Le réseau
de transport
d'électricité

2017

BILAN SÛRETÉ

CONTENTS

SUMMARY

Every year, RTE draws up the safety report for the past year. This document provides the key elements on electrical grid operational safety for 2017 and the ongoing actions to pave the way for tomorrow's safety.

Within the context of energy transition, changes in the European interconnected grid require RTE to make adaptations on a on-going basis.

Self-assessment of grid resilience

The results presented in 2017 attest to the satisfactory level of a safe grid management, in conditions that are occasionally strained. For the future, RTE shall relentlessly adapt itself to the new vulnerabilities mainly caused by the new behaviour of energy sector participants, the rapidly changing European context and massive input of variable renewable energies rendering it more and more difficult to plan ahead and operate the grid in safe conditions.

These changes disrupt the structure and operation of the electricity system, not just voltage and frequency management, but also flow distribution, electric al grid stability, reserve level required to ensure balance of supply and demand, grid studies, operating rules as tools operator skills and asset management.

Planning ahead for expected changes in the context has resulted in RTE launching numerous actions to guarantee high level of safety:

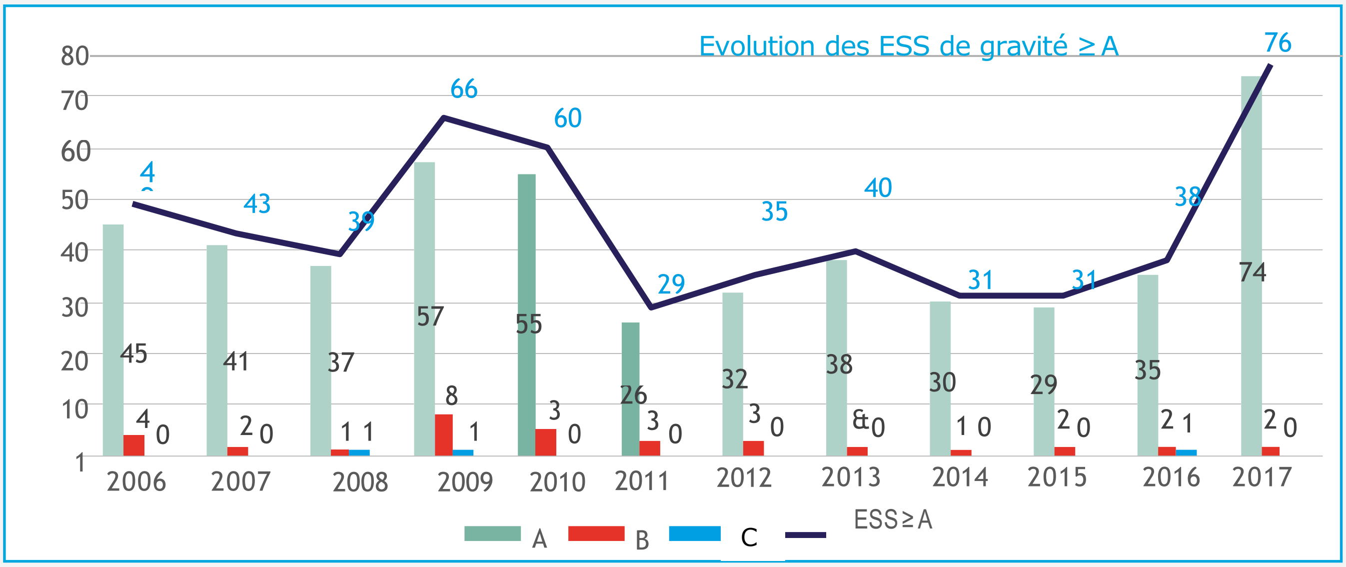
- Increased exchange capacities at the borders with neighbouring countries and conduct of provisional joint studies on balance of supply and demand, proof of strengthened security of supply;
- Development of scenarios to support the energy decisions to be taken by the years 2025 (Ohm) and 2035 (Ampere, Hertz, Volt and Watt);
- Upkeep of the investment level of 1.4 billion Euros a year;
- Participation in experiments and projects (such as Ampacité, iTesla, Apogée and OSMOS) designed to pre-empt future electricity system requirements and set up new tools to face up to the challenges. This work will ease energy transition.

Lastly, the Clean Energy Package, presented by the European Commission at the end of 2016, contains numerous provisions with consequences for electric grid safety and the transmission system operator role (TSO). RTE clarifies the underlying policy stakes of the proposed technical provisions. RTE also provides for appropriate measures in keeping with energy transition and for a reliable electrical grid for the benefit of all of its customers.

SIGNIFICANT SYSTEM EVENTS

Every year, RTE measures the grid safety by recording the Significant System Events (SSE), classified according to a severity scale that ranges from 0 to F. These events correspond to incidents that can result from a broad range of causes. RTE's scale is more differentiated and is compatible with the ICS (Incident Classification Scale) severity scale based on four levels defined by ENTSO-E

This increase was partly caused by strained operating conditions encountered in January-February and November 2017 and a large number of situations when maximum grid capacities were reached with the overload protection triggers.



Tracking of the SSEs over several years flags up weak signals requiring more detailed analysis, in order to assess safety measures set up to increase the grid management safety over time

With 74 level A incidents and 2 level B incidents, **the report for 2017 showed a sharp rise in SSEs compared to the past few years without any alert** (see the graph above).

The first level B SSE was caused by transmission of a safeguard order due to a shortfall in the margin of 2 hours for 30 minutes on 25 January 2017 during the strike affecting power generation. Whereas the second one reflected a risk situation that could have resulted in an extended power cut zone further to malfunction of the protection function on the 225 kV line.

OPERATIONAL CONDITIONS ENCOUNTERED

Regarding the weather conditions, 2017 was **another warm year** with temperatures in France 0.8°C higher than normal.
However, it was not particularly exceptional, and 2017 was ranked as the 5th hottest year behind 2014 (+1.2 °C), 2011 (+1.1 °C) and 2015 (+1 °C).
From a very general perspective, the following are noteworthy in terms of grid operation:

In terms of balance of supply and demand:

- during the winter of 2016/2017, RTE was deployed by the cold snap to plan ahead for balance of supply and demand, with widespread involvement of neighbouring TSOs and CORESO,
- Sunshine fostering solar power generation,
- Several periods of drought resulted in a sharp drop in hydropower generation of -16.3% against 2016,
- Wind power generation hit an all-time record high on 30 December with 11075 MW observed at 13.30 and an increase of nearly 15% in wind power generated due to a stronger windy year than in 2016.

Concerning grid management:

- Numerous storms (EGON, KURT, LIEV, MARCEL, ZEUS, ANA, etc) with high winds and numerous shutdowns but not causing any major impact on the grid partly due to the mechanical control policy finalised in 2017,
- 2017, a moderate year for the keraunic level,
- Numerous fires from June to September in the region of Marseille effectively managed with the Fire and Rescue Services and requiring around forty lines to be powered off,
- A summer heatwave which resulted in RTE monitoring the forecast temperature changes in its substations in order to prevent any consequences for the measuring transformers,
- Sticky snow and ice at the end of 2017 causing numerous shutdowns of the lines and requiring adaptation of the generation plan and power exchanges with abroad.

CONTINUING GROWTH OF RENEWABLE ENERGIES

In mainland France, composition of the generation capacity continued to change in favour of renewable energies with an **additional wind and solar power generation** connection **of nearly 2800 MW.**

GIVEN ITS GROWING SHARE IN THE ENERGY MIX, RENEWABLE ENERGY GENERATION (37.3% AT THE END OF 2017 FOR THE RENEWABLE ENERGY GENERATION CAPACITY OUT OF TOTAL RENEWABLE ENERGIES WITH HYDROPOWER), DESPITE BEING DECENTRALISED, PLAYS AN INCREASINGLY IMPORTANT ROLE IN ENSURING ELECTRICITY SYSTEM STABILITY AND SAFETY (FREQUENCY, VOLTAGE, MARGIN, ETC).
THIS NEW SITUATION REQUIRES INCREASINGLY FLEXIBLE RESOURCES.

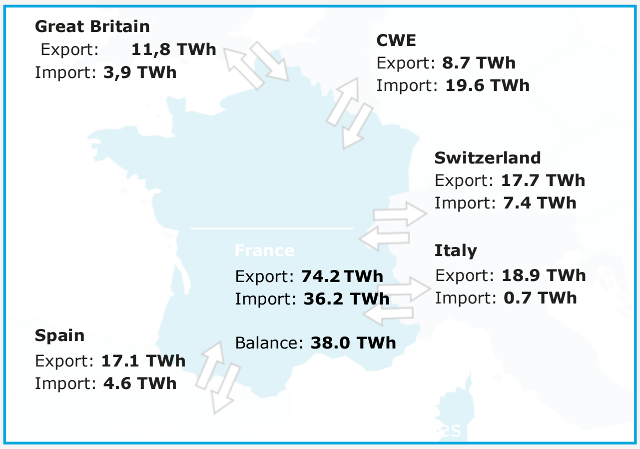
Total electricity generation dropped slightly by 0.4% against 2016 to reach 529.4 TWh.

