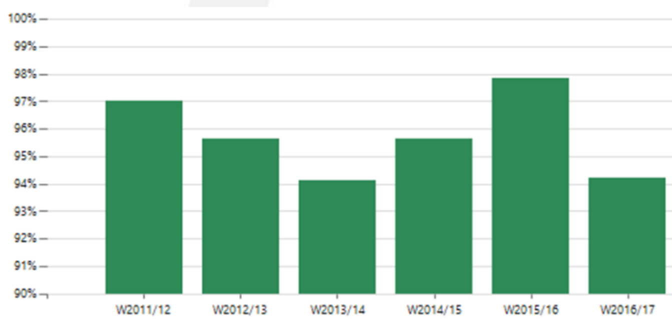


Figure 31 - European peak simultaneity.

Winter	Day	Peak Demand (GWh/d)	EU Peak Simultaneity (%)
W2011/12	07/02/2012	29,452	97%
W2012/13	12/12/2012	25,772	96%
W2013/14	30/01/2014	21,769	94%
W2014/15	05/02/2015	22,715	96%
W2015/16	19/01/2016	24,326	98%
W2016/17	18/01/2017	25,521	94%

Table 1 - Peak demand and European peak simultaneity. Winters 2011-2017.

Figure 32- Simultaneity of the highest single day between last 2 winters.

4. Supply

4.1. European seasonal gas supply

The graph below shows the evolution of the aggregated gas supply in Europe during Winter 2016/2017.

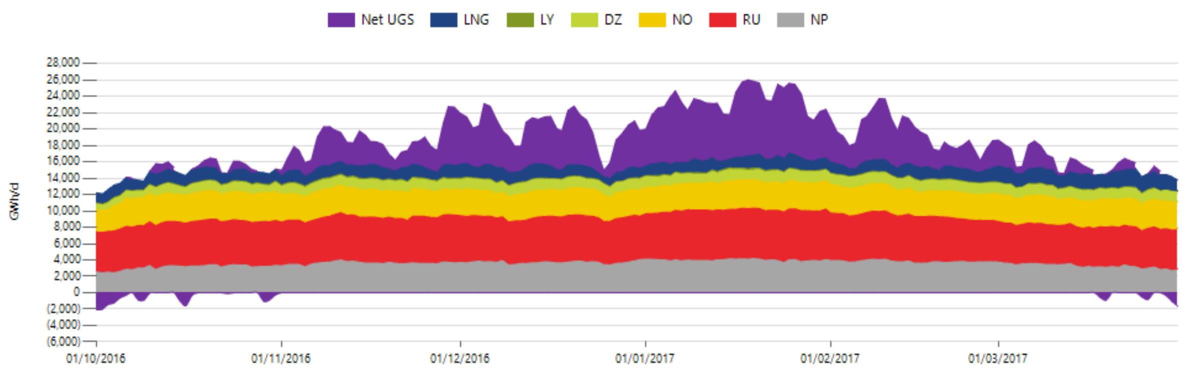


Figure 33 - Supply profile. Winter 2016/2017.

The next graphs give an overview of Imports and National production supply shares during Winters 2016/2017 and 2015/2016 in both absolute and relative terms.

Figure 34 shows the seasonal supplies by source for the last two winters in absolute figures. The average increase of the different gas supplies was 12%, but it was not homogeneous between the different supply sources.

There were significant increases from Algeria (57%), Russia (19%) and LNG (13%), while the Norwegian and Libyan imports decreased (-10% each). In the case of National Production the supply was stable in regards to the previous winter.

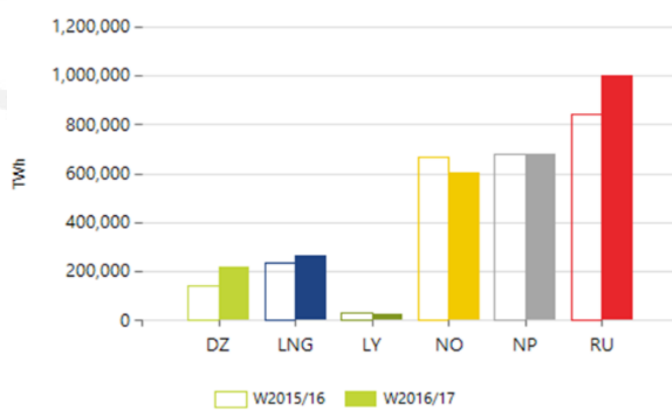


Figure 34 - Total supply by source.

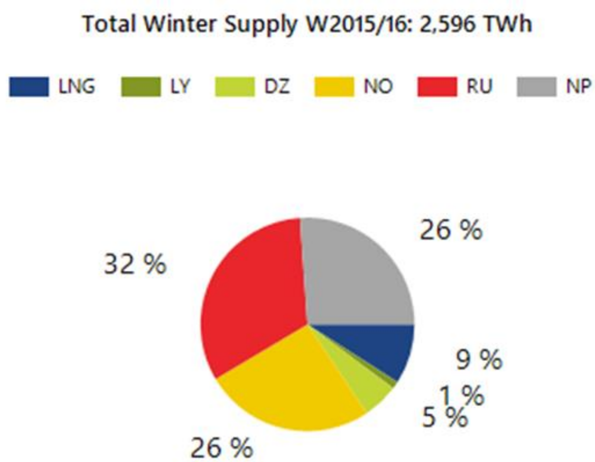


Figure 35 - Supply Mix. Winter 2015/2016.

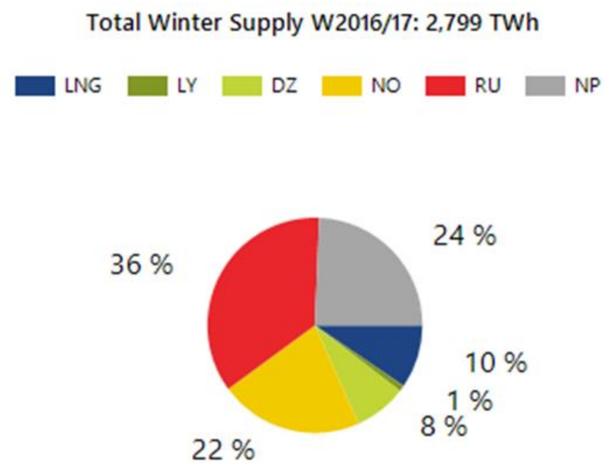
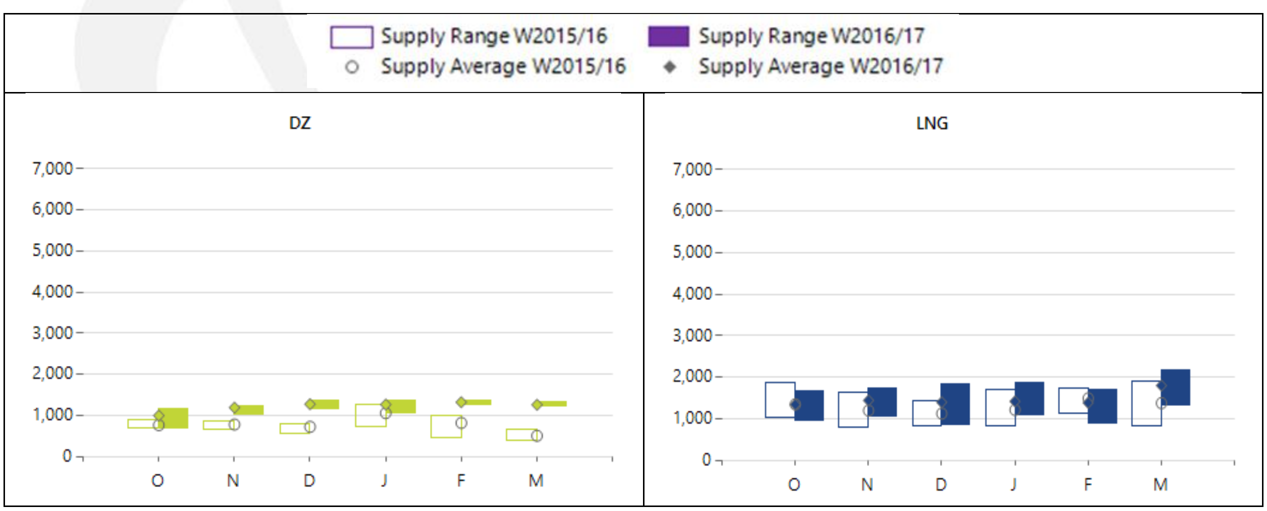


Figure 36 - Supply Mix. Winter 2016/2017.

The total supply (without UGS) was 2,799 TWh in Winter 2016/2017, an increase of 7.8% compared to the last winter (2,596 TWh).

4.2. Supply Modulation

The following graphs illustrate for national production and each import supply source, the average flow and the monthly range (between the lowest and highest daily flow of each month during the whole winter).



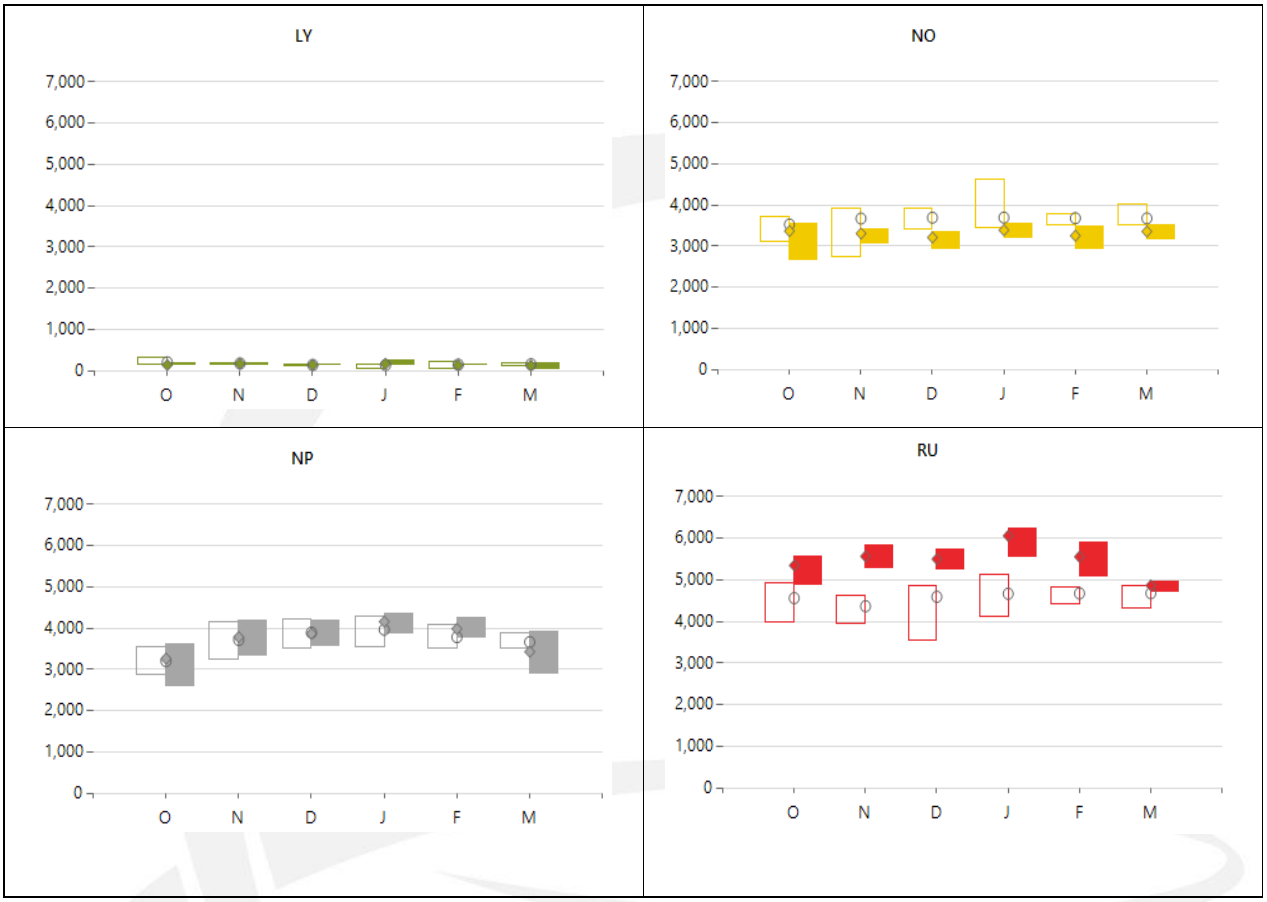


Figure 37 - Supply daily range (GWh/d)

4.3. Underground Storages

The utilisation of the underground storages depends on many factors, linked to price signals such as summer-winter spread or climatic and economic considerations having impact on gas demand. As previously mentioned in this report, the use of UGS this winter has been driven by its use as an alternative to other supply sources that saw reductions from the previous winter. This was facilitated by the high stock level, comparable to previous winters.

