MANAGING CRITICAL GRID SITUATIONS – SUCCESS & CHALLENGES

ENTSO-E REPORT OF THE JANUARY 2017 COLD SPELL

MAY 2017

European Network of
Transmission System Operators
for Electricity

entsoe

CONTENT

EXECUTIVE SUMMARY

An exceptional situation in January 2017 in Continental Europe resulted in system adequacy and network security issues due to cold spell in several countries. This report confirms that the measures applied during the cold spell period were effective in preventing supply interruption during all times and even more, helped to avoid use of extraordinary measures such as manual load shedding in most critical times.

The cold spell, combined with the effects of the other factors which took place, in its severity was unexpected and while indeed the Seasonal Outlook did not foresee this type of event, potential adequacy issues were foreseen for France.

The extended nature of the cold spell affecting multiple countries simultaneously coupled with the challenges faced in terms of generation adequacy issues (low reservoir levels, outages of key nuclear units, coal and gas supplies disrupted, etc.) by each country over this period was also unprecedented over many past decades.

At the same time and despite such a rare and serious event, the measures developed and the steps undertaken by TSOs, ensured uninterrupted supply and secure system and market operation during the whole duration of cold spell; it is evident that the coordinated approach of European TSOs prevented further crisis escalation.

Furthermore, cooperation of TSOs and RSCs was demonstrated throughout the whole period. The cold spell was managed effectively at both: the regional and the local level, showing the efficiency and complementarity of the existing inter-TSO coordination and the efficiency of RSCs support to TSOs in the regions where RSCs are active, both in their regular and extraordinary conditions. The new RSC service "short-medium term adequacy", although still under development, already demonstrated in the Continental Western Europe (CWE) region, its added-value to better manage the adequacy issues at regional level. Regional coordination in South East Europe, if it had been implemented such as in CWE, would have supported the TSOs in this region in addressing the adequacy shortages.

Updating forecast in shorter time periods has been shown as very relevant, whereas mid-term forecasts (week-ahead) showed they allow to trigger and set-up exceptional organisation sufficiently in advance to deliver adapted answers closer to real time. For example, there were big differences between Week-1 forecasts and real time, e. g. 94 GW actual consumption in France compared with 101 GW forecasted in Week-1, making it difficult to anticipate the effective adequacy scenarios and actions to be taken. In case the forecasts would have been realised the situation would have been much more complicated.

Our Key Focus Areas are to show that improved processes at TSO and regional level would be beneficial ensuring both, security of operation and security of electricity supply in Europe. The steps foreseen through the application of the proposed regulation on risk preparedness plans in the Clean Energy Package seem promising to develop and implement enhanced principles and processes at regional level in order to face very rare and tight situations affecting more than one country.

This report provides factual information as to the events which occurred during cold spell of winter 2016/2017 in countries which experienced exceptional challenges during that period. Based on these facts, lessons learned and related areas of focus for the future are presented in chapter 6. It is expected that this report will be updated at a later date with further analysis in regard to market aspects of the cold spell.

1. SETTING THE SCENE

The ENTSO-E Winter Outlook 2016/2017 indicated that cold weather combined with reduced generation capacity in some areas could lead to adequacy problems in France and in some neighbouring countries. The actual situation we faced was indeed affecting this area but was also exceptional in the east of Europe.

The system operation in reality confirmed this forecast as correct and the tight situation was indeed experienced in Continental Europe in January 2017. In South Eastern European countries, a very severe cold wave occurred with temperatures even much lower than one-in-ten-year situations which were assessed in Seasonal Outlook. Further weather phenomena, including snowstorms, avalanches, rivers droughts, occurred which had a significant impact on generation and transmission.

This report provides factual information as to the events which occurred during cold spell of winter 2016/2017 in countries which experienced exceptional challenges during that period. Based on these facts, lessons learned and related areas of focus for the future are presented in chapter 6. It is expected that this report will be updated at a later date with further analysis in regard to market aspects of the cold spell. From mid of January 2017, the tight situation spread quickly through a number of countries and the challenge of meeting electricity demand became even bigger. Weather conditions led to a reduction of reserve capacities, demanding extraordinary efforts and measures from TSOs to maintain security of operation and supply. The lowest temperatures and hence worsening adequacy situation was reached in the 3rd and 4th week of January, with some regional differences. On 25 January 2017, in some countries, the status of the "European Awareness System" (This is an important system which contains "traffic lights" indicating power system conditions of a given TSO in terms of N-1 security, reserves, adequacy, etc.) was raised at an alert level indicating insufficient short-term reserves compared to required values to cover demand-generation equilibrium variability. Nevertheless, and despite such extreme conditions all the affected TSOs were able to manage the situation with collective collaboration and mutual support by other TSOs of Continental Europe.

With consideration to its role to inform stakeholders, citizens and institutions on the power system management, especially in crisis situations, ENTSO-E provides this report focusing on the management of the cold spell affecting Continental Europe in January 2017. This is consistent with the mandate provided to ENTSO-E by European legislation and to the role of its member TSOs. The report builds upon the actual experiences and daily information exchange with coordination among the TSOs' control centres and operational staff, which have been included here in order to extract the most important experiences and lessons learned.

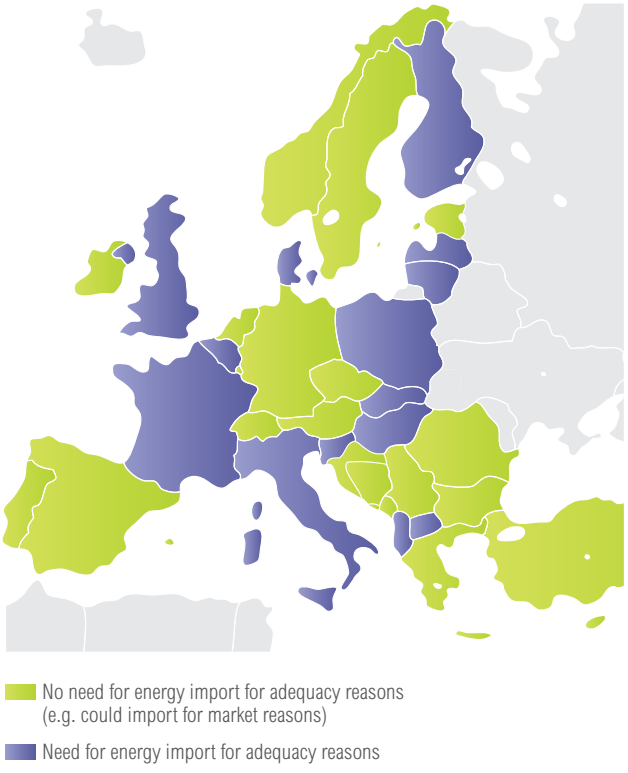

Figure 1.1: Generation adequacy map at peak time under severe conditions
(Source: ENTSO-E Winter Outlook Report for 2016/2017)

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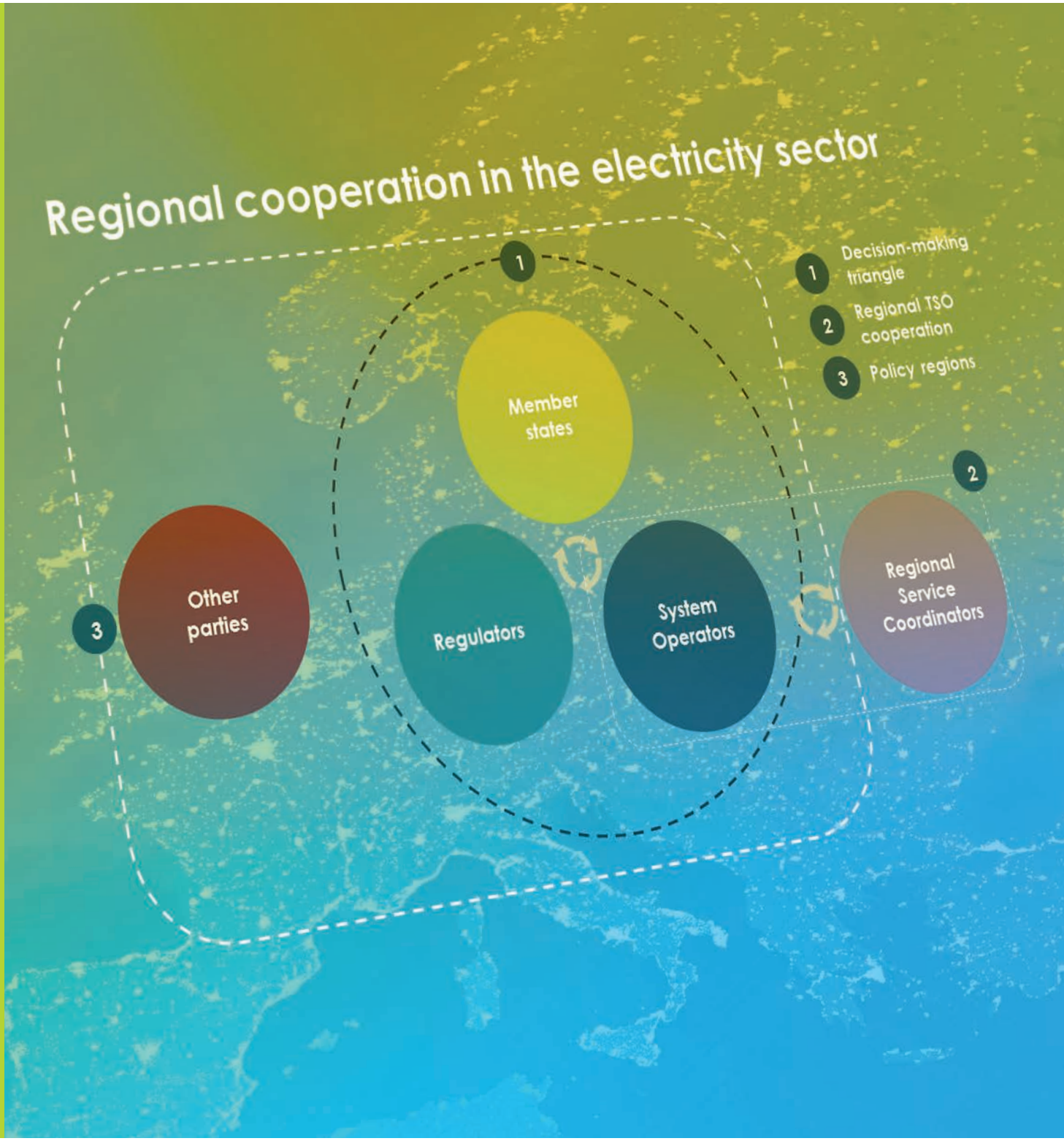
2. OUR ROLES

TSOs are responsible for maintaining the security of the power system and are supported by Regional Security Coordinators (RSCs) who provide valuable regional services. ENTSO-E fosters the cooperation of TSOs and supports the development of new tools and analysis.



2.1 WHAT'S THE ROLE OF THE TSO?

The Transmission System Operator (TSO) is responsible for a stable power system operation, including the organisation of physical balance, of a transmission grid in a geographical area. Transmission means the transport of electricity on the extra high or high voltage network with a view to its delivery to final customers or to distributors.

Operation of transmission system(s) includes the tasks of system operation concerning its management of energy flows, reliability of the system and availability of all necessary system services.

The TSOs are therefore responsible for security of supply in a geographical area(s) and plan decades ahead, the 10-year Network Development Plan (TYNDP) at national and European level, how the grid will need to evolve. This plan takes into account key aspects in the power system such as movement toward more decentralisation, more renewables, storage, greater role for markets. TSOs need to plan 5 to 10 years in advance to assess whether the system can meet the demand called a System Adequacy Assessment at National but also European level called the Medium-term Adequacy Forecst (MAF).

From a year in advance to real time, TSOs review maintenance outage plans, run a continuous series of calculations and adapt their assumptions constantly to new issues arising on their grid but also that of their neighbours – notably through RSCs but also through the European Awareness System. In real time, where the situation deviates from that expected in a way that security of supply is or could be endangered, TSOs have to react quickly, sometimes even in a minute, to correct the situation and the control rooms have to remain in close coordination to handle these situations.

Market parties role is to establish commercial transactions between them in order to allow suppliers to deliver the expected energy requested by consumers. TSOs ensure converting those transactions into a physical reality through the safe operation of the system, second by second.

2.2 WHAT'S THE ROLE OF ENTSO-E?

ENTSO-E's role is to facilitate the regional coordination between TSOs to ensure effective and transparent access to the transmission systems and to provide coordinated and forward-looking planning.

In December 2015[1)], ENTSO-E and TSOs signed the Multi-Lateral Agreement (MLA) for Regional Security Coordinators and in May 2016 the System Operation Guideline was adopted by law mandating the Regional Coordination by all TSOs in the EEA.

ENTSO-E's role in the MLA and the System Operation guideline is to support the TSOs and facilitate the implementation of the Regional Coordination Strategy. ENTSO-E provides a data exchange platform for all TSOs to share IT tools and systems including the development of the Operational Planning and Data Exchange, the Common Grid Model which will enhance operational planning at regional and pan European level.

Under ENTSO-E's Regional structures for Continental Europe, there is an important group called Coordinated System Operation where all TSOs exchange information with each other on the status of the power systems.

1) Multilateral Agreement on Participation in Regional Security Coordination Initiatives, December 2015, www.entsoe.eu.

2.3 WHAT SERVICES DOES AN RSC OFFER NOW AND IN THE FUTURE?

Today, RSCs are already playing a key role in regional TSO cooperation providing grid models, based on TSOs individual set of data and deliver services for regional security analysis and capacity calculation to a number of TSOs in continental Europe.

Operating the power grid in real-time remains the responsibility of TSOs, but TSOs will increasingly perform this task by relying on the information provided by the RSCs. In regions where RSCs are operational, the RSCs support TSOs from one year ahead up to one hour before dispatch and run calculations and make recommendations that TSOs validate and apply.

The TSO coordination with the supporting role of the RSCs increases efficiency in system operation, minimises risks of wide area events, such as brownouts or blackouts, and lowers costs through maximised availability of transmission capacity to market participants. Additionally, a much deeper coordination between operators close to real-time is needed to integrate more renewables into the grid and reduce carbon emissions cost-effectively and safely.

The System Operations Guideline formalises the role of the RSCs and makes it mandatory for all TSOs to join a RSC. In that sense, the previously voluntary character of TSO cooperation, in line with which all TSOs had subscribed, has become a legal framework on a formal arrangement.

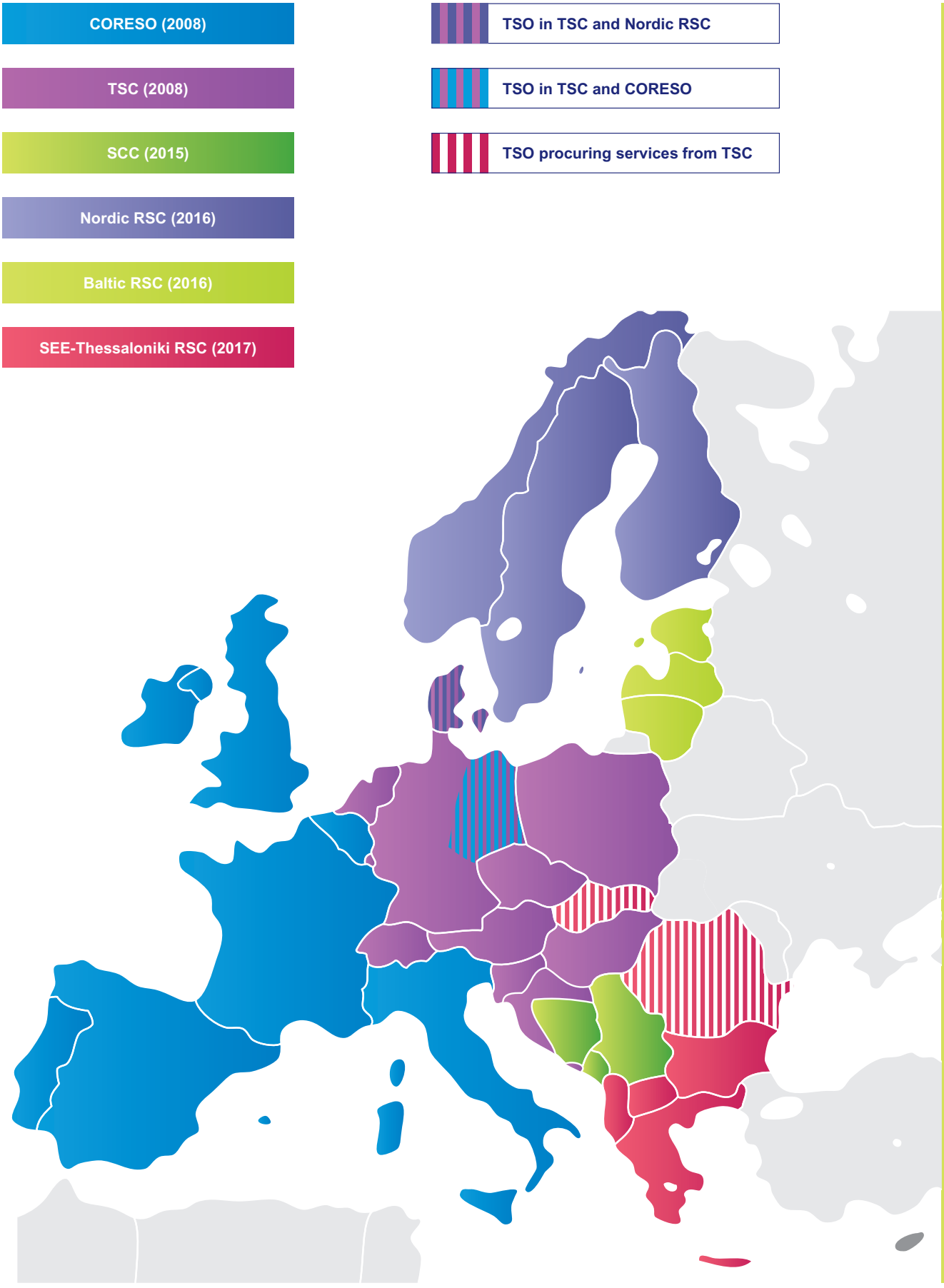
In the multilateral agreement that ENTSO-E members have all signed – which is just about to be legally enforced by the Part III of the European regulation establishing the guideline on electricity system operation[2)], RSCs must carry out five services.

- Security analysis
- Capacity calculation
- Outage coordination
- Adequacy forecast
- Common grid model

The formal legislation through the System Operation Guideline, most importantly, allows for future amendment of the legal framework and addressing dynamic developments in regional cooperation. The tasks performed by RSCs include monitoring and assessing the security of the electrical system at the regional level and initiating and coordinating appropriate initiatives with the relevant TSOs to ensure the security of the supply on a European scale.

It is expected that by 2019, as the first step, all five services must be implemented across Europe. For the next decade, ENTSO-E expects more services to be regionalised, with amendments to the System Operations Guideline accordingly.

2) System Operation Guideline, SO GL expected to enter into force during summer 2017


CORESO (2008)
TSC (2008)
SCC (2015)
Nordic RSC (2016)
Baltic RSC (2016)
SEE-Thessaloniki RSC (2017)
TSO in TSC and Nordic RSC
TSO in TSC and CORESO
TSO procuring services from TSC

3. THE COLD SPELL AT A GLANCE

This section provides a snapshot assessment of the Cold Spell and the following tables provide an overview by countries affected by the cold spell in terms of:

1. What did the Seasonal Outlook say?
2. How was the System Security affected?

Whereas the high coherence between the forecast and actual operational situation confirms the value and accuracy of Seasonal Outlooks, the details – including national/regional specifics – presented thereafter, highlight the full complexity and depth of the "actual" situation in the system operation and market.

3.1 FRANCE

What did the Seasonal Outlook say?	How was the System Security affected?
• Due to the high sensitivity of load to temperature in France, risk can appear during cold waves (at least 3 °C and 5 °C below normal conditions in December and January respectively). • Lowest nuclear power availability in the last 10 years (−5 GW). • Adequacy risk is assessed at 4 % in the Weeks 49 to 51 of December compared to 3 % in Week 2 of January 2017. • Measures were put in place including contracted emergency load reduction measures and potentially load curtailment during peak hours to mitigate potential adequacy risks for the coming winter.	• With respect to lack of generation availability, due to sensitivity of load to temperature (2,400 MW/°C), it was forecasted a high level of consumption and so it was anticipated the need for so-called "exceptional measures" such as activating contractual industrial shedding, reducing 5 % of voltage and even domestic load curtailment during peak hours. • Temperature was finally not so cold (−6 °C below normal conditions), but "only" corresponding to a decennial occurrence, hence there was no need to activate exceptional measures. • Market-based demand side response played a significant role to face the situation during all the cold spell • Day-ahead and real time margins were below requirements at some peak hours (weeks 3 and week 4). • IFA cable capacity was limited to 1 GW due to unplanned outage since November 2016

3.2 ITALY

What did the Seasonal Outlook say?	How was the System Security affected?
• From 2012 to the end of June 2016 about 15 GW of conventional dispatchable generation was decommissioned. In addition, reduction of available capacity around 6 GW due to mothballing or authorisation and legal constraints (e. g. environmental constraints) • In normal conditions, no adequacy problem expected • Under severe conditions, national remaining capacity (not considering imports) was expected to become negative in some weeks, but import capacity was expected to be sufficient.	• Problems in fulfilling operational security limits • Trip of 3 OHLs of 400 kV connecting the north and the south of Italy due to heavy snow conditions, with consequent reduction of the possibility to share operational reserves at national level • 18 and 19 January: NTC in export direction on the Italian northern border was limited

3.3 SWITZERLAND

What did the Seasonal Outlook say?	How was the System Security affected?
• No problems expected in general, but it did note that deterministic capacity-based assessments [MW] cannot reveal potential problems faced by hydro-dominant countries like Switzerland.	• Potential critical network situation for 18 and 19 January 2017 which was addressed by an NTC reduction on Swiss-Italian border by up to 2,500 MW. This was based on a forecast of unusual simultaneous high export to both France and Italy.

3.4 BELGIUM

What did the Seasonal Outlook say?	How was the System Security affected?
• The Belgian power system expected no adequacy issues for winter 2016/2017 because of the return of nuclear power plants Doel 3 & Tihange 2 last year (each ~ 1,000 MW). The balance between generation and consumption should be ensured. However, in a severe winter situation, Belgium is still dependent on imports to cover the demand. • The forecasted NTC values are based on the max import calculation of flow-based approach. • For winter 2016/2017 Belgium still has 750 MW of strategic reserves contracted to be used to avoid scarcity situations. Without the strategic reserves, the margins for Belgium would be smaller.	• As foreseen during the week-ahead adequacy forecasts for Belgium, margins were expected to be very tight. It was however expected that the Belgian strategic reserves would be sufficient to avoid more extreme measures in Belgium. • Finally, during the cold spell, Belgian market parties could source sufficient volumes abroad leading to an overall situation where adequacy in Belgium could be maintained, even without the use of strategic reserves. • Due to significantly lower solar and wind infeed compared to the day-ahead forecasts, on one day (25/01), Elia had to activate a large portion of its contracted reserves to maintain balance (and consequently set a yellow EAS status). • In general, system security was maintained throughout the cold spell. High flows through the Belgian grid have however led to the extensive use of topological actions including the use of the Belgian PSTs (Phase Shift Transformers) in order to avoid further constraints.

3.5 ROMANIA

What did the Seasonal Outlook say?	How was the System Security affected?
• The Outlook for winter 2016/2017 did not indicate any problem which could affect the Romanian Power System adequacy, for both normal and severe conditions. • In case of a gas crisis, certain thermal power plants can be switched from gas-fired operation to oil fired operation. In this way, a possible gas crisis will not endanger the system adequacy during the coming winter.	• High level of commercial deficit needed to cover the hourly load curve. • High system load lead to very high use of reserves, but without exhausting all the reserves and breaking the N-1 criterion. • No limitations on interchange capacity and/or export schedules. • Government Decision from 10 to 13 January 2017 related to safeguard measures (e.g. curtailment of exports) was preventively issued but not applied. No Force Majeure applied.

3.6 BULGARIA

What did the Seasonal Outlook say?	How was the System Security affected?
• No risk of adequacy identified even in case of a 2-week cold spell with a simultaneous interruption of gas transit through Ukraine. • Under severe conditions there would be 2 GW of remaining capacity.	• 06/01: the cold reserve capacities (total 550 MW) were able to produce only 350–400 MW. • 11/01: emergency assistance requested, but no neighbouring TSOs could provide. • The Minister of Energy issued an order for limitation of power exports with Bulgarian origin, but without interfering with the commercial power transits.

3.7 GREECE

What did the Seasonal Outlook say?	How was the System Security affected?
• The most critical period during winter: the second half of December 2016 and January 2017. • Moderate imports are needed to meet the operating criteria under normal conditions	• Attempts to receive emergency assistance from neighbouring TSOs were not successful. • Export NTC reduced to zero on 11 and 12 January on all borders. • GR–IT interconnection out of operation.

4. DETAILED OVERVIEW OF EACH COUNTRY'S ACTIONS

This section contains an in-depth overview of specific conditions as described by individual TSOs from the affected countries and includes a number of other countries which were involved in the support to the affected TSOs during the Cold Spell.

ELIA CONTROL ROOM

4.1 FRANCE / RTE

4.1.1 SEQUENCE OF EVENTS

Ahead of the January cold spell, preparation was undertaken during the Autumn 2016. As regards the regional coordination to facilitate mitigating the forecasted adequacy risk, significant and conclusive work was achieved with the TSOs of the region and with Coreso and TSCNet to find specific exceptional solutions to improve the import capacities during the cold spell. Design of these solutions included use of measures such as cancelling planned outages, which are not used in normal operation. This resulted in particular organisations set-up for capacity calculations (see 4.1.7), all-TSOs daily conference to exchange on forecasted situations in each country and optimize possible operation solutions.

The main sequence of events, including the cases where optimised import capacity was made available mainly due to cooperation with neighbouring TSOs and support from the RSC which RTE relies upon (Coreso) is shown for France in the following table.

