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2010 Reliability Report

40 Pages 1 Annex

Cancelled documents:

Reference documents:

Functional reference:

Summary:

RTE publishes a yearly reliability report based on a stable model to facilitate comparisons and the detection of long-term trends. The 2010 reliability report highlights the main elements of electrical system reliability without being limited to a factual report of Significant System Events (ESS).

Through the publication of this report, RTE aims to bring to the foreground the different dimensions contributing to the building of current and future reliability. RTE also aims to contribute to the development of a reliability culture, by encouraging the various companies involved (RTE and network users) to improve their assessments of their roles, and by further encouraging the inclusion of the European dimension of power system reliability.

Accessibility :	
Open	
RTE	X
Restricted	
Confidential	

Department and processes directly involved:

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Summary of the 2010 Reliability Report

RTE publishes a yearly reliability report based on a stable model to facilitate comparisons and the detection of long-term trends. The 2010 reliability report highlights the main elements concerning electrical system reliability without being limited to a factual report of Significant System Events (ESS), which are ranked on a 7-level scale (0, then A to F).

A- Operating situations encountered

In the context of a cold winter season, the maximum consumption level of 96,700 MW was reached on December 15th at 19:00, with a mean temperature 6.3°C lower than average climatic conditions. The temperature gradient in winter reached 2300 MW/°C. The operating landscape was characterized by contrasted import/export situations, varying rapidly on a daily and intraday basis as a result of supply & demand balance optimisation at a European scale, linked to production and consumption parameters (e.g.: sensitivity of French consumption to meteorological conditions, increasing volume of intermittent production, etc.).

A-1 Supply / demand balance management

The consumption forecasting activity's performance results are comparable to previous years, with 3 ESS level A for underestimations of between 3300 and 3500 MW. The need for intraday reforecasts to reduce the forecasting gap is growing with the increase in load sensitivity to weather conditions.

For the supply & demand balance, which results from demand and the positioning of market participants, RTE encountered situations with upward insufficient margins evaluated for several hours ahead, leading to 18 ESS level 0, an identical result to 2009. There were no major difficulties in overall supply & demand balance in 2010 (abstraction of network congestion situations) although several very cold days were quite tense.

For several years now, the frequency stability of the European interconnected system, a value (?) shared by all companies and TSO's, has been, and remains, a serious concern. This was confirmed in 2010, but the total duration of exposure to a serious risk due to a major production loss remained limited to 6400 seconds over the year, with a maximum event duration of 6 minutes and 20 seconds. The setting up of a European task force in 2010, with all the types of concerned actors, finally gave rise to encouraging prospects for the reduction of this risk in future.

A-2 Flow and voltage profile management

As in previous years, the main operating challenge for RTE was to guarantee reliability in the face of the risk of voltage collapse, in particular at high consumption levels, due to structural limitations – production localisation, difficulties in building new production facilities, growing consumption levels – mainly in the West region, while the situation in Provence Alpes Côte d'Azur (PACA) improved with the completion in mid-2010 of the 400 kV double line supplying eastern PACA and the reinforcement of production in the Fos area. These structural difficulties were worsened as of 2009 by substantial limitations in the reactive power production capacities of generating units compared with contractual capacities. These limits were generally only slightly reduced in 2010, decreasing from 6500 MVAr at the end of 2009 to roughly 5000 MVAr at the end of 2010. Given this situation and the requests from RTE, the producer agreed in January 2011 to define a "multi-year plan to bring the units back to conformity" and to study the implementation of transitional protocols to provide additional capacity from certain constrained units over short periods. RTE's awareness of a reliable schedule to return to conformity is essential to decide on additional investments in reactive power compensation.