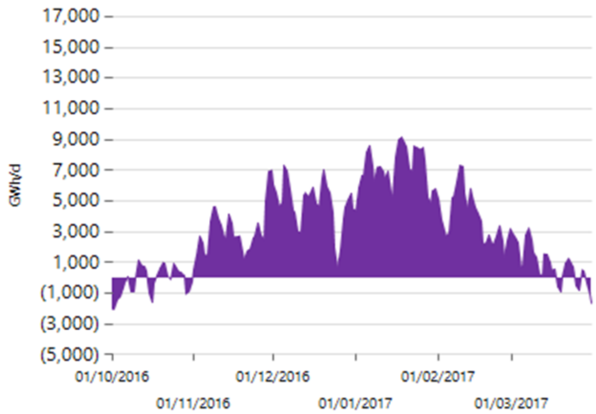


Figure 38 - UGS injection/withdraw profile. Winter 2016/2017.

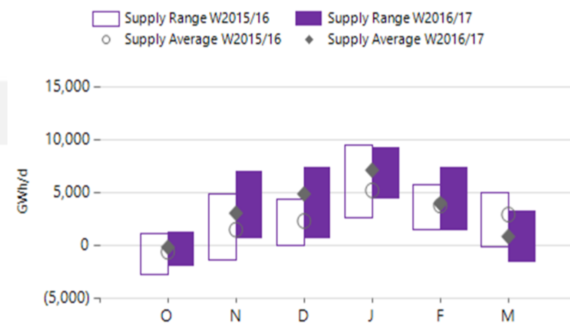


Figure 39 - UGS daily range of withdrawal and injection. Winter 2016/2017 vs. Winter 2015/2016.

The peak deliverability of UGS was 9,272 GWh/d, meaning a 5.7% decrease from the previous year in spite of the cold spell that happened this winter.

Figure 40 compares the stock level evolution curve of the last 6 winters. The stock level for the Winter 2016/2017 started from a level of 90.4%, 8 points higher than in the previous winter. The injection period was short and the maximum stock level (91.15%) was reached on 17th October. At the end of this winter the level reached 25.75%, the lowest seen in last six winters. In the same way, the curve of stock level in the UGS had a larger slope than last six winters, especially from November to January. One of the main factors for this high utilisation was the cold spell.

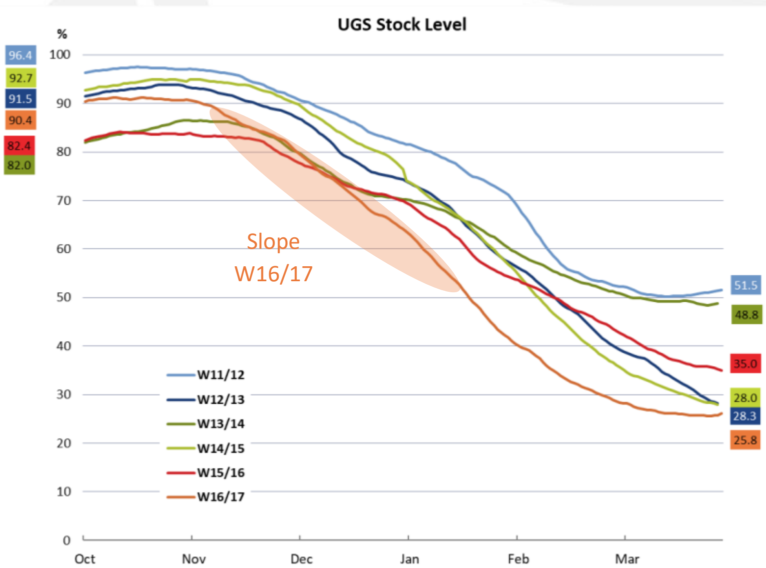


Figure 40 - Evolution of UGS stock level. Winters 2011-2017 (Source: AGSI).

Winter	UGS Utilisation (% WGV)
W11/12	47
W12/13	66
W13/14	36
W14/15	66
W15/16	48
W16/17	66

Table 2 - UGS Utilisation (% WGV). Winter 2011-2017. (Source: AGSI).

The UGS utilisation was much higher than the previous winter (66% vs. 48%), but similar to other years, like winters 2014/2015 and 2012/2013.

4.4. Supply coverage of high daily demands

Due to the different ability of the different supply sources to increase or decrease the supply levels in response to demand, the supply mix varies significantly depending on the demand level. The following graphs compare the supply level of the different sources under different demand conditions. It shows that underground storages are the main source of flexibility in high demand situations.

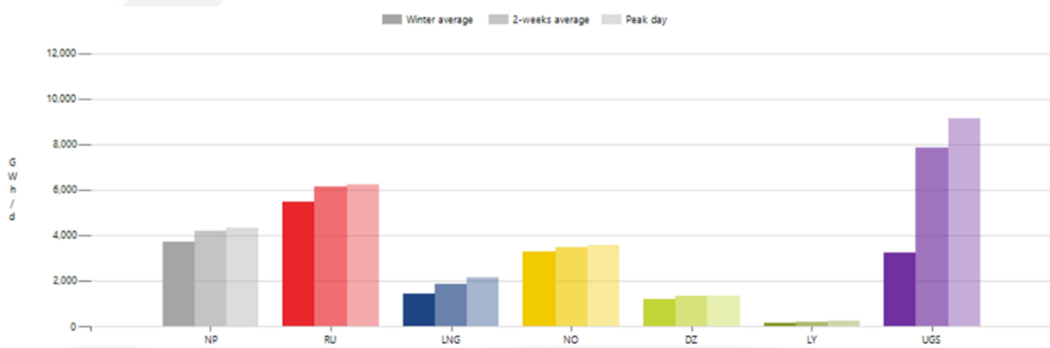


Figure 41 - Daily average supply / Average daily supply for highest 14-day demand period / Supply for peak day demand. Winter 2016/2017.

4.5. Winter supply evolution 2011-2017

The following graph show the evolution of the different supply sources during the last six winters.

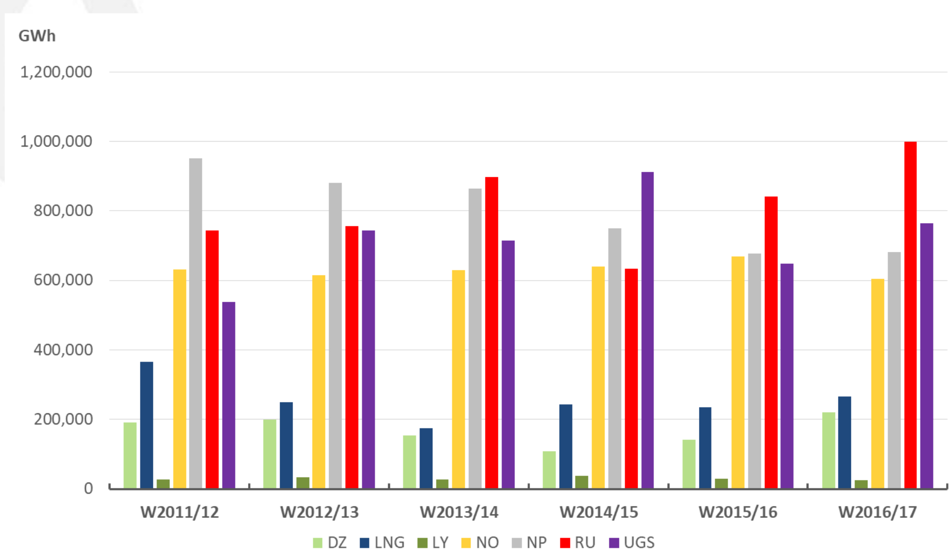


Figure 42 - Evolution of winter gas supplies 2011-2017.

5. Cold Spell in January 2017

During January 2017 the European power and gas system faced an exceptional situation due to extraordinarily cold temperatures combined with other events.

The extended nature of the cold spell affected multiple countries simultaneously coupled with the challenges faced in terms of demand adequacy issues (for both power generation and domestic consumption) by each country over this period was also unprecedented over past decades.

At the same time and despite such an event, the measures developed and the steps undertaken by TSOs, ensured uninterrupted supply and secure system and market operation during the whole duration of the cold spell.

This section provides factual information on the events which occurred during the cold spell of Winter 2016/17, in countries which experienced exceptional challenges during that period. Based on these facts, lessons learned and conclusions are presented at the end of this section.

5.1. Introduction

The total gas demand in Europe during January 2017 was 715,394 GWh, 21% higher than the previous January (590,705 GWh). Precisely, the gas transported in the EU from 1st to 16th January accumulated 381,372 GWh, meaning a 20% increase when compared to the same period of the last three years.

The following graphs show the daily gas demand profile since December 2016 to February 2017 compared to the previous year and also the comparison between the demand levels reached during the last seven years compared to the demand reached in January 2017 (annual demand, highest daily demand and highest 2 week demand).

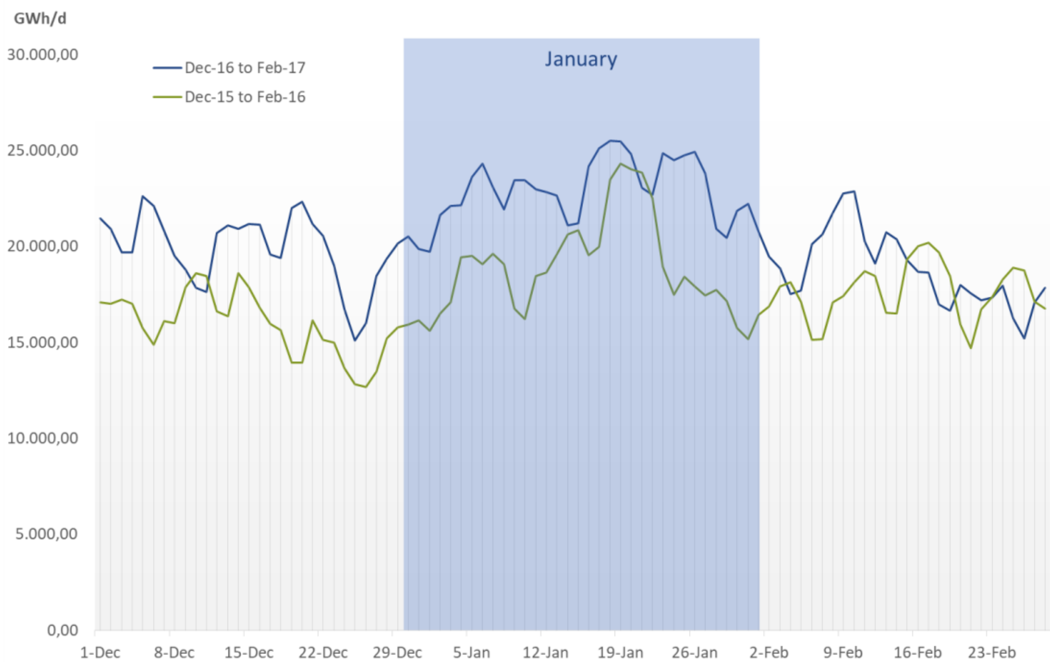


Figure 43 - Daily gas demand profile (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

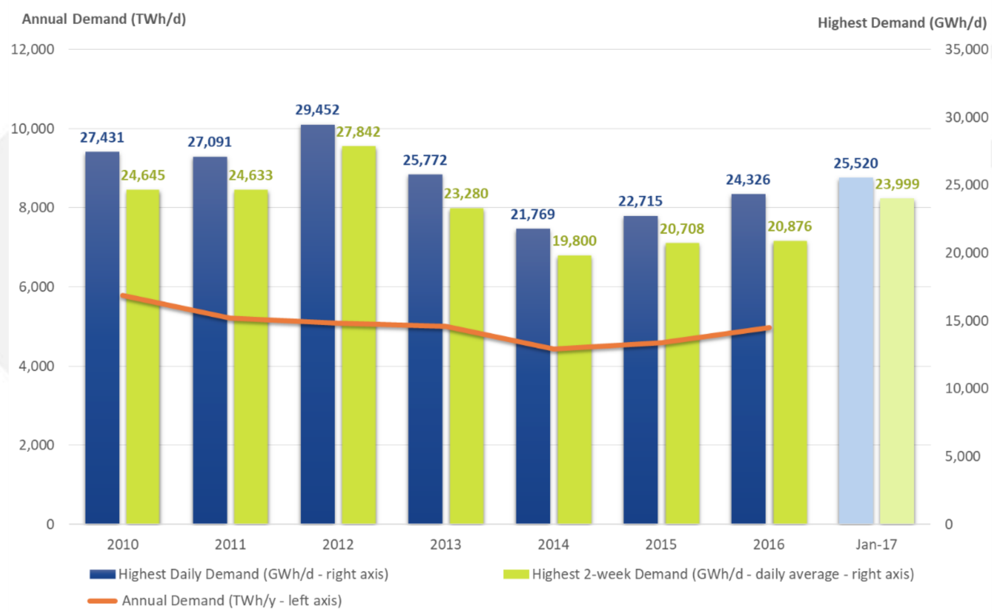


Figure 44 - Highest daily demand, highest 2-week demand and annual demand. 2010-2016 and January 2017.[8]

[8] Data of annual demand for 2016 is provisional (Eurostat).