Day	Hour	Events
16/01/2017	05:00 h	Numerous forced outages on generation (up to 1,700 MW) during the weekend 14 – 15 January
	21:00 h	RTE declares Mutual Emergency Assistance Service (MEAS) TSO-TSO contracts unavailable until 17/01 10:00 h. BALIT service made unavailable until 17/01 23:59 h
18/01/2017	23:30 h	RTE declares MEAS TSO-TSO contracts unavailable to Belgium, Germany, Switzerland, Italy
19/01/2017	15:00 – 24:00 h	Import capacity from Spain raised to 2,500 MW
	18:00 – 22:00 h	Import capacity from Switzerland raised to 2,200 MW
20/01/2017	00:30 h	RTE declares MEAS TSO-TSO contracts unavailable to Belgium, Germany, Switzerland, Italy from 07:00 h to 13:00 h
	00:00 – 24:00 h	Import capacity from Spain raised to 2,500 MW
	18:00 – 20:00 h	Import capacity from Switzerland raised to 1,600 MW
25/01/2017	07:00 h	RTE declares MEAS TSO-TSO contracts unavailable until 09:00 h
	11:00 h	Forced outage CCGT (– 400 MW)
	13:00 h	Alert State EAS (insufficient margin) RTE declares MEAS TSO-TSO contracts unavailable until 20:00 h
	13:50 h	TSO-TSO contract activated with TERNA (300 MW) from 14:00 h to 17:00 h
	15:30 h	Forced outages Fuel (– 300 MW) and Nuclear (– 300 MW)
	16:00 h	Emergency State EAS (insufficient margin)
	16:45 h	TSO-TSO contract activated with ELIA (250 MW) from 17:00 h to 19:00 h

4.1.2 GENERATION OVERVIEW

The installed and available capacities for three most critical days of 16 January, 20 January and 25 January 2017 are shown below.

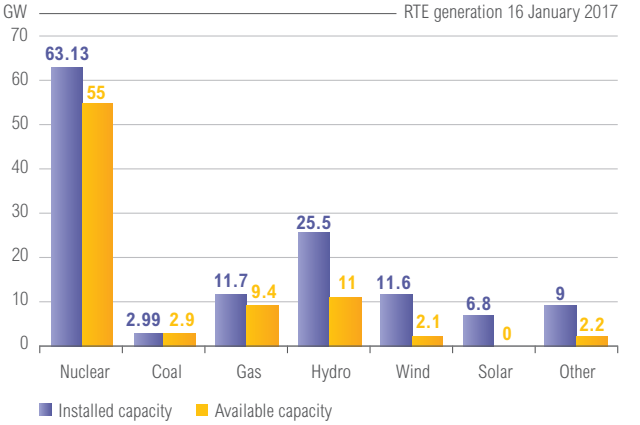


Figure 4.1: RTE generation 16 January 2017

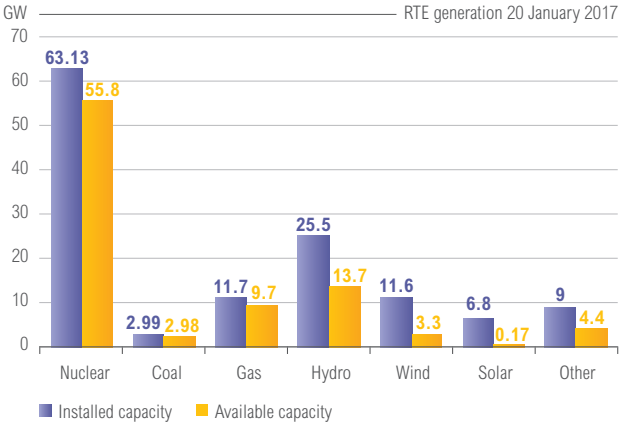


Figure 4.2: RTE generation 20 January 2017

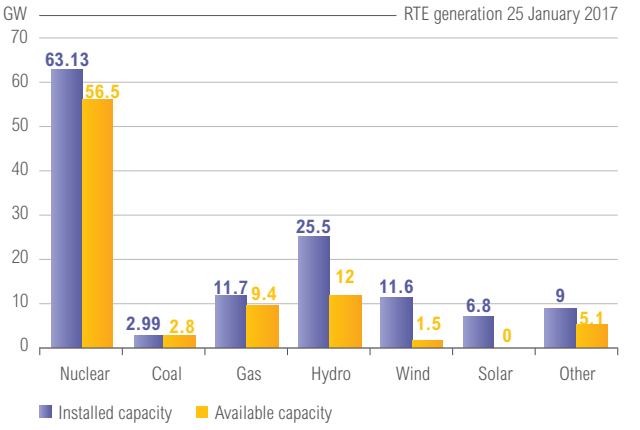


Figure 4.3: RTE generation 25 January 2017

COMMENTARY

The key facts and information from these three figures:

- Generation unavailability was even higher due to five nuclear units which were out of operation for (exceptional) maintenance
- In total up to 10 GW thermal generation was unavailable (nuclear and conventional).
- The "Available" hydro generation reported is the maximum used value. The "maximum" value is not meaningful as a large part of this capacity is located in a valley equipped with successive dams, subject to limited energy linked to reservoir levels and operational/environmental constraints.

4.1.3 CONSUMPTION RECORDED

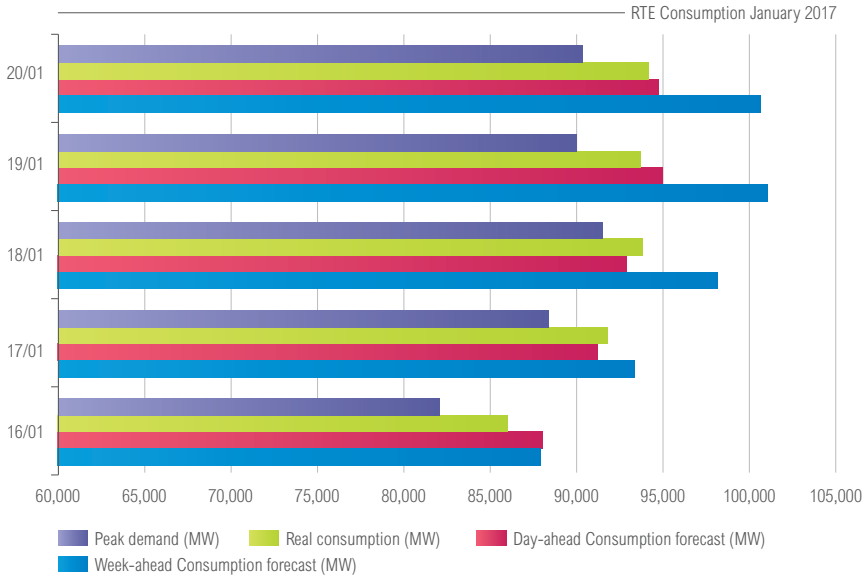


Figure 4.4: RTE consumption January 2017

COMMENTARY

- Week-ahead forecasts are built on Friday for next week and do not take account of possible unknown market-based DSR, whereas Day-ahead forecasts include market-agreed DSR activations.
- French consumption increases around 2.4 GW for 1 °C temperature drop.

4.1.4 SYSTEM RESERVES*

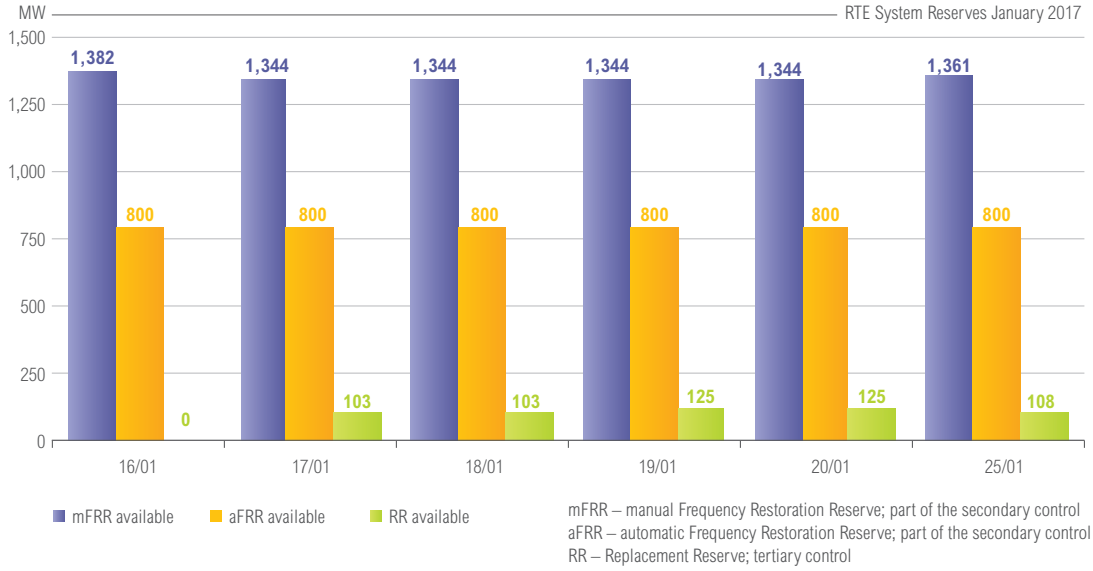


Figure 4.5: RTE system reserves January 2017

COMMENTARY

- FRRs described are composed of mFRR values and aFRR values (capacity required by RTE can change from 1/2 h, but was around 800 MW all week, as shown).
- The whole FRR capacities were used as needed to face real time regulation.
- mentioned RR values concern only additional RR available within 30 minutes delay

*Note that Replacement Reserve (RR) is not mandatory as defined in Operational Handbook for Continental Europe.

4.1.5 WEATHER SITUATION

Day	Temperatures recorded [°C]	Delta to normal Average temp [°C]
16/01	3.3	−1.9
17/01	−0.2	−5.1
18/01	−1.2	−6.1
19/01	−1.1	−6.1
20/01	−0.5	−5.5
25/01	−0.2	−5.4

COMMENTARY

- The temperatures presented are national averages.
- Very low temperatures recorded, equivalent to decennial cold wave. The table illustrates the strong impact of weather conditions on the load level and therefore the forecasted adequacy issues when combined with reduced generation availability.
- 5 to 6 °C below reference temperature, which implies an increase of the load in the range of 13,000 MW.

4.1.6 POWER GRID SITUATION

The interconnector between France and the United Kingdom (IFA) cable capacity limited to 1 GW (usually 2 GW) due to unplanned outage since November 2016.

4.1.7 KEY ANALYSIS

Due to cooperation with other TSOs, and with support from Coreso, the following experiences are underlined:

- The tight adequacy situation had been anticipated since October 2016.
  - In the Central West Europe area: specific grid studies were conducted on the timescale from D-2 to intraday, in order to maximise exchanges towards countries with higher adequacy needs.
  - At the France-Switzerland interconnector: specific grid studies on the timescale of D-1, in addition to D-2 computations, were conducted with the support of Coreso, to optimise exchanges based on the last hypotheses available.
- Extraordinary coordinated capacity calculation process (from D-2 to intraday) between RTE and REE was established. The focus was to guarantee the maximum exchange capacity between both Spain and France. In this sense, the measures agreed between the TSOs were:
  - Postponing one outage in the Spanish system until the cold spell was finished;
  - Daily reevaluation and coordination between REE and RTE of offered capacities, which are normally computed only on a weekly basis, from Spain to France in D-2 and D-1 horizons (using more precise information allowed to optimize computations on some hours);
  - Analysis and proposal in D-1 of costly remedial actions to maximise the exchange capacity between Spain and France.
- Extraordinary operational information exchanges between RTE and Terna and capacity evaluation in D-2 on the Italian North borders was equally introduced.
- Mutual Emergency Assistance Service (MEAS) activation on France-Italy and France-Belgium borders was utilised.

Those actions to optimise import capacities were exceptional with respect to the tight situations and possible only during this period, as the optimisation could have negative impacts on electricity quality, in some French areas, normally not allowed by operational rules, and they needed to set-up operational staff and organisation to perform computations in addition to normal processes.

It shall be also underlined the usefulness of the arrangements developed in France in the last years to develop the participation of Demand Side Response in the market, notably: participation to spot market, participation to balancing markets, participation to FCR reserves, congestion handling. For example, during these days, up to 1,200 MW of DSR were activated on 25 January, while an average peak value around 1,000 MW was activated by suppliers every working day of the cold spell. During the first 3 weeks of January, about 15 GWh of DSR transactions were exchanged on D-1 and intra-day markets. This participation of the demand was for sure a significant contribution to the global adequacy and this availability of DSR (but also of some other units) was notably due to the entry into force of the capacity mechanism at the end of 2016. Since the functioning of the markets and the measures listed above were effective, no exceptional measure (like manual load shed) were needed in France during the cold spell.

4.2 ITALY / TERNA

4.2.1 SEQUENCE OF EVENTS

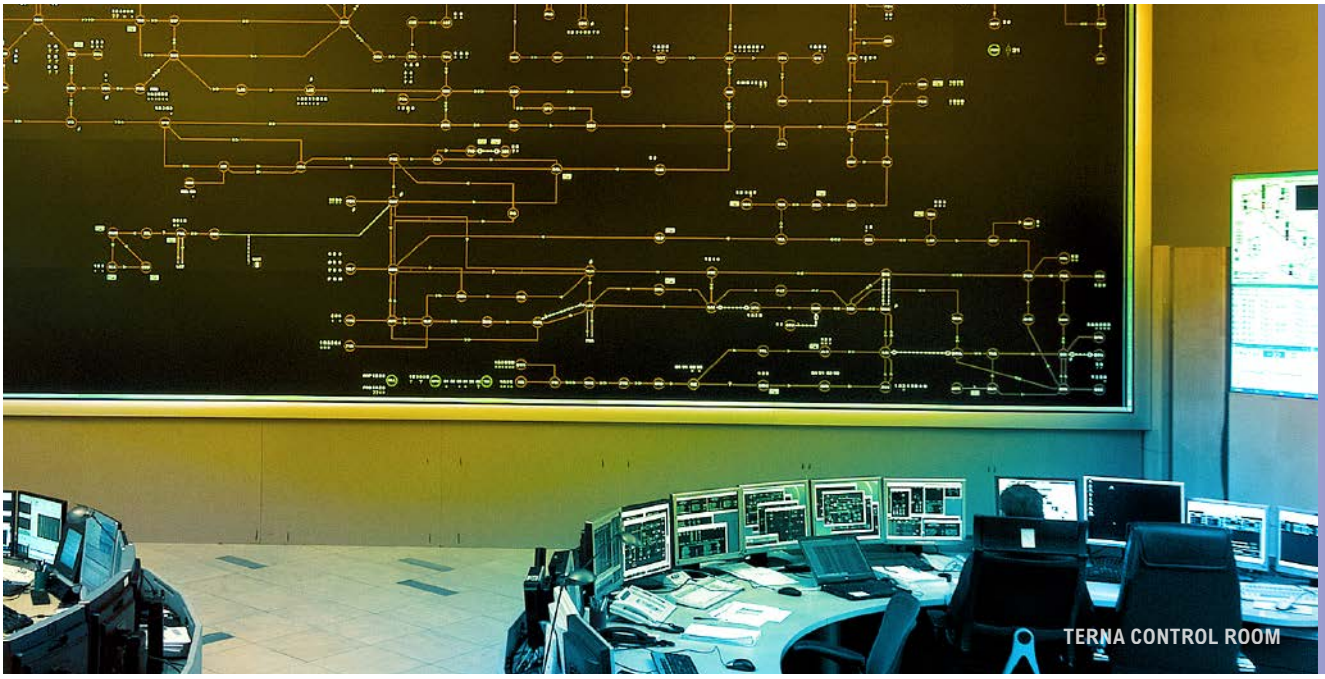
Before entering in the details of the actual data, it is necessary to remind that a strict relation between weather/temperature conditions (which are extremely variable) and security of supply does exist. In particular, extreme weather events induce a significant increase in demand consumption as well as in the fault probability of transmission or generation devices. Hence, in light of the reduced generation availability in Europe, during the operational planning phase, the probability of facing Security of Supply issues was expected to be quite high taking into account the weather forecasts and their uncertainties.

Some of the potential risks identified during the operational planning stage for the Italian Power System materialised: several transmission lines tripped due to heavy snow storms significantly reducing the available transmission capacity between the southern part (typically characterized by an excess of capacity) and the northern part (typically characterized by a lack of capacity) of Italy. Anyhow Security of Supply issues have not been experienced mainly thanks to a less stressed situation in the rest of Europe (e. g. high imports from neighbouring countries).

Day	Hour	Events
17/01/2017	05:18 h	Tripping of 'Teramo – Villanova' 380 kV Overhead Line due to overhead ground wire breaking caused by heavy snowfalls (i. e. ice-wet coatings).
18/01/2017	03:33 h	Tripping of 'Rosara – Teramo' 380 kV Overhead Line due to overhead ground wire breaking caused by heavy snowfalls (i. e. ice-wet coatings).
	03:49 h	Tripping of 'Villanova – Villavalle' 380 kV Overhead Line due to overhead ground wire breaking caused by heavy snowfalls (i. e. ice-wet coatings).
19/01/2017	17:47 h	Bring back into operation of 'Teramo – Villanova' 380 kV Overhead Line
21/01/2017	13:58 h	Bring back into operation of 'of 'Rosara – Teramo'380 kV Overhead Line
	20:15 h	Bring back into operation of 'Villanova – Villavalle' 380 kV Overhead Line

COMMENTARY

» The tripping of the three OHLs caused a significant reduction of transfer capacity from South (S) to North (N) of Italian power system.



TERNA CONTROL ROOM

4.2.2 GENERATION OVERVIEW

The generation figures per type of resources that were recorded during the cold wave period within Italy, as well as within the internal macro zone North and Centre-North of Italy (i. e. NORD/CNOR) are presented below.