Development of renewable energies constitutes a major component of energy transition. Energy transition is mainly driven by renewable energy development. For RTE, the main challenge involves understanding and **predicting their variability**, so that balance of supply and demand can be properly managed, and the impact that they have safe grid operations can be forecast (flows, voltage, etc). The demand response mechanisms need to be adapted on a continuous basis so as to **harness any potential for flexibility** among the various stakeholders and tackle the uncertainties surrounding renewable energies.

INTERCONNECTIONS: NEW POWER TRADE RECORDS REACHED IN 2017 FOR IMPROVED SAFETY

The French balance of trade was positive with 38 TWh (39.1 TWh in 2016). It should be pointed out that this record in January, when France had a negative balance of trade of 1 TWh, a level previously never reached, enabled France to overcome the cold snap and illustrated the importance of interconnections between European countries to

guarantee security of electricity supply.



In November, the balance of trade was also negative 0.826 TWh when nuclear availability was limited and temperatures were lower than normal for the season (-0.8 °C on average).

The French balance of trade reached new records with:

- a positive balance of 17 GW on Thursday 30 March between 18.00 and 19.00, i.e. more than 1 GW compared to the previous record,
- Negative balance of 10.6 GW between 23.00 and midnight on Saturday 2 December.

Significant interconnection capacities and import and export possibilities constitute a strong asset for successful energy transition with massive input from the renewable energies.

THE ELECTRICITY SYSTEM MUST BE ABLE TO ADAPT TO HIGHLY UNCERTAIN WEATHER CONDITIONS - PARTICULARLY FUTURE COLD SPELLS

Electricity consumption peaked at 19.00 on Friday 20 January with power of 94.2 GW. At the end of 2017, it was the third highest peak ever recorded in France. Sensitivity to consumption currently shows **a winter gradient estimated at 2400 MW per °C,** stable compared to previous years.

The last few relatively mild winters have had a tendency to hide the variability of consumption levels - both in terms of annual energy consumption and peak demand. However, even if the underlying trend is most likely heading towards an average increase in temperatures, the electricity grid must be able to cope with any cold spells, the frequency and severity of which are difficult to forecast. This is why emergency exercises for dealing with cold snaps are run on a regular basis so that operators can prepare themselves.

In the summer, the lowest power consumption was on Sunday 13 August 2017, with 30.2 GW.

Gross consumption in 2017 remained stable at nearly 482 TWh, a drop in -0.3% against the previous year. This very slight drop can mainly be attributed to higher temperatures than last year (+0.6 °C).

> SIGNIFICANT VARIABILITY IN CONSUMPTION SHOWS THAT THE POWER GRID NEEDS TO BE ABLE TO ADAPT TO HIGHLY UNCERTAIN WEATHER CONDITIONS - PARTICULARLY FUTURE COLD SNAPS.

2.1 SHORT-TERM SUPPLY-DEMAND BALANCEAND FREQUENCY

MONITORING OF MANAGEMENT OF BALANCE BETWEEN SUPPLY AND DEMAND

With 43 instances of lack of add-on margin (22 in 2016) and 6 occasions below the margin (4 in 2016), 2017 was more restricted than 2016 for management of balance between supply and demand. There was also an increase in the number of alerts sent, mainly as a result of industrial disputes among power generation companies.

Shortfalls in time margins can, depending on how long they last and the time of day at which they occur, impact the grid safety. The various initiatives that RTE has implemented with the stakeholders involved should therefore be maintained in order to **strengthen contractual requirements and perform monitoring and checking**, making sure that power generation companies declare the technical limitations affecting generation and actual availability with the Balancing Mechanism, with specific attention paid to demand response.

In terms of grid safety, when strain occurs such as during cold snap, it is important for **the demand**

response proposed to be activated in a reliable manner to contribute to safeguard of the grid. However, in 2017, checking of effective deployment of the offers still highlighted a few failures for a restricted number of participants. This matter is particularly sensitive for RTE, which needs to assess as accurately as possible the resources that can be activated and encourage the participants to declare capability loss as early as possible even if the likelihood of activation remains slight.

Equivalent outage time totalled 1 minute and 47 seconds, including 1 minute and 27 seconds outside exceptional events. This result, obtained in favourable weather conditions, is a record high for RTE.It also confirms relevance of the **actions set up by RTE to improve grid reliability and enhance quality of the electricity supplied to its customers.** In particular, accelerated replacement of its instrument transformers limited the impact of these malfunctions. It should be noted that malicious acts resulting from various industrial disputes at the end of 2017 added around 16 seconds to equivalent outage time.

SYSTEM FREQUENCY CONTROL, WHOSE QUALITY IS A CONCERN

There was a sharp rise in frequency deviations in 2017, contrary to the trend observed since 2013.

At the start of 2018, significant frequency deviations were also observed, including the most noteworthy since 2006 below the level were observed on 6 (-168 mHz) and 7 (-146.6 mHz) February at 20.00 during sudden changes in the exchange programmes. In response to this situation, RTE has set up an action plan to improve quality of French adjustment and deploy capacities of analysis and discussion within ENTSOE.

These deviations from reference frequency (50 Hz ±1 mHz) are recorded in the table below.

Frequency deviations	2013	2014	2015	2016	2017
F-Fref < - 100 mHz / 30s	25	20	18	31	**72**
F-Fref < - 80 mHz / 1 min 30	26	25	32	25	**47**
F-Fref < - 65 mHz / 4 min	21	16	22	12	**19**
F-Fref < - 50 mHz / 15 min	5	0	0	0	**1**
F-Fref > +50 mHz / 1 min 30	4	5	8	3	**18**
F-Fref > +100 mHz / 5 min	29	4	4	9	**7**
Total	110	70	84	80	**158**

For instance, 7 deviations of more than 100 mHz with duration of more than 5 minutes were recorded in 2017.

If frequency deviations below the level are currently deemed the most critical for the European system, a significant risk is also incurred for frequency deviations above the level related to massive shutdown of solar power generation, which could result in frequency collapse and application of frequency load shedding. In 2017, an additional extraordinary procedure was set up for the TSOs with retrofit overdue (alignment of frequency protection adjustment for the solar power generation capacity so as not to shut down at 50.02 Hz) to apply drivers for decrease during long-term frequency deviations above the level.
A new project was launched in March 2017 to work on sharing of the secondary reserve in the event of exceptional operating conditions. This mechanism thus enables the TSOs to procure secondary reserve from its neighbour in accordance with fixed and shared conditions.

WINTER 2016-2017: OPERATING EXPERIENCE ON THE COLD SNAP

Winter showed that cold snap could exert extensive strain on French system balancing. Load shedding was even considered in the most restrictive scenarios at the start of 2017, but which turned out not to be necessary in the end. Within the weekly, D-day-1 and intraday timeframe, only application of the first exceptional drivers (éCO2mix alert, request for interruptibility, and a 5%-drop in HTA voltage) was prepared without having to deploy these measures.

Actions were thus undertaken to prepare RTE for any emergency concerning balance of supply and demand and inform stakeholders operating on the electricity system and the general public of the exceptional and progressive measures that could be set up in order to ensure system safety. A warning system was developed in close cooperation with the public authorities and the Distribution System Operators as part of preparation to manage any emergency. Cooperation with CORESO once again proved effective for better understanding the possibilities of trade between each country and preparing the system for operation in real time.

In 2017, the ENTSOE taskforce was set up and run so as to improve coordination in the event of emergency. The conclusions of this work resulted in setting up of a procedure for communication between the TSOs and the RSC, defining clearly the measures for lifting an alert and the roles and responsibilities of every stakeholder.

In France, the alert process which was built to identify and share situations with risk as early as possible consists in concrete terms of setting up a colour code on a weekly basis with fine-tuning of the analysis as close as possible to real time. On D-day-1, a green signal indicates that all is well, orange announces the risk of resorting to exceptional and emergency measures (–5% Un) and red shows deployment of load shedding. The load shedding strategy is mainly based on transmission of rotating load shedding orders to the distributors, which are scheduled with the DSOs on a provisional basis. Application of the emergency measures, –5% Un and load shedding, is only considered after all the normal and exceptional measures have been deployed, including interruptibility of industrial sites.

PHENOMENON OF INTER-ZONE FREQUENCY OSCILLATION OBSERVED

If the phenomenon of frequency oscillation can just be observed further to loss of a single power generation unit (such as on 30 September in the south-west of France), inter-zone oscillation (or inter-zone mode) is a more complex electromechanical phenomenon between two or more parts of the electricity system, which oscillate in opposition of the phase and incur active power oscillation, especially on the interconnection lines, with real risks for grid safety in Europe.

This phenomenon occurred on 1 December 2016 and on 3 December 2017 and oscillation with extensive amplitude and long duration were observed everywhere in mainland Europe.

Analyses were conducted with participation from several European TSOs and a report was published by this group within ENTSOE to explain this phenomenon.