Natural gas consumption in power generation reached its highest level in the last seven years in January 2017 due to the combined effect of the low availability of nuclear plants and the limited renewable generation. The total electricity generated from gas amounted to 65 TWh in the EU, the highest since the beginning of the available time series (January 2010). [9]

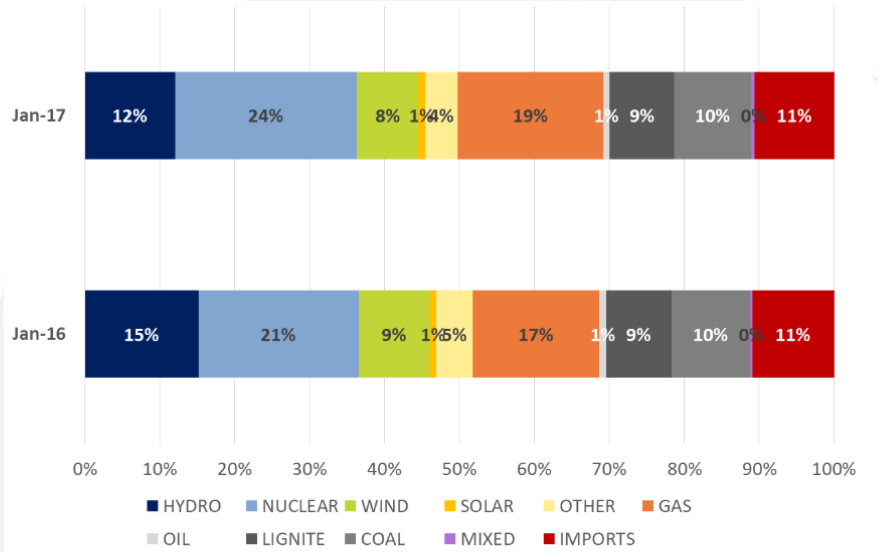


Figure 45 - Generation Mix in Europe. Jan-17 vs. Jan-16 (Source: ENTSO-E)

During the cold spell, withdrawal from storages was 660 TWh (until March) higher than that withdrawn in five previous winter, showing that they were intensively used and a key source of seasonal flexibility. It is also important to note that daily withdrawal rates in December and January were very high, about 8 TWh, and in some countries provided half of the daily consumption. This situation led to the gas stock level in EU 28 stood at 26% (278 TWh) on 31st March, the lowest value in six years. The refilling of storages during summer has led to a level on 1st October 2017 of 85% - close to its six year minimum.

[9] Quarterly Report on European Electricity Markets. First Quarter of 2017 (Market Observatory for Energy. DG Energy. European Commission).

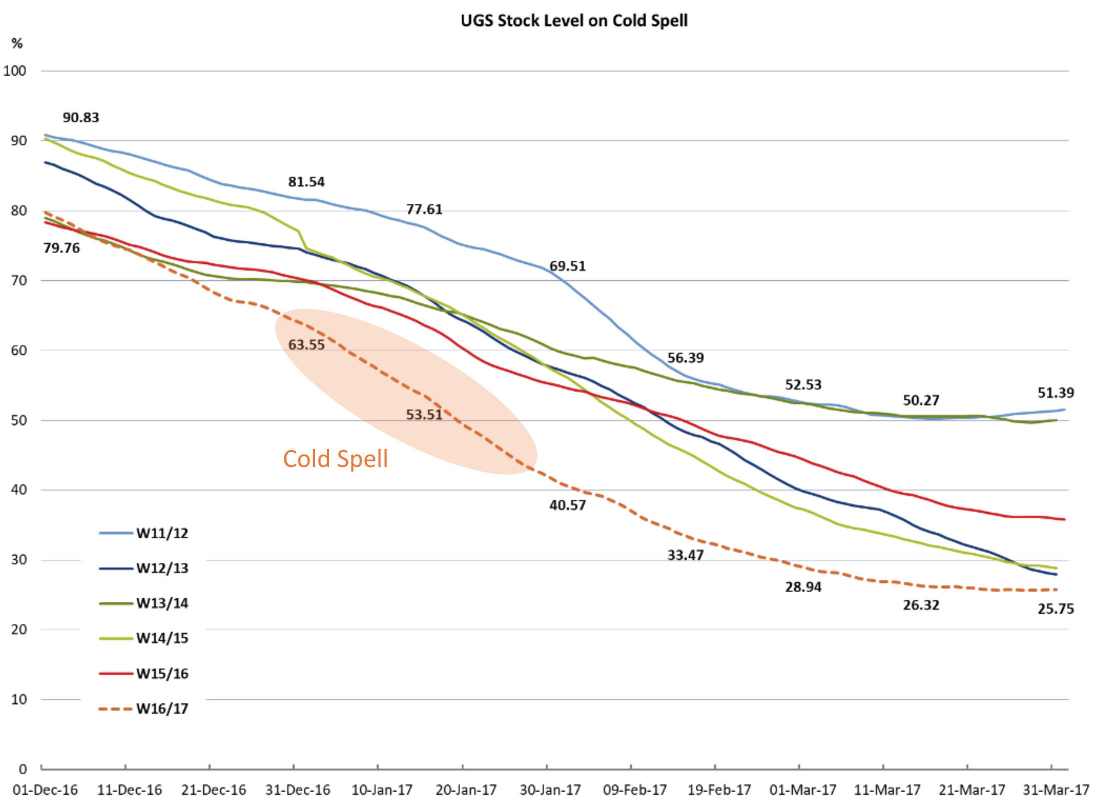


Figure 46 - UGS withdraw profile. Dec-16 to Mar-17 (Source: AGSI)

Regarding the spot prices, during cold spell the prices in all European hubs experienced an important increase, reaching the higher values during the winter period. The most important increments were in Spain (MIBGAS), France (TRS) and Italy (PSV), countries affected by cold spell in different ways and where their markets have a churn rate lower than the other European hubs.

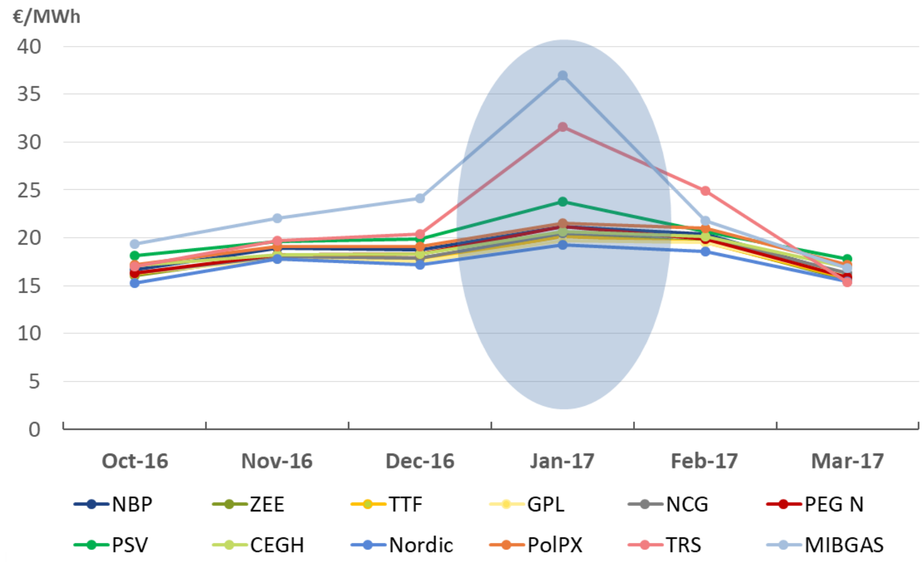


Figure 47 - Day-ahead average prices at European hubs in €/MWh (Source: Bloomberg and MIBGAS).

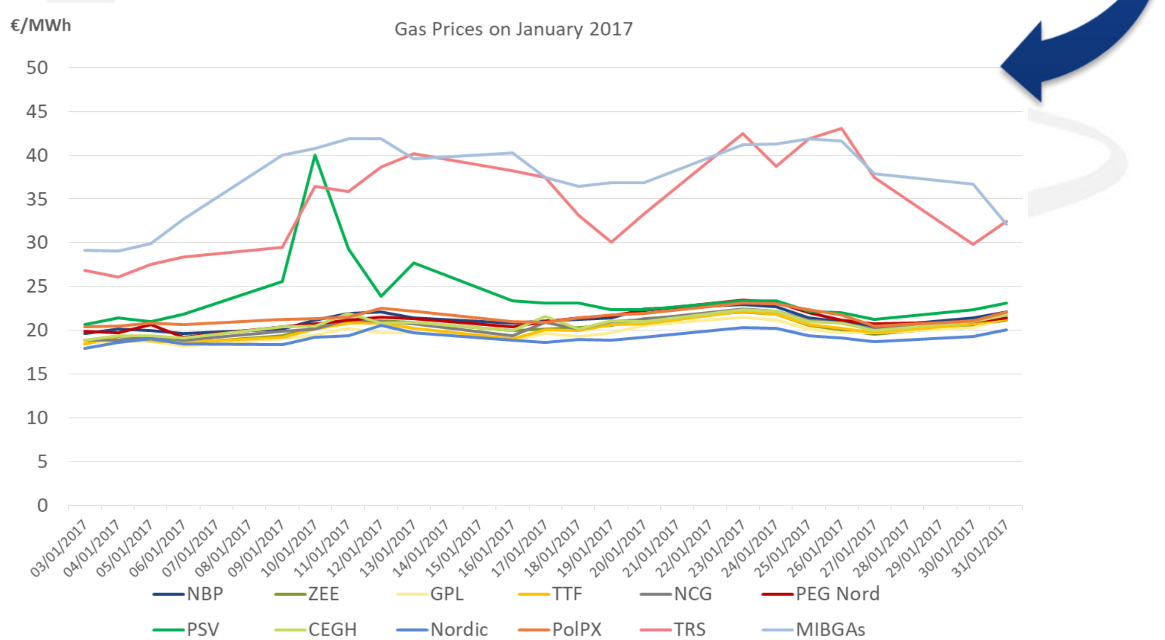
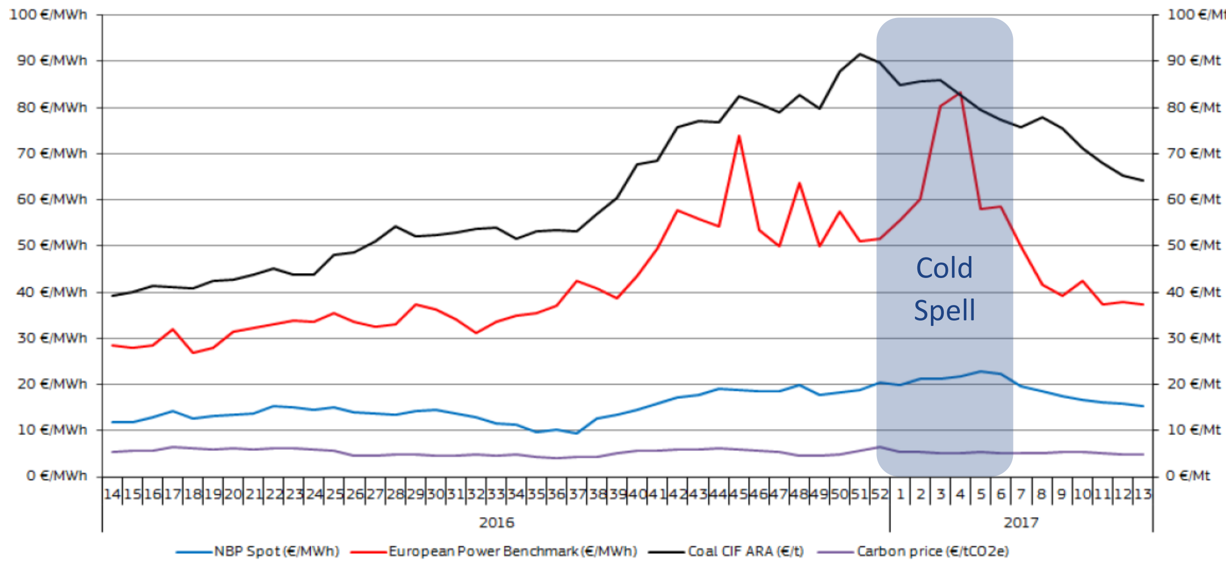


Figure 48 - Zoom on January 2017. Day-ahead prices at European hubs in €/MWh (Source: Bloomberg, Powernext and MIBGAS).[10]

[10] The prices considered in the case of TRS are from Powernext (End of Day Price).

The cold spell in January not only impacted gas prices but the European wholesale electricity prices, showing a significant peak, as presented in the following figure.



Source: Platts,
European Power Benchmark (in €/MWh) is the replacement of the Platts PEP as of January 2017
Coal CIF ARA: Principal coal import price benchmark in North Western Europe (in €/Mt)
NBP spot stands for the National Balancing Point (UK) gas spot price (in €/MWh)
Carbon price: EUA emission allowance spot pirce, in €/t

Figure 49 - Weekly evolution of European average wholesale power prices compared with coal and gas prices (Source: Quarterly Report on European Electricity Markets. Market Observatory for Energy. DG Energy)

The following subsection contains an in-depth overview of specific conditions and events that occurred during the cold spell in the affected countries. These countries could be divided in groups, taking into account the different factors which took place. These groups are:

- Exceptionally cold situation and restrictions on electricity exports (BG, RO, GR).
- Exceptionally cold situation (IT)
- Cold situation combined with nuclear outage (FR, ES and BE).