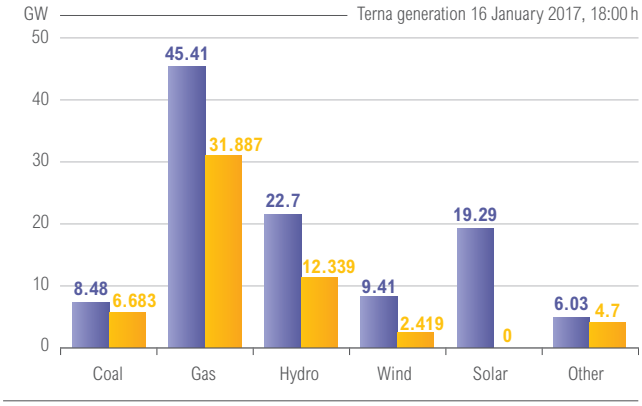


Figure 4.6: Terna generation 16 January, 18:00 h

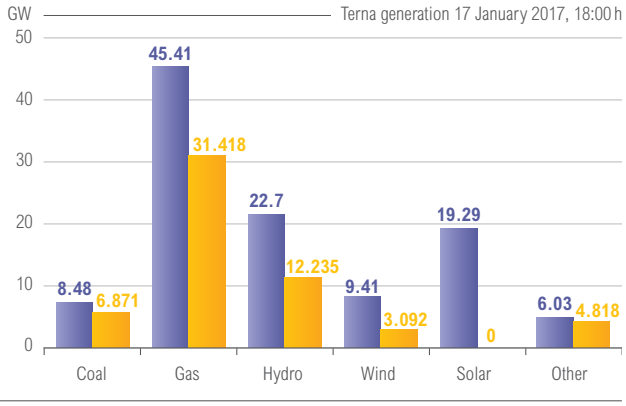


Figure 4.7: Terna generation 17 January, 18:00 h

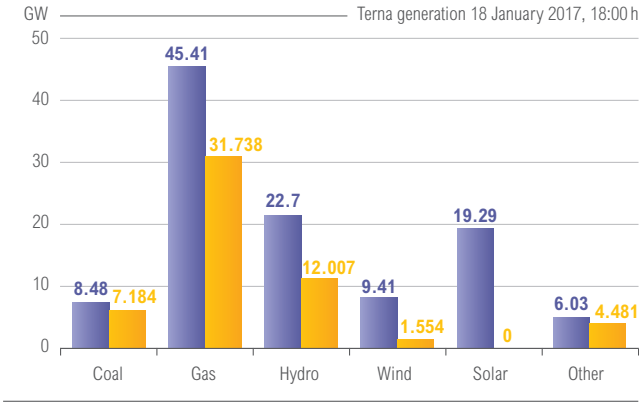


Figure 4.8: Terna generation 18 January, 18:00 h

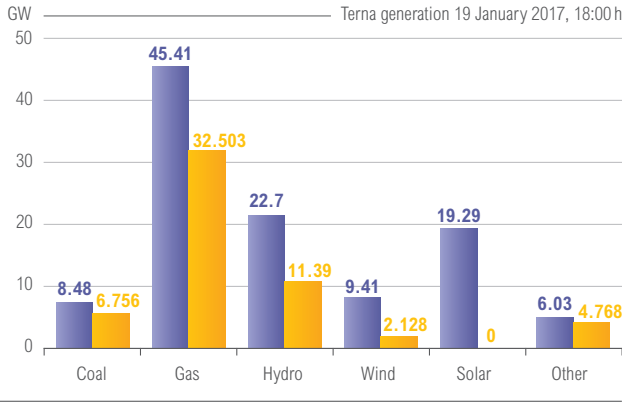


Figure 4.9: Terna generation 19 January, 18:00 h

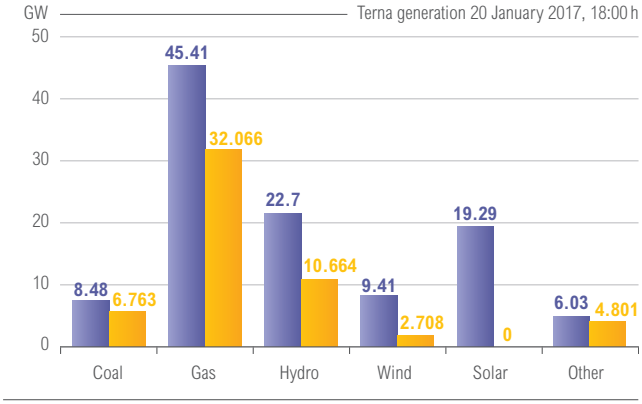


Figure 4.10: Terna generation 20 January, 18:00 h

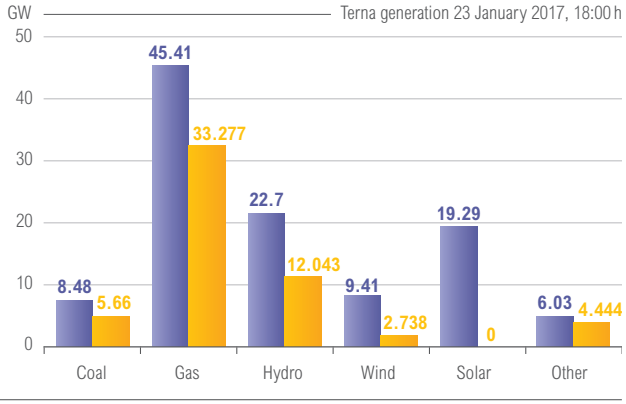


Figure 4.11: Terna generation 23 January, 18:00 h

Installed capacity Available capacity

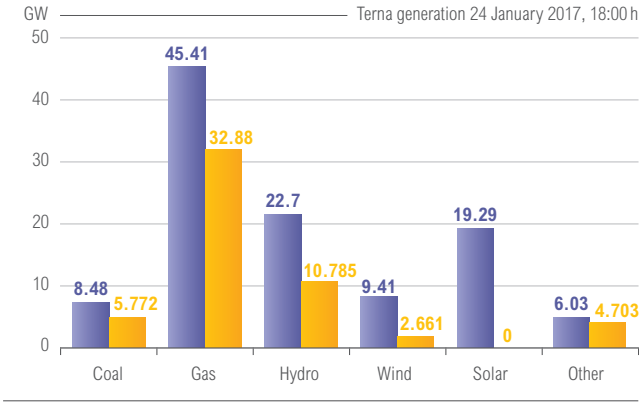


Figure 4.12: Terna generation 24 January, 18:00 h

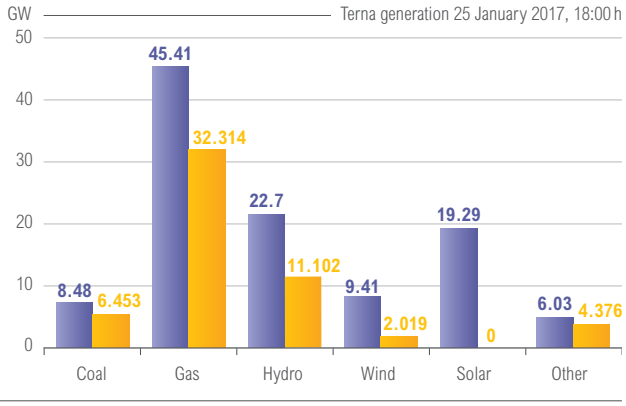


Figure 4.13: Terna generation 25 January, 18:00 h

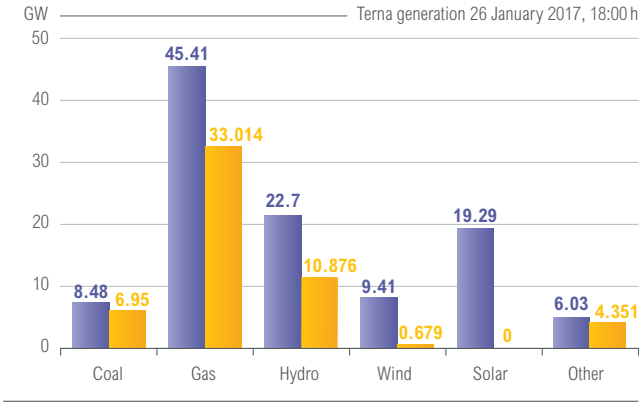


Figure 4.14: Terna generation 26 January, 18:00 h

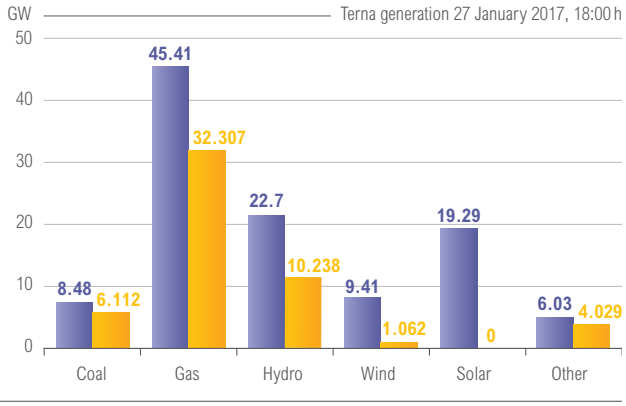


Figure 4.15: Terna generation 27 January, 18:00 h

Installed capacity Available capacity

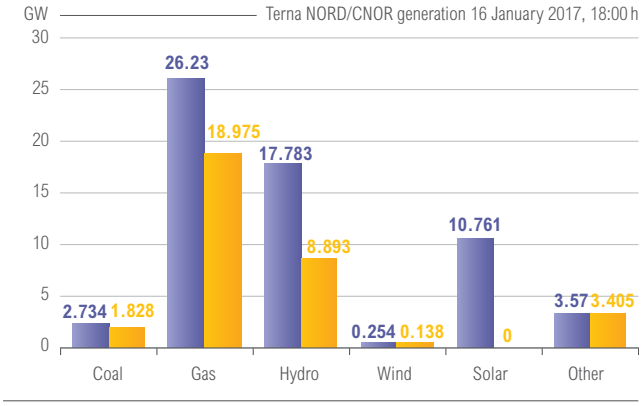


Figure 4.16: Terna NORD / CNOR generation 16 January, 18:00 h

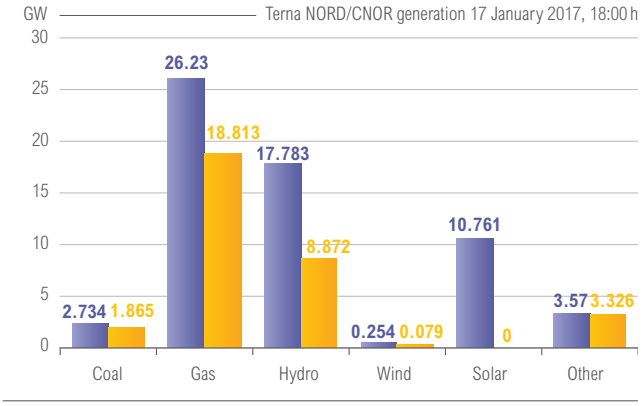


Figure 4.17: Terna NORD / CNOR generation 17 January, 18:00 h

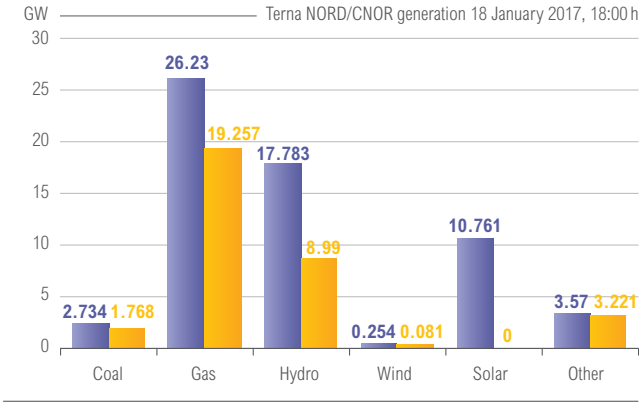


Figure 4.18: Terna NORD / CNOR generation 18 January, 18:00 h

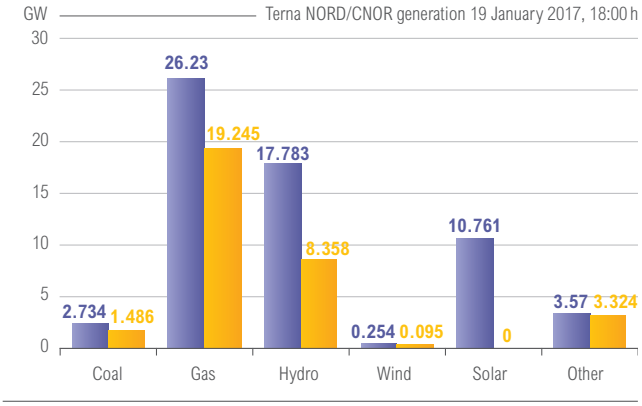


Figure 4.19: Terna NORD / CNORg eneration 19 January, 18:00 h

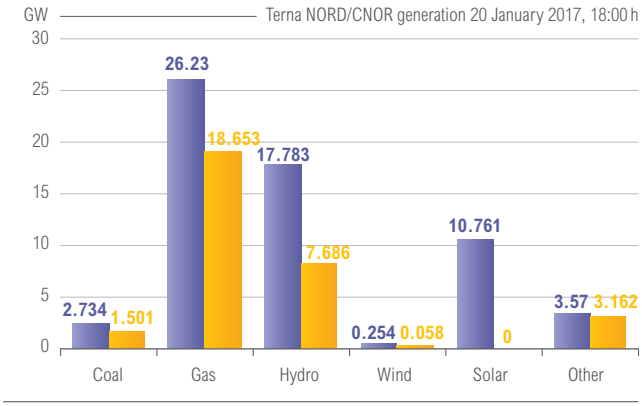


Figure 4.20: Terna NORD / CNOR generation 20 January, 18:00 h

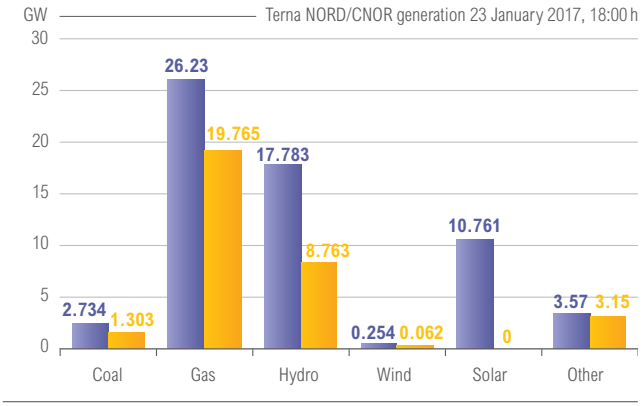


Figure 4.21: Terna NORD / CNOR generation 23 January, 18:00 h

Installed capacity Available capacity

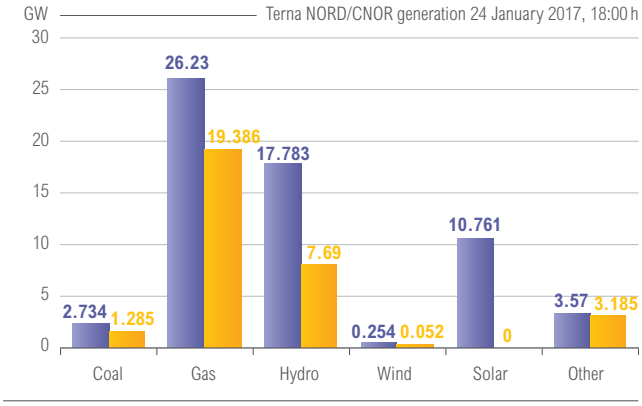


Figure 4.22: Terna NORD / CNOR generation 24 January, 18:00 h

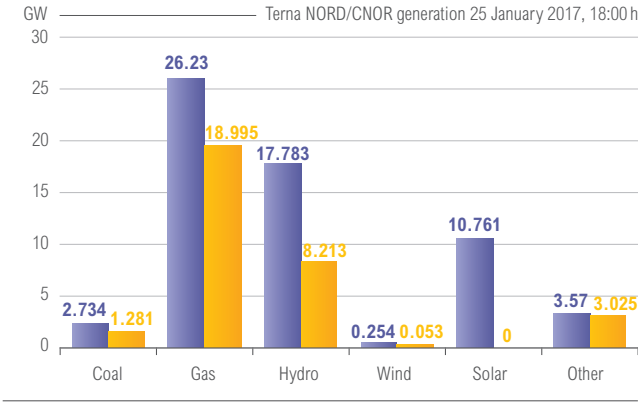


Figure 4.23: Terna NORD / CNOR generation 25 January, 18:00 h

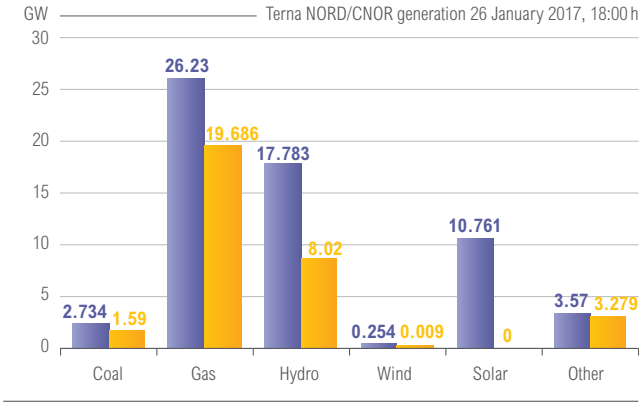


Figure 4.24: Terna NORD / CNOR generation 26 January, 18:00 h

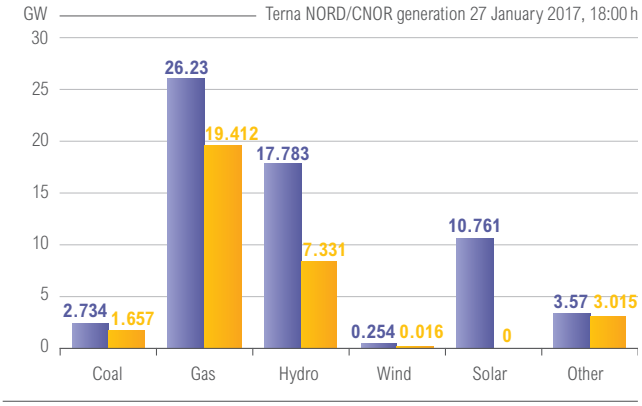


Figure 4.25: Terna NORD / CNOR generation 27 January, 18:00 h

Installed capacity Available capacity

COMMENTARY

» The values represented above refer to 18:00–19:00 h since it is generally the period with highest load and lowest margins.

4.2.3 CONSUMPTION RECORDED

Below are presented the consumption figures recorded during the cold wave period within Italy, as well as within the internal macro zone North and Centre-North of Italy (i. e. NORD/CNOR).

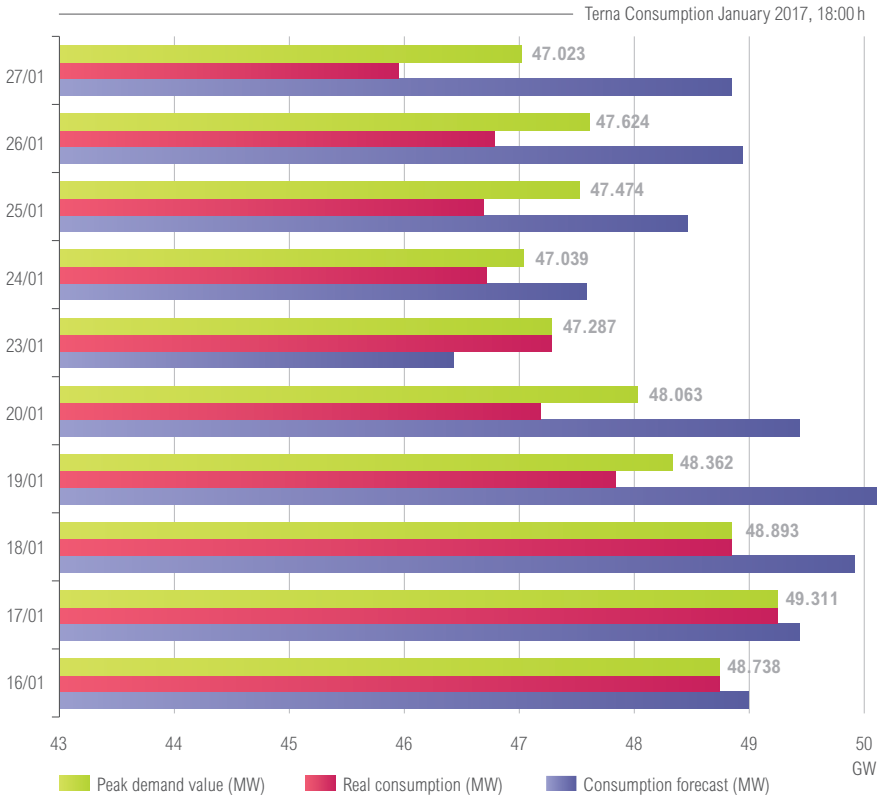


Figure 4.26: Terna Consumption January 2017, 18:00 h

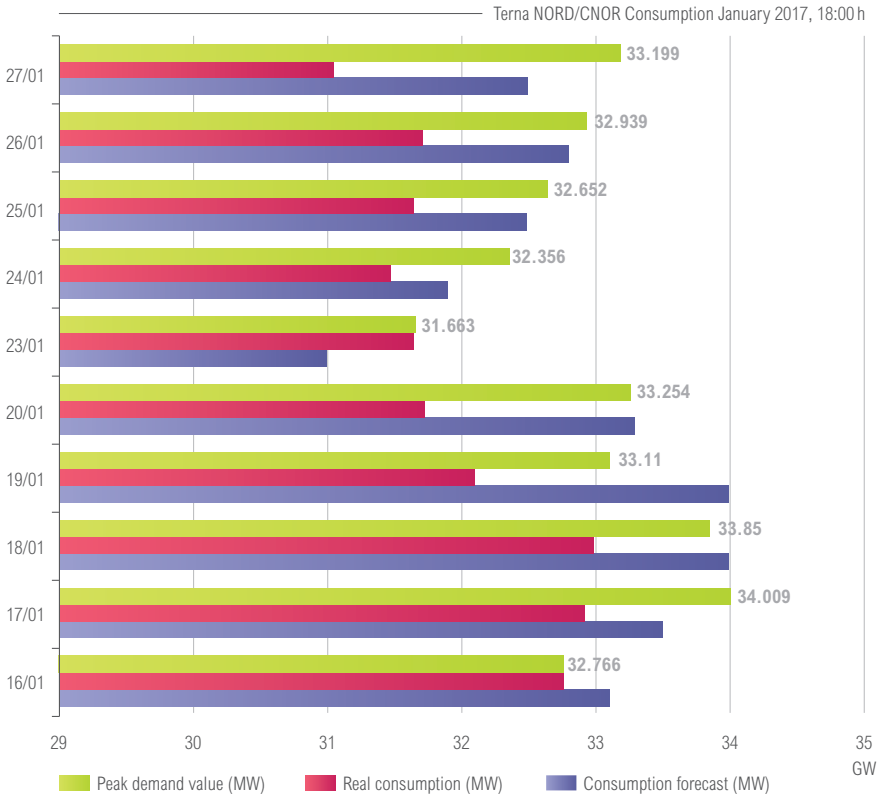


Figure 4.27: Terna NORD/CNORD Consumption January 2017, 18:00 h

COMMENTARY

- The values represented refer to 18:00–19:00 h of the day since it is generally the period with highest load and lowest margins.
- The consumption values refer only to the energy infeed into the grid.

4.2.5 SYSTEM RESERVES*

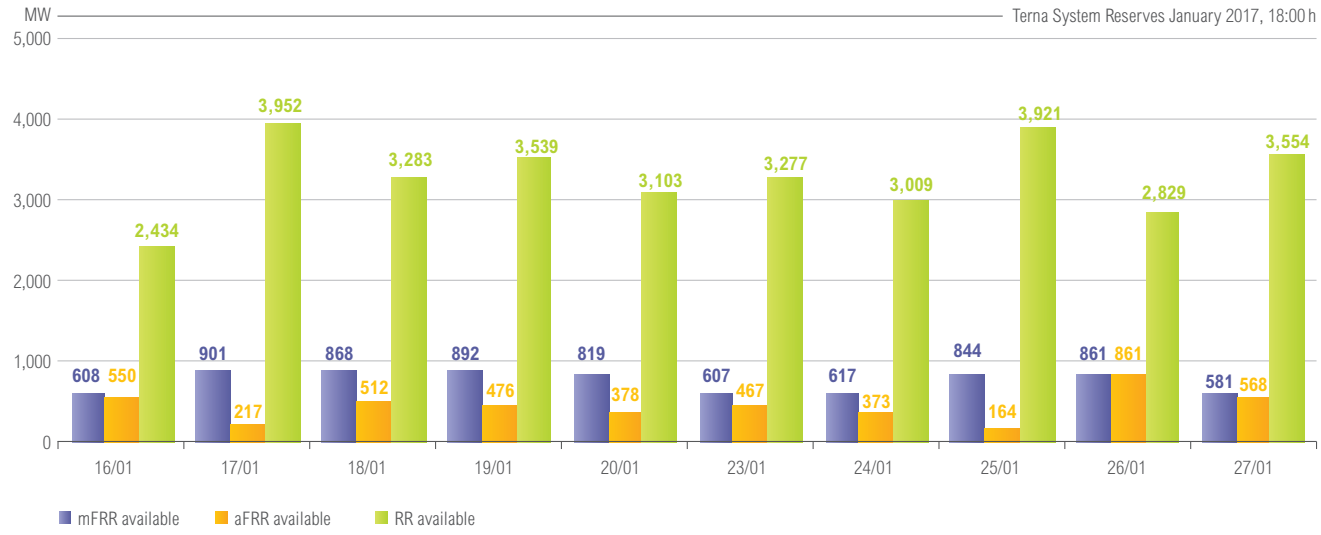


Figure 4.28: Terna System Reserves January 2017, 18:00 h

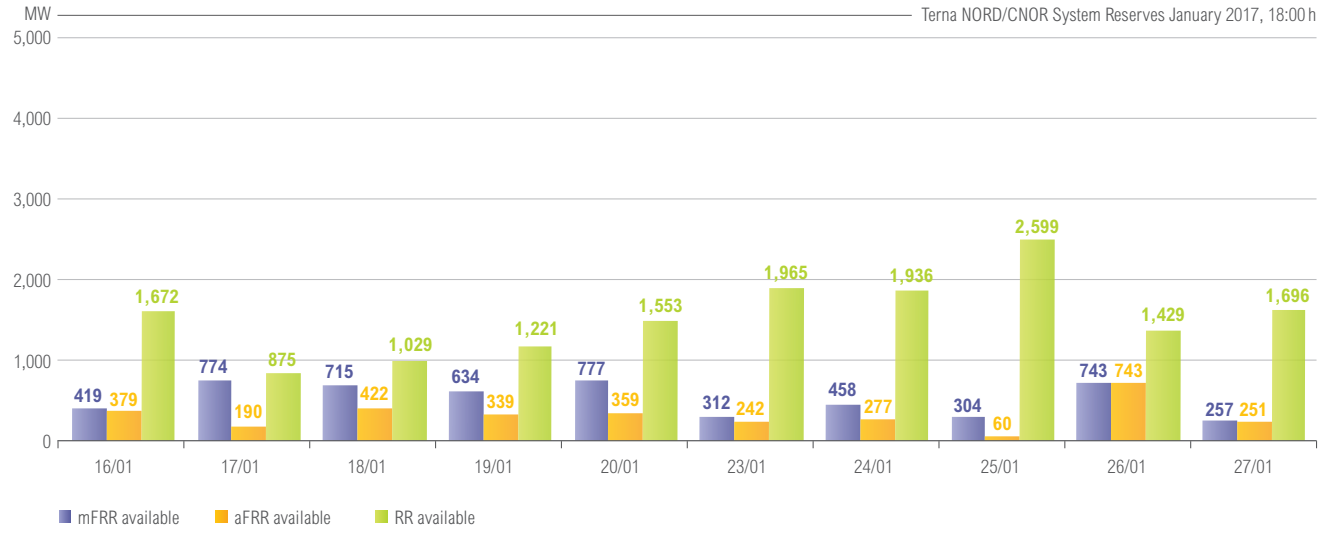


Figure 4.29: Terna NORD / CNOR System Reserves January 2017, 18:00 h

*Note that Replacement Reserve (RR) is not mandatory as defined in Operational Handbook for Continental Europe.

4.2.6 WEATHER SITUATION

Day	Temperatures recorded [°C] ITALY	Weather events*
16/01/2017	2,8 (−2,4)	Snow Storm
17/01/2017	3,5 (−1,6)	Snow Storm
18/01/2017	4,0 (−1,1)	Snow Storm
19/01/2017	4,6 (−0,9)	Snow Storm
20/01/2017	3,9 (−1,8)	Snow Storm
23/01/2017	6,3 (0,5)	
24/01/2017	6,7 (0,5)	
25/01/2017	5,4 (−0,5)	
26/01/2017	3,8 (−1,8)	
27/01/2017	3,7 (−2,1)	

COMMENTARY

- The table contains daily average temperatures.
- In brackets, delta versus reference seasonal average temperature.
- A heavy snowfall hit the central part of Italy starting from 16 January. Very stressful weather conditions have been experienced for the whole period of week 3 and week 4, with very low temperatures also in the Southern part of Italy.

4.2.7 POWER GRID SITUATION

Problems in fulfilling operational security limits (power flows from South to North expected to reach security limits).

Trip of 3 OHLs of 400 kV connecting the north and the south of Italy due to heavy snow conditions which affected the transmission capacity (huge transit limitations between CSUD-CNOR bidding zones).

The snowstorm has caused the Energy Not Suppled (ENS) in Centre\South Italy that involved above all the regions of Abruzzo and Marche. It has caused also many problems in distribution grid with ENS to final consumers in many places for several days in Centre\South Italy that involved above all the regions of Abruzzo and Marche

4.2.8 CRITICAL FLOWS ON TIE LINES/CRITICAL INTERNAL FLOWS

To avoid critical situations on internal lines, it was applied the reduction of scheduled power flows from South (S) to North (N) market zones due to the weakness of the power system.

4.2.9 KEY ANALYSIS

Additional measures used including preventive and intervention measures in market, re-dispatching and countertrading

Seasonal assessment (see ENTSO-E WOR 2016–17) showed that under severe conditions remaining capacity was expected to become tight and even negative in some weeks. In this situation, taking also into account the situation in Europe, the secure operation of the system was expected to be at huge risk and, consequently, several preventive measures have been implemented in the last months of 2016:

Enhanced inter-TSO coordination in forecast studies and daily operation among TSOs (facilitated and supported by Coreso and TSCNET, see also the communication on strengthen cooperation dated back 12 January):

- Improvement of Short & Medium Term Adequacy service (part of the 5 coordination services assigned to RSCs in System Operation Guideline);
- Extraordinary operational information exchanges among TSOs of the North Italian Borders and high level calls of ENTSO-E Coordinated System Operation Group;
- Net transfer capacity recalculated in D-2 on the Italy North borders;
- Rescheduling of maintenance work in order to reduce the impact on cross border exchange;
- Activation of Mutual Emergency Assistance Service (MEAS) exchange on France-Italy border.

Preventive and market measures reported above were all taken before the limitation of the cross-border export capacity. Actions taken in the Italian Power System:

- Return to operation of some mothballed power plants;
- Procurement of 500 MW additional instantly interruptible load resources in order to face more severe security conditions;
- Call for 1,000 MW of demand side resources to be activated with 15 minutes' advance notice;
- Request to come back to operation to certain generation power plants that had filed for decommissioning;
- Re-dispatching.

Preventive and market measures reported above were all taken before the limitation of the cross-border capacity.

Reasons behind additional measures with respect to: supply/demand situation, network conditions, cross-border capacity limitation, taking into account import capabilities

Based on the forecasts made available (e.g. in the WOPT) by some neighbouring TSOs, we expected grid scenarios in net export conditions from Italy. On 18 and 19 January, i.e. the days of the limitation of the cross-border export capacity from Italy, temperatures were quite low (2.5 °C below reference temperatures) and the peak load reached very high values for the winter season. Huge snowfalls in central Italy caused the unplanned outage of three important 380 kV lines leading to significant reduction of transfer capacity from South to North Italy (– 40 %). Call for 1,000 MW of demand side resources to be activated, during the winter period (January–March), with 15 minutes' advance notice.

On 12 January, Terna preventively informed neighbouring TSOs that, in order to avoid violations of operational security limits, allocation constraints, in export direction from Italy, were likely on 18 and 19 January. Terna communicated the cross-border capacity reductions to the involved TSOs and Joint Auction Office (JAO) according to the agreed regular operational procedures in force between Terna and the relevant parties. ENTSO-E was also informed through extraordinary daily calls organised in the framework of the ENTSO-E Coordinated System Operations (CSO) Group.

Reduction of the cross-border capacity on 18 and 19 January did not affect cross border exchanges (Italian net position as a result of market cross-border schedules was in import during the constrained hours, hence the reduction of the exports had no effects).

4.3 SWITZERLAND / SWISSGRID

4.3.1 SEQUENCE OF EVENTS

Day	Events
Beginning of December 2016	Swissgrid triggers "short-/medium-term adequacy" the analysis of some extreme scenarios.
End 2016 Beginning 2017	On initiative of RTE Coreso starts coordinating operational measures in case of entrance of the worst case; identification of emergency procedures and measures with CWE, Swissgrid and others.
10/01/2017	Swissgrid informs Amprion that reservoir levels are low and re-dispatch can only be provided in case of critical grid situations.
12/01/2017	Press release: European transmission system operators – Amprion (Germany), Elia (Belgium), REE (Spain), RTE (France), Swissgrid (Switzerland), TenneT (Netherlands), Terna (Italy) and TransnetBW (Germany) – improve their cooperation with a view to optimising electricity exchange capacity.
	Switzerland and Germany inform each other on the operational situation; Swissgrid announces that it will not be longer able to support German requests for re-dispatch resulting in higher production in Switzerland; German TSOs reduce using Swiss re-dispatches and activate reserves in Italy.
	Swissgrid announces to TSOs that there are no power problems expected in Switzerland. However, because of low water levels in lakes (mid-term adequacy problem) Swissgrid cannot guarantee any longer re-dispatch actions with increasing volumes in Switzerland.
14/01/2017	Swissgrid study with analysis of consequences for the Swiss grid based on developments in Italy, France and Germany. Expectation of grid problems in the triangle Italy – France – Switzerland (structural weakness in the Swiss transmission grid); based on the outcomes of the study Swissgrid prepares for D-2 NTC reductions towards Italy.
16/01/2017	Swissgrid initiates a high-level telco in order to explain the water situation to neighbouring TSOs; Risk of not being able to guarantee balancing in the end of the winter due to heavy use of lakes by hydro storage plants; RTE announces tight margins due to heavy imports; Germany informs that cold reserves have been started and are running on minimal load.
	Swissgrid identifies in D-2 potential N-1 violations of up to 126 % in the Lake Geneva area due to simultaneous high exports towards France and Italy and a high load in the region; reduces consequently D-2 NTC values towards Italy by about 2,000 MW to 2,500 MW (NTC towards France already at minimum).
	Swissgrid informs the TTF (Technical Task Force, APG, ELES; RTE, SWG, TERNA – responsible for the grid security of the Northern Italian Border) for a potential reduction of the NTC Swiss-Italian border. Grid Model was delivered to the participants for review with the different hypothesis assumed by Swissgrid. Participants acknowledged the results provided by Swissgrid.

Day	Events
17/01/2017	2nd Swissgrid high-level telco with update of the water situation in Switzerland; RTE informs that latest forecast result in only 96 GW in France; Terna expects an all-time load-peak; Agreement between TSOs that further coordination takes place on CSO-level (daily telco).
	Swissgrid requests to improve the coordination process between TSOs/TSCNET/CORESO/SSC in order to better take into account impacts on its grid when designing solutions to solve critical grid situations
18/01/2017	Swissgrid NTC reductions towards Italy by about 2,000 to 2,500 MW between 16:00 and 22:00 h take place, to prevent from possible N-1 violations of up to 126 % in the Lake Geneva region. The reduced NTC was not fully used by the market.
20/01/2017	Unplanned outage of hydro power plant Bieudron (production 800 MW at the time of the outage). In normal circumstances, producers can compensate the missing production from such an outage. Owing to the systematic low amount of water reserves, this is not the case.