Although the studies highlighted the different causes of this oscillation (such as modelling of dynamic behaviour of power generation plant), the concrete measures to be taken in real time require precise modelling of dynamic behaviour of the entire European electricity system and use of specific analysis techniques.

This is a crucial issue for system reliability and viability of the current and future exchange levels with grid developments planned in the medium and long term. This work will be continued in 2018 together with an American university.

2.2 VOLTAGE MANAGEMENT

THE LAST FEW WINTERS HAVE NOT LED TO ANY PARTICULAR DIFFICULTIES IN TERMS OF LOW VOLTAGE MANAGEMENT

The two defence programmable controllers (in the west and in the north) which are part of the voltage collapse defence plan were only armed twice in 2017, without their activation voltage thresholds being reached. No safeguard order was issued for low voltage (-5% Un and controller lock) during the year.

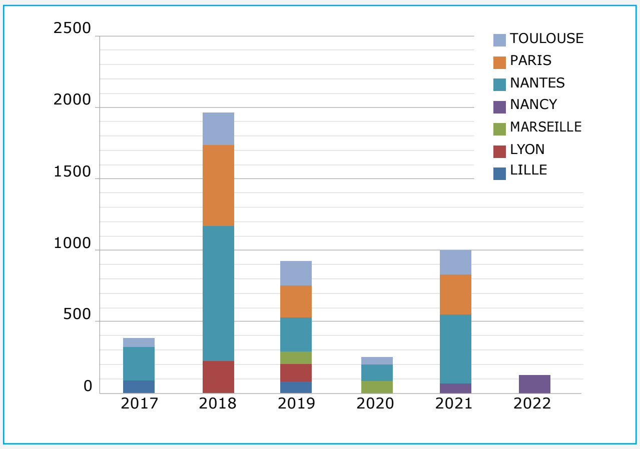
In 2017, the number of upper normal voltage range threshold overruns remained stable and total duration of these overruns fell by around 20% against 2016, demonstrating better management of these phenomena by RTE. Around thirty 400 kV substations are still affected by breaches of voltage range. For the 225 kV network, normal voltage range threshold was exceeded at 503 substations, with significant disparity from one region to another. As far as reliability is concerned, high voltage is less dangerous than low voltage (risk of network collapse). However, it can adversely affect equipment lifetime, as well as contractual voltage ranges for customers.

SPECIFIC ATTENTION IS STILL PAID TO BREACH OF HIGH VOLTAGE THRESHOLDS

The recommendations issued, further to the audit conducted on the matter in the first half of 2018, should drive improvement of the operational processes of managing this high voltage in operation and better understanding of the risk taken by RTE for impact of high voltage on the equipment.

The experiments conducted with Enedis and power generation companies were continued in 2017 to assess the benefits of using the reactive power capacity of power plants connected to the HTA power lines, and more specifically wind power facilities in order to address voltage overruns on the transmission grid: one in Hauts de France from 22 May to 31 August with permanent reactive absorption, and another one requested in Vendée. In the same way, a series of experiments was set up in summer 2017 to assess the contribution that can be made to voltage adjustment by the industrial customers connected to the transmission grid.

In order to control voltage on its network nodes, RTE has set up significant compensation measures over the past twelve years. In 2017, 400 Mvar of inductors was connected (high voltage in the regions of Toulouse, Nantes and Nancy). New investments in compensation measures are scheduled for the coming years, but installing capacitors can now no longer be justified.



Inductor projects (in Mvar excluding off-shore wind power connection) by year of commissioning and by Centre

2.3 INTERCONNECTIONS AND INTERNATIONAL FLOWS

Flows across the French network were generally well managed in 2017. This can be attributed to a number of economic, structural and organisational factors, and especially a **strenghthened regional management efficiency driven by Coreso** (coordination of electricity system operators). This has enabled effective coordinated initiatives to be implemented among TSOs, as was the case during this winter's cold snap.

There was a sharp rise in 20-minute overloads on the 400 kV grid and interconnection links with 34 start-ups in 2017 (6 in 2016).

This solely involved start-ups related to cross-border trade on the France-Spain interconnection.

This border is highly specific for a number of reasons: capacity calculated on a weekly basis, west-east distribution of flows on the interconnection hard to understand in the study files, hourly brackets, local factors, participation in frequency upkeep, imbalance of supply and demand, etc. The work in this region constitutes a priority and a large number of actions were set up in the last quarter of 2017 for better risk management in real time (improved study hypotheses, setting up a more precise operating procedure, etc).

In addition, average capacities available between France and Spain continued to rise with 2525 MW of exports and 2300 MW of imports. For the record, in 2017, exports were greater than 2800 MW for 46% of the time and imports were greater than 2800 MW for 20% of the time.

Flow-based market coupling across the Central Western European zone can be used to operate interconnections as close to their limits as possible, while at the same time maintaining the requisite reliability margins. This trade capacity calculation and allocation method is based on representation of the interconnected systems, close to physical reality (network restrictions, and power injection, especially that of renewable energies).

In terms of grid reliability, price alignment between the two countries also indicates that there is no congestion forecast on the border.

In 2017, price alignment in the CWE region was stable at 34% of the time against 35 % in 2016. Unusual situations of alignment were regularly recorded, as was the case between 3 and 4 AM on 19 April 2017, when prices were identical from Portugal to Finland.

In 2017, the electricity marketplace function was opened to competition in France to strengthen liquidity of the French market. After invitation to tender, the companies EPEX Spot and Nord Pool were selected. The European regulation on capacity allocation and congestion management (CACM) defines the methods for appointing market operators (electricity exchanges) participating in daily and intraday coupling to the market. These operators, known as Nominated Electricity Market Operators (NEMO), are appointed by the regulators in every country (the CRE in France).

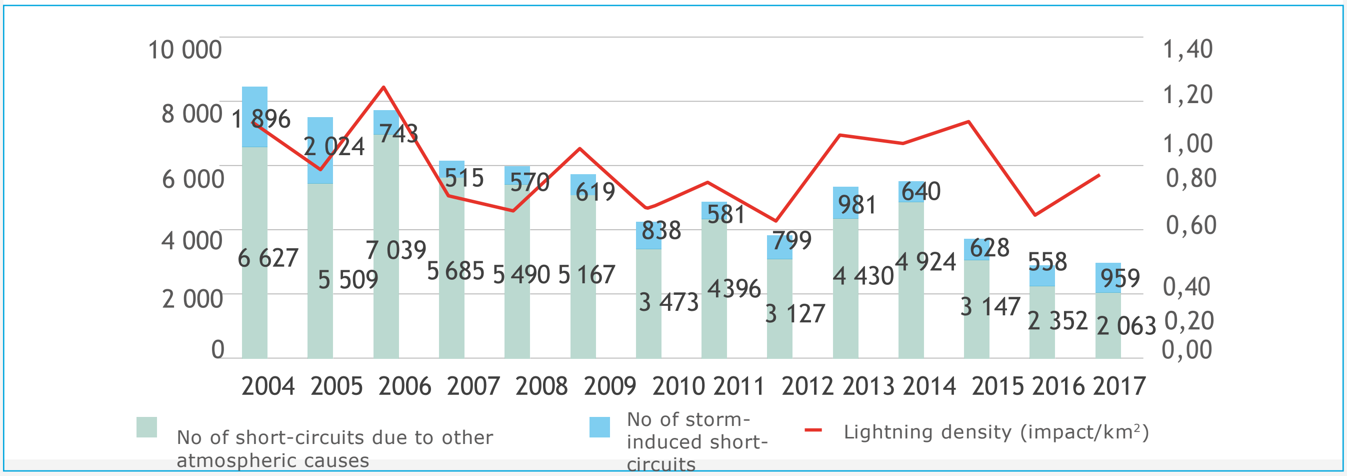
2.4 SHORT-CIRCUITS AFFECTING TRANSMISSION STRUCTURES

The number of short-circuits (7339) affecting transmission structures fell for the fourth year in a row (7912 in 2016, 8352 in **2015 and 9818 in 2014). This drop is attributed to better lightning resistance of the structures. Since 2015, the number of short-circuits on the grid has no longer been connected to the number of lightning strikes in the territory.**

In the same way as in 2015 and in 2016, encouraging results concerning the cases of striking with vegetation were observed in 2017 highlighting effectiveness of the maintenance actions (tree trimming and retight of conductors) with only 0.5% of short-circuits.
In terms of grid safety, analysis should be focused on contingencies resulting in loss of 400 kV double lines likely to cause major disruptions.

In 2017, 8 fleeting double faults occurred on the 400 kV lines without any definitive shutdown.