5.2. Exceptionally cold situation (BG, RO and GR).

Bulgaria, Romania and Greece faced a cold spell during the first weeks of January with very low temperatures and a long duration. This situation triggered an extraordinary high demand in terms of power generation and gas natural demand. In some cases, it was necessary to take preventive measures like the limitation of power exports from these countries.

The following charts show the daily gas demand profile in the area in the period from December to February in Winter 2016/2017 compare with the Winter 2015/2016 (with special focus on January 2017) and the peak demand in January 2017 compared with previous years and, also, the highest 2 week demand in terms of daily average demand.

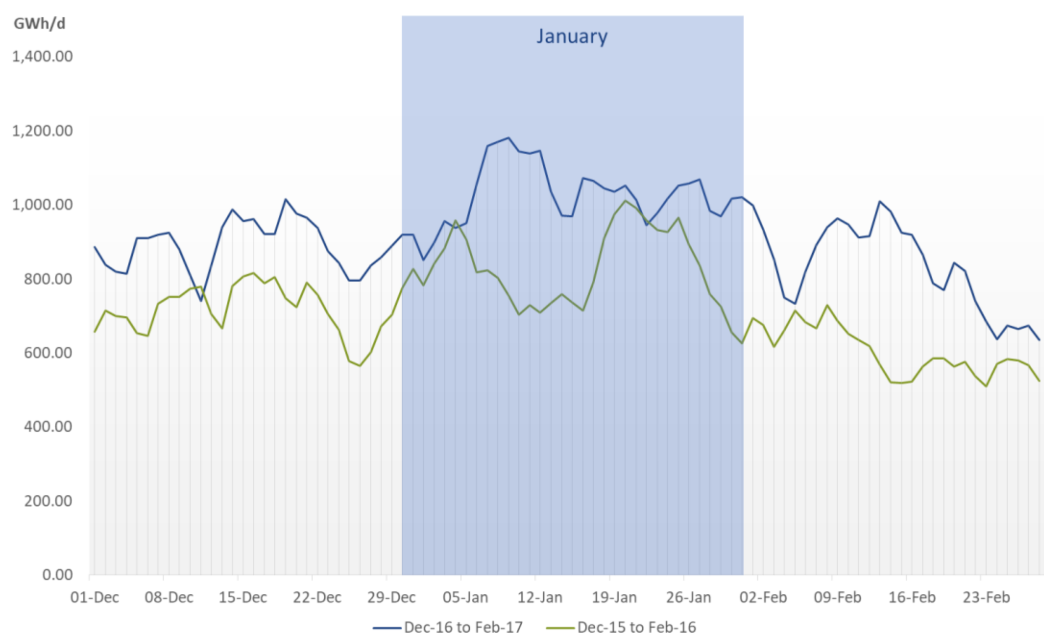


Figure 50 - Daily gas demand profile in the area of Bulgaria, Romania and Greece (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

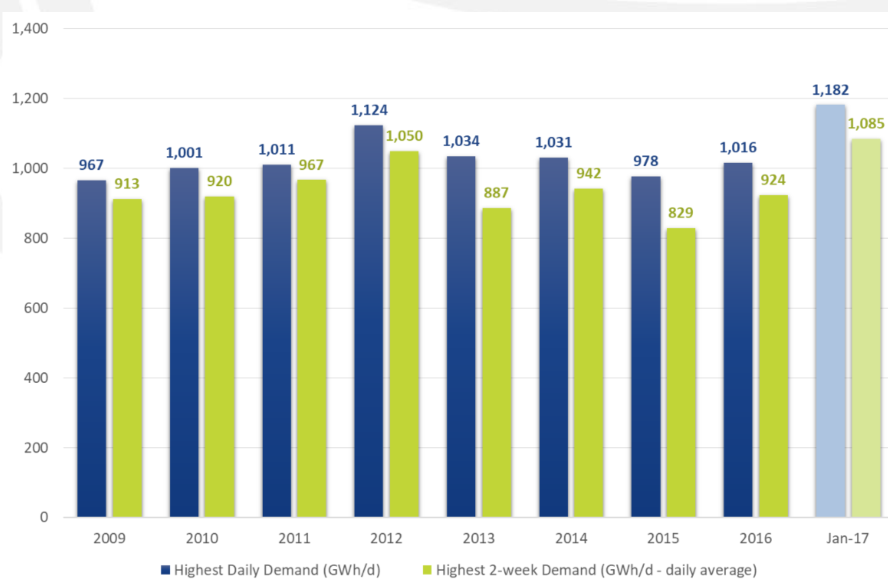


Figure 51 - Highest daily demand and highest 2-week demand in Bulgaria, Romania and Greece.

Bulgaria (BG):

The cold spell in Bulgaria caused extreme negative deviations from the normal temperatures over a long period. The last cold wave with similar parameters was reported to be observed 69 years ago (in 1948).

Bulgaria reached its peak gas demand on 11th January with a consumption of 172.7 GWh/d. One of the main supply sources used to handle the high demand was the underground storage in Chiren that, at the beginning of the cold snap, had more than 3,740 GWh of available gas (more than 20 times the Bulgarian peak demand).

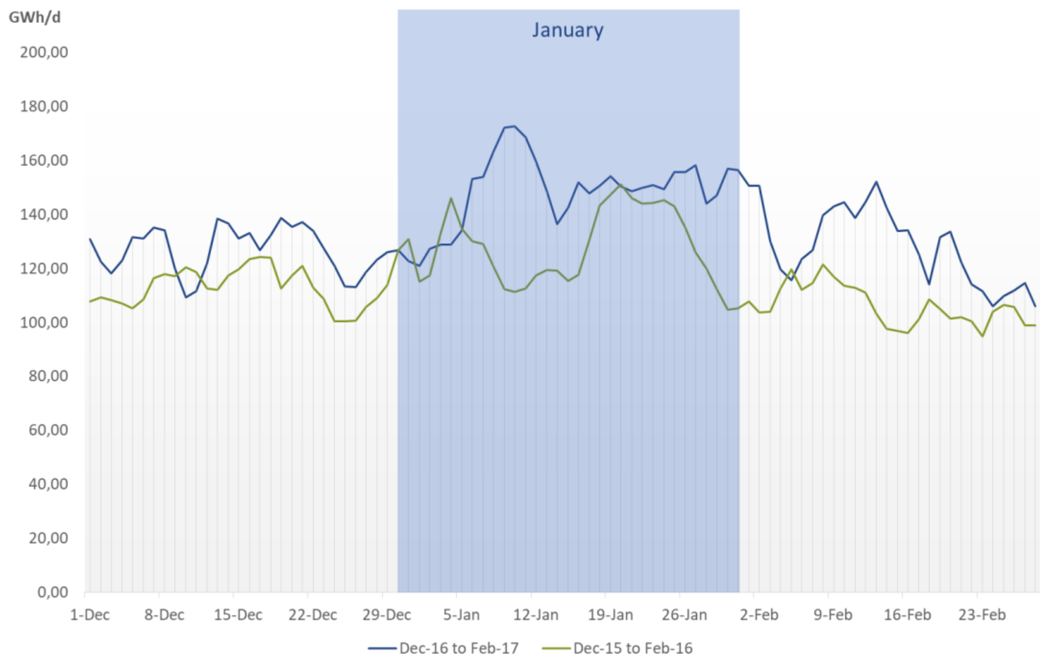


Figure 52 - Daily gas demand profile in Bulgaria (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

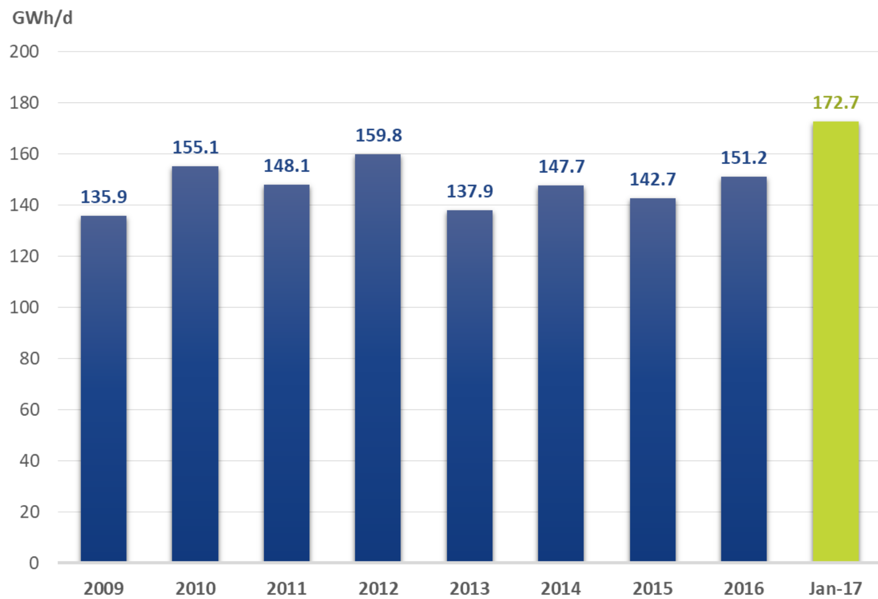


Figure 53 - Daily peak demand in Bulgaria.

The main challenge in Bulgaria was the high electricity demand together with the difficulties experienced in some thermal generation plants. As a consequence, Bulgaria was forced to cut exports of electricity. Moreover, the neighbouring countries didn't have the possibility to assist Bulgaria as they were also affected by the cold snap.

As a measure of last resort, on 13th January the Minister of Energy issued an order for limitation of power exports from Bulgarian origin but without interfering with the commercial power transits (import and export) through Bulgaria. The suspension lasted till 01:00 EET on 9th February 2017.

Regarding the thermal plants, Bulgaria could not respond in accordance with their cold reserve contracts during the cold spell due to various issues: freezing of coal, freezing of the Danube River which supplies cooling water and repeated technical failures. In the same way, it is important to mention that only 6% of total installed capacity in Bulgaria is gas fired power generation.

Figure 54 shows the generation mix in Bulgaria during January 2017 compared with January 2016.

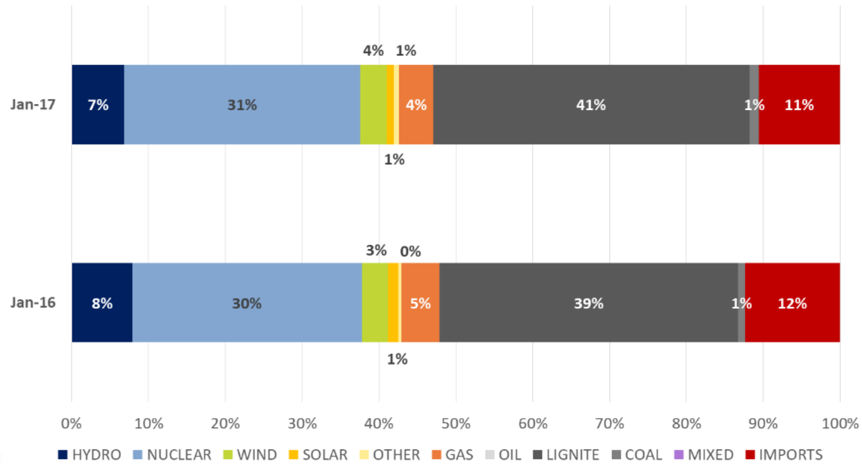


Figure 54 - Generation Mix in Bulgaria. Jan-17 vs. Jan-16 (Source: ENTSO-E).

Romania (RO):

During January 2017, bad weather events occurred in the form of strong winds, high amounts of snow, fog and frost in large areas of the country. Very low temperature values were recorded. The average minimum low temperature in the country was in the range of -11°C and -15°C, and the lowest reached local value was -32°C.

Measures taken within the power system were:

- The Government Decision no. 10-13 January 2017 related to safeguard measures (e.g. curtailment of exports) was issued for the cold spell between 16th January and 15th February 2017, but was finally not applied.
- Ordinary preventative measures were applied, like cancelling programmed outages, minimum voltage level on distribution grids, etc.

In spite of the above mentioned events, the Romanian Power System was operated under safe conditions. It also maintained export contracts running despite the record peak loads in 20 years.

Nevertheless, related with gas system, the Gas National Operator requested to switch from gas generation to Heavy Fuel-oil (HFO) for some units in order to protect the natural gas system. This measure was applied from 08/01/2017 to 11/01/2017 for 190 MW thermal generation[11]. However, the share of natural gas to power generation in mix increased from 8% to 10% during January 2017 compared with January 2016, during which time the share of lignite was lower.

[11] Managing Critical Grid Situations – Success & Challenges (ENTSO-E report of the January 2017 cold spell).