COMMENTARY

- During critical periods like the cold spell, it is important that TSOs have access to information such as reserves activation and utilisation. Without this, the regional security of supply could be endangered.
- The cold-spell period demonstrated the importance of proactive coordination and information exchange in order to facilitate safe system operation and adequacy
- As mentioned above, energy constraints coming from the hydro storage are often an issue for Switzerland because the reservoirs can be depleted outside the control of Swissgrid and these water reserves are needed to secure system operations.

4.3.2 GENERATION OVERVIEW

The following set of graphs show the Swiss production and consumption in the period from October 2016 to end of January 2017.

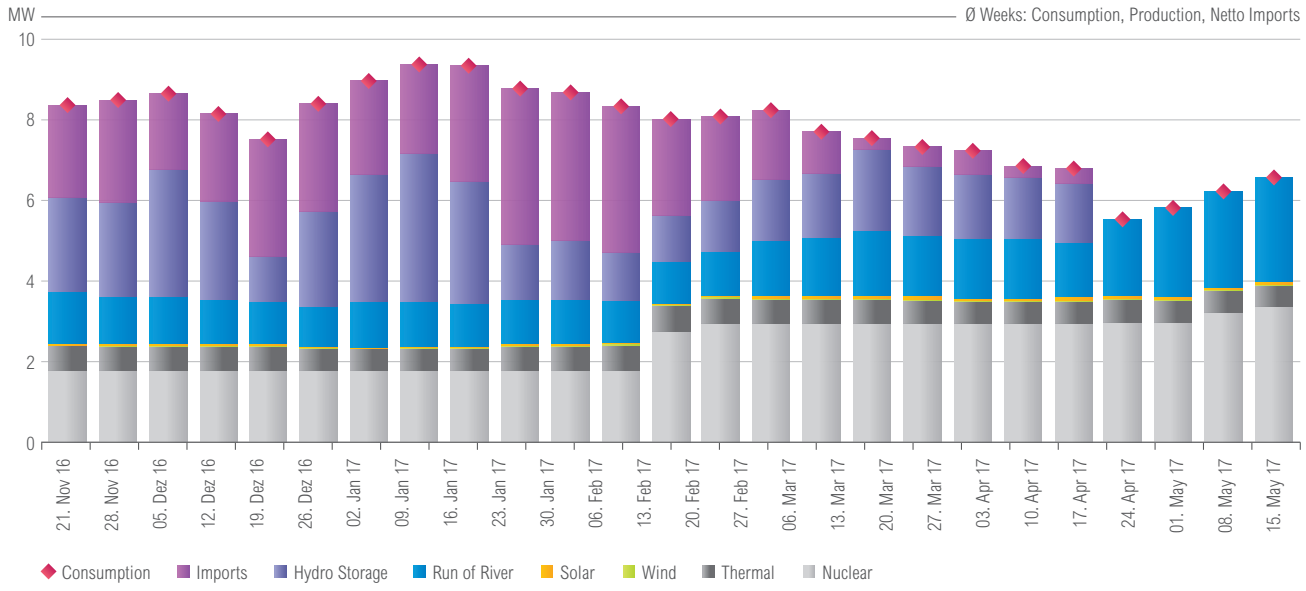


Figure 4.30: Consumption, production per technology and netto-imports as weekly averages. Data stems from various sources. Partly observed/measured values, partly modelled values. (Source: Swissgrid)

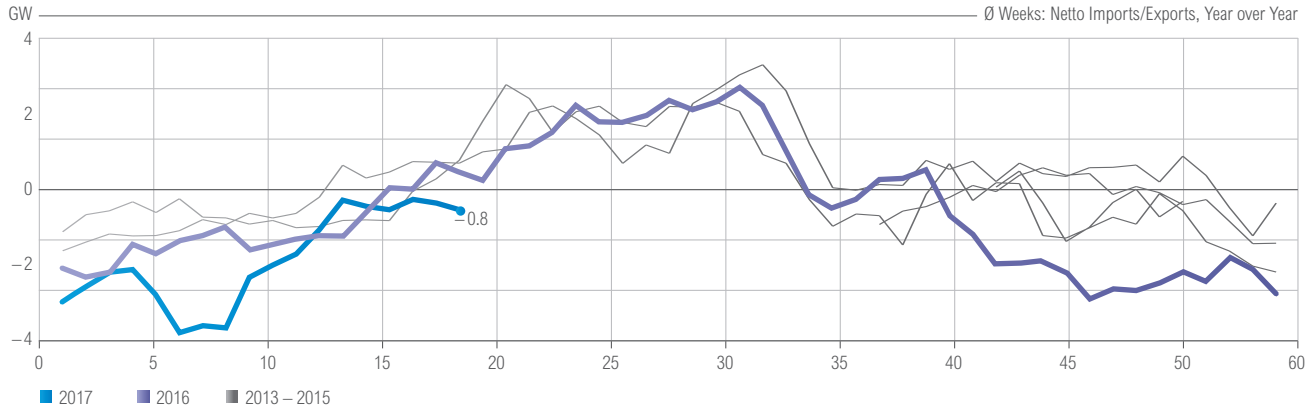


Figure 4.31: Weekly averages of imported/exported electricity to/from Switzerland in a year over year comparison. (Source: Swissgrid)

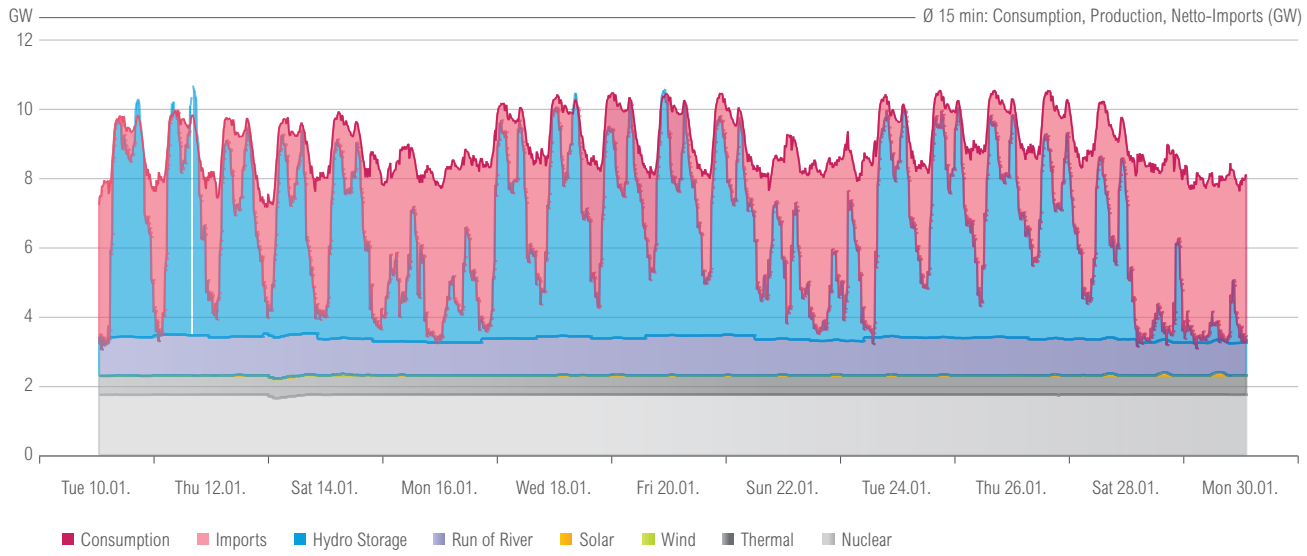


Figure 4.32: Consumption and Production per technology as 15min averages. Data stems from various sources. Partly observed/measured values, partly modelled values. (Source: Swissgrid)

COMMENTARY

- It should be noted that there is over-capacity of generation in Switzerland (i. e. total installed capacity is bigger than peak load). However, owing to the energy-restricted nature of hydro storage and the dependency of Run of River production on weather conditions, the effective capacity is in general less; in a prolonged period of dry conditions and high production, it could reduce to zero.
- Furthermore, Swiss production in January 2017 was especially low due to two long-term outages of nuclear power plants (in total about 1,600 MW offline). All these effects were leading to a high need of electricity import.

4.3.3 CONSUMPTION RECORDED

The following graphs show the historical and forecasted load for the year 2017.

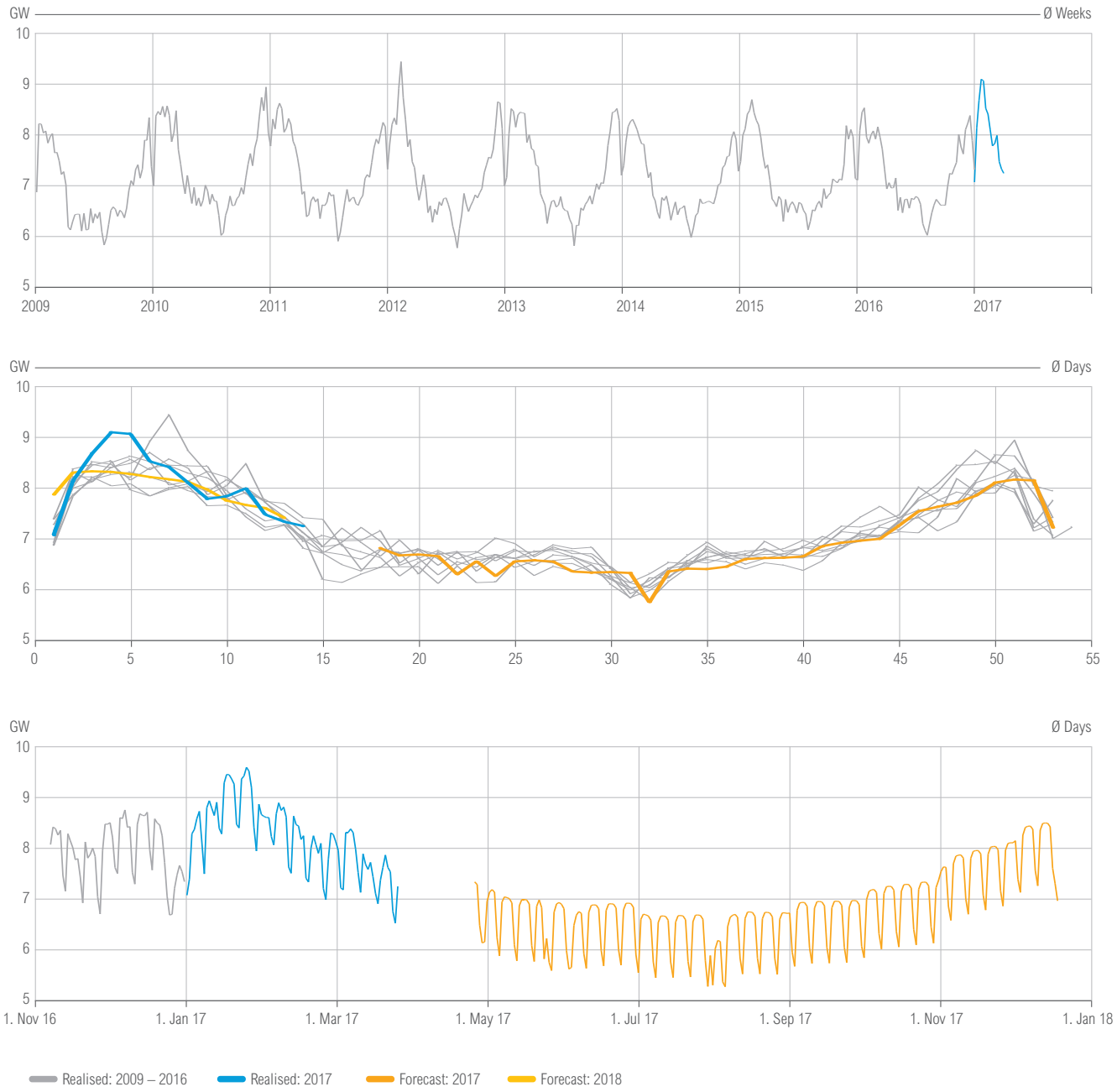


Figure 4.33: Consumption of Switzerland, as weekly and daily averages

COMMENTARY

- Higher peaks as well as overall higher consumption were recorded during the cold spell, but this is in general not a problem for Switzerland because of over-capacity of generation and high import capacity from direct neighbours. This would however become a problem if the cold spell were to last longer.
- High load can also become a problem for the grid in cases where France and Italy are also heavily importing at the same time. This situation was never experienced before.

4.3.4 SYSTEM RESERVES*

- Because of different measures implemented as described in the section "Key Analysis", the procured amount of system reserves was kept at at least at the usual level to secure system operations.
- Because of the low amount of water reserves, Swissgrid capability to assist Germany (re-dispatches would lead to higher production in Switzerland) had to be restricted to the minimum. Regardless, Switzerland was providing about 28 GWh in January 2017 for international re-dispatches with Germany.

4.3.5 WEATHER SITUATION

- The following graphs show the temperature, rainfall (in electricity equivalent) and snow-reserves (in electricity equivalent) in Switzerland from September 2016 to September 2017.

2016 was a dry year in Switzerland with little rainfall, together with higher than normal hydro production during the cold-spell and the reservoir content sunk to a historic minimum for that time of the year.

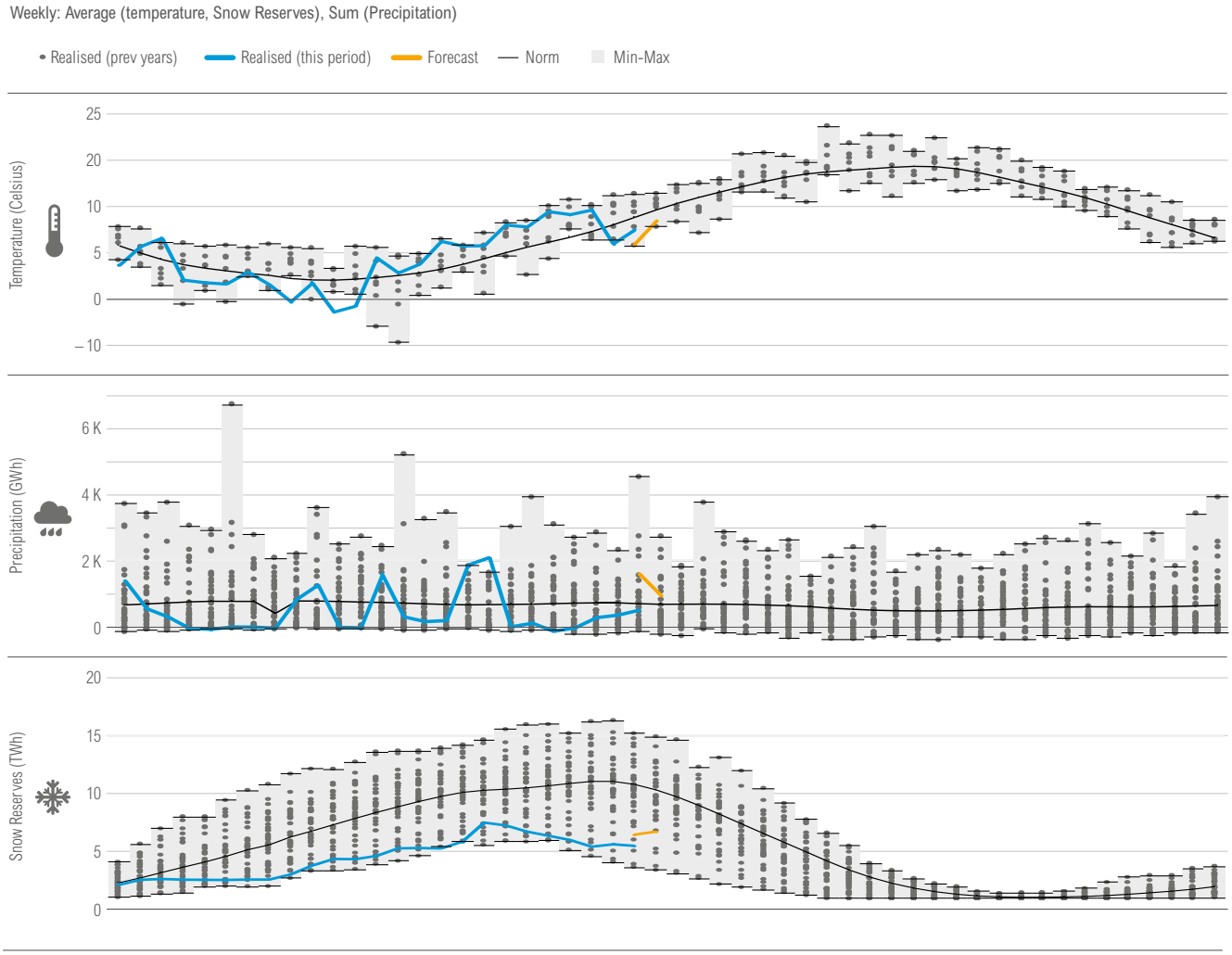


Figure 4.34: Temperature: Electricity consumption weighted average, Percipitation: Modelled in terms of an effective energy for electricity production by the hydro system in Switzerland (RoR, Hydro storage). (Source: Swissgrid)

*Note that Replacement Reserve (RR) is not mandatory as defined in Operational Handbook for Continental Europe.

4.3.6 POWER GRID SITUATION

The low amount of water reserves led to difficulties in system operations, as described in the Events table.

The transmission network in the Lake Geneva region was expected to suffer from massive N-1 contingency violations as reported in the Events table on 16 and 18 January. The reason for this was an expected high export (energy produced within Switzerland) to both France and Italy at the same time due to their simultaneous adequacy issues.

Up to the end of January, (and not at the exact same time as the other events) there were also observations of N-1 contingency violations on a 220 kV tie-line with Germany up to 127 % and on some 220/380 kV transformers in northern Switzerland.

4.3.7 KEY ANALYSIS

There were a number of workshops with the Swiss NRA, ElCom, and market participants during the winter period to ensure transparency and coordination between all parties, in particular regarding import capacities, overall transmission grid situation and system adequacy. To increase the mitigation options within Switzerland, Swissgrid developed additional "winter re-dispatch products" for extreme events (e. g., combination of transformer loss and additional load in range of a nuclear plant), which were procured for 30 days starting from February 6, but were not activated. In addition, Swissgrid purchased the required minimum amount of secondary reserve requirements for the 2016/17 winter in advance, thus providing a clear price signal to the market and ensuring sufficient reserve availability.

In general, Swissgrid takes the following actions with following priorities: first non-costly topological measures, internal re-dispatch, and then international re-dispatch (bilateral then multilateral when possible) and finally NTC reduction for the following days in case an occurred congestion persists or is forecasted. The first measure taken was to purchase the full volume of secondary reserve, followed by the development of the "winter re-dispatch product", which was then purchased in January. Finally, as a preventive measure in the week of 16 January, the NTC to Italy was reduced by about 2,000 MW to 2,500 MW between 16:00 and 22:00 h on 18 January, so as to avoid potential N-1 security violations of up to 126 % in the Lake Geneva area (c. f. explanations before).

Again, the following steps were taken. All measures were validated with the Swiss NRA ElCom to ensure they were market-based and non-discriminatory. The NTC reduction was prepared by Operational Planning and validated by the Heads of the Market and Grid business units (market and system operations).

An exceptional D-2 analysis for 18 January showed a combination of high forecasted loads, maximum hydro production across all of Switzerland and in particular in the Valais region, and significant transits through the Swiss-French interconnectors in the Lake Geneva area, as France was acting as the main sink. The resulting load flow situation led to N-1 security violations of up to 126 % on the Romanel–St-Triphon 220 kV line and 119 % on the Riddes–Cornier 220 kV line, with possible cascade risks. The only feasible solution to mitigate the N-1 security violation, after the application of additional Remedial Actions, was to reduce the NTC to Italy in order to avoid to high production in the Swiss control block.

The TSOs at the affected borders (e. g. for NTC reduction) were informed via the normal D-2 processes as well as through phone conferences.

4.4 BELGIUM / ELIA

4.4.1 SEQUENCE OF EVENTS

Day	Hour	Events
11/01/2017		First warning was sent to all CSO Group on the expected tense situation for BE for the next week. Detailed adequacy analyses still ongoing.
12/01/2017		Adequacy forecast for the next week shows a very tight situation due to the forecasted cold spell. Import needs for Belgium are estimated between 1 GW and 1.4 GW for the next week. While those are not exceptionally high, due to the very large import need for FR a risk is identified that sufficient imports for BE and FR together might not be achieved. It is however expected that the available volume of strategic reserves in BE will be sufficient to avoid further extraordinary measures in BE. The following actions were taken: · All maintenance works on the grid that reduces cross-border capacity or that encompass any additional operational risk for the BE system are cancelled · Actions were taken to inform balance responsible parties and to stress the importance of a reliable and fully available generation fleet (to the extent feasible) · The use of dynamic line rating and cold weather limits allowed increasing the technical capacity for the crucial grid elements. This additional capacity was also included in the grid models and available for the market parties for cross-border trading · The Belgian ministry was informed about the tense situation. This was followed by a systematic daily update during the cold spell · Even further increased attention on the capacity calculation process, with a specific focus on optimizing the maximal importing capacity for BE and FR together
13/01/2017		Elia sends adequacy flag to all CWE CSO Group indicating the importance of an optimal capacity calculation process (both in DA and ID) with focus on BE+FR imports in CWE. This message was delivered to all TSOs.
		Publication of a Market Message to inform the market about the increase of grid elements limits due to the cold temperatures and dynamic line rating
16/01/2017	06:00 h	Full generation fleet in BE back available except for one nuclear unit at Tihange (Forced outage since September 2016) and one CCGT: maintenance that could not be postponed. During the weekend the following units returned in the market: 3 CCGT units, 1 nuclear unit at Doel (Forced Outage)
From 16/01/2017 onwards		Daily telco with CSO Group to update the situation.
19/01/2017	05:10 – 10:00 h	Forced Outage of a CCGT unit (400 MW). Back fully available and running at 10:00. No severe balancing issues were encountered during the FO.
21/01/2017	21:30 h	Very high flows on the Belgian grid around the Northern border. Extreme tap positions combined with additional preventive topological actions were needed to remain within N-1 limits, thanks to the increased cold weather limits on the concerned grid elements.
25/01/2017	09:00 –15:00 h	Due to much lower solar (max 400 MW less) and wind infeed (100 MW less) compared to the day-ahead forecasts, mFRR needed to be activated to maintain the balance. Emergency exchanges from Belgium towards FR and NL are declared unavailable. BE EAS is set to alert due to the activation of more than 50 % of our reserves.
25/01/2017	17:00 – 19:00 h	Delivery of 250 MW of emergency exchanges from BE to FR
26/01/2017	16:38 h	Elia informs CWE CSO Group members that the adequacy flag (which is a forecasted flag, not an EAS one, to alert neighbouring TSOs) can be cancelled for business day Saturday 28/01 onwards.