In 2017, continued **experimentation with the AMELIE tool** (a weather warning system for overhead power lines) enabled **new alerts to be set up to predict the formation of frost sleeves** on the overhead lines in addition to existing alerts (storm and sticky snow). These warnings tell RTE when to deploy technical and human resources for tackling these incidents and help ensure that nominal operation is restored as quickly as possible on the network.
In 2017, **the new fault finding method, designed to return defective infrastructure to service as quickly as possible** was deployed. It is based on analysis of various sources of information, including that derived from **the automatic fault finding (LAD) project, so as to target inspection of the structures.** Use of the fault finding method remained low due to the limited number of outgoing feeders fitted with automatic fault finding, but it has already enabled certain actions to be targeted. Deployment is scheduled to be completed by the year 2020.
In addition, the **SCHREK/SCRAT application,** for automatic correlation of incidents with causes (storms, etc) and consequences (customer, etc) was deployed throughout the territory. **Its purpose is to notify in real time the customers affected by the fault** (great expectation of knowing whether or not the fault is on the RTE grid) and the RTE regional and national on-call and stand-by teams.
In order to further improve return to service and ensure better monitoring of incident resolution, in 2018, RTE deployed the RUBICUB application to digitalise incident management for the operational teams.



Trends in storm and other atmospheric causes of short-circuits and lightning density

EQUIPMENT COMPONENT SAFETY

3.1 GENERATION UNITS

Twice a year, electricity generators and RTE hold discussions about the multi-year programme to reduce the limitations of reactive capacity of nuclear power plants, in terms of both supply and absorption. These limitations can be disadvantageous for managing low voltage (risk of collapse) or high voltage (risks for equipment). Although deviations increased in 2016, a sharp drop was observed in 2017, so that reaching of the reactive supply target can be envisaged in 2018 (the target for absorption has already been met).

93% OF HOUSE LOAD OPERATING TESTING ON NUCLEAR POWER PLANTS ON TARGET

Successful house load operation of nuclear power plants in the event of a widespread incident is important for nuclear safety and is vital for reinstating the network and restoring power supply for customers. In 2017, 15 house load operating tests were performed on nuclear power plants: 14 house load operations were successfully completed, a success rate of 93.3% (92.3% in 2016), an 85% success rate over a four-year rolling period to be compared with a 60% multi-year lower limit.

3.2 NETWORK EQUIPMENT

On the 400 kV network, 473 short-circuits were eliminated in 2017 (383 in 2016), 287 of which were single-phase faults. **The response rate** in keeping with deployment of protection devices and programmable controllers in the event of electrical faults on the 400 kV network **is in compliance with the rules** with a compliance rate of 98% on the 400 kV network. Furthermore, the good results on the "225 kV HDP (high-density generation area and the vicinity) network" attest to effective deployment of the specific protection plan for these networks.

The 400 kV differential busbar protection devices, which play a major role in fast and selective elimination of busbar faults, and although very rare, incur a high risk for safety, caused 9 SSEs (9 in 2016). Their availability rate remained stable at 99.6% against 2016.

Protection devices involving ring opening upon loss of synchronism are part of the Defence Plan and play an essential role in isolating those network zones which have lost synchronism from other zones which are still intact and thus prevent spread in the event of major incident. Although infrequently deployed, they need to be able to respond reliably if required. In 2017, there were no operating anomalies and the ring opening upon loss of synchronism plan was reliability-audited, indicating that the system is properly managed on the whole.

The share of generic anomalies of the measuring assemblies continued to fall in the contribution of high voltage equipment to equivalent outage time with less than 6% of total equivalent outage time, a rate comparable to the years prior to the emergency involving the measuring assemblies. This confirmed relevance of the corrective actions deployed (preventive replacement of the equipment, equipment condition measurements and real time monitoring).

The purpose of the Ampacité project is to test a more flexible type of operation, determining cable transmission capacities in real time depending on external conditions measured (temperature, perpendicular wind, sunshine levels, etc) so as to free up additional margins and optimise the countermeasures available. These measures, which ensure optimised use of the structures to the best of their physical characteristics, help facilitate incorporation of electricity generated by wind turbines and improve quality of power supply to customers, reducing the number of operating restrictions and related risk of power cuts.

Within the framework of this project, the 400 kV Tavel-Réaltor line and three other 63 kV and 90 kV lines were fitted with sensors at the start of 2017 in the regions of Marseille, Lille, Nantes and Nancy. The purpose of this equipment is to confirm the validation assumptions and test implementation. Initial feedback on the 400 kV Tavel Réaltor link is highly encouraging both in terms of insertion in operation and return on investment. **Implementation of the Ampacité project outside the experimental framework is planned for 2019.**

INFORMATION AND TELECOM SYSTEMS

4.1 TOOLS

In 2017, a single case of unplanned unavailability with shutdown of transmission at secondary frequency control level for 16 minutes affected the **National Control System (SNC).** Changes were made to the operating tool in 2017 so as to improve robustness of the grid and address slowdown issues. The main focus in 2018 will be placed on developments of the version so it can fulfil the requirements of the "aFRR Assistance" project, whose purpose is to ensure an inter-TSO support function for secondary reserves.

In 2017, 20 significant system events of level 0 (against 16 SSEs in 2016 and 11 SSE of level 0 and 3 level A in 2015) occurred on the **Regional Control Systems.** The year 2017 stood out for rolling out of a new version of the application in all the centres and replacement of all the hardware and software enhancement.

RTE launched the STANWAY project to deal with ageing of the **programmable logic controller (PLC)** currently in use in order to provide operators with a unique PLC system based on the market Supervisory Control and Data Acquisition (SCADA) System**.** Commissioning of the new tool is planned in 2020 for the National System Operations Centre, followed by the Operations Centres.

Skills upkeep for operating the tools in the **regional inter-dispatching support centre (SIDRE)** is based on periodic changeover testing (partial or total), at an accelerated rate in 2017, whereas knowledge is now refreshed with a quiz.

The average monthly number of remote commands issued per Operations Centre was around 8700, with amplitude varying from centre to centre. The annual average unavailability rates for the remote measurement and remote signalling systems at the 7 regional dispatching centres were respectively 1.50% (1.33% in 2016) and 1.06% (1.09% in 2016 and 1.14% in 2015).

The **Alert and Safeguard System** (SAS) is a key tool for managing high-risk (alert orders) or degraded (safeguard orders) situations, during which availability and reliability need to be excellent.

In 2017, **39 SSEs of level 0 and 3 SSEs of level A were logged** (39 SSEs of level 0 and 1 ESS of level A in 2016). The high number of SSEs can mainly be explained by **messages not being acknowledged** by generators and distributors during periodic tests performed by RTE, which is more disruptive within the context of real critical situation orders for insufficient margins transmitted by RTE. A reminder was issued to ensure response in keeping with expectations in high-risk or degraded situations requiring deployment of the Alert and Safeguard System.

The Convergence test platform is the reference tool used to conduct electrotechnical research to prepare for operation in real time. This application is also by RTE’s Regional Security Coordinator, CORESO, and by Nordic RSC, the regional coordinator for the Finnish (Fingrid), Norwegian (Stattnett), Swedish (Svenska Kraftnät) and Danish (Energinet) TSOs. Overall availability rate of the Convergence servers was excellent with 99.96%.

The wind power transmission software program (IPES) is used for short-term tests and during operation in real time. It supplies estimates about the actual quantities of electricity generated by solar energy and wind power and forecasts for these renewable sources on a local, regional and national scale. It can do this for adjustable periods ranging from D-day-4 to D-day+2, with timeframes selected by the user. As at the end of 2017, total observable power generated by renewable energies either directly by remote operation by the generator, or with means set up following agreements concluded with partners (generator associations, Distribution System Operators, etc) was 19.8 GW out of installed capacity of 21.2 GW. In order to tackle the growing volume of renewable energy data, in 2017, RTE continued to study sustained deployment of the IPES tool with the results expected by the end of 2018.

The **Voltage Map** application was declared operational following a prototyping phase. It enables users to visually monitor the voltage plan at national or local level and issues warnings in the event of voltage overruns.
Optimisation of the Voltage Map application planned for the end of 2017 has been postponed to the start of 2018, to factor in improved input availability and to boost operability.

4.2 TELECOMMUNICATIONS AND IT SECURITY

Operational reliability of the power system is closely linked to good working order of the security telecommunications networks on the one hand, and the IT system on the other, with its capability to withstand cyber-attacks.

The **ROSE** Optical Security Network, an infrastructure owned and operated by RTE, is distributed over approximately 21,000 km of optical cables and provides telecommunication services which contribute to system reliability: high-level remote operation (observability, manoeuvrability and control), information exchange for protection against electrical faults and safety telephones. In 2017, no significant system events occurred (two SSEs in 2016).

In 2017, operation of the **Safety Telephone System (STS)** was affected by 13 level 0 SSEs, all concerning unplanned unavailability of safety telephony of a single subscriber, without any impact (in 2016 on 1 level A SSEs and 9 level 0 SSEs were logged).

RTE IT security is pivotal to operational reliability of the electricity system. This applies in particular to the distributed control (DCS) system and remote operating activities, as well as to the way in which information is shared with customers, market players and partners.

RTE's Operational Security Centre (COrS'R) thwarted several IT alert situations in 2017 (outsmarting around 5800 attacks preventing 6.6 million spam emails from getting through and eradicating 200 viruses on RTE's IT system every month).