From a factual standpoint, to manage the voltage profile, RTE had to call on warning or safeguard means giving rise to 31 ESS level A (20 in 2009), of which 23 for the very tense passage of consumption peaks during cold periods, whose amplitude and duration were however not exceptional. The safeguard orders, issued when the consumption level is expected to exceed the limit guaranteeing reliability in case of the loss of a unit or a 400 kV line, were activated more than 15 times, several times for a large West zone as far as the Ile de France and even in Picardie, ensuring a reduction in consumption up to 1200 MW.
Modifications to tools and organisations in 2010 made it possible to significantly improve decision making for the activation of these orders, by basing them on dynamic collapse risk simulations carried out on network situations in real time, via quasi instantaneous merging of system states recorded in

the national and regional control systems concerned.

The CORESO technical coordination centre has been providing reliability analyses and coordinated resolution proposals for the Central West Europe region since 2009. In November, the TSOs Terna (Italy) and 50Hertz (one of the four German TSOs) joined Elia (Belgium), National Grid (GB) and RTE. This enlargement reinforces CORESO's ability to make pertinent diagnoses and to propose solutions for a larger portion of the European network.
The implementation of a 'coupled market' in November, by the concerned power exchanges and TSOs, covering the French, Benelux and German day ahead electricity markets, was accompanied by the strengthening of technical cooperation between the different TSOs, which is now based on a single data set established with the help of CORESO to calculate the capacities that may be made available to the markets.

A-3 Contingencies affecting transmission facilities

The number of short-circuits affecting transmission facilities dropped by 19% compared with 2009, continuing a trend observed for several years now. 97% of these short-circuits were transient and therefore did not impact the availability of the transmission facilities. In terms of reliability, we observed 12 simultaneous faults on double 400 kV lines (11 in 2009), all transient (for 3 permanent in 2009), and three 400 kV busbar faults (versus 8 in 2009), of which two were due to damaged equipment and one to human error.

B- Evolution of the reliability reference guide

The "NOME" law, dated December 7th 2010, introduced a major change to the reliability of the supply & demand balance by establishing capacity obligations for electricity suppliers in the shape of "direct or indirect guarantees" of production or withdrawal capacities. It also assigned RTE the task of ensuring their effective availability.

Following a consultation process, revisions were made to the provisions for the next Ancillary Services contracts, renewed in 2011. They facilitate the potential participation of renewable energies through the sole supply of voltage services and also complete the management of lasting situations of non-compliance with contractual performances.
A contract was signed with ERDF and Electricité de Strasbourg Réseau, to ensure availability of existing MV capacitors, thus contributing to improved voltage control.

There is a regular verification process, in place since 2006, to check the compliance of continental European TSOs, with a joint reference guide comprising 8 policies. In 2010, this process concerned policies 1 to 3, dealing with fundamental reliability issues. The results show that the implementation of the fairly complex inter-TSO operating measures, adopted during the review of policy 3 after the incident of November 4th 2006, can be perfected, which supports the analysis of RTE that prefers a structure such as CORESO to implement them.

C- Measures contributing to reliability in the equipment field

Among the network evolutions contributing to the reinforcement of reliability, besides the previously mentioned completion of the 400 kV line to supply eastern PACA, we can mention the creation of the Calan 400/225 kV substation near Lorient and the on-going installation of compensation means, which are necessary to improve voltage management (395 MVAr in supply, 130 MVAr in absorption).

The calculation methods for overload temporary current levels for the different types of lines were perfected, which will eventually allow a significant increase in the maximum values for most lines. The deployment of this new policy started in November 2010. A significant improvement during cold waves has already been observed.

The analysis of the use of protections to eliminate the 386 short-circuits on the 400 kV network gave satisfactory results. Among the causes of the anomalies, with limited consequences due to the redundancy of the protections, 30% concerned the functions provided by the telecommunications systems; their progressive transfer to the new internal ROSE network should help to reduce them. Given the critical impact of ROSE on reliability, the project underwent an in-depth review prior to receiving approval to launch of the industrial deployment. As concerns the differential 400 kV and 225 kV busbar protections, their fault behaviour was satisfactory.

In terms of control systems, the availability of the national system was excellent and that of the new regional systems improved compared with 2009 and should continue to do so over time. The availability of the Safeguard and Warning system was satisfactory and the use of critical safeguard order tests is growing.
The use of the IPES tool for intermittent production estimations and wind power forecasting is now well established for real time system management but also for day ahead management. IPES data contributed to improving consumption assessments and forecasts.