4.4.2 GENERATION OVERVIEW

Representative generation mix during cold spell

Generation type	Installed capacity [MW]	Available capacity [MW]
Nuclear	6,000 MW	5,000 MW (one in FO since 09/2016)
Coal	0 MW	
Gas	4,000 MW	3,500 MW (one CCGT in planned outage)
Hydro	1,300 MW	1,300 MW
Wind	2,000 MW	See graph below, in general very low wind infeed during the cold spell, especially in the second week.
Solar	3,000 MW	See graph below
Other	2,000 MW	2,000 MW

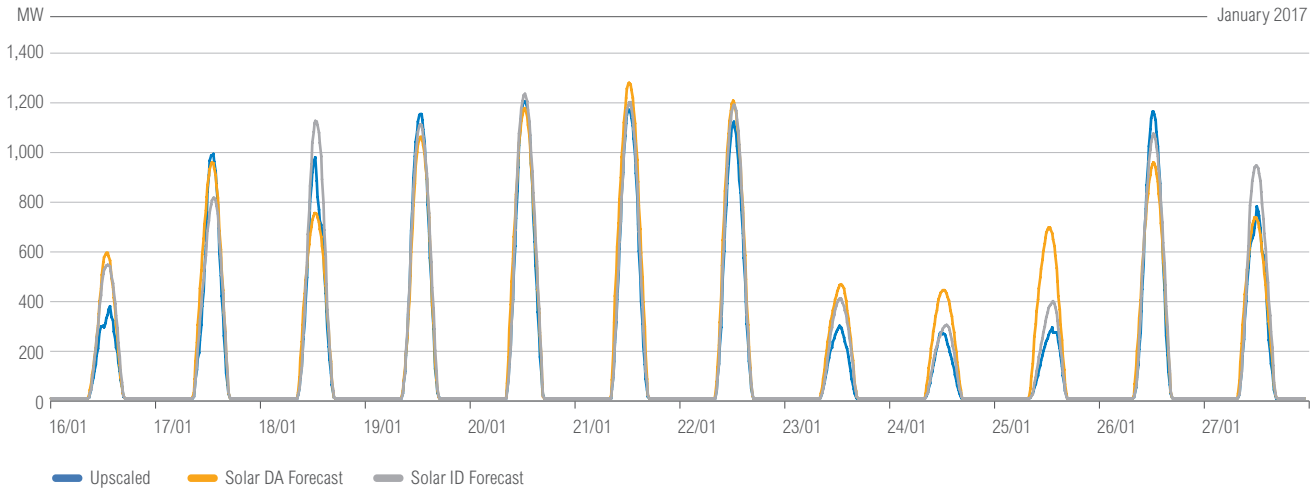


Figure 4.35: Solar generation 16–27 January 2017

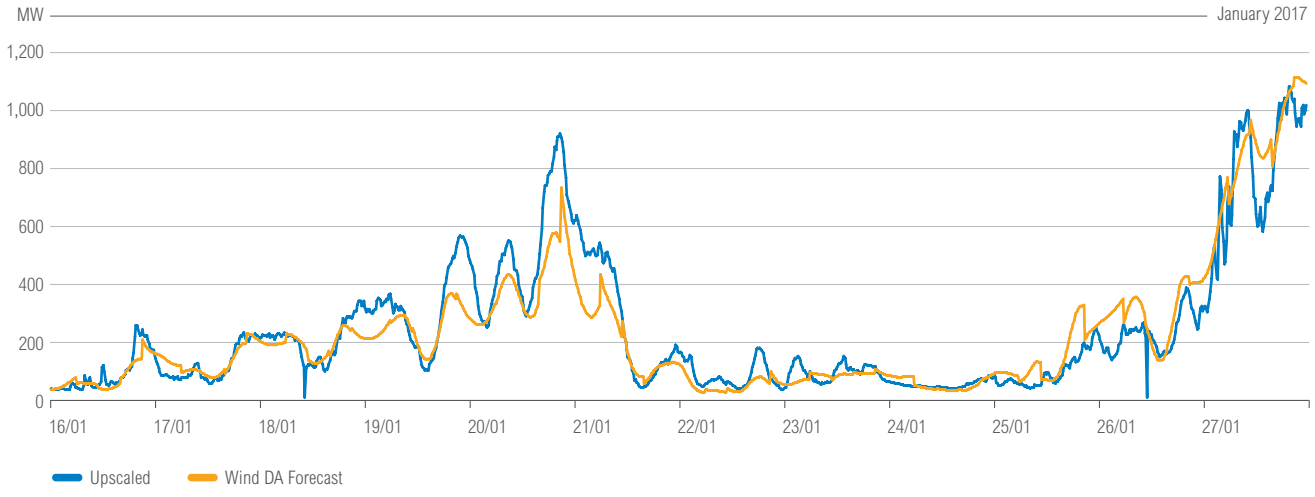


Figure 4.36: Wind generation 16–27 January 2017

4.4.3 CONSUMPTION RECORDED

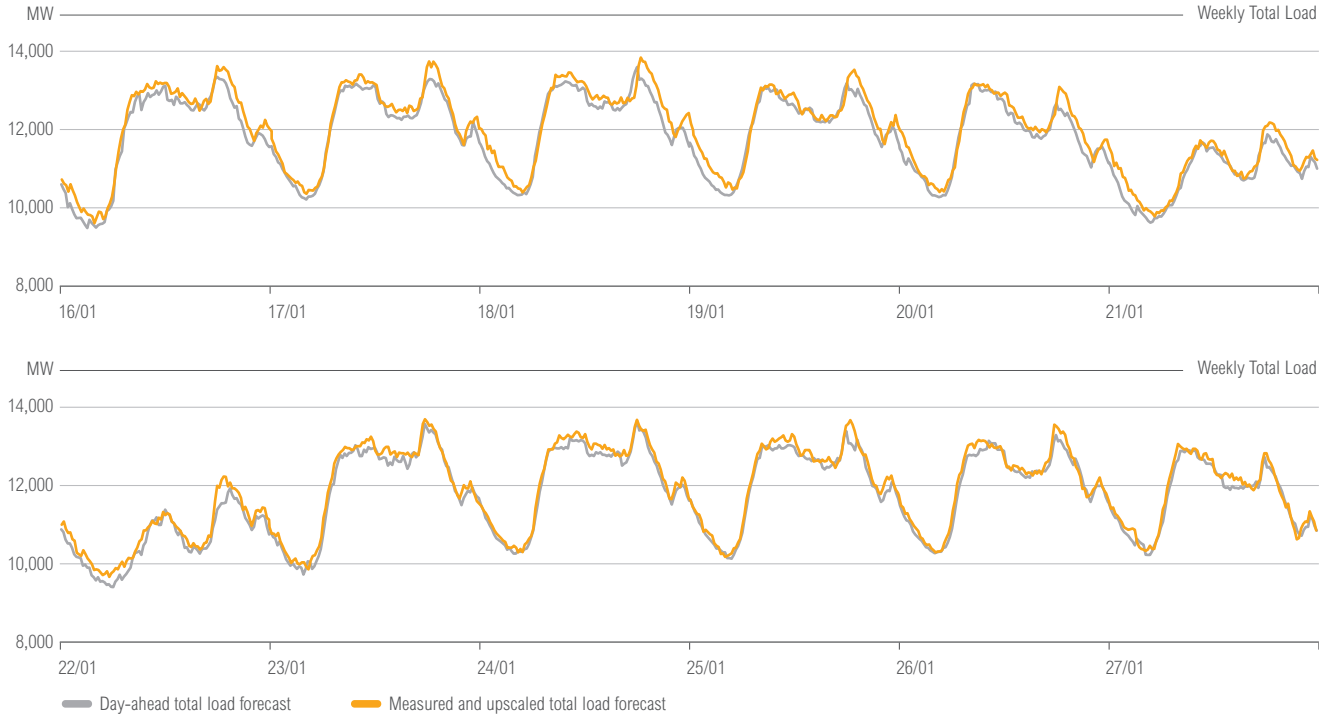


Figure 4.37: Weekly Total Load 16–28 January 2017

4.4.4 SYSTEM RESERVES*

Day	Hour	mFRR available [MW]	mFRR used [MW]	Reason
19/01/2017	07:00 – 09:45 h	Ca. 860 MW	100 MW	Normal imbalances, low non-contracted remaining capacity
23/01/2017	09:00 – 14:00 h	Ca. 830 MW	Up to 100 MW	Normal imbalances, low non-contracted remaining capacity. Not all quarter hours reserves were activated (2 qh 100 MW, 10 qh 50 MW)
25/01/2017	09:30 – 15:15 h	Ca. 790 MW	Up to 460 MW, 230 MW on average	Significant imbalance due to large solar and wind forecast errors.

COMMENTARY

- No significant use of contracted reserves was needed for Belgium during the cold spell, except for one day (25 January).
- On 25 January, due to much lower solar (max 400 MW less) and wind infeed (100 MW less) compared to the day-ahead forecasts, mFRR needed to be activated to maintain the balance. Emergency exchanges from Belgium towards France and The Netherlands are declared unavailable. European Awareness System (EAS) for Belgium was set to alert due to the activation of more than 50 % of our reserves (for some quarter hours).
- In general, Balance Responsible Parties correctly forecasted and balanced their portfolio.
- Only contracted reserves are included in the numbers above. Non-contracted remaining capacity is not included. In addition, emergency exchanges with other TSOs are not included.

*Note that Replacement Reserve (RR) is not mandatory as defined in Operational Handbook for Continental Europe.

4.4.5 WEATHER SITUATION

Day	Temperatures recorded [°C] at evening peak Instantaneous / equivalent
16/01	0,7 °C / 0.8 °C
17/01	–1.0 °C / 1.1 °C
18/01	–1.1 °C / –2.5 °C
19/01	1.7 °C / –2.6 °C
20/01	3.8 °C / –1.7 °C
23/01	2.2 °C / –0.1 °C
24/01	1.6 °C / 0.5 °C
25/01	–1.5 °C / –0.5 °C
26/01	0.0 °C / –1.7 °C
27/01	6.0 °C / 0.0 °C

COMMENTARY

- Cold temperatures were experienced, down to the 95th percentile of coldest seasonal temperatures. The first week of the cold wave was clearly the coldest. In the second week temperatures were slightly higher. Starting from the 27 January, temperatures started rising significantly.
- No weather events affecting the functioning of the grid were experienced.
- Equivalent temperatures represent the average temperature weighted over the past three days; this definition is used to provide a good correlation with electrical consumption.

4.4.6 POWER GRID SITUATION

The week before the cold spell, when the tense adequacy situation was detected, all efforts were made to maximise the availability of the Belgian grid. All planned maintenance with an impact on cross-border exchanges or a potential impact on adequacy (e.g. by putting specific generation units at risk) was cancelled. This resulted in an almost fully available grid. No grid outages occurred during the cold spell.

ELIA CONTROL ROOM

4.4.7 CRITICAL FLOWS ON TIE LINES / CRITICAL INTERNAL FLOWS

In general, high flows, notably on the Belgian-Dutch border were experienced, with daily maxima around 3 GW and with peaks up to 3.8 GW on 16 and 21 January (for comparison: the N-1 secure physical capacity of the grid elements on the Belgian-Dutch border amount to a total of about 4 GW). Thanks to the use of topological measures and the Phase Shifting Transformers (PST)[1)] on the Belgian North border, critical constraints could be avoided and the Belgian grid remained secured throughout the cold spell.

The Belgian PST and especially those in the west (Zandvliet) however had to be used almost to their extreme tap positions to secure the Belgian grid. Below the realised tap positions are shown, with for every day the minimum (green curve), average (red curve) and maximum (blue curve) tap position per PST. Every PST has a tap range of 1–36, with 18 being the neutral tap. Taps below 18 represent a decrease of north-to-south flows through the PST. See Figures below.

1) By changing the voltage angle, the PST enables power flows on a particular transmission line to be reduced or increased to some extent which, in a meshed network, leads to corresponding changes in the power flows on other lines.

Figure 4.38: Realised tap positions for every day with minimum (green curve), average (red curve) and maximum (blue curve) tap position per PST.

4.4.8 KEY ANALYSIS

Strategic Reserves (750 MW) were available to avoid adequacy issues.

No re-dispatch or countertrading was applied to mitigate severe congestion issues. Flows were however very high and one day (21 January) we were close to having to apply cross-border re-dispatching.

Belgian Authorities (Minister) were/was informed about the situation on a daily basis.

Due to the available Strategic Reserves (750MW) no further extreme measures (e.g. load shedding) were foreseen to be required during the cold spell.

4.5 ROMANIA / TRANSELECTRICA

4.5.1 SEQUENCE OF EVENTS

Day	Hour	Events
06/01/2017	08:26 – 22:16	Generation outage: one nuclear unit (714 MW)
10/01– 11/01/2017	10/01, 22:49 h – 11/01, 06:12 h	
10/01 – 16/01/2017		Dramatic decrease of the Danube river flow (1,900 – 2,000 m³/sec. against 4,950 m³/sec. which is the yearly statistical mean).
16/01 – 15/02/2017		Government Decision no. 10/13.01.2017 related to safeguard measures (e. g. curtailment of exports) was preventively issued but not applied. Prepared the legal framework for application as needed.
Temporarily experienced during the cold spell		Generation outage: some thermal units (old thermal generation park) + part of wind generation (over speed of wind).
Permanently experienced during the cold spell		High level of commercial deficit on load curve covering (some intervals almost up to 30 % of the system load). Sale offers < buy offers (no use of previous markets before balancing market).
		High use of inland waters, plights on coal transportation and delivery towards some thermal power plants, low coal quality (humidity, frozen coal).
		The power system was operated under safe conditions and keeping the export contracts alive. No limitations on interconnection capacity and/or export schedules.

4.5.2 CONSUMPTION RECORDED

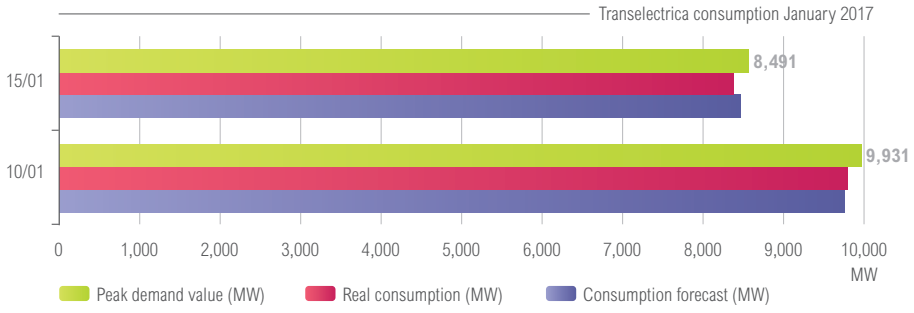


Figure 4.39: Transelectrica consumption January 2017

COMMENTARY

- Peak load records of the last 20 years
- Interval with minimum of reserves

4.5.3 SYSTEM RESERVES*

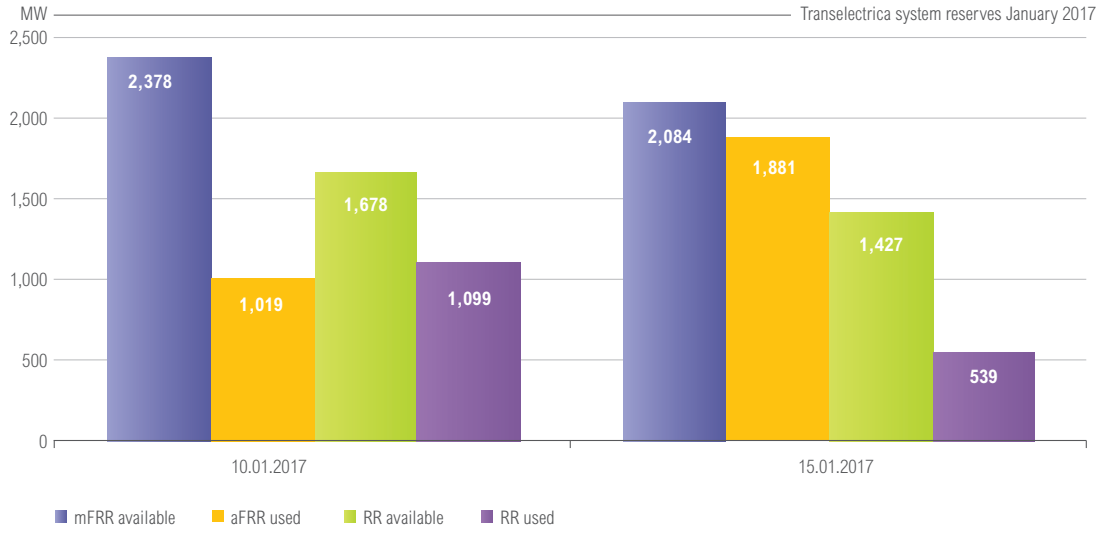


Figure 4.40: Transelectrica system reserves January 2017

COMMENTARY

- Peak load records of the last 20 years
- Interval with minimum of reserves

4.5.4 WEATHER SITUATION

Day	Temperatures recorded [ºC]	Weather events*
06/01/2017 – 07/01/2017		yellow, orange and red code for strong wind and snow: strong wind blows and gusts, high amount of snow
07/01/2017 – 12/01/2017	minimum local temperature recorded: –32 °C; average minimum temperature on country: –15 °C; average daily temperature on country: –11 °C;	yellow and orange code for very low temperatures;
13/01/2017 – 15/01/2017		yellow code for strong wind and snow
16/01/2017 – 20/01/2017	average minimum temperature on country: –11 °C; average daily temperature on country: –8 °C.	frosty weather (yellow code)
12/01/2017 – 02/00/2017		Fog was frequently recorded and frost in large areas of the country

COMMENTARY

During the very strong windy and snowy periods:

- Help from army and other military institutions;
- Many localities and clients without electricity – mainly rural, due to distribution network issues (medium voltage chiefly) caused by the cold spell, snowstorms and extreme low temperatures throughout the country (6 – 15 January 2017);

*Note that Replacement Reserve (RR) is not mandatory as defined in Operational Handbook for Continental Europe.

4.5.5 KEY ANALYSIS

Ordinary preventive measures include: generation loading/starting up; programmed outages cancelling; minimum voltage level on the distribution grids.

Market affecting measure: switch from the gas generation to Heavy Fuel Oil (HFO) for some generation units in order to protect the natural gas system/network (and consequently, the operation of other gas-based generation). Effect on the market: reduced, i.e. the HFO price is higher than natural gas price, therefore the HFO based reserve is declared as additional ancillary paid service (regulated prices by NRA). No re-dispatching and countertrading were activated.

The measures were given the following order of priority:

1. Ordinary measures (see above);
2. Market impacting safeguard measures, endorsed by Government Decision no. 10/2017 (see description of GD no. 10/2017) – if the case;

Measure to switch from the gas generation to HFO fuel can be applied in any moment at the Gas National Operator's request. It was applied between 08/01/2017/18:15 – 11/01/2017/18:00 for 190 MW thermal generation.

The measure to switch from the gas generation to HFO is at Gas National Operator request.

TRANSELECTRICA CONTROL ROOM

4.6 BULGARIA / ESO

4.6.1 SEQUENCE OF EVENTS

Day	Events
06/01/2017	All cold reserve capacities totaling 550 MW were activated; due to frozen coal and/or water for production needs only 350 – 400 MW produced Due to force majeure (frozen coal and/or water for production needs), the central cold reserve providers failed to make available the full-agreed capacity and instead were only able to produce 350 – 400 MW. The frequency restoration reserve (secondary control reserve) was curtailed for most of the cold spell that resulted in generation increase by 95 MW during the same period. Prior to the export limitations in Bulgaria, emergency assistance was requested by all neighbour TSOs. However, the Hellenic TSO (IPTO) declared power export ban starting from 11 January for 2 days.
from 11/01/2017	Prior to the export limitations in Bulgaria, emergency assistance requested: IPTO declared a power export ban from 11 January 2017 on, Transelectrica was unable to provide emergency assistance, and there was no possibility for emergency assistance from FYROM, Turkey, and Serbia Secondary control reserve curtailed for most of the cold spell which resulted in generation increase by 95 MW during the same period Power outputs of Kozloduy NPP and Maritsa East 2 TPP reduced and that energy made available to NEK Public Supplier Number of autotransformers/transformers in service optimised → load decrease 20 MW MV bus-bar voltage decreased by 3 to 5 % → load reduced by 250 MW Rotary excavators of Maritsa East Mines put in idle mode → load reduced 60 MW Higher fault rate of generation capacities whose additional loading resulted in depletion of stored coal reserves in the thermal power plants which only managed to suffice for 2 to 4 days of full load operation of generating set Commercial transit flows through the national power grid ranging from 200 MW to 400 MW per hour In some hours commercial imports for load coverage in Bulgaria reached 225 MW per hour
As of 08/01/2017	As of 08/01/2017 the market participants were unable to cover their demand schedules the commercial schedules deviating from the real load by about 350 MW and in some hours even by 500 – 600 MW – all market mechanisms for coping with that deficit were practically exhausted
	In case of potential failure of 1,000 MW unit in Kozloduy NPP the power system reliability would have been compromised
	As a measure of last resort, the Minister of Energy issued an order for limitation of power exports with Bulgarian origin but without interfering with the commercial power transits (import and export) through Bulgaria.
	Additional difficulties were experienced due to the supply of lignite coals to the TPPs, as well as the operation of some plants related to the supply of fuel and provision of water for technological needs.
	NEK, in its capacity of Public provider, had trouble in ensuring the necessary quantities of energy to meet the consumption of the protected consumers and requested termination of the export with origin Bulgaria. The minister of energy issued such order, the interconnection capacity was not curtailed during this period and the transit through the grid of ESO was possible.

4.6.2 GENERATION OVERVIEW

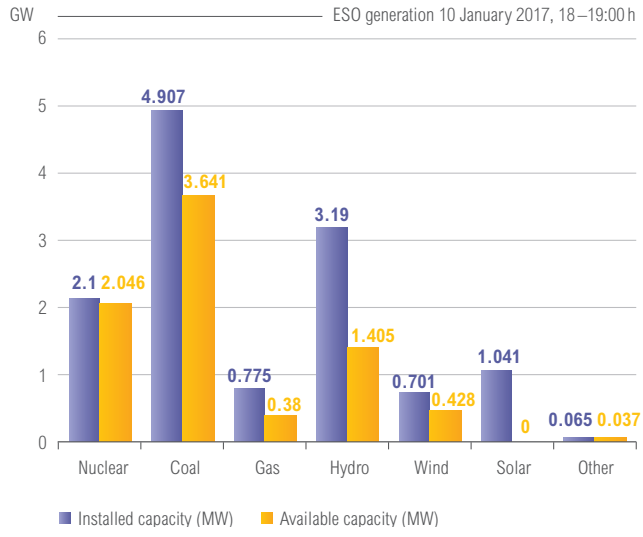


Figure 4.41: ESO generation 10 January

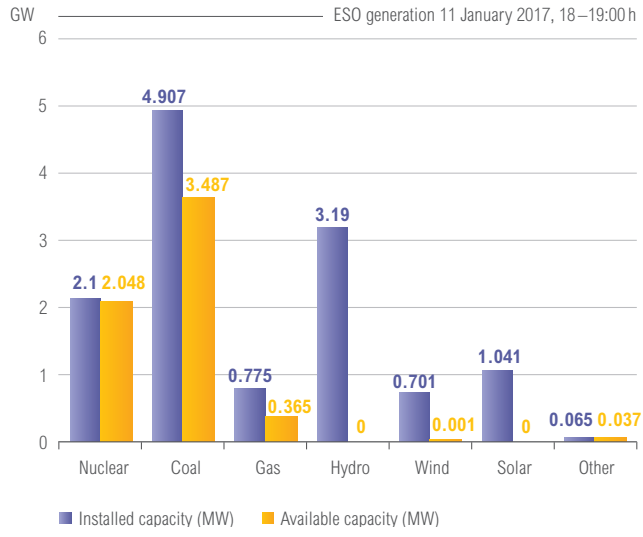


Figure 4.42: ESO generation 11 January

4.6.3 CONSUMPTION RECORDED

Day	Hour	Consumption forecast [MW]	Real consumption [MW]
10/01/2017	18:00 – 19:00 h EET	7,729 MW (day-ahead forecast made on 09/01/2017 at 10:00 h)	7,690 MW
11/01/2017	18:00 – 19:00 h EET	7,704 MW (day-ahead forecast made on 10/01/2017 at 10:00 h)	7,680 MW

COMMENTARY

» 42 hours during which the consumption was above 7,100 MW (the usual maximum of the system in previous years) were registered in the period 07/01/2017–12/01/2017

4.6.4 WEATHER SITUATION

Day	Temperatures recorded [°C] (daily average temp. measured from 16 weather station spread throughout the country)
07/01/2017	–9.9
08/01/2017	–10.6
09/01/2017	–9.4
10/01/2017	–8.9
11/01/2017	–8.7
12/01/2017	–6.6

COMMENTARY

» According to data from the Hydro-meteorological institute of Bulgaria, this winter has been the coldest in 27 years. In some regions, the temperatures fell to minus 29 degrees Celsius. This led to a significant increases in the electricity consumption.

» The extreme winter conditions have caused higher forced outage rates of generation capacities whose additional loading resulted in depletion of stored coal reserves in the thermal power plants that only managed to suffice for 2 to 4 days of full load.

4.6.5 POWER GRID SITUATION

- The number of autotransformers and transformers in service was optimised resulting in a load decrease of about 20 MW;
- In the weekends as well as from 17:00 h to 23:00 h in the workdays, the MV busbar voltage is decreased by 3 to 5 % in accordance with IEC60038 without causing any impact on the quality of power supply to end-use energy consumers, including DSOs. As a result, the electric load was reduced by 250 MW;
- By proposal from Maritsa East Mines, the rotary excavators are put in idle mode from 17:00 h to 23:00 h without any interference with the coal supply. As a result, the electric load was reduced by another 60MW.

4.6.6 KEY ANALYSIS

On 6 January 2017 all facilities in cold reserve were activated – 550 MW. The cold reserve suppliers were not able to reach the agreed power due to force majeure (freezing of coal and/or water for industrial needs) and supplied only 350–400 MW. The frequency restoration reserve (secondary control reserve) was reduced for most of the cold spell, which provided additional 95 MW of free capacity to be used by the public supplier to cover its obligations on the regulated market, thus decreasing the security of supply.

Before the imposed limitation of exports originating from Bulgaria, emergency assistance requests were sent to all the neighbouring operators but the circumstances were as follows:

- The Greek system operator limited commercial exports to Bulgaria starting from 11 January 2017;
- The Romanian system operator had refused delivery of emergency assistance with a preliminary notice on 23 December 2016;
- There was no opportunity for emergency assistance from FYROM, Turkey and Serbia, as extreme winter temperatures realised on their territory as well.

At the same time, the situation in the region continued to be delicate in regards with supplying of electricity demand.

In practice, the two largest exporters in the region Bulgaria and Romania were struggling to balance their own power systems.

In addition to the above measures, the Bulgarian TSO implemented extra ones:

- The number of autotransformers and transformers in operation was optimised resulting in load reduction of around 20 MW;
- The medium voltage of the buses in the substations was decreased by 3 to 5 % in accordance with IEC60038 without affecting the quality of supplied energy to end users, including the distribution companies. As a result, the electrical load was reduced by more than 250 MW;
- At the suggestion of Maritsa Iztok mining complex the rotary excavators were put in idle mode in the time span from 17:00 to 23:00 without interruption of coal supply. As a result, the electrical load was reduced by up to 60 MW.

Owing to the extreme winter conditions, the failure rates in the production facilities increased and the extra loading led to depletion of coal stocks in the thermal power plants, which were sufficient only for 2 days of full load operation.

There were commercial transit flows through the national power grid ranging from 200 MW to 400 MW per hour and, in some hours, commercial imports for load coverage in Bulgaria were realised reaching 225 MW per hour, which was indicative of power deficit in the country despite the activation of all reserve generating capacities.

As of 8 January 2017, market participants were unable to meet their consumption schedules even by buying cross border electricity since there was a shortage in the whole region. Therefore, the commercial schedules of the market participants kept deviating from the real load by about 350 MW and in some hours even by 500–600 MW in deficit.

All market mechanisms for coping with power deficit were practically exhausted. This would have compromised the power system reliability in case of a potential failure of a 1,000 MW unit in NPP Kozloduy whose compensation would have been impossible as all other available generation ca-

pacities were operating at full load. Such an accident would have led not only to an imbalance between production and consumption in the country but also to a serious deviation in the physical exchange power flows with prerequisites for cascading faults in the power system not only in Bulgaria but on a regional level as well.

Considering the above circumstances and a subsequent letter from NEK Public Supplier informing of its inability to meet its obligations for power supply to protected consumers in Bulgaria, as a measure of last resort, the Minister of Energy issued an order for limitation of power exports with Bulgarian origin but without interfering with the commercial power transits (import and export) through Bulgaria.