In 2017, an audit was conducted on RTE's IT security system to assess the level of control exerted for the different threats of cyber-attack to ensure continuity of its critical routing activities and operational reliability of the electricity system and markets and issue organisational and operational recommendations.

OTHER OPTIONS FOR GRID MANAGEMENT

GREATER COOPERATION BETWEEN THE TRANSMISSION GRID AND THE DISTRIBUTION GRID

With a network that is both more strained and more difficult to manage as a result of decentralised generation and smart grid projects, exchanging information between the distribution grid and the transmission grid and having a sound reciprocal understanding of the difficulties encountered are now vital for controlling future operation of both networks and managing relations at the interfaces.

In 2017, the work was continued by RTE and several Distribution System Operators. It covers the fields of managing programmable controllers, exchanges of operating data and voltage management at the interface between the transmission grid and the distribution grid. Development of joint information systems is thus envisaged for 2018 so as to foster exchange of operating data and setting up of new programmable controllers, for which the first demonstrators will be produced in 2019. This work will be rolled out to all the French DSOs.

CAPACITY MECHANISM

The **capacity mechanism** is designed to ensure long-term security of supply in France, during peak electricity consumption. By remunerating the availability of generation and demand response means, the capacity mechanism encourages participants in electricity system to maintain and develop, at the lowest possible cost, demand response and generation means required to cover the supply commitments in their customer portfolio and thus contribute to security of supply.

MODERATION AND DEMAND RESPONSE SYSTEMS

Demand response, regardless of whether it concerns industrial consumption or aggregated consumption, is a source of flexibility that involves consumers waiving or postponing some or all of their power consumption in response to a signal. Demand response can be used by market operators to optimise their own portfolios or to sell energy directly to other stakeholders or to RTE.

DEMAND RESPONSE IS NOW A SOURCE OF POWER AND FLEXIBILITY FOR MANAGING BALANCE OF SUPPLY AND DEMAND AND FREQUENCY IN THE SAME WAY AS IT IS FOR MANAGING GENERATION. IT CONSTITUTES AN OPERATIONAL DRIVER FOR GRID RELIABILITY.

In 2017, 1810 MW of demand response capacity was certified as part of the capacity mechanism for 2017 (1900 MW for 2018).

Furthermore, since November 1 2014, the **Tempo signal** project has been managed by RTE and featured on éCO2mix so that all suppliers can offer their demand response electricity supply packages. For the fourth year, companies have been able to use the NEBEF (Block Exchange Notification of Demand decrease Response) mechanism to validate demand decrease directly on the market. By the end of 2017, 22 companies had concluded contracts with RTE to participate in this mechanism with continued growth of demand decrease volume to 39 GWh (11 GWh in 2016).

Since December 2016, RTE has used its **educational éCO2mix** application as a new means for issuing alerts within the framework of its emergency communication system. When exceptional resources are deployed during periods of strain on the electricity system, the éCO2mix application sends out warning messages, suggesting that consumers reduce their energy consumption by adopting more civic-minded behaviour.

The **environment-responsible EcoWatt** initiative, initially deployed in Brittany and in the Provence-Alpes-Côte d'Azur region as a means of addressing weaknesses in electricity supply, is now designed to encourage the inhabitants to moderate their power consumption, particularly in the winter and at peak times.

Although in 2017, the status of security of supply fulfilled the public criterion of security of supply, there is no longer any additional margin in the medium term.

This unrivalled situation constitutes the outcome of widespread restructuring of the fossil-fuel fleet, both in France and in Europe, with the closing of several coal-fired and oil-fired plants over the past few years. The structure of the French fleet has thus changed. Balance achieved is now based on management of peak consumption, appropriate availability of the nuclear fleet, upkeep of the existing fossil-fuel fleet and improved reliability of the current potential of demand response. This situation should remain stable up to the year 2020.

GRID DEVELOPMENTS AND CHANGES

RTE invested 1.4 billion Euros in 2017. The total amount of investments made by RTE within the scope regulated by the CRE came to €1393 million, €1166 millions of which was dedicated to the grid.
The main investments concerned the 225 kV line ensuring interconnection between the Rhone Valley and the Massif Central (2Loires project), commissioning of reinforcement of the Brittany Centre (Brittany safety net), start of work on the new interconnection with England (IFA2), continued construction work on the DC interconnection between France and Italy through the security gallery of the Fréjus tunnel (Savoie-Piémont), and restructuring of the 225 V network in Haute Durance. 66% of the grid investments were for existing structures.
Investments in information systems and real estate and logistics amounted to €144 million and €83 million respectively.

FUTURE GRID DEVELOPMENTS AND CHANGES ARE BASED ON A FORWARD LOOKING APPROACH INVOLVING THE FOLLOWING WORK

The **provisional report** on balance of electricity supply and demand in France constitutes the first link in the reliability chain. It is the starting point for developing a set of potential supply-demand scenarios which will then be broken down into network hypotheses to be factored into all the national and regional network development studies up to the year 2035.
The 2017 edition of the provisional report (also available on the digital platform http://bpnumerique. rte-france.com) especially highlights the fact that in order to meet the target of 50% of nuclear power generation by the year 2025 laid down by the energy transition law, decommissioning of a large number of reactors (around twenty-four) must be accompanied by extensive acceleration of the development of renewable energies and construction of new gas-fired power plants (more than 11000 MW). 5 deliberately different scenarios have been envisaged up to the year 2035 to support the decisions on which tomorrow's electricity system is built.

ALL THE SCENARIOS ENVISAGED (OHM, AMPERE, HERTZ, VOLT AND WATT) RESULT IN EXTENSIVE GROWTH OF RENEWABLE ENERGIES, DECOMMISSIONING OF NUCLEAR REACTORS, TRENDS IN ELECTRICITY CONSUMPTION (STABLE OR DECREASING), MASS DEVELOPMENT OF ELECTRIC VEHICLES AND GROWTH IN ELECTRICITY.

RTE published a new edition of its Ten Year Network Development Plan for 2016 after the public consultation completed in January 2017. This plan breaks away from previous editions and lists all the adaptations which will need to be made over the next three years and the main infrastructure that should be considered over the next ten years. The actions adopted are transposed in the **Impulsion & Vision** project. In this particular corporate project, the "digital revolution" and "technological breakthrough" challenges result in construction of five "New Generation" substations by the year 2020 and deployment of digital control systems at all the RTE substations by 2030, as well as in 50% of the network being equipped with monitoring solutions by 2030 in order to adjust maximum network capacities based on weather conditions or in response to multiple equipment measurements.

In line with and as a continuation of the Ten Year Network Development Plan (TYNDP) and the provisional report, more than 400 projects are discussed in this plan, most of which are in response to the challenges related to energy transition. These projects are designed to facilitate incorporation of the new generation mix both in France and abroad, and support localised changes in consumption, as well as ensuring solidarity in terms of access to electricity between the regions.

In addition to inter-regional exchanges, RTE is also developing interconnections between France and its European partners. Taking all borders together, **an increase of up to 10 GW** in interconnection capacity is being investigated or is being developed with a view to being brought into service within the next decade.

INTEGRATION CHALLENGES

Within the context of energy transition and continuing on from the scenarios described in the provisional report, progressive reduction in the share of nuclear power generation in France will be accompanied by integration of an increasing volume of electricity generated with renewable energies, such as solar and wind power.

However, extensive penetration of variable electricity power generation, mostly decentralised, may pose different types of problem for the transmission and distribution grids which were not originally designed to absorb it.

First of all, most of the renewable energy generation facilities are small and currently do not provide any support for the transmission grid for management of the system services (frequency and voltage), contrary to the long-standing generation companies for which this is required.

Whereas the share of renewable energies is increasing and the fossil-fuel fleet is decreasing, the needs for voltage and frequency remain identical and the challenge for RTE is to identify other means and certainly other ways to continue to ensure reliable voltage and frequency adjustment.

This is why RTE is investigating technical solutions, mainly by conducting experiments together with the renewable energy generation companies and Distribution System Operators.

In addition, the significant share of electricity generated by solar and wind conversion systems without a generator could also have specific consequences for operation of the electricity grids.

In schematic terms, the European electricity grid is a system composed of generation plants, loads (consumption) and electricity transmission structures. If it can be considered that frequency is uniform throughout interconnected Europe, it is because the generators at conventional power plants are connected to each other with electromagnetic forces and rotate at the same speed. It is thus inertia of the generators rotating on the grid that elicits collective response to compensate for sudden consumption or capability loss throughout Europe.

FOR RENEWABLE ENERGIES

This is why, with massive integration of renewable energies:

- the conventional methods for managing grid transits and congestions shall gradually change;
- RTE shall be capable of checking that the transient phenomena induced by short-circuits in such an electricity system do not result in unstable conditions or inadmissible levels of degraded conditions concerning the reliability rules to be complied with in operation.

In addition, the intermittent nature of renewable energy generation also obliges RTE to enhance quality of generation forecast for these sectors so as to reduce uncertainty surrounding operational integration for management of balance of supply and demand. RTE is also working on improving observability and controllability of this renewable energy generation and developing new probabilistic models, such as IMAGRID and iTesla, so as to better factor in the uncertainty surrounding renewable energies.