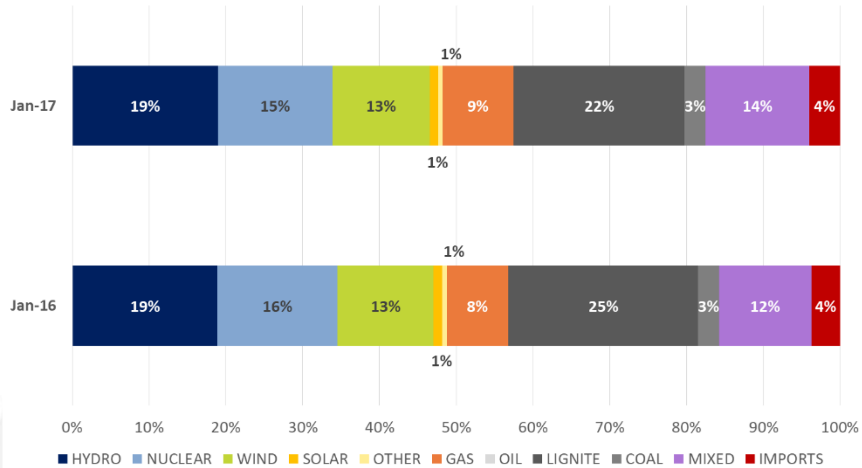


Figure 55 - Generation Mix in Romania. Jan-17 vs. Jan-16 (Source: ENTSO-E).

Figure 56 shows the comparison between daily gas demand in Romania from December to February in Winters 2016/2017 and 2015/2016, with special focus on January 2017.

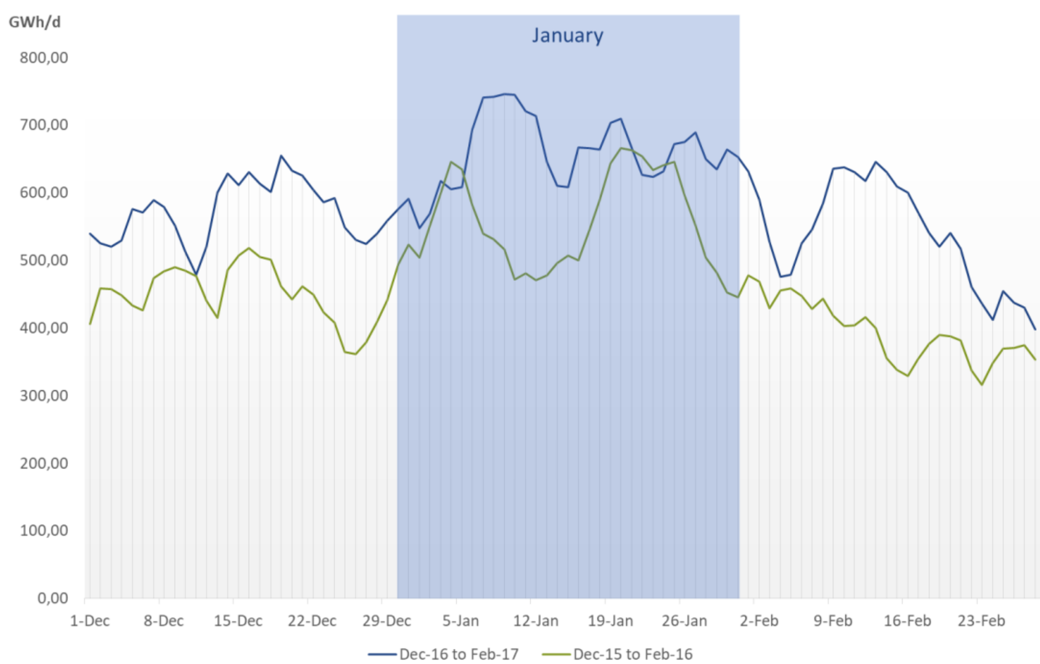


Figure 56 - Daily gas demand profile in Romania (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

The average daily demand in January 2017 was 19% higher (662 GWh/d). The peak demand observed during this month also increased by 12% compared to the previous January.

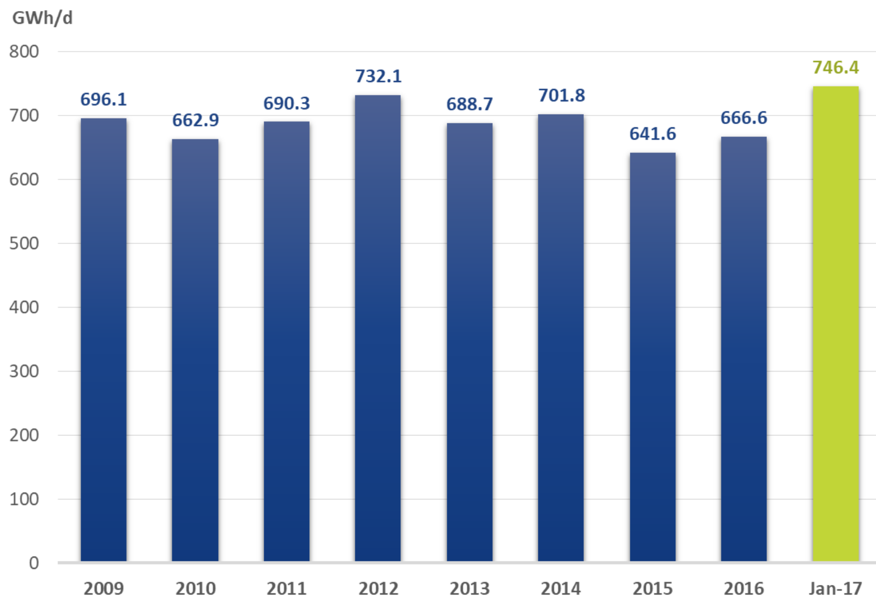


Figure 57 - Daily peak demand in Romania.

<u>Greece (GR):</u>

Greece faced a first cold spell in December 2016, causing the winter demand of both gas and electricity to increase (around 50% of the gas demand was linked to power generation). Additionally, weather conditions got worse in Greece soon after the beginning of 2017. This situation complicated the possibilities to respond properly to the second cold event.

As of 20th December 2016, the National Natural Gas System of Greece was declared at alert level by the Greek Authorities after the gas demand had been increasing for a consecutive seven days combined with an insufficient supply (LNG cargo arrival was delayed since 24/12 until 26/12 due to bad weather at Algeria's harbour).

On 9th January, another exceptionally high day of gas demand occurred (263 GWh) together with delayed LNG leading the Greek Authorities to declare a second alert level. In this period, at least three extra cargoes of LNG from Algeria were delivered to Revithoussa terminal. Also, Greece has two import points: one with Turkey and other with Bulgaria. During the cold spell, the interconnection point with Bulgaria (Kulata (BG) / Sidirokastron (GR)) was near to its maximum capacity and sometimes exceeded it. The interconnection point with Turkey had two increments of flows during the cold spell, but it did not reach its maximum. At the same time, it is important to mention that Greece doesn't count on any UGS facilities and the main source of flexibility is the LNG terminal.

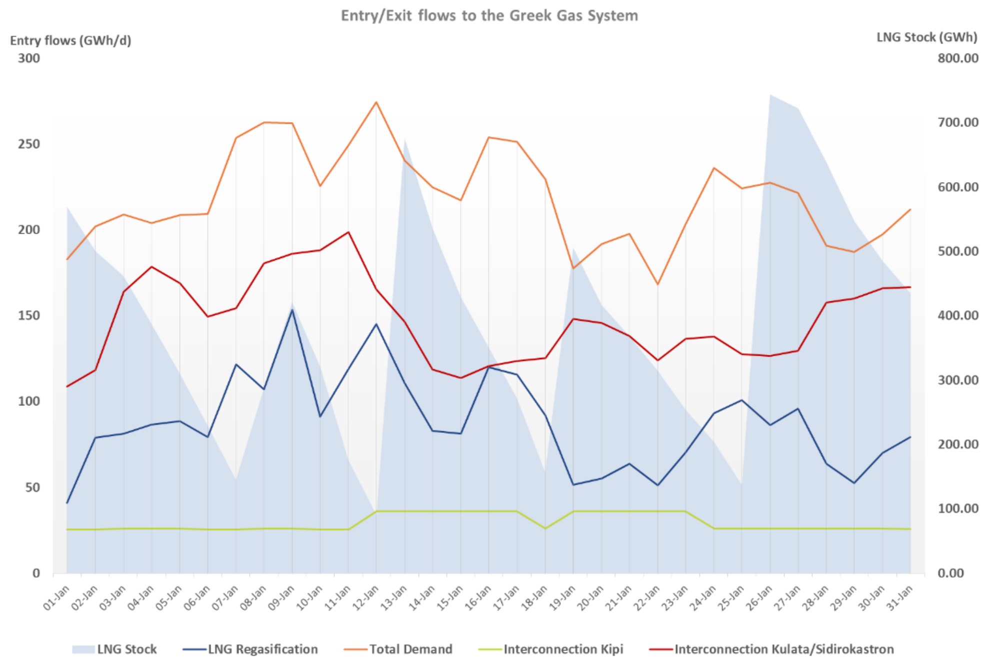


Figure 58 - Entry/Exits flows to the Greek gas system and LNG stock. January 2017 (Source: Transparency Platform and DESFA)

As a result of the alert level declared, Greece activated its Emergency Plan with the measures to be taken by the gas TSO and other stakeholders[12].

The main challenge in the Greek gas system was the concurrency of peaks, in other words, the simultaneous peak demand in power generation and domestic consumption, leading to a historical peak demand.

[12] Greek Emergency Plan:
http://www.desfa.gr/wp-content/uploads/2016/01/%CE%95%CE%99%CE%A3%CE%97%CE%93%CE%97%CE%A3%CE%97_%CE%94%CE%95%CE%A3%CE%A6%CE%91_031115_Rev2_ENGLISH.pdf

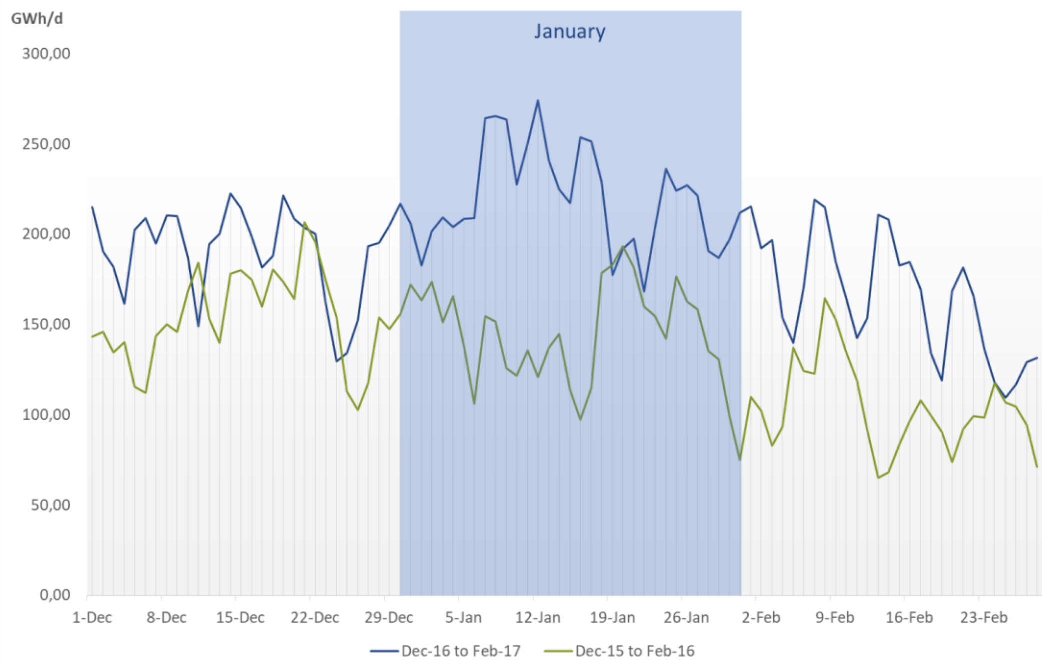


Figure 59 - Daily gas demand profile in Greece (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

Figure 60 – Daily peak demand in Greece.

Figure 61 shows the split between power generation consumption and domestic (residential, commercial and industrial) consumption. Around 50% of the gas used was power generation demand.