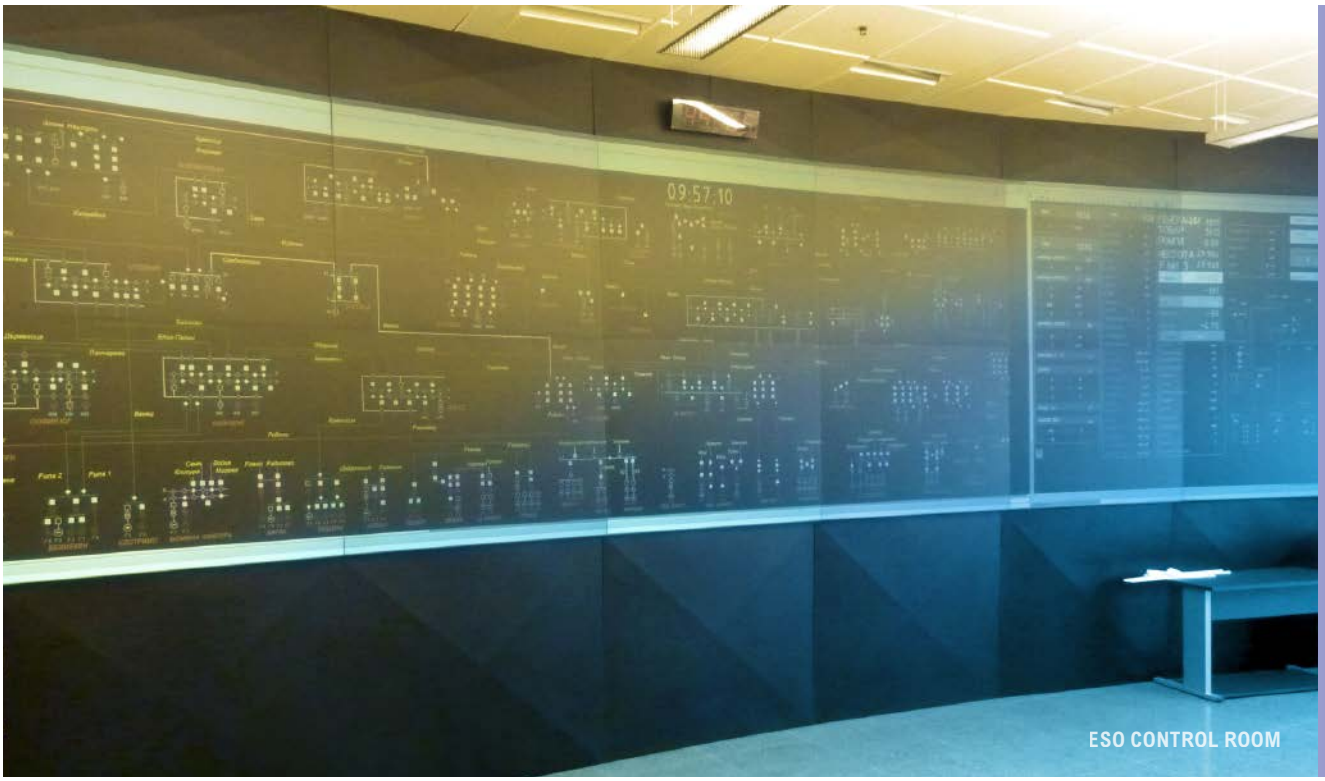
As mentioned above, after exhausting all market mechanisms and technical means for handling the power deficit as a measure of last resort, the Minister of Energy issued an order for limitation of power exports with Bulgarian origin.

Measures related to activation of balancing energy sources were taken by ESO, whereas the Minister of Energy issued the order restricting the power exports originating from Bulgaria after the depletion of all other technical and market mechanisms.

The reasons were already explained in the previous answers. It should be noted that complete ban on cross-border electricity delivery was never applied. The commercial cross-border transits through the Bulgarian transmission grid were not restricted.

All market participants eligible for nominating cross border schedules to ESO were informed on 11 January 2017, two days in advance of the limitation on exports with Bulgarian origin. Later on the same day, 11 January 2017, all neighbouring TSOs were notified of the imposed restriction. The message about the restriction was communicated to the involved parties via email and telephone and was subsequently published on the official web site of ESO and on the market management platform as well.

There was a power deficit in the whole region including the neighbouring MS. The market segments (day-ahead and intraday markets, power exchanges) continued to operate albeit offering limited quantities at much higher marginal prices on the power exchanges that is normal in shortage conditions.



ESO CONTROL ROOM

4.7 GREECE / IPTO

4.7.1 SEQUENCE OF EVENTS

Day / Hour	Events
19/12/2016 – 12/02/2017	Deficit of LNG, due to delay in arrival of LNG shipments of Hellenic Gas Transmission System Operator (HGTSO) and limitation of NG supply through pipelines. As a result, the availability of gas power plants was limited, in real time, for the mentioned period.
08/01 – 20/01/2017	Reduced availability of several thermal units, in real time, due to severe weather conditions.
08/01/2017	Major unplanned outage of KARDIA 4 thermal unit (280 MW), estimated unavailability period 10 months.
10/01/2017	Enable interruptibility service from industrial consumers committed by a contract with IPTO. In order to stabilise the operation of Greek system, export NTC reduced to zero – (curtailment of PTRs according to the current auction rules) on 11/01 on all borders; Greek-Italian interconnection out of operation. During the afternoon of 10/01 IPTO followed the same procedure for the curtailments of PTRs on 12/01. The Crisis Management Committee (composed by National Regulators, Gas organisations, TSO, Governments representatives in Greece) took the decision of PTRs curtailment.
11 – 12/01/2017	Attempts to receive emergency assistance from neighbouring TSOs not successful as neighbour were in similar situation.

4.7.2 GENERATION OVERVIEW

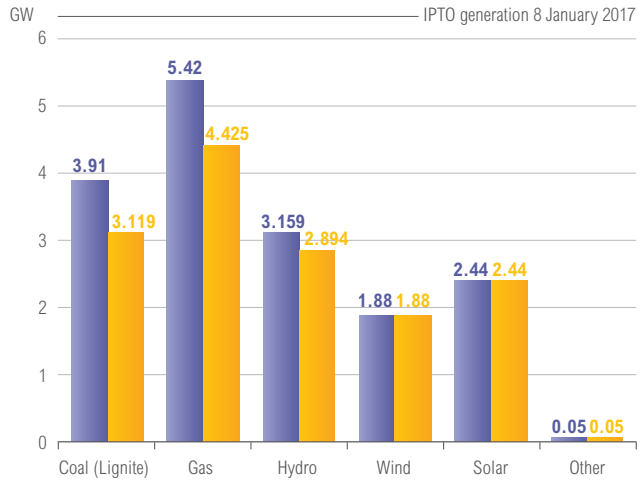


Figure 4.43: IPTO generation 8 January 2017

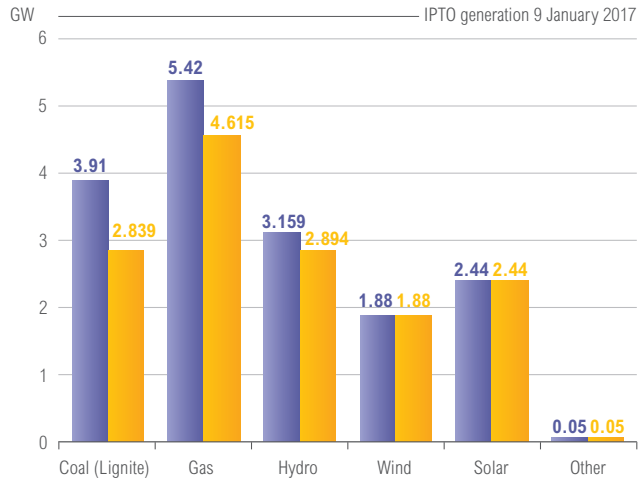


Figure 4.44: IPTO generation 9 January 2017

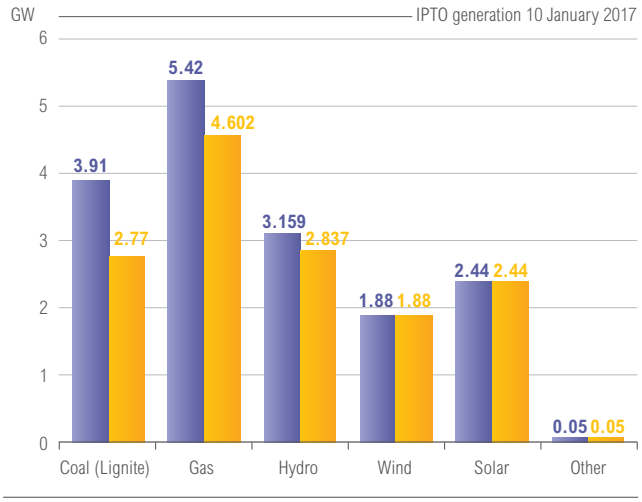


Figure 4.45: IPTO generation 10 January 2017

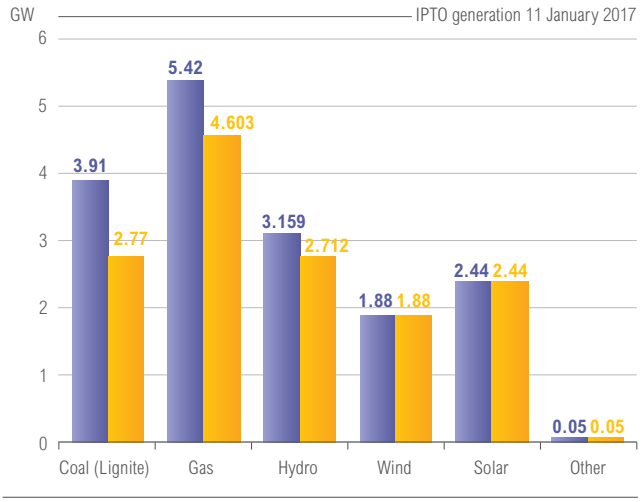


Figure 4.46: IPTO generation 11 January 2017

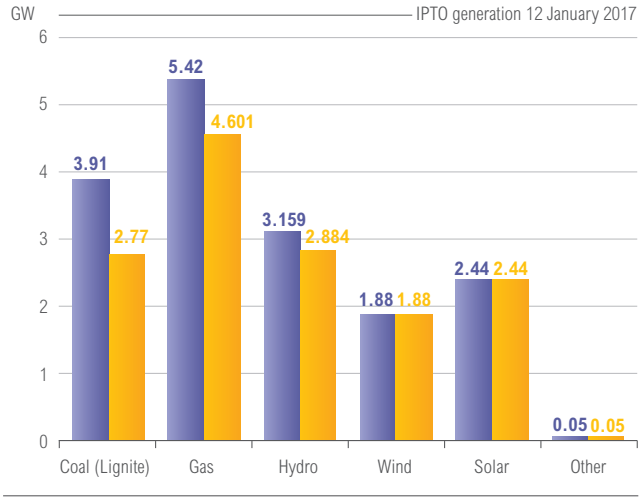


Figure 4.47: IPTO generation 12 January 2017

4.7.3 CONSUMPTION RECORDED

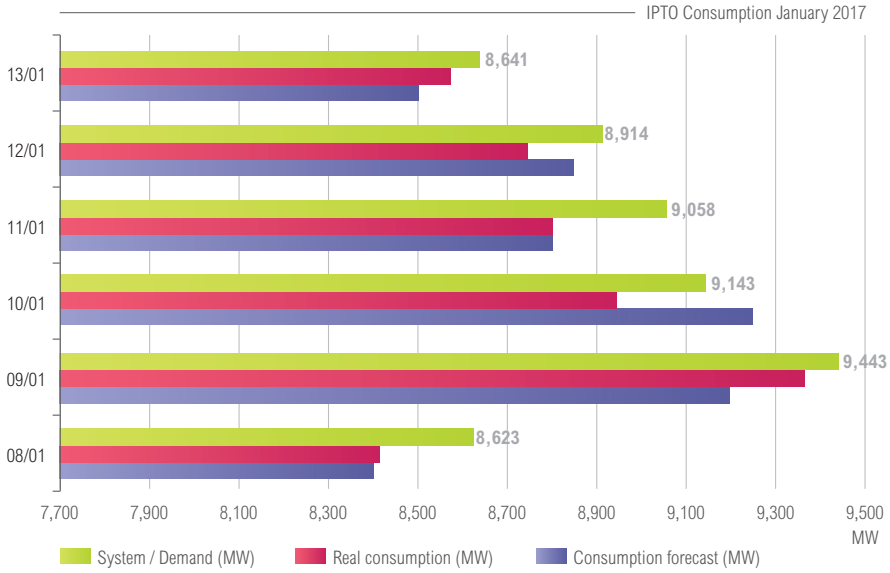


Figure 4.48: IPTO consumption January 2017

COMMENTARY

» Some industrial customers interrupted based on "interruptible" contracts.

4.7.4 SYSTEM RESERVES*

Day	FRR available [MW]	FRR used [MW]	Reason
8–20/01/2017	600 up FRR	400 up	For regulation
8–20/01/2017	100 down FRR		For regulation

FRR upwards = frequency in the system is low and we need more generation in order to stabilise

FRR downwards = frequency in the system is high and we need to reduce the generation in order to stabilise

4.7.5 WEATHER SITUATION

Day	Temperatures recorded [°C]	Weather events*
08–13/01/2017	Northern region: – 20 °C Central region: – 10 °C Southern region: – 3 °C	Snow falls all over Greece region.

COMMENTARY

» – 20 °C in certain locations of northern Greece and the gas supply limitation

» Bad weather conditions affect the lignite power production.

*Note that Replacement Reserve (RR) is not mandatory as defined in Operational Handbook for Continental Europe.

4.7.6 POWER GRID SITUATION

GR – IT interconnection was out of operation between 20 October 2016 and 22 January 2017 due to an unplanned outage; a fault occurred at the end of October and its reparation required till 21 January 2017.

4.7.7 KEY ANALYSIS

The following other 'crisis measures' were put in place:

1. Activation of all types of Interruptiblity Mechanism on 10 January 2017.
2. Crisis Management Team decided the switching of fuel from gas to diesel, to several units (where applicable).

The following order of priority was given to the measures:

1. Voluntary participation of gas power plants in limitation of gas use and in alteration of fuel type (from gas to diesel).
2. Activation of all types of Interruptibility Mechanism on 10 January 2017.

Crisis Management Committee took the decision to introduce these measures, under the coordination of the NRA.

The combination of severe weather conditions, of limitation of electricity production from gas power plants and of the increased system demand led IPTO to take such measures. In addition, the GR-IT interconnection (HVDC cable) was out of operation and, as a result, only the north interconnections of Greece were available for cross-border delivery of electricity. The possible imports were taken into account but they were extremely limited. Moreover IPTO attempted to receive emergency assistance from neighbouring TSOs, but it was not successful as all neighbors were in a similar situation.

The procedure for the exports curtailment was as follows and it is in agreement with the procedure described in the current Auction Rules concerning Network Security or Force Majeure situations:

- During the morning of 10 January IPTO proceeded to the following according to the relative border Auction Rules and the Agreement for services with SEE CAO concerning the 11th January.
- Informed SEE CAO for the curtailments on 11th January at 06:35 h CET and sent the agreed curtailment docs.
- Informed the neighbouring TSOs for the curtailment on 11 January at 06:41 h CET by e-mail and by phone where possible.
- Informed the market participants for the curtailment on 11 January at 07:01 h CET time by e-mail, by phone where possible and by announcement on its web site.
- During the afternoon of 10 January IPTO followed the same procedure for the curtailments on the 12 January.

The effect of these measures was the reduction of the cross-border trade, which affected the Day Ahead Market of Greece in 11 and 12 January 2017.

Due to the prompt exports curtailment, the exporters were not exposed to imbalance costs because the curtailment concerned the exports PTRs and not the scheduled exchanges. For this reason there was not an imbalance in Greek and neighbouring energy markets.

5. MARKET PRICES

This report is focused on the system operation and in providing factual elements to stakeholders, public authorities and citizens on the way the power system was managed during the cold spell in winter 2017. However, regarding its responsibilities in terms of market design and knowledge of market functioning, ENTSO-E is willing to add more information on market aspects. This section is providing a first analysis (as the report is firstly based on operation) and will be completed.

18 JANUARY

CENTRAL WESTERN EUROPE

- For Belgium Intra-day Market prices the values are not available, but further analysis will be conducted.
- In France, Italy and Switzerland, Imbalance Prices were significantly higher than Day ahead and Intraday.
- Day ahead prices in France and Italy were very similar, with Belgium following similar pattern and large convergence. All in all strong price differences from up to €40 on average across countries.
- Intraday prices follow a similar curve with high convergence between France and Switzerland, Germany intraday price around €30 lower than France and Switzerland.
- Imbalance prices quite different with Switzerland reaching up to €210.

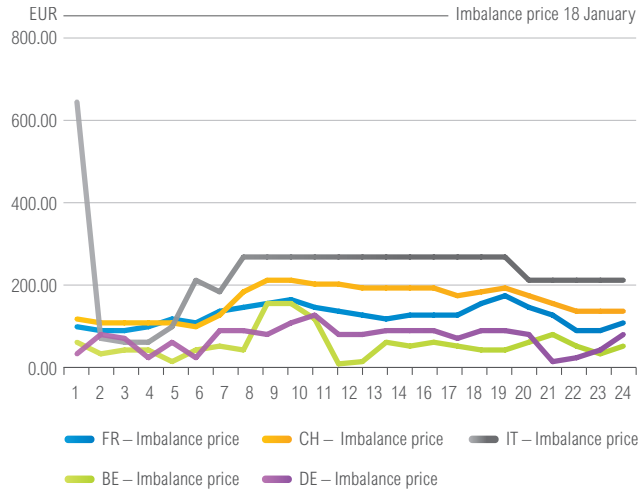


Figure 5.1: Imbalance price 18 January 2017

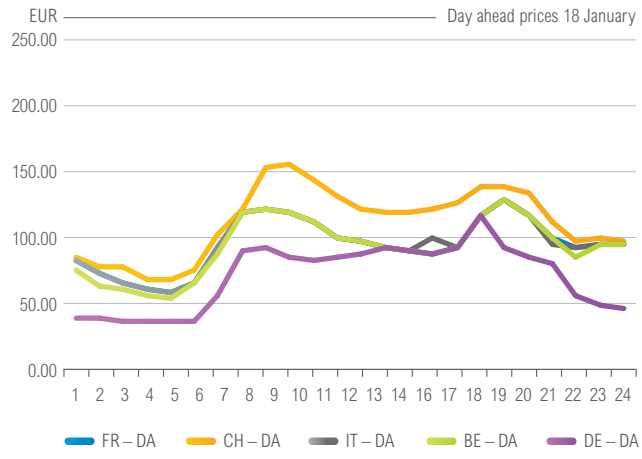


Figure 5.2: Day ahead prices 18 January 2017

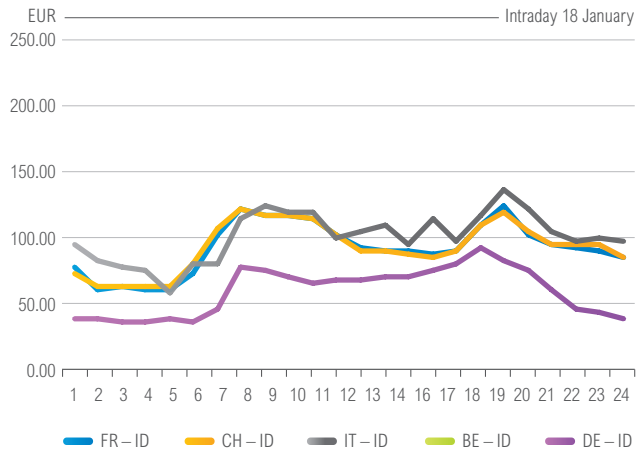


Figure 5.3: Intraday 18 January 2017

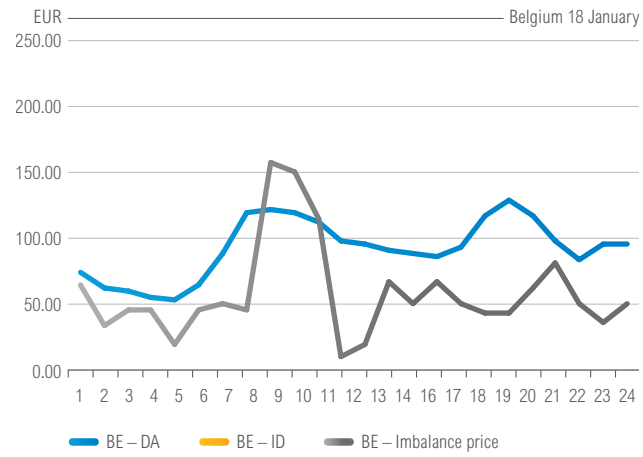


Figure 5.4: Belgium 18 January 2017

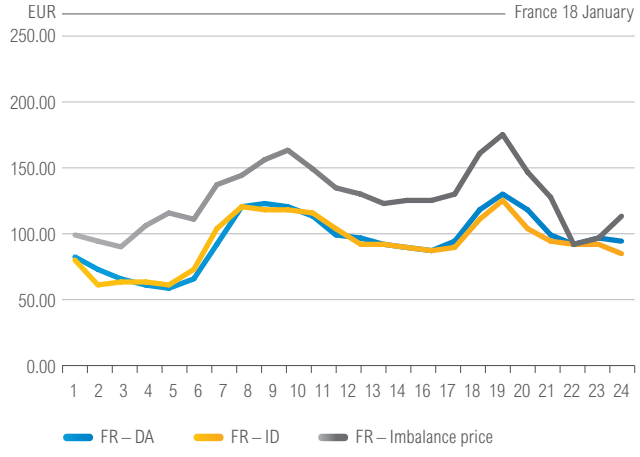


Figure 5.5: France 18 January 2017

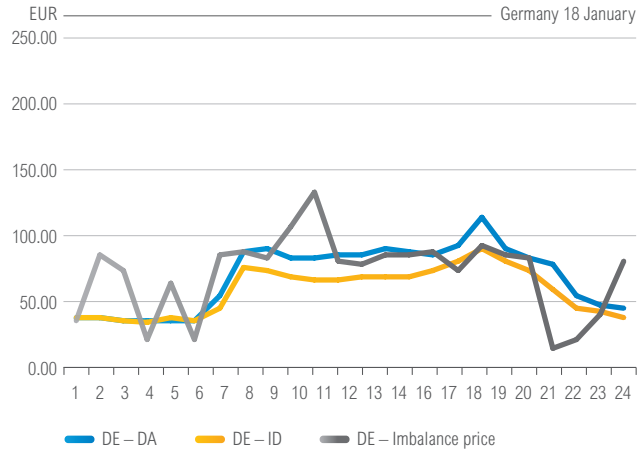


Figure 5.6: Germany 18 January 2017

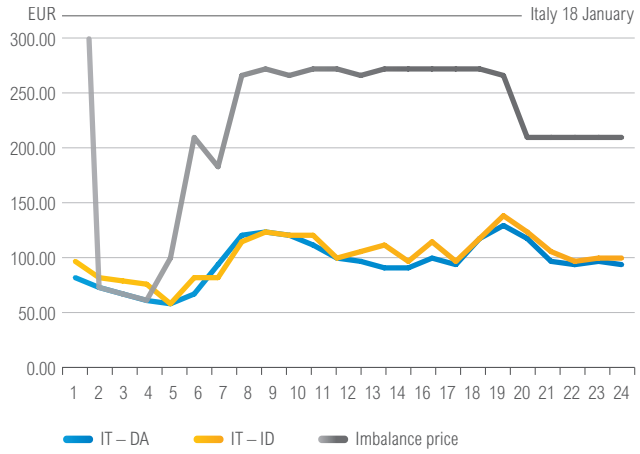


Figure 5.7: Italy 18 January 2017

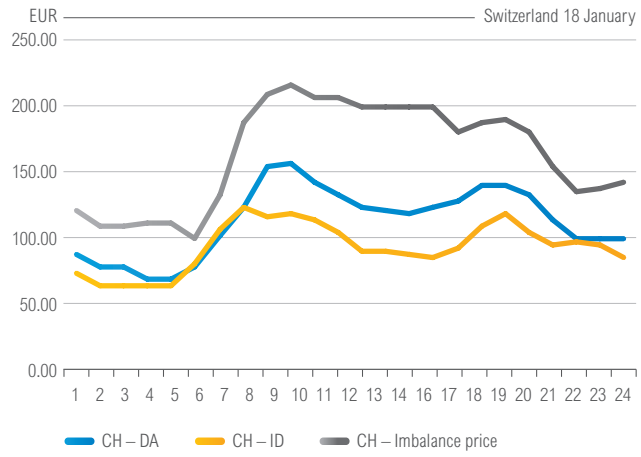


Figure 5.8: Switzerland 18 January 2017

18 JANUARY

SOUTH EAST EUROPE

- Bulgaria and Greece do not have Intra-day Market, so for this reason there are not available any Intra-day prices.
- Romania Intraday price significantly lower than Day ahead.
- Greece Day ahead (€ 145) and Imbalance prices of up to € 150.
- On Day ahead Romania reaches around € 100, Bulgaria € 106 and Greece peaks up to € 150.
- Imbalance prices vary mostly between € 90 and € 147.