In addition, massive input of variable generation will progressively result in RTE using new means to better manage transit and prevent congestion on the grid. RTE is thus experimenting with the use of area programmable controllers and is running projects to optimise transit (Ampacité) and storage and retrieval of electricity (RINGO). In addition, RTE is also envisaging development of the consumption management mechanisms to ensure balance of supply and demand, breaking away from traditional hypotheses underlying current system design.

RENDERING SUCH A SYSTEM RELIABLE AND ECONOMICALLY VIABLE CONSTITUTES A CHALLENGE FOR RTE. THE OPERATING METHODS AND RESOURCES NEED TO BE CHANGED ACCORDINGLY.

This is why RTE remains very active in the European projects MIGRATE and OSMOSE. The purpose of these projects is to develop and validate innovative technological solutions for management of the European electricity system, in which more and more power electronic devices are involved to connect the power generation and consumption sites. They analyse the impact of increasing penetration of power electronics on stability of the electricity system and also focus on the effect of extensive insertion of converters on dynamic operation of the electricity system.

HUMAN RESOURCES AND ORGANISATIONAL BENEFITS TO ELECTRICAL GRID SAFETY

PERFORMANCE IMPROVEMENT WITH WORK PRACTICES

The improved performance through professionalism initiative involves recording and sharing of Human Factor deviations, regardless of whether or not they have consequences on industrial safety in the broadest sense of the term, in order to collectively improve performance.

In 2017, 962 human factor related events were reported, including 761 in operation, which demonstrates the impetus in this field over the past few years.

TRAINING AND SKILLS UPKEEP TAILORED TO NEEDS ON A PERMANENT BASIS

In addition to the annual training programme for operator skills upkeep, including days during which exceptional circumstances are simulated, the large number of projects and policy changes require special training in operations-related areas.

The centralised training programmes are regularly modified so as to be in line with grid changes, kept up-to-date with the fast and numerous changes to the methods and tools used for design and grid operation and for preparing and carrying out maintenance work on the transmission grid structures.

In 2017, the maintenance team training programme for uninterruptible power supply systems was further developed to include operation of the breakers for the upgraded version of the remote control and remote operation equipment in the substations at the request of the operators passed on by the operations supervisor.

In addition, the first inter-centre distance training experiments were conducted in 2017. The training courses are being revamped to integrate the new RTE training methods (e-learning, tutorials, video training, etc).

Local training courses play an additional role in skills acquisition and upkeep. The key role that coordinators, promotion mentors and managers play in enhancing proficiency and professional development in the field should be emphasised.

In 2017, there were very few visits from external parties due to the strengthened security measures set up in the wake of terrorist attacks. However, there were a number of meetings held in all regions of France with generation companies and distributor operations centres in their area of action. Training courses, entitled rally round reliability, were run for generators and distributors in partnership with the Performance Control Team.

EXTENSIVE REGIONAL EMERGENCY RESPONSE EXERCISES WERE RUN FOR PERSONNEL PREPAREDNESS IN 2017

The purpose of these exercises is to consolidate the operational documents and ensure skills upkeep for a high number of employees at local level.

CHANGES IN REFERENCE FRAMEWORKS AND CONTRACTUAL RULES

FOCUS ON THE NEW EUROPEAN PACKAGE OF LEGISLATIVE MEASURES "CLEAN ENERGY FOR ALL EUROPEANS" On 30 November 2016, the European Commission unveiled a package of legislative measures, collectively known as the "Clean Energy for All Europeans". Its aim is to make changes to the European framework, implement the aims of the energy-climate packet and continue to build the Energy Union.

This legislative package focuses in particular on market design, so as to adapt it for use with renewable energies and development of new flexible means for the system (demand response and storage). It also contains an important section on regional cooperation between TSOs and structural measures regarding the tools which can be used for security of supply (definition of criteria and capacity mechanism). The proposals also concern adapting the way in which all energy issues are governed at regional and European level.

These proposals are therefore important issues for France, RTE and all stakeholders in the electricity system, including future responsibilities for ensuring electricity system reliability. Discussions about these documents are already under way with the European Council and European Parliament. The Commission would like them to be definitively adopted by 2019. In particular, RTE will clarify the underlying political issues related to these technical provisions and will proactively ensure that this new energy packet is appropriate for the task of creating a fully-fledged, sustainable Energy Union. It will ensure that it fulfils the electricity system needs in compliance with the principle of subsidiarity, creating an environment in which innovation can develop at a time when the sector has to address wide-ranging changes.

MAIN CHANGES IN REFERENCE TECHNICAL DOCUMENTATION

In 2017, they pertain to: the procedure for processing generation plant connection requests, information exchanges and remote operating system for consumers and distributors and rules for the voltage system services.

Work has been undertaken or will continue into 2018 together with the customers to make changes to other articles. This work mainly covers reactive power management at the interface between the transmission and distribution grids and application of the European connection codes in the French regulations.

SYSTEM SERVICES

Applicable as from 1 April 2017, changes were made to the terms of payment for the voltage system services to make the system both more transparent and easier to understand. In 2017, the agreements for participation in the voltage system service rules were also signed, with connection of a wind power farm to the transmission grid. This farm now receives payment for primary voltage control. Several other wind power and solar energy facilities connected to the transmission grid are studying the possibility of signing a participation agreement.

As far as frequency system services are concerned, since 16 January 2017, RTE has covered primary reserve requirements with a weekly invitation to tender common to the TSOs in Belgium, Germany, Switzerland, Austria and the Netherlands.

In 2017, France had an average export balance of 7 MW for its frequency system service needs. (Primary reserve exports were 59 MW on average for 42% of the time with imports of 60 MW for 54% of time.)

At the end of 2017, certified power for the frequency control of consumption sites stood at 92 MW (of which 25 MW of secondary reserve). This potentially equales to 16% of the primary reserve required for France. This reserve includes the first battery certified by the Performance Control Team for frequency control (1 MW, on the distribution grid).

BALANCING MECHANISM

The invitation to tender launched in September 2016 covered the period from January to December 2017. During this period, RTE concluded RR-CR (rapid and complementary reserves) contracts with 11 balancing service providers in order to ensure 1000 MW of rapid reserves that can be activated in less than 15 minutes, and 500 MW of complementary reserves that can be activated in less than 30 minutes.

The contractually-agreed volumes of RR now stand at 1319 MW, of which just over a half is supplied by demand response capacities. The volume of complementary reserves subscribed to is mainly ensured by generation.

Changes in contracts over the last few years highlight the **growing contribution of industrial demand response** on the one hand, and the increased vigilance with which RTE manages balance of supply and demand in real-time on the other. This vigilance is **manifested by strict control of subscriber performance** and the processes for renewing approvals.

SAFETY BEYOND RTE IN EUROPE

In 2017, the System Operations Guidelines, Emergency and Restoration and Electricity Balancing codes were published and are being enforced. All the codes have been published and are now applicable.

Certain elements of these three codes shall be transposed at national level and consultation is ongoing in France to be concluded in 2018.

The fourth edition of the Ten Year Network Development Plan (TYNDP) was published at the end of 2016.
It sets out the ways in which Europe's transmission network will develop up to the year 2030 in order to complete energy transition and set up the European single energy market. The significant role played by direct current technology in this plan is worth mentioning. The essential points with major impact on system operations over the coming years include:

- Europe's future energy mix which will ensure that between 45% and 60% of power consumption needs are met by renewable energies, with specific initiatives designed to reduce the limitations of electricity generated by wind power,
- interconnection capacity which is set to double in Europe by 2030, mainly for more effective incorporation of peninsulas into the European electricity market (Portugal-Spain, Italy, the Baltic states, Ireland and Great Britain).

COOPERATION BETWEEN TSOs

The highlight for 2017 is the fact that two new members joined CORESO: Irish TSOs Eirgrid and SONI.
CORESO located in Brussels is one of 6 Regional Security Coordinators (RSC) in Europe and provides cooperation services to 9 TSOs to ensure electricity system security at European level. The 9 TSOs that are members of CORESO are Elia for Belgium, National Grid for England, RTE for France, 50Hertz for Germany, Terna for Italy, REN for Portugal, REE for Spain and Eirgrid and SONI for Ireland.

CORESO is assigned more and more coordination remits in greater jurisdictions. The added value provided by the regional coordination centres is now recognised and has increased over time, with strengthened axes of cooperation of the different centres bolstering reliability of the entire European system.

AS FAR AS R&D AND MAJOR EUROPEAN PROJECTS RELATED TO RELIABILITY ARE CONCERNED, THE FOLLOWING KEY DEVELOPMENTS SHOULD BE HIGHLIGHTED FOR 2017:

The Migrate and OSMOSE projects: the aim of these projects is to develop and validate innovative technological solutions for the grid to manage the electricity system in which more and more power electronic devices are involved (direct current links and connection of renewable energies).
Smart substation: The purpose of this project is to use demonstrators to redesign the functional substation architecture in response to new electricity system requirements. It incorporates in its design environmental targets and technological solutions envisaged over the coming decades. In 2017, the basic functions of BLOCAUX's Smart Substation were started up and will be used in observation mode in 2018. Action mode is being considered followed by the decision for deployment by the year 2020.