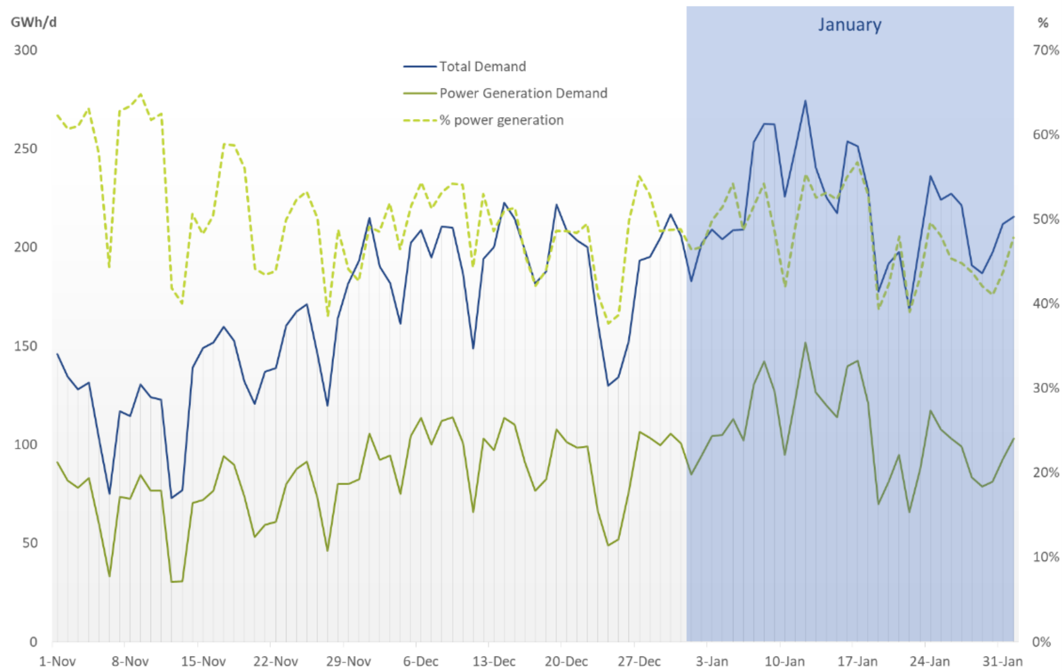


Figure 61 - Daily demand profile in Greece with a split for power generation and its percentage (Dec-16 to Feb-17) (Source: DESFA).

Regarding to electricity sector, several events influenced the situation in Greece:

- Outage of HVDC Link GR-IT. This interconnection was out of operation for months.
- Export NTC reduced to zero (curtailment on 11th and 12th January on all north borders) in order to ensure the security of supply.

Because of high electricity demand and events mentioned above, Greece was forced to cut its exports of electricity to neighbouring countries. The following figure show the generation mix in Greece during January 2017 compared with January 2016.

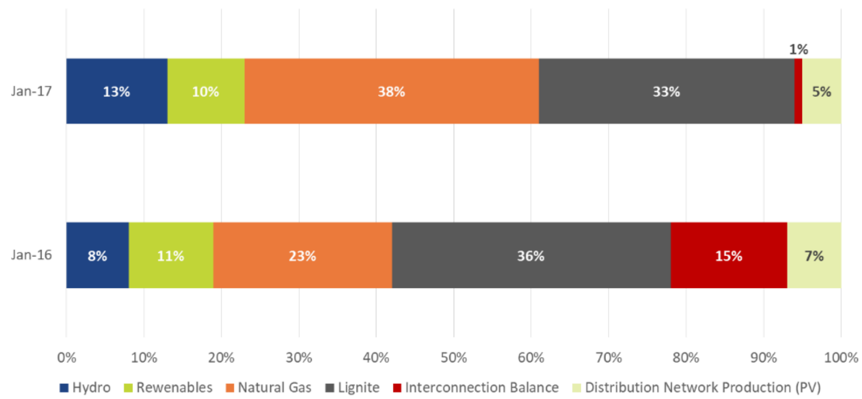


Figure 62 - Generation Mix in Greece (Jan-17 vs. Jan-16) (Source: GCG. Regulatory Authority for Energy. RAE)

5.3. Exceptionally cold situation (IT)

Italy (IT):

Weather conditions in Italy got worse soon after the beginning of 2017. Consequently, the Ministry of Economic Development declared the alert level in the natural gas system on January 9th, as adverse climatic events of exceptional intensity occurred and the contractual withdrawal threshold from storages was exceeded (in line with the emergency plan[13] in force).

The measures adopted were to perform a communication of the declaration to the stakeholders encouraging to increase imports using contract flexibility or by stipulating spot contracts.

- On 11th January, the Italian gas demand reached a peak of 4,482 GWh/d with an average of near to 4,200 GWh/d in the ten central working days of the month[14]. The aggregated country demand on January was exceeding 11 Bcm, a level not exceeded since 2006. Power generation sector counted for around 2.7 Bcm – with several days exceeding 100 mcm/d – and DSOs aggregated demand attained 6.7 Bcm, with peaks of near to 260 mcm/d on 10th and 11th January. .
- Also, in terms of power generation, the share of natural gas significantly increased up to 56% in January 2017 in parallel with receding of imports and wind generation.

[13] Italian Emergency Plan: http://www.sviluppoeconomico.gov.it/images/stories/documenti/Emergency_Plan-Italy_DM271213.pdf

[14] Average consumption registered in the periods between 9th to 13th and 16th to 20th January.

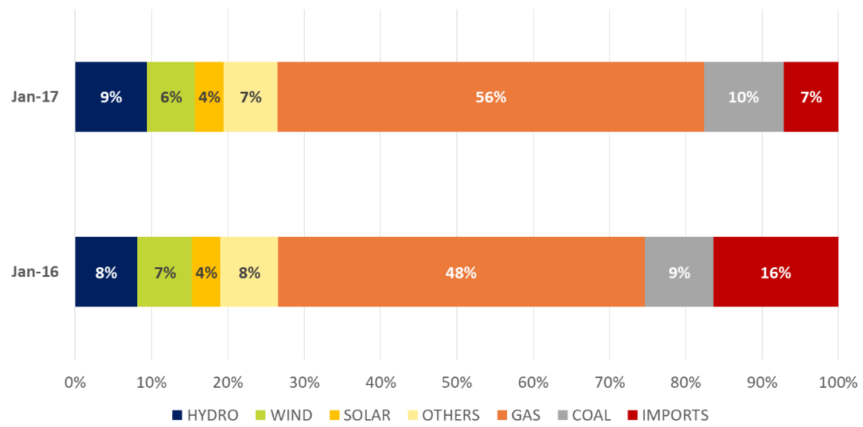


Figure 63 – Generation Mix in Italy (Jan-17 vs. Jan-16) (Source: Terna and ENTSO-E)

The following figure shows the comparison between daily gas demand in Italy in the period from December to February in Winters 2016/2017 and 2015/2016 with special focus on January 2017.

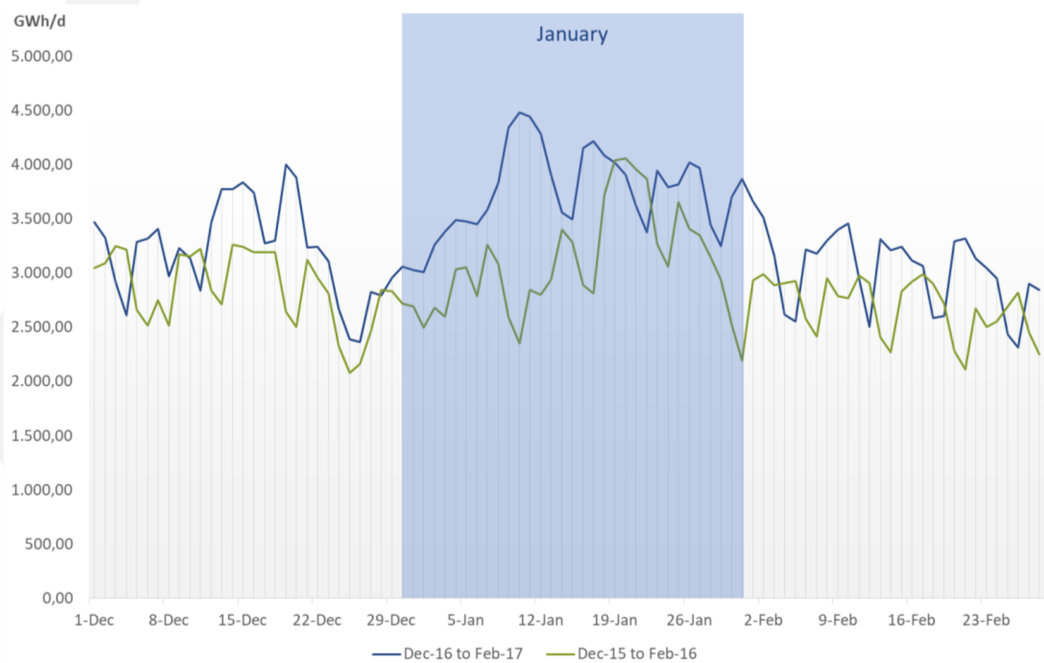


Figure 64 - Daily gas demand profile in Italy (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

The average daily demand in January 2017 (3,780 GWh/d) was 22% higher than in January 2016, while the peak demand in this month increased by 10% compared to previous January.

The main supplies during cold winter were UGS and gas imports. The following graph shows the gas imports to Italy during January and February 2017.

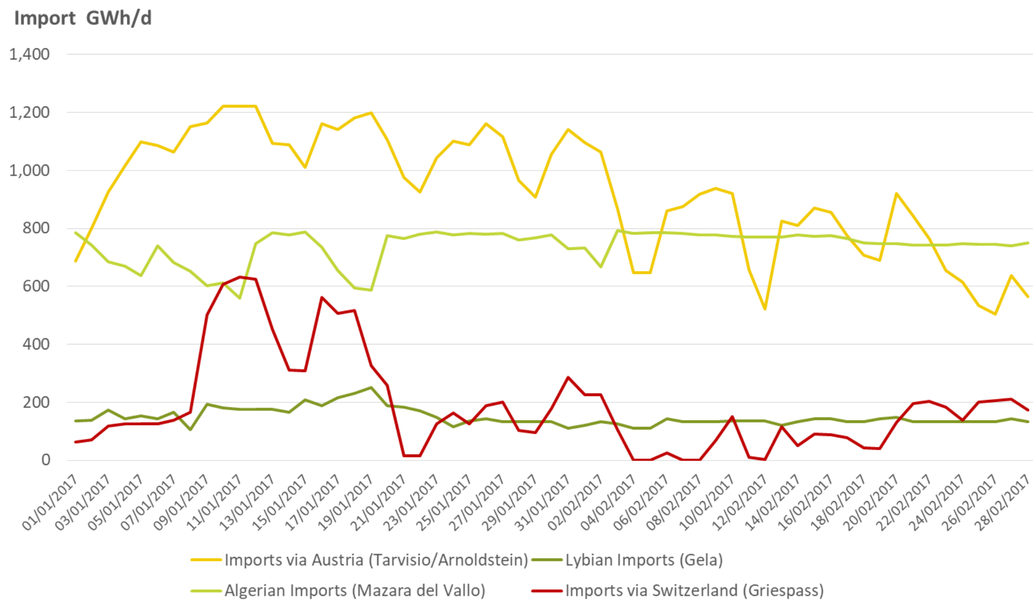


Figure 65 - Import flows to Italy at cross-border IPs during early 2017 (January cold snap and following period) (Source: Snam Rete Gas)

In Italy, the gas installed generation capacity represents 39% of the total installed capacity of power generation, with an availability around 71% during the cold spell. Therefore, the gas plants were the main support to supply the power system.

5.4. Cold situation combined with nuclear outage (FR, BE and ES).

France, Spain and Belgium contended with a cold spell during January combined with a lowest nuclear power availability in lthe ast ten years in France (five nuclear units were out of operation for exceptional maintenance). This situation triggered an especially high demand in terms of gas natural demand and power generation due to the increase of the exports of electricity to France to manage its situation.

The following chart shows the daily gas demand profile in the area in the period from December to February in Winter 2016/2017 compare with the Winter 2015/2016 (with special focus on January 2017).

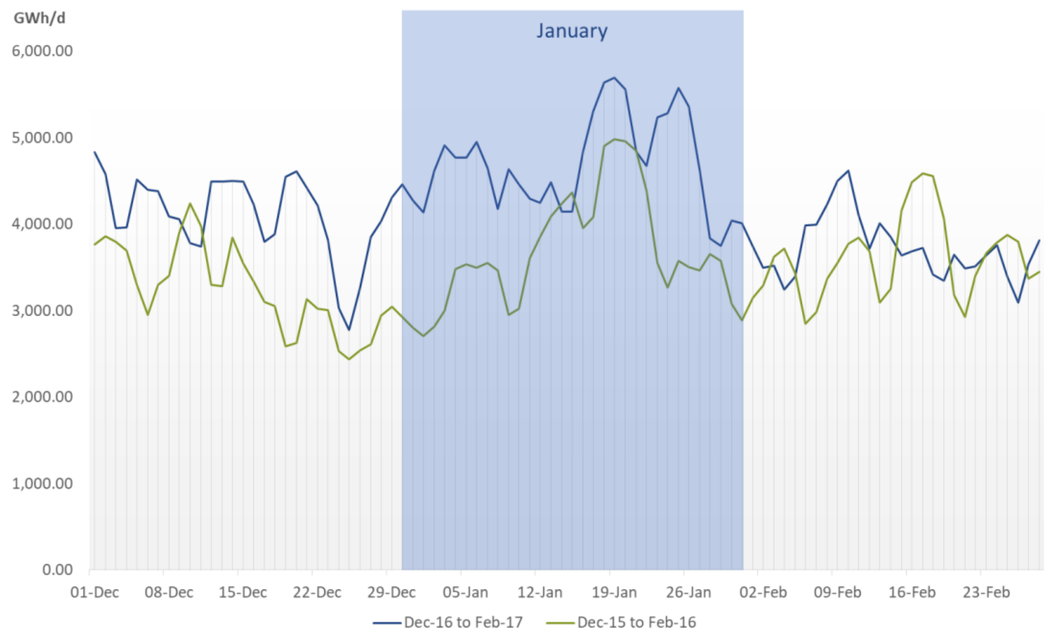


Figure 66 - Daily gas demand profile in France, Spain and Belgium (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

France (FR):

France experienced a difficult situation for both gas and electricity supplies in Winter 2016/2017.