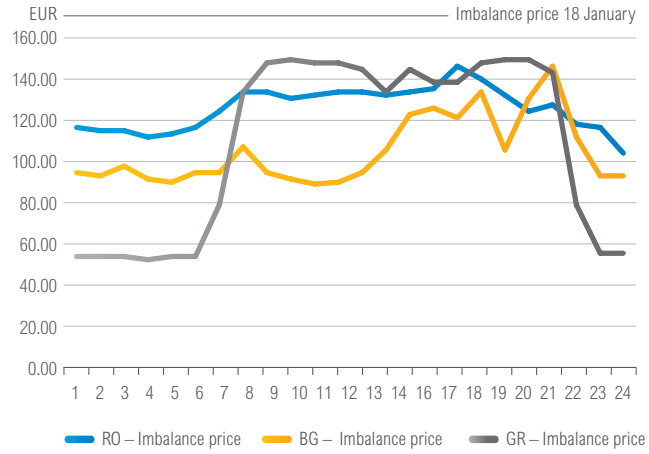


Figure 5.9: Imbalance price 18 January 2017

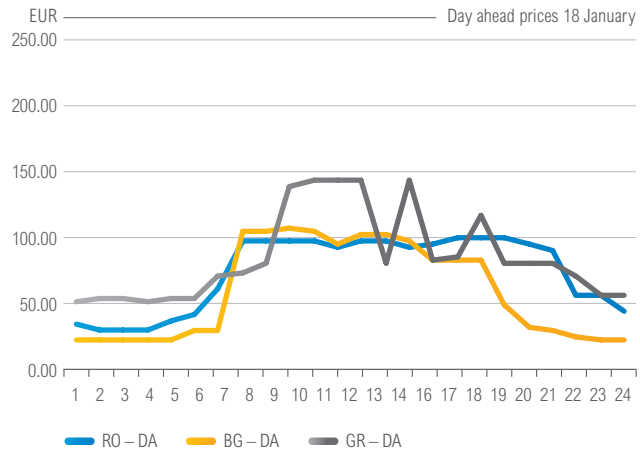


Figure 5.10: Day ahead prices 18 January 2017

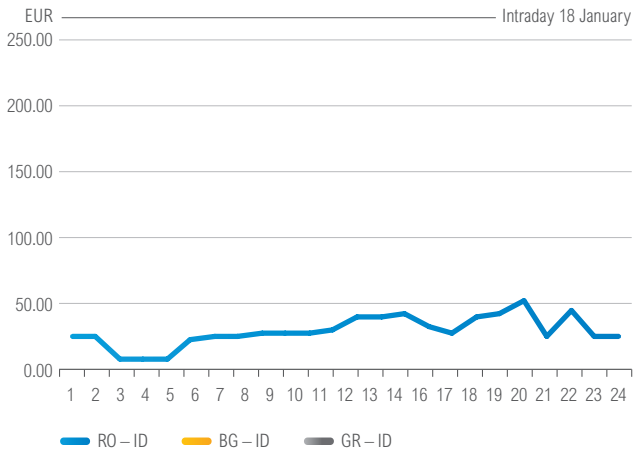


Figure 5.11: Intraday 18 January 2017

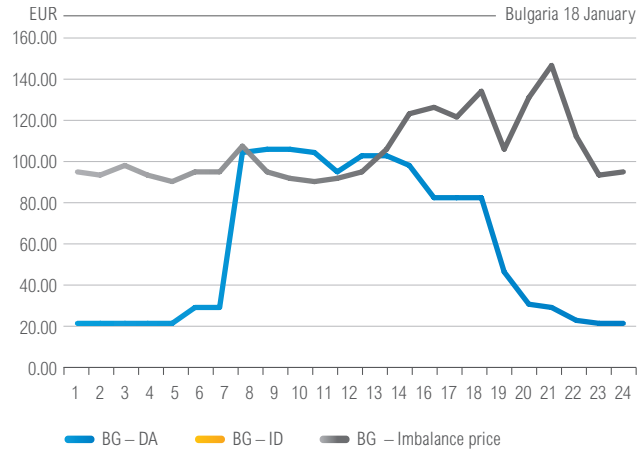


Figure 5.12: Bulgaria 18 January 2017

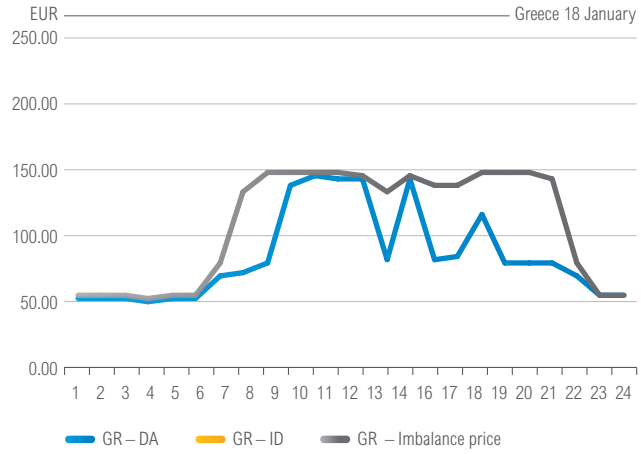


Figure 5.13: Greece 18 January 2017

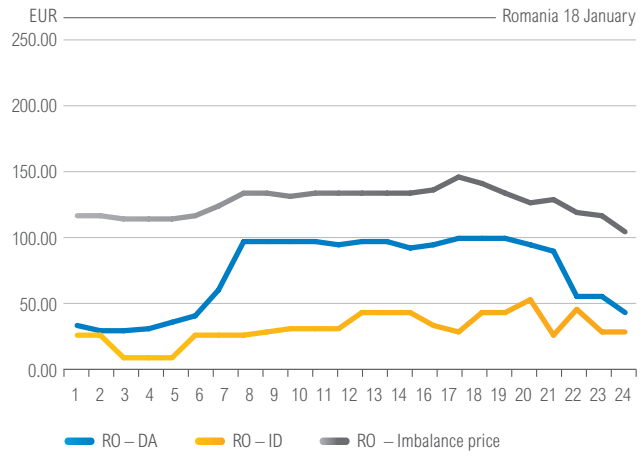


Figure 5.14: Romania 18 January 2017

20 JANUARY

CENTRAL WESTERN EUROPE

- For Belgium Intra-day Market prices the values are not available, but further analysis will be conducted.
- In France imbalance price around € 40 higher than Day ahead/Intraday. In Switzerland peak imbalance prices of € 2,288 at 9 am and € 1,237 at 10 am, Intraday peak at 10 am around € 452 and € 714 at 11:00 h.
- In Italy, imbalance prices higher than € 250 have been registered.
- Day ahead prices in Germany around € 40 lower than in the other countries.
- Intraday prices in France and Switzerland converge except during the Switzerland peak hours. Germany prices significantly lower on average € 54 compared to € 104 (France), € 151 (Switzerland) and € 87 (Italy).
- Imbalance price show the peak in Switzerland. Prices between Germany and France differ on average around € 70.

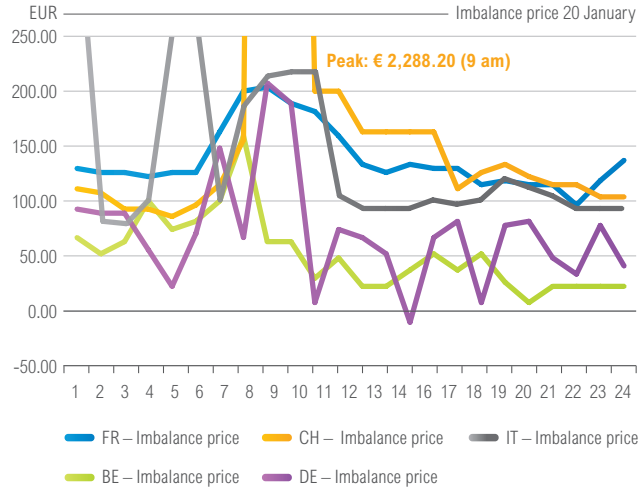


Figure 5.15: Imbalance price 20 January 2017

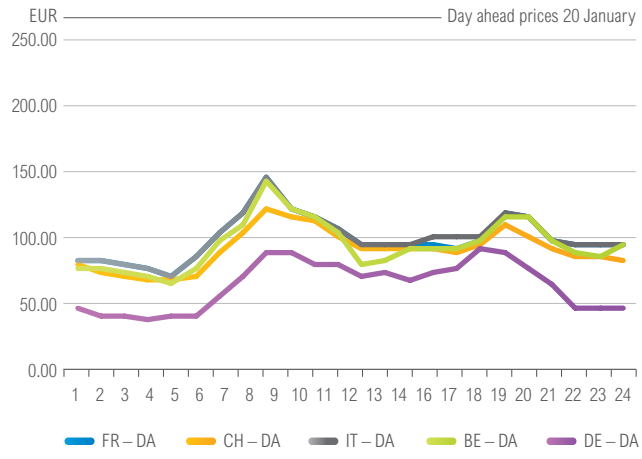


Figure 5.16: Day ahead prices 20 January 2017

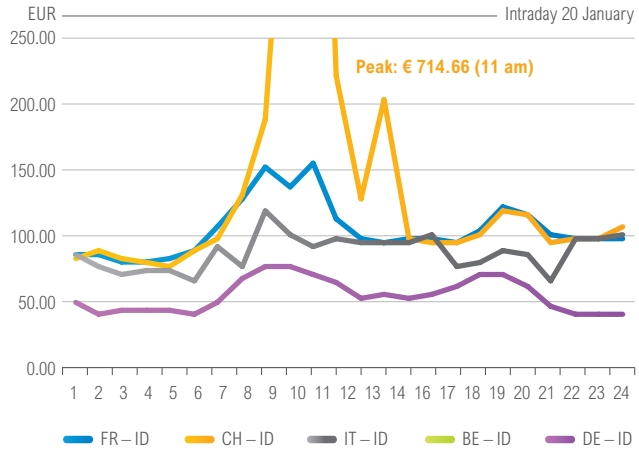


Figure 5.17: Intraday 20 January 2017

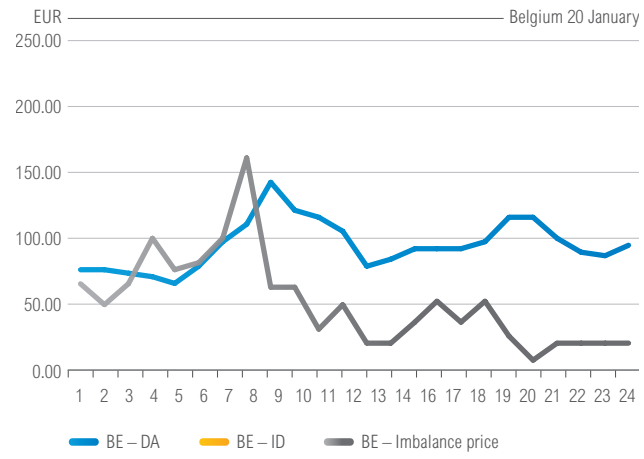


Figure 5.18: Belgium 20 January 2017

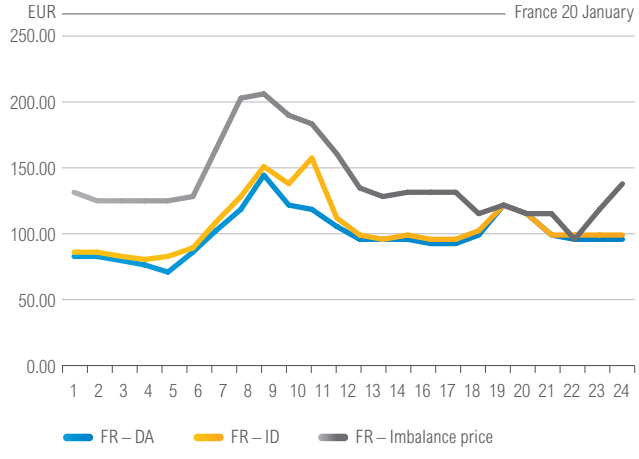


Figure 5.19: France 20 January 2017

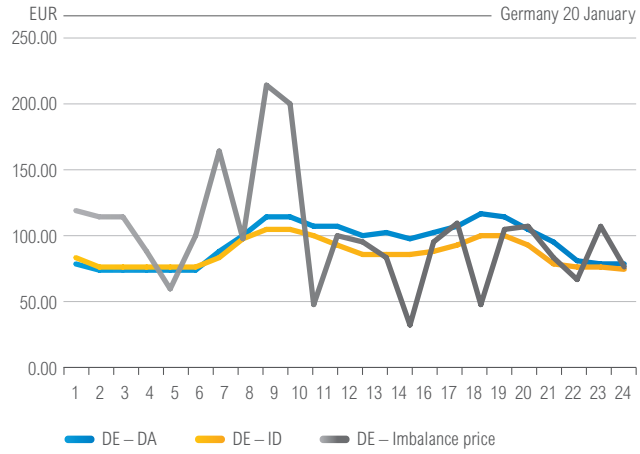


Figure 5.20: Germany 20 January 2017

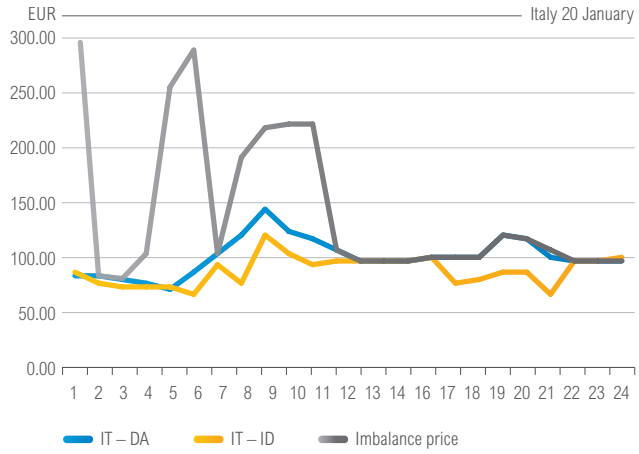


Figure 5.21: Italy 20 January 2017

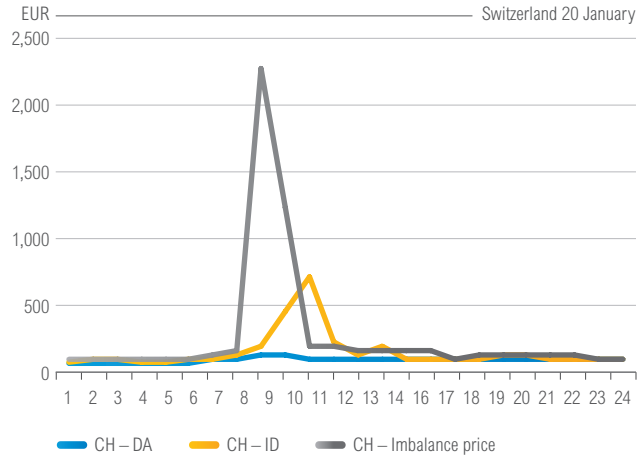


Figure 5.22: Switzerland 20 January 2017

20 JANUARY

SOUTH EAST EUROPE

- Bulgaria and Greece do not have Intra-day Market, so for this reason there are not available any Intra-day prices.
- Romania Intraday prices significantly lower than Day ahead.
- Bulgaria with Imbalance prices up to € 350.
- Greece Day ahead and Imbalance prices of up to € 144.
- Bulgaria Day ahead price on average € 62 and Romania and Greece Day ahead price on average € 98.
- Large difference in imbalance prices between Bulgaria and Romania/Greece.

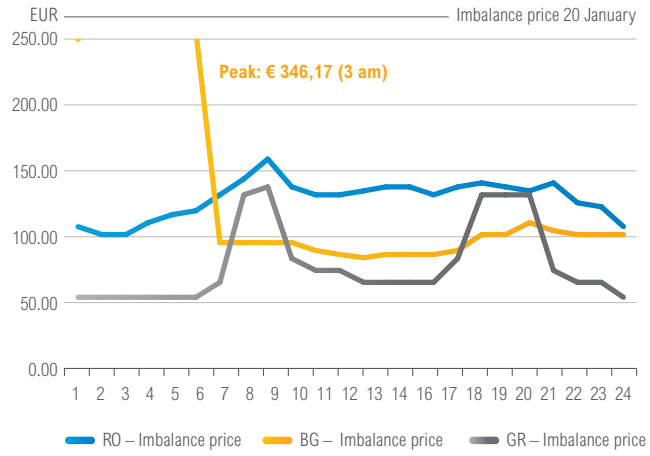


Figure 5.23: Imbalance price 20 January 2017

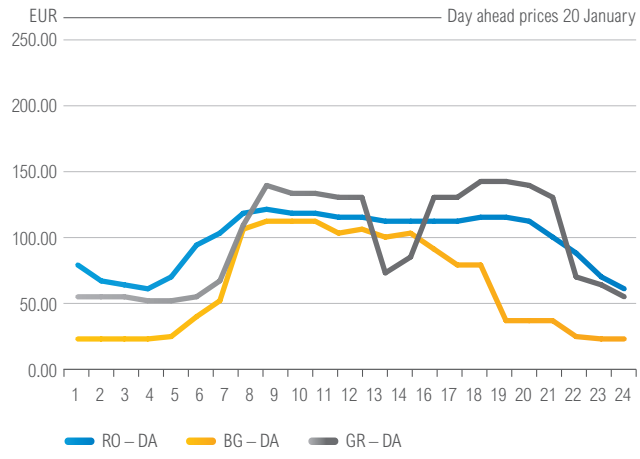


Figure 5.24: Day ahead prices 20 January 2017

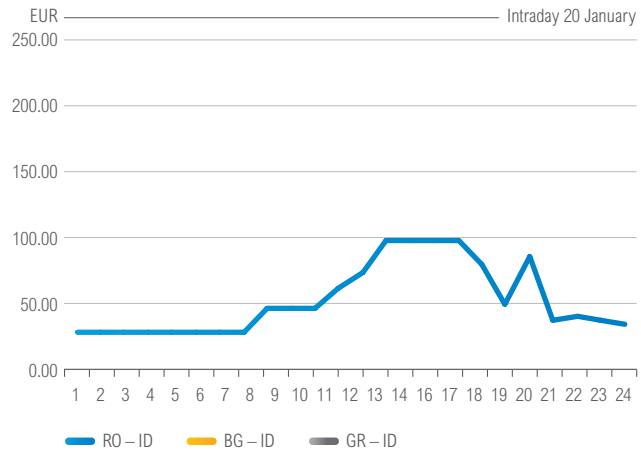


Figure 5.25: Intraday 20 January 2017

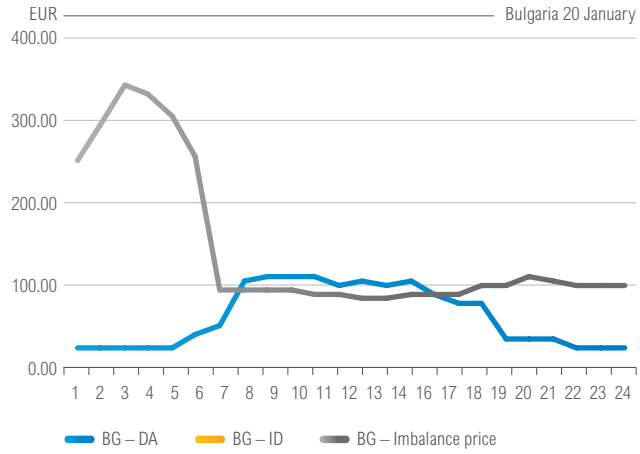


Figure 5.26: Bulgaria 20 January 2017

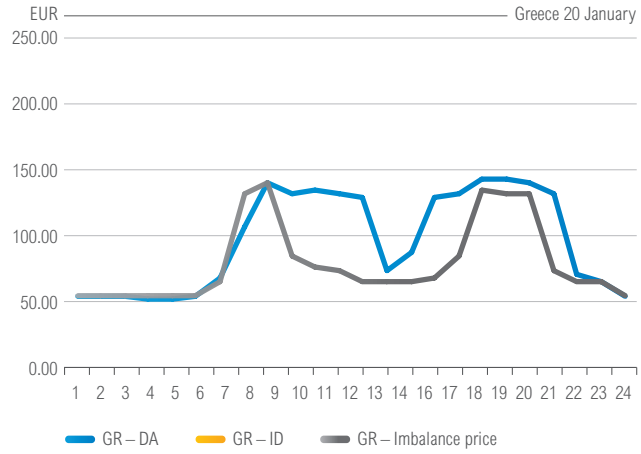


Figure 5.27: Greece 20 January 2017

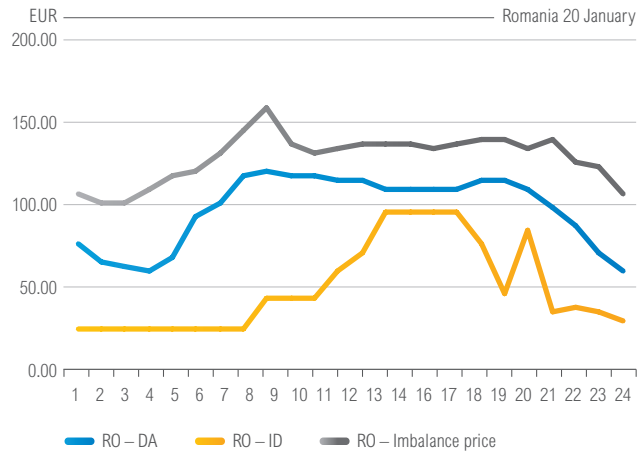


Figure 5.28: Romania 20 January 2017

25 JANUARY

CENTRAL WESTERN EUROPE

- For Belgium Intra-day Market prices the values are not available, but further analysis will be conducted.
- Over all countries high price levels.
- Day ahead prices in France, Switzerland, Italy and Belgium relatively high (around € 120).
- Intraday prices over all countries relatively high.
- Imbalance prices overall very high, DE prices have sharp peaks of up to € 362. Also Belgium Imbalance price reaches up to € 324.

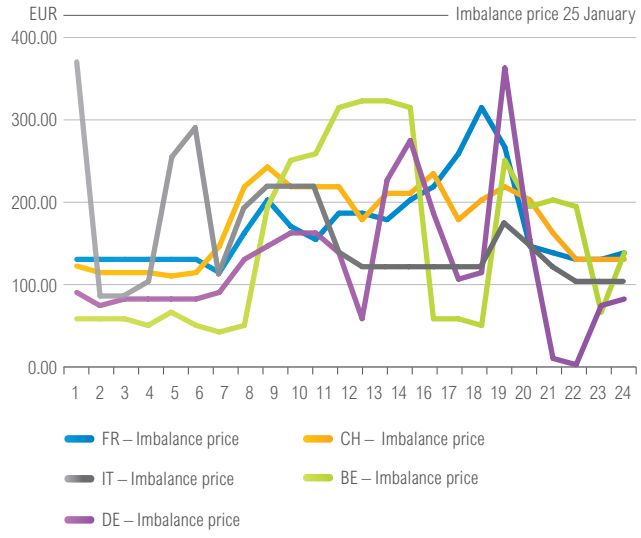


Figure 5.29: Imbalance price 25 January 2017

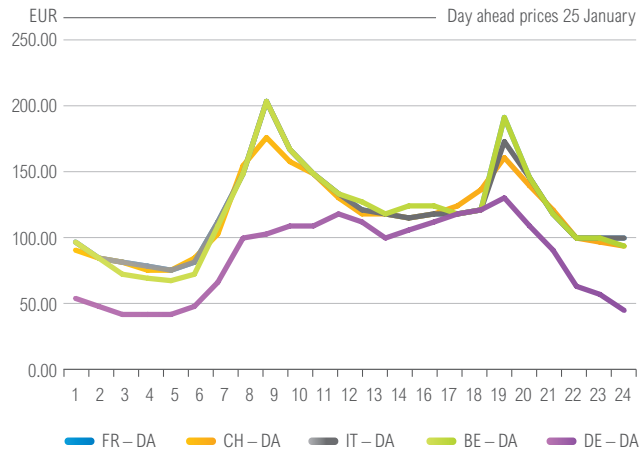


Figure 5.30: Day ahead prices 25 January 2017

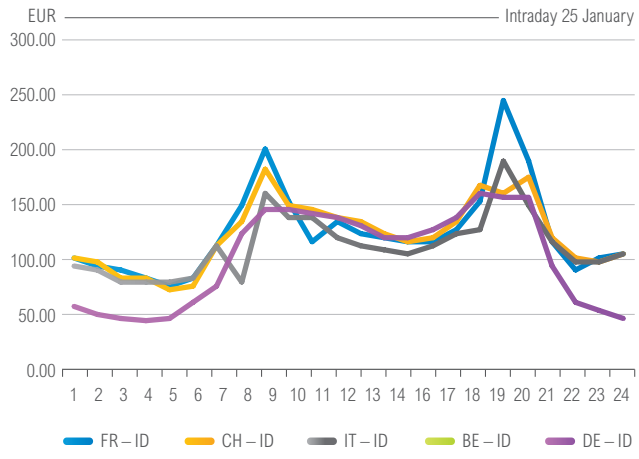


Figure 5.31: Intraday 25 January 2017

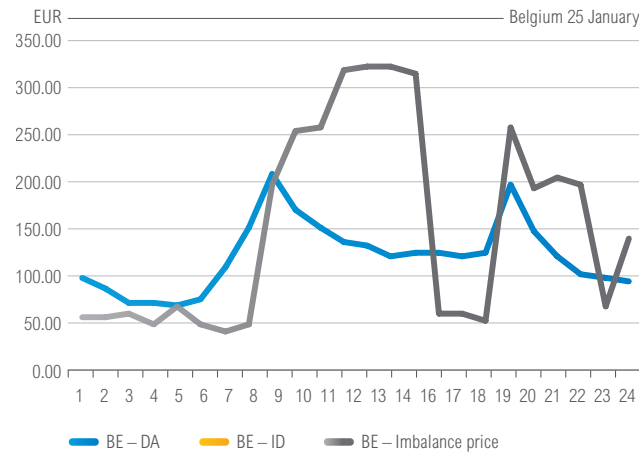


Figure 5.32: Belgium 25 January 2017

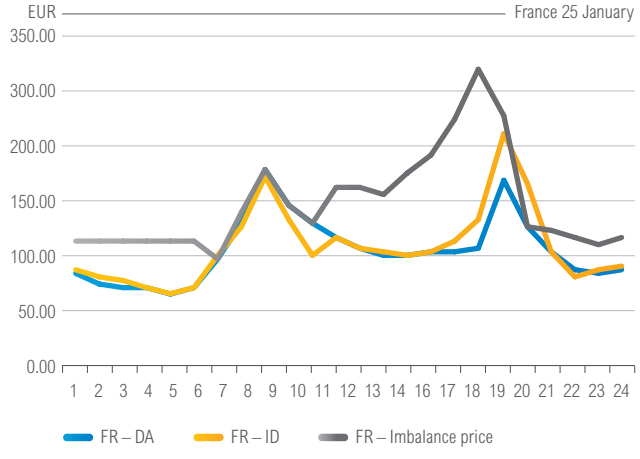


Figure 5.33: France 25 January 2017

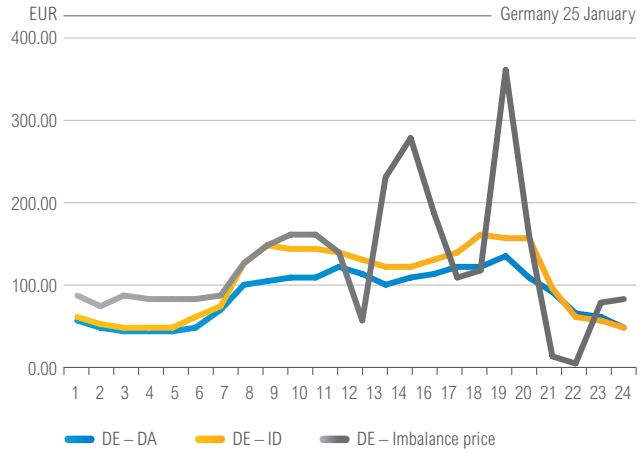


Figure 5.34: Germany 25 January 2017

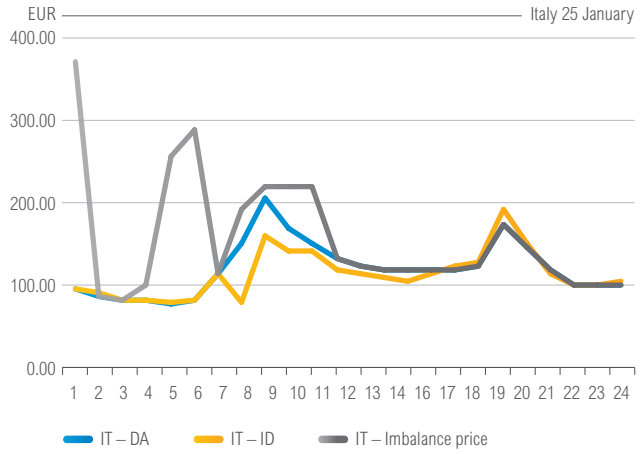


Figure 5.35: Italy 25 January 2017

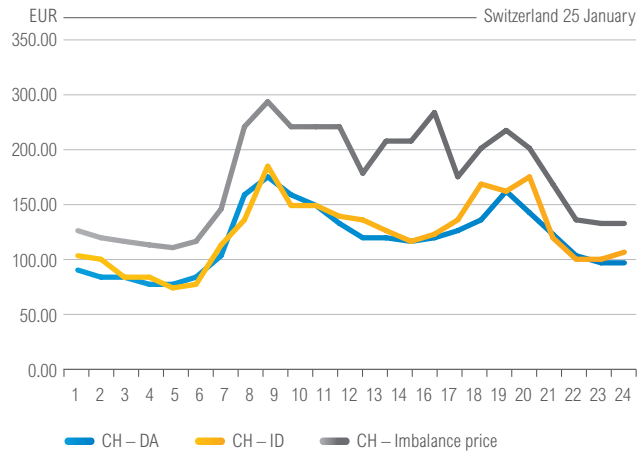


Figure 5.36: Switzerland 25 January 2017

25 JANUARY

SOUTH EAST EUROPE

- Bulgaria and Greece do not have Intra-day Market, so for this reason there are not available any Intra-day prices.
- Romania Intraday price significantly lower than Day ahead.
- Bulgaria imbalance price peaks at € 291.
- Greece Day ahead (€ 138) and Imbalance prices of up to € 150.
- Day ahead price in Bulgaria on average € 60, in Romania and Greece € 97/90.