BESTPATHS project: development of the instrumentation and control interoperability test platform for the AC-DC conversion station on a DC grid with multi-terminals. The purpose of the European BestPaths project is to pay the way for the Supergrids. In 2017, the instrumentation and control operability test equipment platform was commissioned for the HVDC station. Testing was performed, the results were published, and the project should be completed in 2018.

Operating tools for round the clock control rooms: the concept of the projects described below (Apogée, I-Tesla, Garpur and Flexibility) is based on changeover from mostly manual operation to a grid control system based on forward planning, automation and centralised supervision of information.
In addition, the purpose of this ecosystem of tools and methods is to integrate an environment requiring more flexibility of generation, consumption and storage by changing over from a deterministic approach to probabilistic risk management.

Apogée project: The year 2017 was significant for testing of the periodic manoeuvres module on the experimental Apogée console in the RTE Operations Centre in Nancy and paving the way for experimentation with the withdrawal module in Nantes planned for 2018.

iTesla project: iTesla foreshadows the next generation of grid security analysis platforms and uses a probabilistic approach to analysing the risks incurred during operation, by factoring in possibilities for countermeasures and dynamic phenomena.

GARPUR project: completed in 2017, the results will be rolled out at RTE in R&D projects, such as i-Tesla, Imagrid (research tools for grid development) and MONA (support tools for asset management strategies), fostering risk assessment for isolations.

Impact and integration of operating flexibility: penetration of renewable energies and European harmonisation of electricity system balancing foster strengthening of RTE capacity in the very short term with solar and wind power generation. They also require changes in the balancing process, which has to be adapted to developments of the electricity system and its flexibility.

Implementation of new means of action, such as area programmable controllers, experimentation for batteries with the RINGO project and setting up of exchange platforms for harmonised balancing products, will strengthen the links between the management processes for balance of supply and demand and the grid.

Launched in 2017, these R&D activities should be spread between 2018 and 2020.

11

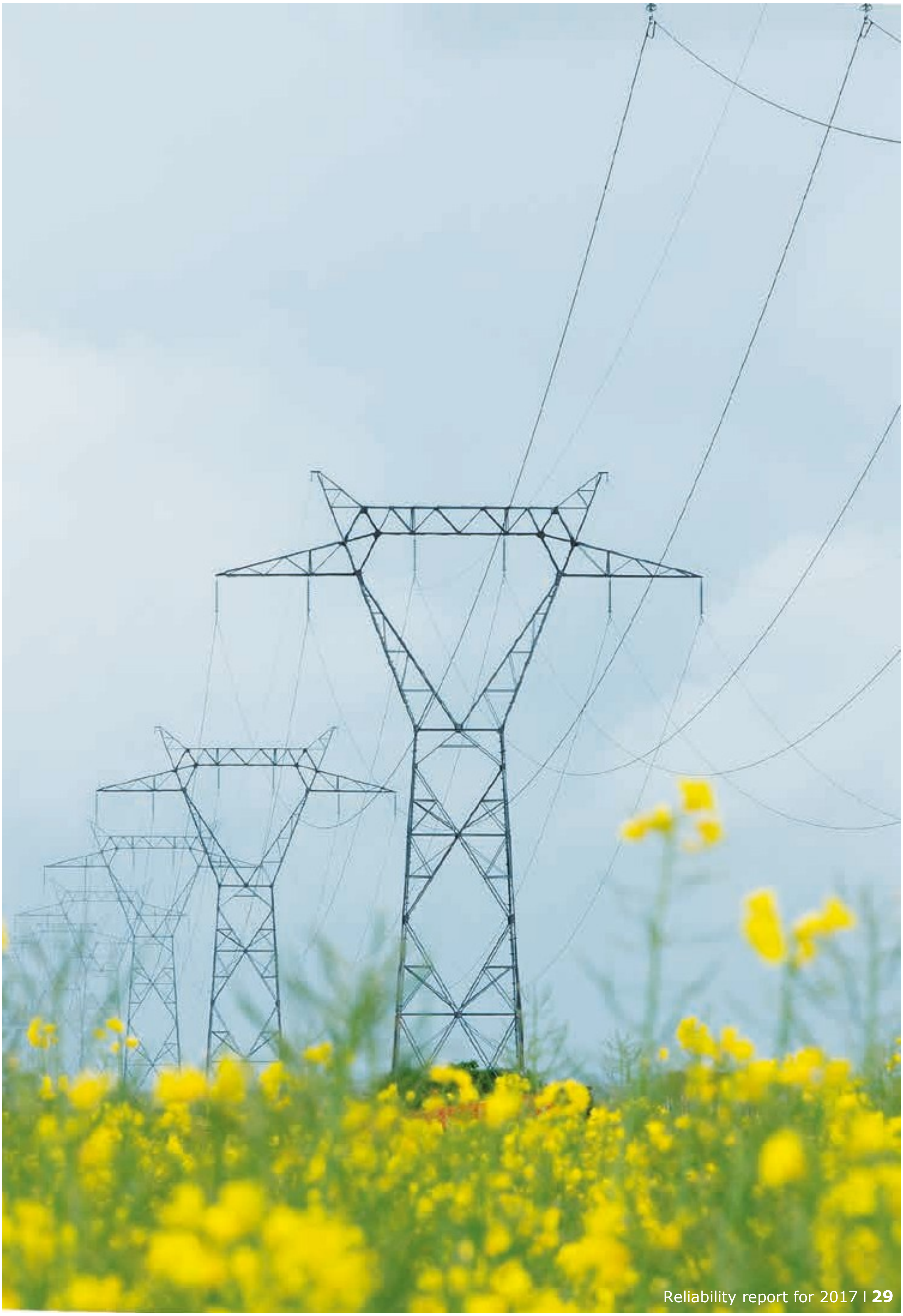
SAFETY AUDITS

The topics targeted by the audits are designed to ensure that all the major reliability aspects are covered over a period of 2 to 3 years. In particular, risks flagged up by operating experience from the past year are monitored. The audit findings are presented to the RTE Executive Committee. Recommendations are then issued to improve risk management. The initiatives undertaken based on these recommendations are covered by an action plan, the progress of which is monitored by the Audit and Risk Division. An annual report is submitted to the RTE Executive Committee and to the Economic Monitoring and Audit Committee (CSEA).

Three reliability audits were conducted in 2017 on the following topics:

- defence plan
- risk management for operating transits,
- work management for the remote control and remote operation network.

They concluded as to generally satisfactory operation of the electricity system in terms of reliability and made recommendations for improving operation.



CONCLUSION AND OUTLOOK

THE RESULTS OBTAINED DEMONSTRATE A GENERALLY SATISFACTORY LEVEL OF OPERATIONAL RELIABILITY MANAGEMENT BY RTE, against the backdrop of increased renewable energy generation that is playing an increasingly important role in electricity system reliability and stability (frequency, voltage, margin, etc). Within this context, RTE is continuing, along with its partners, to develop means of flexibility (Ampacité, RINGO, programmable controllers, demand response, etc) and innovative solutions in order to uphold its reliability requirements, while facilitating energy transition.

However, **adverse emergent trends identified in 2017 indicate that further attention should be paid to electricity system balancing against the backdrop of a profoundly changing energy mix with variable renewable energies** (insufficient margin, extensive strain, inter-zone oscillation, frequency deviations and overload on the grid). Although **these situations were contained** in 2017, and even served as opportunities to put in place additional management means (warning systems, load shedding arrangements, etc), **they should not hide the risk of more strained conditions being encountered over the next few years, particularly in the event of cold snap and lower generation capability in France in coming winters.**

Monitoring of the SSEs over several years flags up any adverse emergent trends so that they can be analysed. Effectiveness of any initiatives implemented to increase operating reliability can then be measured over time. In 2017, there was a sharp rise in SSEs compared to the past few years, which can be attributed to operation as close as possible to the grid limits so as to maximise use.

These satisfactory results are the fruit of work that has been done both internally and externally with our partners over a number of years. They emphasise the fact that ensuring system reliability is an ongoing task that is underpinned by corrective actions, as well as scheduled initiatives implemented over time across an extremely broad scope and involving expertise from a number of different specialisations.

ALL THESE ACTIONS PREVENT THE MAJOR RISK OF BLACKOUT.
THEY CONTRIBUTE TO CONSOLIDATING SUSTAINED OPERATIONAL RELIABILITY OF THE ELECTRICITY SYSTEM, THE FUNDAMENTAL ROLE PLAYED BY RTE TO THE BENEFIT OF ALL, BOTH IN FRANCE AND IN EUROPE.