The situation for gas concerned a congestion in the South East of France, which was previously identified with investments decided after a market consultation. Starting from November 2018, the congestions will be resolved by the commissioning of PCI Val de Saône pipeline and Gascogne Midi pipeline, and by the design of specific market mechanism to deal with remaining congestions, then creating a single market place in France.

During the month of January, LNG deliveries in Fos, an early and important withdrawal from salt cavern storages of the South-East, a high gas demand for power generation due to low availability of nuclear and hydro generation, and a period of cold days in in the South of France contributed to worsen the situation in the South of France.

LNG deliveries in Fos were below average values in December and January due to delivery problems related with a force majeure event on the liquefaction unit at Skikda in Algeria.

The following figure shows the total gas demand in France from December to February for this winter and for the previous winter.

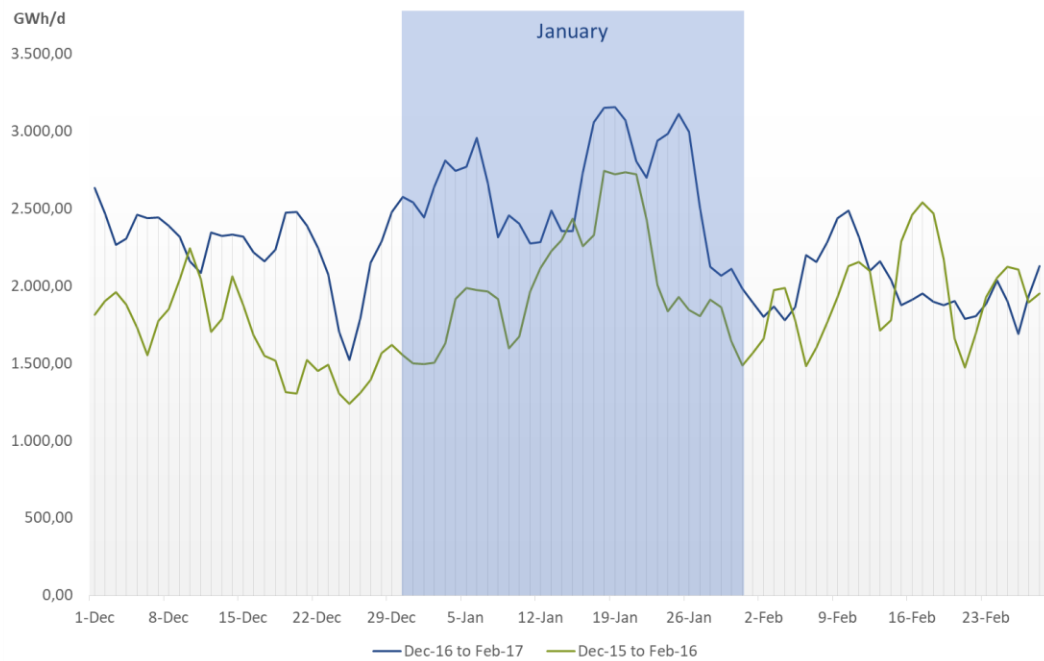


Figure 67 - Daily gas demand profile in France (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

The average daily demand during January 2017 was 30% higher than the previous January. Likewise, the peak demand during January 2017 compared to 2016 was 15% higher.

During this period of high demand, most of the flexibility in France was provided by UGS, taking a key role to provide security of supply during the peak days.

Measures taken during the winter: use of all compression units at maximal level, issue of warning messages requiring LNG deliveries, in particular in Fos, and recourse to specific contractual instructions to shippers (AIO).

The situation went back to normal in the beginning of February with the end of the cold period, and larger LNG deliveries in Fos, inducing available capacity at the North South Link and price convergence between TRS and PEG Nord.

For winter 2017-2018, French TSOs have prepared a new mechanism, called “spread localisé” designed to reduce congestions.

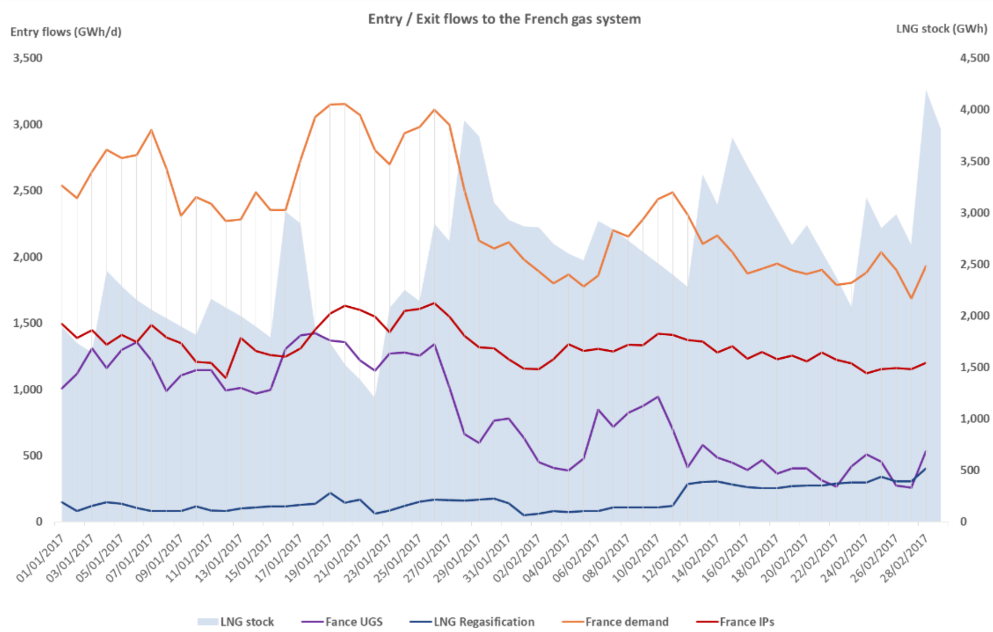


Figure 68 - Entry/Exits flows to the French gas system and LNG stock[15]. January and February 2017 (Source: TIGF and ALSI).

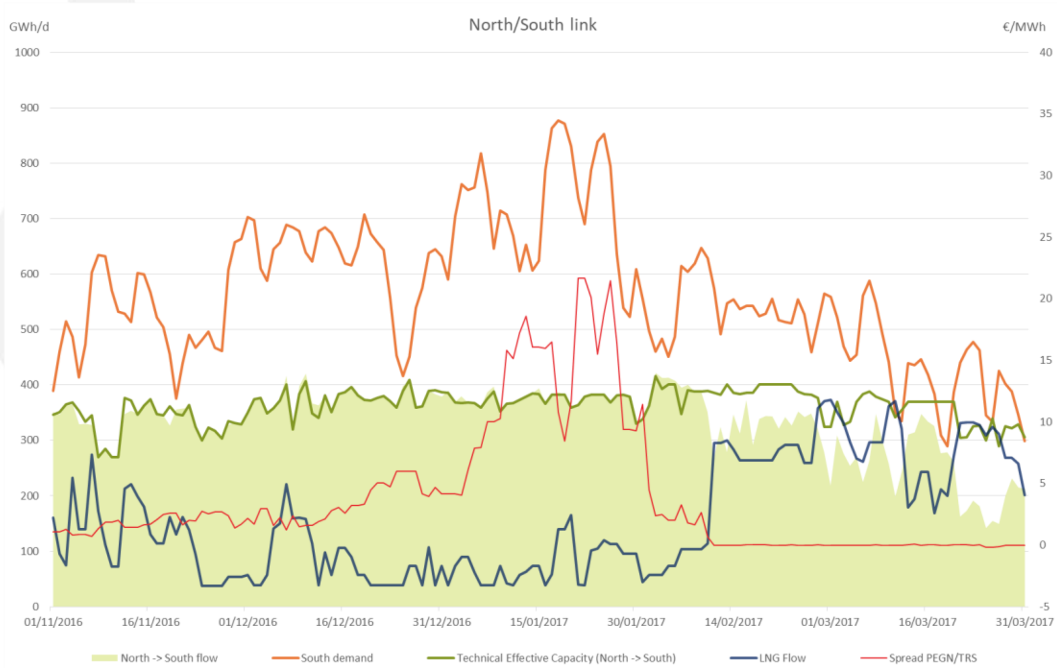


Figure 69 - Flows on North/South Link and spread PEGn/TRS from November 2016 to March 2017 (Source: GRTgaz).

[15] LNG Regasification and LNG stock are not directly related because of two reloads occurred in Montoir and two downloads in Fos during the period showed.

Regarding the power system during December 2016 and January 2017, France was in import balance for electricity for the first time since February 2012. This winter there were numerous long-lasting planning outages in nuclear power supply (up to 11 additional planned outages) reaching the lowest nuclear power availability in the last 10 years (-5GW). All these outages were performed in response to a request from the French nuclear security regulator (ASN) to carry out safety checks. These checks led the ASM to confirm all reactors are operational. In addition, low levels of rainfalls led to a low availability for hydraulic power generation. This lack of availability for nuclear and hydraulic generation led to a tense situation regarding the balance between demand and supply of electricity, particularly during the cold spell.

Gas fired power generation was one of the key elements used to cope with power demand. The average availability of the gas plants was 81% of installed capacity.

Other key features in addition to the cold snap were the electricity imports. The main imports to France were from Switzerland and Spain. The electricity imports from Spain reached 50% of the total of import needs of France (the other countries are Belgium and UK). This situation caused an increase in Spanish gas demand.

The following chart show the generation mix in January 2017 compared with January 2016 where the nuclear, wind and hydro generation are lower than the previous year while the gas generation and imports are higher.

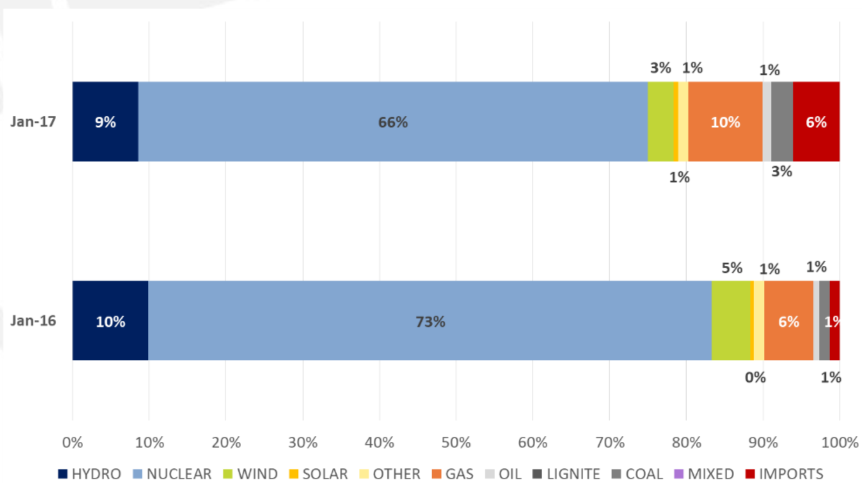


Figure 70 - Generation Mix in France. Jan-17 vs. Jan-16 (Source: ENTSO-E).

Spain (ES):

The power import needs of France caused an increase of gas demand in Spain and electricity exports from Spain to France (covered by gas power generation in Spain), as well as the low temperatures registered in some areas of Spain.
The gas demand on 19th January was the highest since 2012, reaching 1,589.19 GWh. This new record was mainly triggered by the high consumption of gas by combined cycle power stations. More specifically, deliveries of natural gas for electricity generation reached 360.71 GWh, reflecting the important role that natural gas plays in guaranteeing the power supply at a time of high demand and low hydropower generation. Meanwhile, conventional demand (for domestic, commercial and industrial use), reached 1,228.48 GWh.