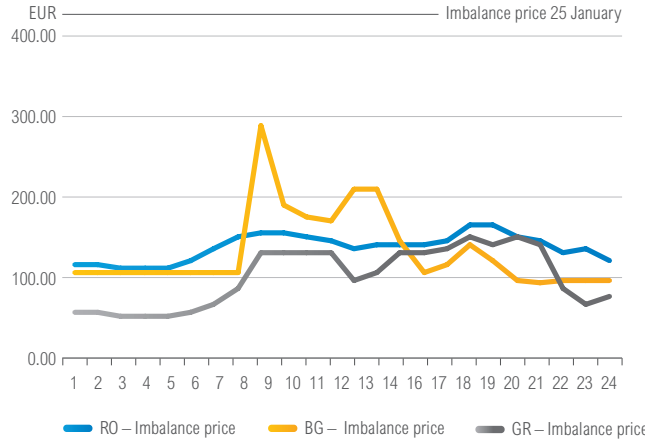


Figure 5.37: Imbalance price 25 January 2017

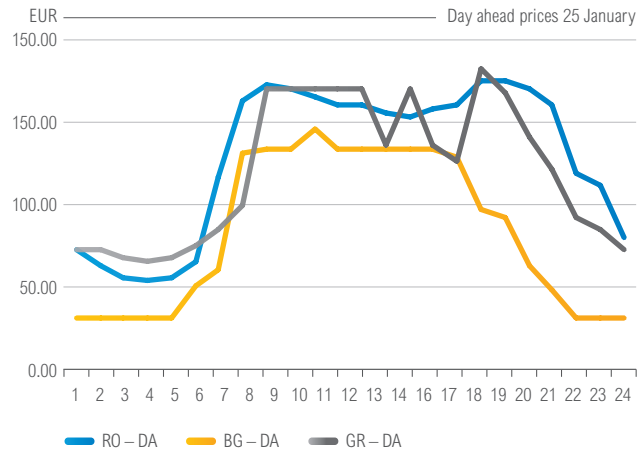


Figure 5.38: Day ahaed prices 25 January 2017

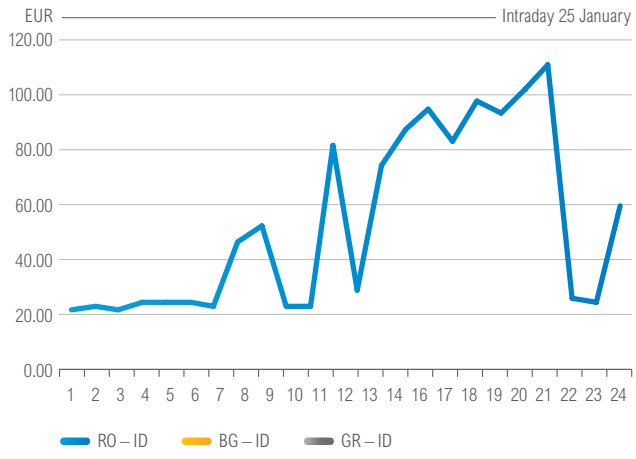


Figure 5.39: Intraday 25 January 2017

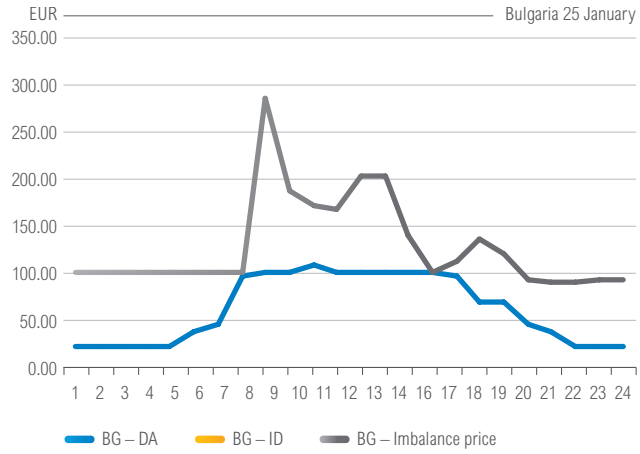


Figure 5.40: Bulgaria 25 January 2017

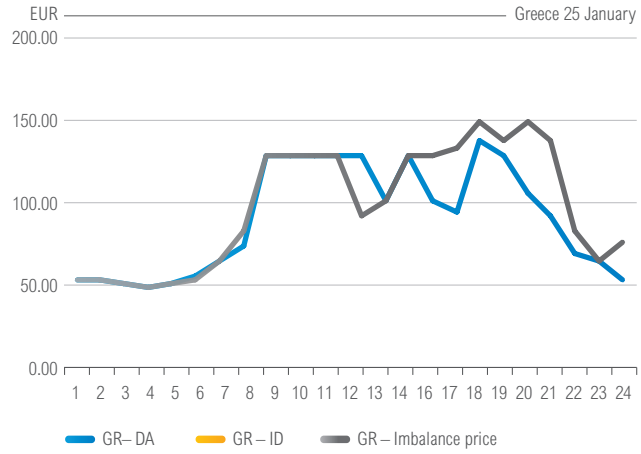


Figure 5.41: Greece 25 January 2017

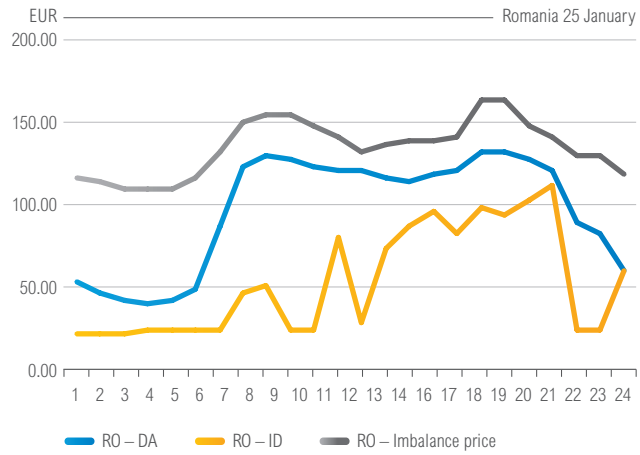


Figure 5.42: Romania 25 January 2017

26 JANUARY

CENTRAL WESTERN EUROPE

- For Belgium Intra-day Market prices the values are not available, but further analysis will be conducted.
- All countries show relatively high prices except Germany. Switzerland continuously higher imbalance price compared to Day ahead and Intraday of about € 50.
- Day ahead prices in France, Switzerland, Italy, Belgium with strong peaks, Germany does not show peaks and is significantly lower.
- Intraday prices show also high difference between Germany and France of on average € 75 and between Germany and Switzerland/Italy of € 50 on average.
- Imbalance prices follow similar levels in France, Italy and Switzerland. Prices in Germany and Belgium largely lower. Difference between Germany and Switzerland on average € 130.

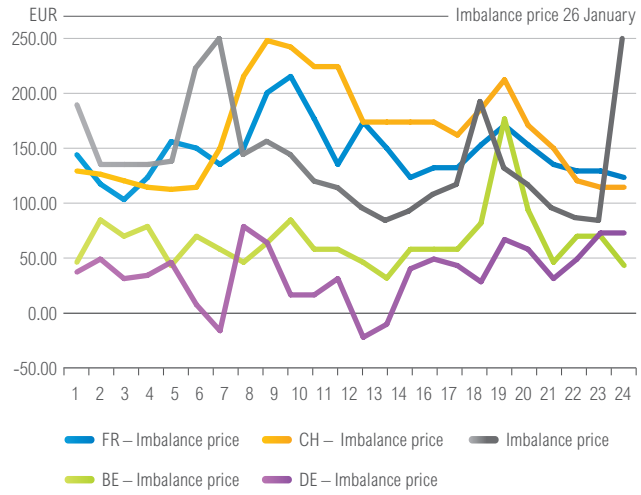


Figure 5.43: Imbalance price 26 January 2017

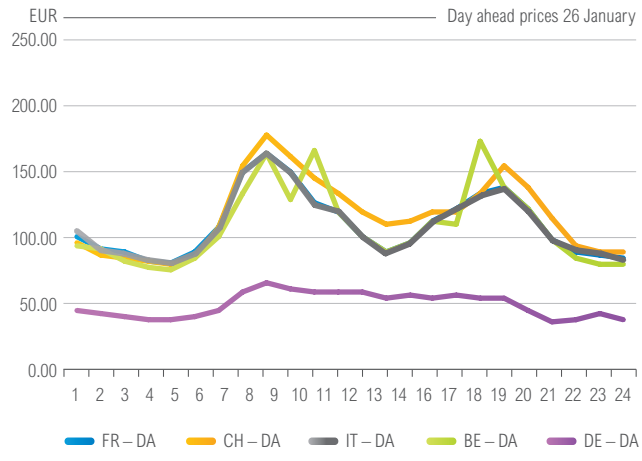


Figure 5.44: Day ahead prices 26 January 2017

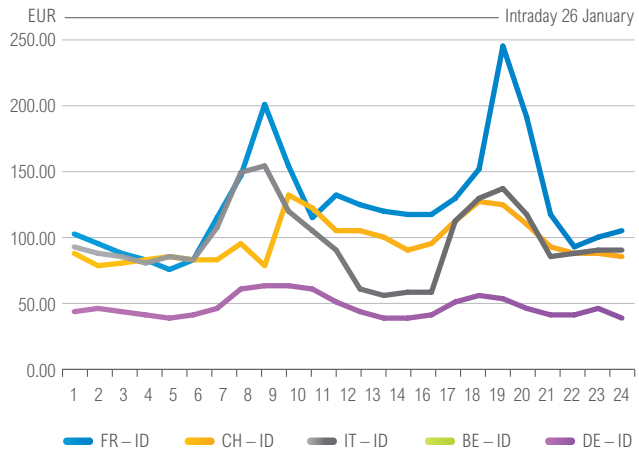


Figure 5.45: Intraday 26 January 2017

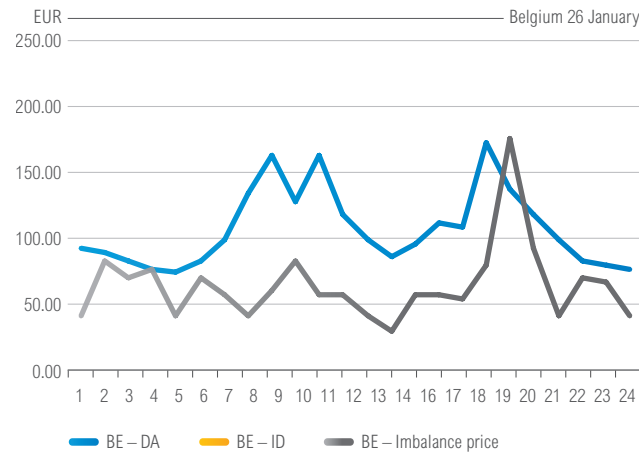


Figure 5.46: Belgium 26 January 2017

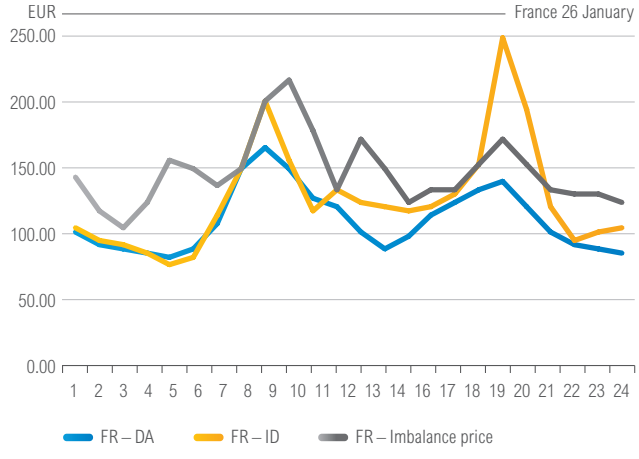


Figure 5.47: France 26 January 2017

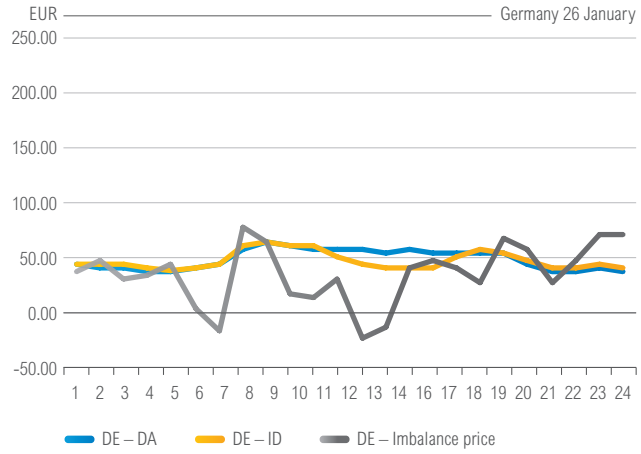


Figure 5.48: Germany 26 January 2017

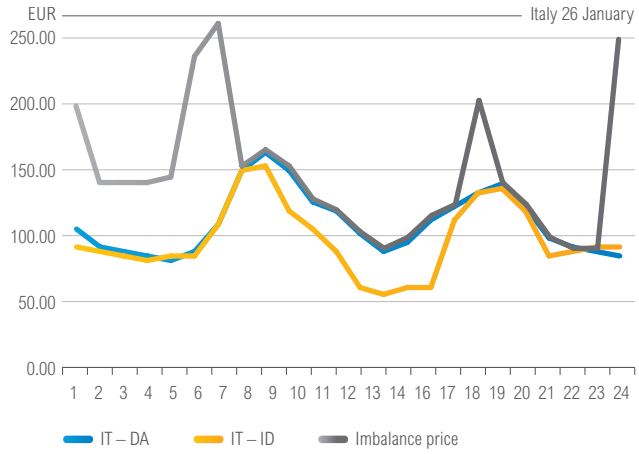


Figure 5.49: Italy 26 January 2017

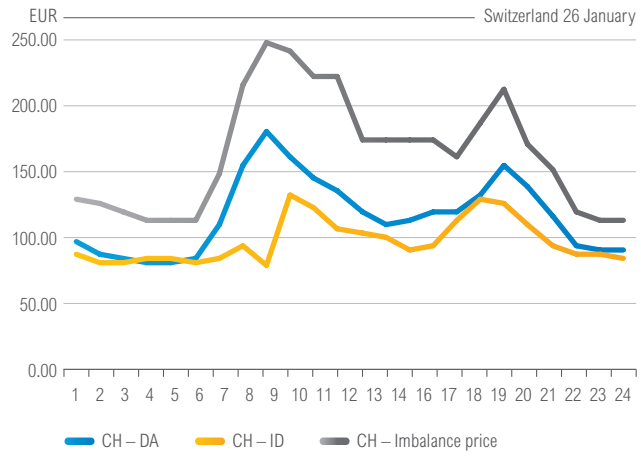


Figure 5.50: Switzerland 26 January 2017

26 JANUARY

SOUTH EAST EUROPE

- Bulgaria and Greece do not have Intra-day Market, so for this reason there are not available any Intra-day prices.
- Romania Intraday price significantly lower than Day ahead.
- Bulgaria imbalance price peaks at € 503.
- Greece Day ahead (€ 138) and Imbalance prices of up to € 145.
- Day ahead price in Bulgaria (€ 68) on average significantly lower than in Romania (€ 87) and Greece (€ 102).

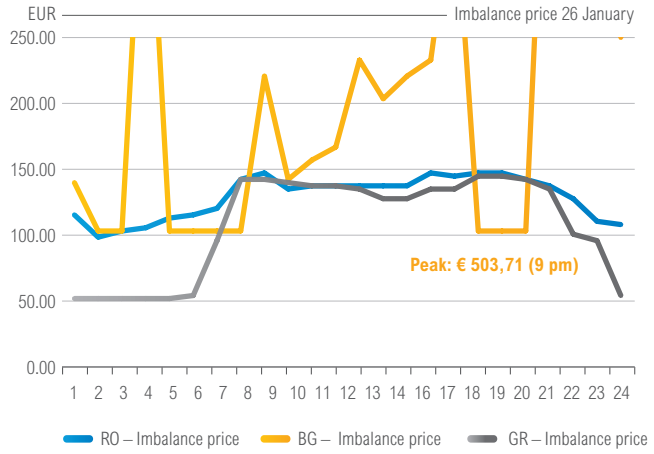


Figure 5.51: Imbalance price 26 January 2017

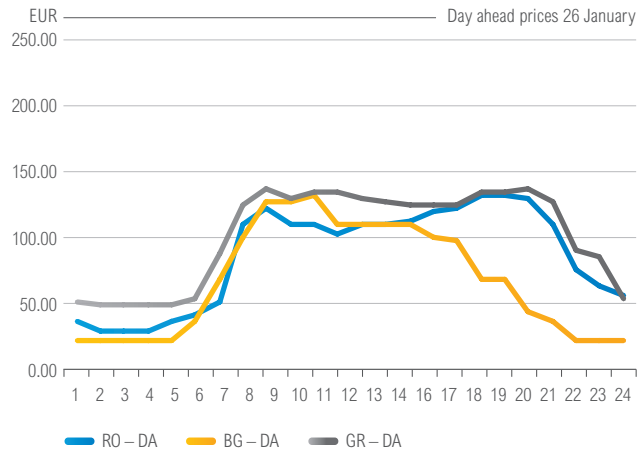


Figure 5.52: Day ahaed prices 26 January 2017

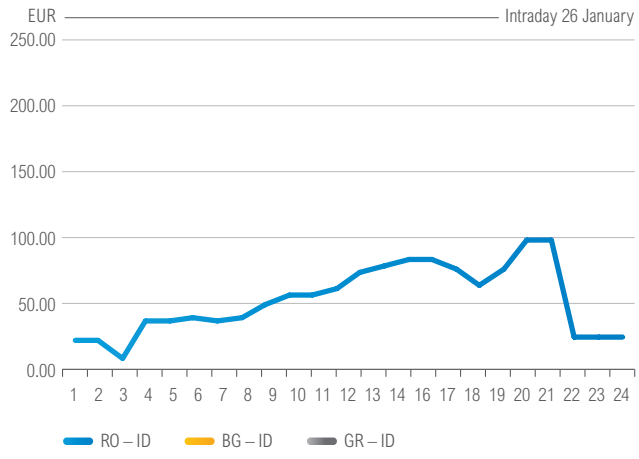


Figure 5.53: Intraday 26 January 2017

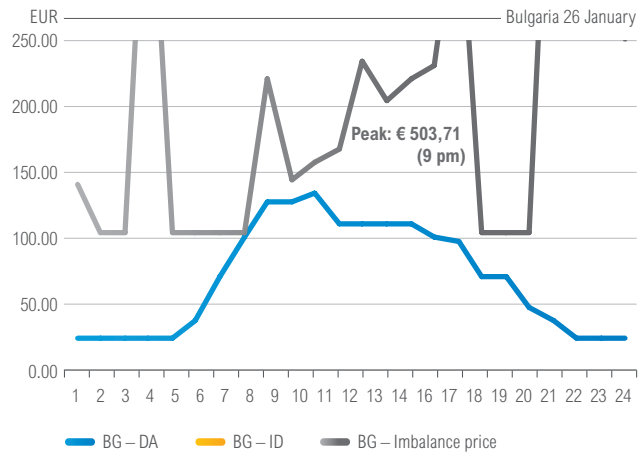


Figure 5.54: Bulgaria 26 January 2017

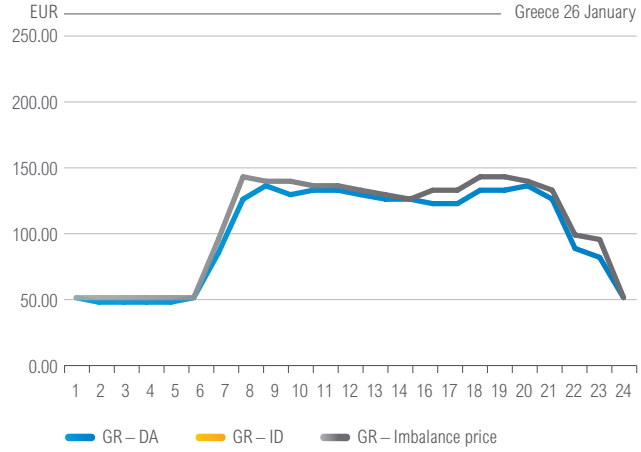


Figure 5.55: Greece 26 January 2017

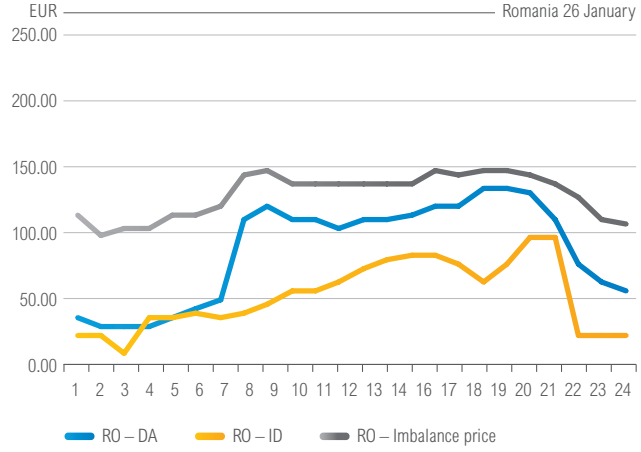


Figure 5.56: Romania 26 January 2017

NEXT STEPS

ENTSO-E IS INVESTIGATING THE FOLLOWING:

- analyse market prices and their link with system needs (eventually scarcity situations) from a system point of view
- evaluate the tightness of markets
- analyse the extent to which cross border capacities were used by market participants
- analyse incentives linked to balancing prices and imbalance prices schemes.

6. OUR KEY FOCUS AREAS

In accordance with its roles to implement and further enhance regional coordination, the following recommendations are proposed for implementation primarily at pan-European level. For South East Europe region, as the regional coordination is not yet implemented there are recommendations affecting this region specifically.

SEASONAL OUTLOOK

- "Stress tests" should be conducted by all TSOs supported by ENTSO-E for pan-European result and by RSCs for (short-term) regional adequacy forecast, not only regarding temperature but also regarding also other relevant conditions based on historical experience and exceptions (e.g. exceptionally dry years, multiple outages, etc.).
- Extremely low temperatures can lead to unplanned outages (incidents) like e.g. frozen river impact on hydro generation, power plant cooling, and coal /gas supply interruptions. ENTSO-E should investigate within the seasonal outlook, how to address multiple outage situations, including the risk level of probabilistic outages of generators by country.
- Hydro modelling is to be investigated including possible synergies with the Short/Medium Term Adequacy forecasting tool. Hydro modelling improvements would further require the implementation of a new tool for the Seasonal Outlooks.

REGIONAL COORDINATION AND ANALYSIS

- Improve the efficiency of inter-TSO cooperation and the involvement of RSCs from week-ahead to intraday especially in SEE where regional cooperation is now being established.
- Mutual exchange of information for safeguarding measures applied among the TSOs needs to be continuously reviewed and information updated between TSOs where the situation may change year on year.
- The Short & Medium Term Adequacy service has proved its importance today as well as in the future as one of the 5 standard services provided by RSCs. Future evolution both, in the direction of short time (D-2, D-1) as well as for longer periods beyond a week is being delivered through pilot projects being implemented within ENTSO-E.
- The implementation of CACM Guideline and more specifically the setup of D-2 to intraday coordinated capacity calculation processes on all borders is a necessary precondition for ensuring secure operation of the interconnected system.

ENERGY MARKET

- For South East Europe, further evolution and effectiveness of regional electricity market would need to be of top priority.

CRITICAL GRID SITUATIONS AND COMMUNICATION

- Coal storage in the thermal coal based is in general based on market expectations. TSOs to investigate the need of appropriate procedures to monitor and to take measures in the management of coal storages depending on individual risk levels of coal shortages and in line with the national regulation framework
- Due to the link between gas and electricity supply, the TSOs for gas and electricity need to ensure the close cooperation and forward planning of risk scenarios ensuring measures can be taken to guarantee security of supply in both gas and electricity.

ABBREVIATIONS

ATC	Available Transmission Capacity
BRP	Balance Responsable Party
CACM GL	Capacity Allocation and Congestion Management Guideline
CCGT	Combined Cycle Gas Turbine
CGM	Common Grid Model
CSO	Coordinated System Operation Group
CSO SG	Coordinated System Operations SubGroup
CWE area	Central-West Europe area
DAN	Day-Ahead Market
DSO	Distribution System Operator
EAS	European Awareness System
EEA	European Economic Area
ENS	Energy Not Supplied
mFRR	manual Frequency Restoration Reserve
aFRR	automatic Frequency Restoration Reserve
HFO	Heavy Fuel Oil
IDM	Intraday Market
IFA	Interconnexion France-Angleterre
JAO	Joint Auction Office
MEAS	Mutual Emergency Assistance Service
MAF	Medium-term Adequacy Forecast
MLA	Multi-Lateral Agreement
NRA	National Regulatory Authority
NTC	Net Transmission Capacity
OPDE	Operational Planning and Data Exchange
OHL	Over-Head Lines
PST	Phase-Shift Transformer
PTR	Physical Transmission Rights
RR	Replacement Reserve
RSC	Regional Security Coordinator
SEE CAO	South-East Europe Capacity Allocation Office
SO GL	System Operations Guideline
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
WOPT	Weekly Operational Planning Teleconference

PUBLISHER:
ENTSO-E AISBL,
Avenue de Cortenbergh 100
1000 Brussels – Belgium

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DESIGN:
DreiDreizehn GmbH, Berlin
www.313.de

Publishing date: May 2017

CONTACT

ENTSO-E AISBL
Avenue de Cortenbergh 100 · 1000 Brussels – Belgium
Tel +32 2 741 09 50 · Fax +32 2 741 09 51
info@entsoe.eu · www.entsoe.eu

European Network of
Transmission System Operators
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