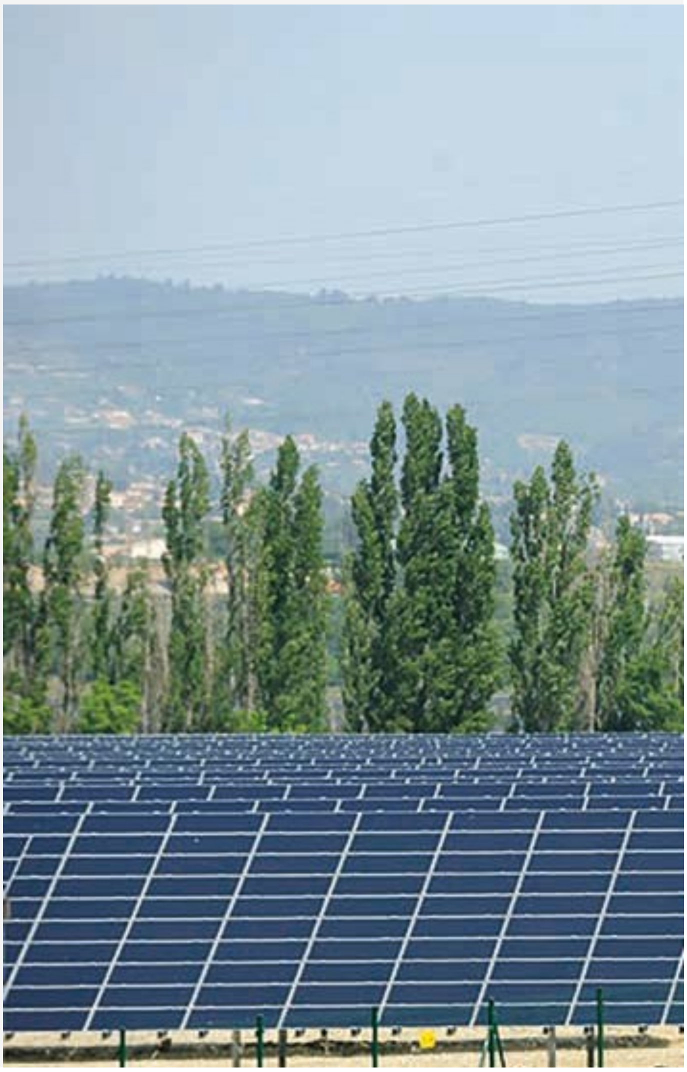
The key issues that have been highlighted in this report involve the need to continue with and bolster initiatives that have already been implemented at various different levels over the next few years.

RELENTLESS VIGILANCE TO ENSURE FUTURE RELIABILITY

This mainly involves:

Internally to RTE:

- **improving** quality of frequency control and detection of inter-zone oscillation for better management in real time,
- **strengthening** tracking of the margins, mainly by investigating the operational tools to be set up,
- **continuing** improvement of the operational processes for managing extensive strain on operation,
- **strengthening** setting up of operator aids,
- **continuing** improvement of research methods and tools by integrating changes in context and increasing uncertainty,
- **innovating** by experimenting in the field and taking up new options provided by digital technology,



- **evaluating** effectiveness of contractor maintenance and renovation actions in order to minimise malfunctions on reliability-sensitive equipment (differential busbar protection devices, load shedding relays, etc),
- **improving** running of the continuous improvement loop.

Together with its partners:

- **consolidating** and adapting tools used to manage balance of supply and demand to ensure that they fulfil future requirements,
- **improving** quality of data shared at the interfaces,
- **broadening** the range of market participants in order to increase economic efficiency and flexibility in managing short-term balance of supply and demand (demand response, asymmetrical frequency system services, etc),
- **consolidating** the mechanisms for systematically checking the stakeholder commitments and performance in order to ensure that reliability is properly managed,
- **continuing** discussions and experiments with our partners who play a significant role in ensuring system reliability (reactive power generation, voltage control at the interface between the transmission and distribution grids, programmable controllers, etc).

And more specifically in Europe:

- **working** on communication to be carried out with the other TSOs and the RSCs in Europe concerning drastic shortfalls in balance of supply and demand and on the roles and responsibilities of every stakeholder,
- **improving**, at French and European level, understanding and control of frequency deviations and working on predicting them,
- **pre-empting** enforcement of European grid codes in tools and methods,
- **guaranteeing** capacity of data exchange between real-time platforms for all reliability participants,
- **stepping up** cooperation with system operators and the European coordination centre during the cold snap at the start of 2017,
- **actively taking part** in analysis of the package known as clean energy for all Europeans, with strengthened vigilance, especially concerning definition of ROC prerogatives.

APPENDIX 1: GLOSSARY OF SPECIALIST TERMS

Term	Definition
Operational reliability of the electricity system	System reliability is defined as the ability to: • ensure normal operation of the electricity system, • limit the number of incidents and prevent major incidents, • minimise the consequences of major incidents when they do occur. Ensuring reliability is one of the key responsibilities entrusted to RTE by the law of 10 February in its capacity as the French Transmission System Operator.
Significant system events (SSE)	Pre-established criteria are used for detecting events from which lessons can be learned for electricity system reliability. They are grouped together in the significant system event classification grid. The grid is used for classifying events based on their actual level of importance in terms of reliability, by placing them on a severity scale with seven levels. Level 0 is assigned to events which have the lowest consequences for reliability, but which should be recorded nonetheless. Levels A to F are assigned to incidents of growing severity up to a wide-ranging nationwide incident. The method used to classify incidents involves assessing combined severity based on two types of input: • one input records the occurrence of concrete elementary events which affect the way operation is carried out in a certain number of areas (transmission grid, generation, system operation, control means and distribution); • the second input shows the extent to which the event has a damaging impact on system operation.
Operating margins and reliability rules	The reliability rules stipulate: • a minimum margin of more than 1500 MW that can be deployed in under 15 minutes. This figure is arrived at so that the loss of the largest connected generation unit can be compensated for at any time, • a minimum margin at the furthest deadline, the required volume of which increases from a 15-minute timescale to one of several hours. If these conditions are not fulfilled, depending on the circumstances, RTE issues an alert message on the Balancing Mechanism or an S order for critical situation.
Primary and secondary frequency control	Primary control is for automatically ensuring that balance is restored virtually immediately after any contingencies affecting balance between generation and consumption, by all of the partners involved in synchronous interconnection working together as one. Rules are laid down by the set by the ENTSO-E's regional "continental Europe" group so that this action then maintains the frequency within defined limits. Then, secondary control of the partner behind the disruption automatically cancels residual frequency discrepancy relative to the reference frequency, as well as deviations from the scheduled cross-border schedules between the various control zones.
Emergency response arrangements	The ORTEC (RTE emergency response arrangements) system was set up in the wake of the storms at the end of December 1999. It lays out the measures to be taken and the organisational structure to be set up at both national and regional levels when a serious emergency is declared by RTE. In addition to sourcing the necessary human resources and technical expertise, it specifies implementation of communication initiatives for emergency response management. In concrete terms, emergency response teams can be rapidly deployed across all of RTE's Units and at its Headquarters. In addition, Priority Response Groups have been set up for each of the regional units. Their main aim is to ensure that the lines that have sustained serious damage, and which are particularly important for electricity system reliability, can be restored in less than five days.

APPENDIX 2: GLOSSARY OF ABBREVIATIONS

ADN — Northern defence programmable controller)

APGP — Improved performance through professionalism

CACM — Capacity Allocation and Congestion Management

CE —Operations Centre

CNES — National System Operations Centre

CORESO — CO-oRdination of Electricity System Operators

COrS'R — RTE's Operational Security Centre

CSEE— Economic monitoring and audit committee

CWE —Central Western Europe

DTR — Technical Reference Documentation

EnR — Renewable energies

ENTSO-E — European Network of Transmission System Operators for Electricity

EOD — Balance of supply and demand

ESS — Significant system event

GIP — Priority Response Group)

GRD — Distribution System Operator

GRT — Transmission System Operator

HDP — High density generation

HVDC — High Voltage Direct Current link

ICS — Incident Classification Scale

IFA — France-England interconnection

IPES — Wind power transmission software program)

IST — Transient overload intensity

LAD — Automatic fault finding system

MA — Balancing mechanism

NEBEF — Block Exchange Notification of Demand Response

NEMO — Nominated Electricity Market Operator

ORTEC — RTE emergency response arrangements

RC — Complementary reserve

ROC — Regional Operations Centre

ROSE — Optical Security Network

RR —Rapid reserve

RSC — Regional Security Coordinator

RSFP —Secondary Load Frequency Control

RST — Secondary Voltage Control

RSTN — Secondary Renovated Voltage Control

RPD — Distribution grid

RPT — Transmission grid

SAS — Alert and Safeguard System

SDIS — Departmental Fire and Rescue Services

SIDRE — Regional inter-dispatching support centre

SNC — National Control System

SOGL — System Operation GuideLine

SRC — Regional Control System

STANWAY— SRC replacement project

STS —Safety Telephone System

TCE — Equivalent outage time

TSO — Transmission System Operator

TURPE — Transmission grid usage tariff

TYNDP — Ten Year Network Development Plan

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