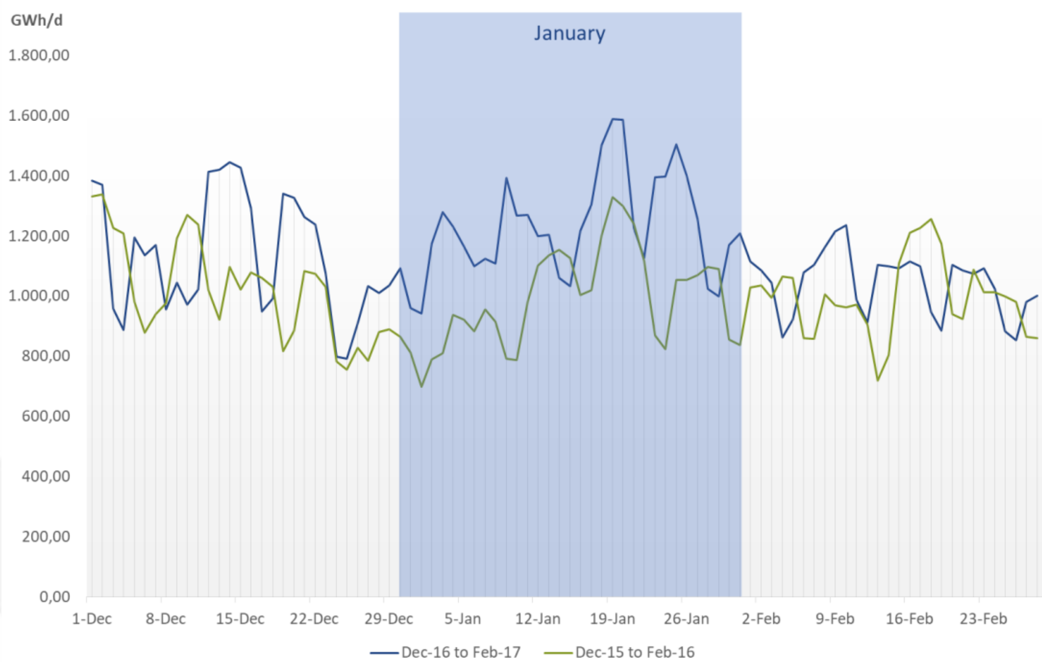


Figure 71 - Daily gas demand profile in Spain (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

The average daily demand during January 2017 was 24% higher than the one from previous year. Likewise, the peak demand during January 2017 compared with January 2016 was 20% higher.

During this high demand period in Spain, most of the flexibility was provided by LNG terminals, especially thanks to the high storage capacity in their tanks.

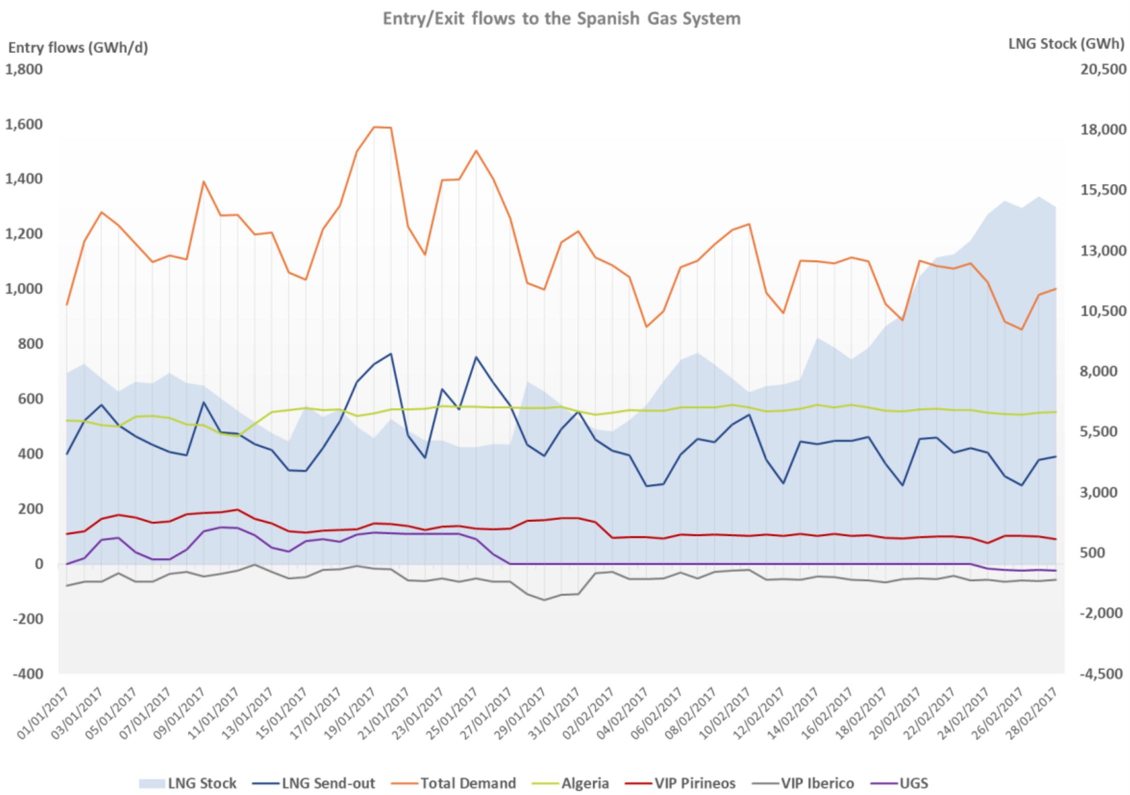


Figure 72 – Entry/Exits flows to the Spanish gas system and LNG stock. January - February 2017 (Source: South GRIP).

The generation mix in Spain during January 2017 has the same characteristics of the prior mentioned mixes. The wind and hydro generation was lower than the same period in the previous year whereas the use of natural gas to produce electricity was higher.

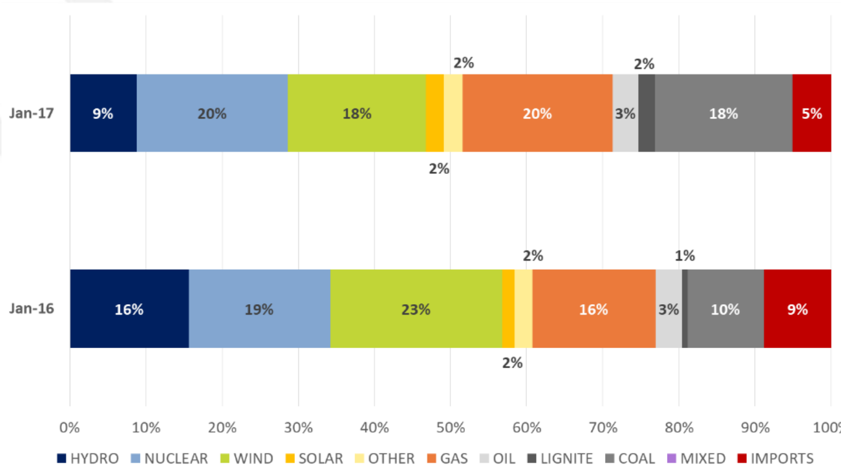


Figure 73 - Generation Mix in Spain. Jan-17 vs. Jan-16 (Source: ENTSO-E).

Belgium:

During the last two weeks of January, Belgium faced a cold spell. Combined with very weak wind conditions and the unavailability of one nuclear power plant, this set of conditions increased the gas demand needed for gas fired electricity production.

Therefore, the gas fired power plants ran at a relatively high load factor at the end of January. An emergency level of electricity supply was never reached and the strategic reserve, built up to secure enough supply of electricity during situations when market based electricity production is not able to cover consumption, did not start up during that period.

The following figure show a comparison between the generation mix in January 2016 and in January 2017. The use of natural gas to produce electricity increased since 23% to 34% providing the flexibility to the system while the wind and nuclear generation was lower than the previous year.

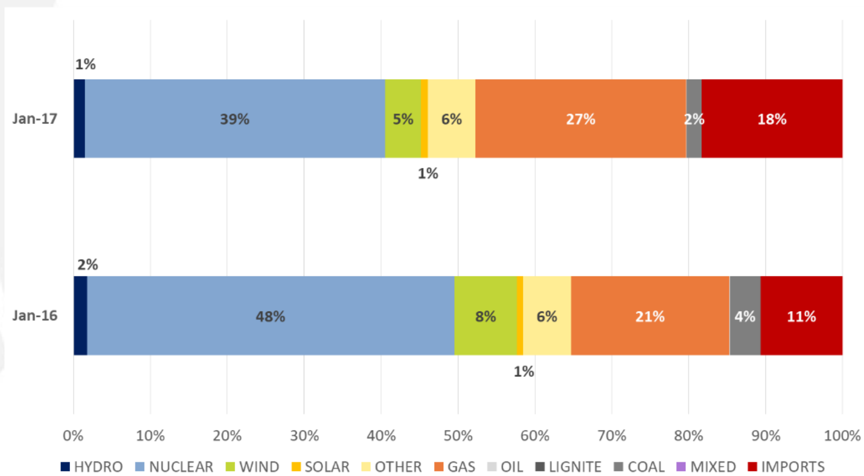


Figure 74 – Generation Mix in Belgium. Jan-17 vs. Jan-16 (Source: ENTSO-E).

The following figure shows the comparison between total gas demand in Belgium in the period of December to February in Winter 2016/2017 and in Winter 2015/2016 with a special focus on January 2017.

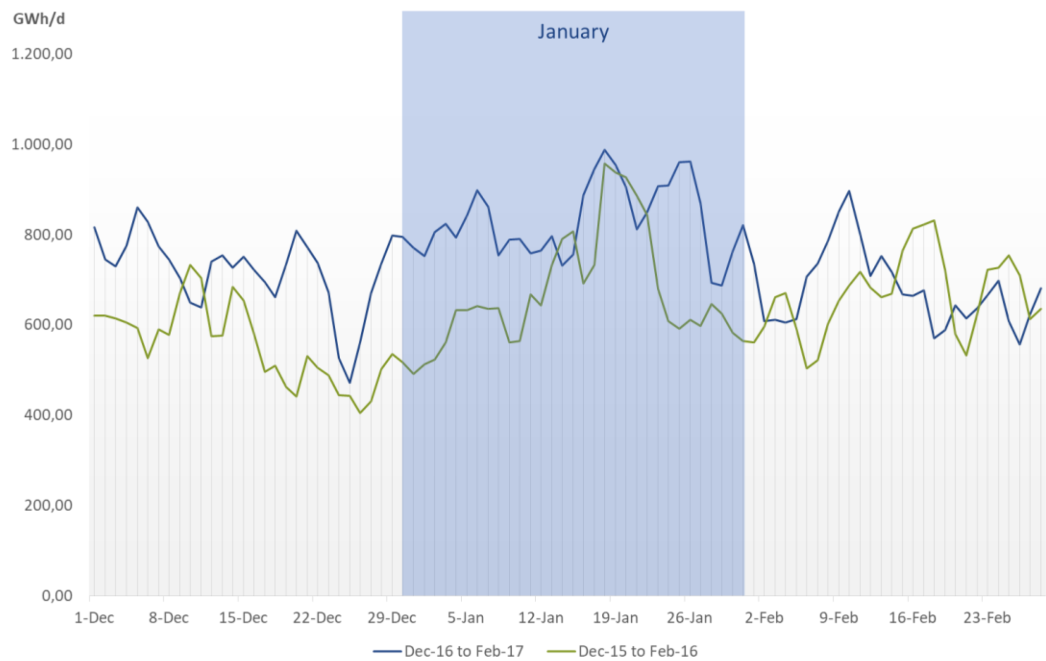


Figure 75 - Daily gas demand profile in Belgium (Dec-16 to Feb-17 vs. Dec-15 to Feb-16).

The average daily demand in January 2017 was 23% higher than in January 2016, while the peak demand during the same month was only slightly higher than previous January.

The Belgian gas network never encountered a restricted situation, which was reflected by the relatively low gas price at the ZEE and ZTP trading points. Compared with the electricity spot price, the gas price at ZPT and ZEE was stable all over the winter period.

High entry flows at some border points were observed, although the peak entry capacity was not reached. Moreover, the diversification of gas sources (Norway/Netherlands/Germany) guaranteed a high level of security of supply, even with the observed low LNG deliveries.

Together with the increased need for gas to supply the domestic market and power plants, significant quantities were transported towards UK and France.

This analysis shows the Belgian gas network was able to deliver the necessary gas supply for electricity production. Furthermore, there is enough flexibility and supply diversification to cover limited situations with lower temperature than those observed during last winter.

5.5. Conclusions about Cold Spell on January 2017

The European gas system coped with different events and extraordinary conditions that showed the robustness and flexibility of the system and the infrastructures, providing the power system a secure energy source.

The capacity to handle fluctuations of the gas system is even more important to meet these situations (cold snap, etc.), as the share of renewable generation in the power system continue to increase. In this sense, the gas infrastructure, storages, LNG terminals and pipelines have allowed the transport of energy efficiently, providing flexibility and reliability to the overall energy system at an acceptable cost for society.

This winter, natural gas has been essential in the provision of flexibility and security to power generation system, as a backup to both renewables energies and nuclear plants, and in the supply energy to the final consumers.

Regional Coordination System for Gas (ReCo).

A dedicated ReCo System for Gas has been established with means and tools to help TSOs towards their efforts to improve capacity of reaction under a security of gas supply (SoS) crisis and to coordinate the necessary actions on an operational level. The ReCo System for Gas is an international standing transmission system operators' expert group able to provide operational expertise on an ad-hoc basis to concerned TSOs in order to mitigate the consequences of a gas supply crisis. This can involve the TSOs providing an overview of the gas supply flows and exchanging relevant operational information, to enable an efficient coordination and cooperation between TSOs in the regions impacted by the specific SoS situation.

The main tasks for the ReCo System for Gas are:

- Preventing and operating SoS crises.
- Facilitating regional activities on SoS Regulation.
- Providing expertise to the Gas Coordination Group.
- Providing maintenance information if required.

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