Several operating incidents illustrate the risks linked to the growing use of measures for the frequent adaptation of network PLC parameters, for example overload protections and their pertinent integration in network reliability calculations. More generally, operational data mastering is currently a risk factor for control and requires the close attention of the operational teams and their managers.

RTE tends to favour the development of actions on demand. In Brittany and PACA, the reputation of the Ecowatt system was reinforced. The participation of consumer and industrial withdrawals, and to a lesser extent the aggregation of withdrawals from small consumers, is developing little by little and RTE has carried out an experiment to assess the potential of flexible offers of this type.

D- Measures contributing to reliability in the organizational and human domain

The reduction of consequences due to human error has been a focus of continuous improvement for several years now. When compared with the 2009 diagnosis, we find the same trends: increase in the self-declaration of events, in events recorded and analysed by the teams, and transparency seen a vector for success. There are however no sufficient improvements and it's difficult to assess the effectiveness of the corrective actions taken. Four ESS level A or more are at least partially due to human error. Given the risks for reliability, we must continue to pay close attention to the reduction in the occurrence of errors and their consequences.

For operation and control, it is important to highlight that the initial and refresher training for the various professions involved were organised at a national or regional level in accordance with the planned programmes. Beyond the operating staff, regular awareness raising with other personnel whose work has a direct impact on reliability (calculations, adjustments, interventions, etc.) must be a growing concern for each Regional Unit.

At an operational level, the events feedback process has been fully revised with weekly national steering coordinated with regional steering, to improve its effectiveness. Another aim of the review was to improve the management of sharing of lessons learnt from events (intra- and inter-regional) that are always difficult to organize efficiently.

An essential point was the revision of the "N-k" directive, a security rule that determines which potential incidents should be studied (loss of facilities, production, etc.), which consequences are allowed, when (on a preventative or remedial basis) and how to guard against them. The new rule confirms the importance of comparative risk analyses for reliability and should enable the optimisation of the use of the network, to better manage constrained situations and to facilitate planned outages.

Moreover, we must stress that changes in work organization made it possible to better prepare the forecasted reliability analysis, in particular with regard to the voltage profile reliability calculations based on a single set of joint data providing a better day ahead vision. This change must be extended to intraday and all of the regions.

E- Lessons drawn from the year's events

The incidents that affected the reliability of the electrical system, assessed in terms of ESS, had significantly increased in 2009. 2010 is characterized by a return to the average trend from 2005-2008, even though the number of ESS level A and more remains fairly high (linked to the tense situations in cold periods): 55 level A and 5 level B (for 57 level A, 8 level B, 1 level C, 1 level D in 2009). Vigilance with regard to reliability remains a timely issue and hence RTE must keep up its efforts to fully exploit feedback and to disseminate its lessons.
The level B ESS involved: two, well managed, double busbar faults; one N-k reliability guarantee loss following a busbar fault with a duration limited to one and a half hour; a (very low) risk of the loss of a production volume higher than 3000 MW following a busbar fault during a differential busbar

protection scheduling of outage; failure to execute a safeguard order by a transmission control centre, with limited impact.
The evolution of ESS 0 reveals an increase in the number of problems involving busbar switch disconnector in 400 kV substations, knowing that incomplete operation can lead to major risks for the reliability of the electrical system. It is necessary to ensure that the current actions are continued and that they are relevant.

The passage of windstorm Xynthia confirmed observations made in 2009 during the passage of windstorm Klaus, that the resistance of the network managed by RTE is satisfactory.
During the flooding, on June 15th, in the Var, the 225 and 63 kV Trans substations were severely damaged while the more recent 400 kV substation was not impacted, which is consistent with the requirements established for its construction. The efficient management of the crisis must be underscored as must the rapid definition of corrective actions.

F- Progress actions

RTE initiates or contributes to many progress actions aiming at reinforcing reliability. These actions are increasingly being carried out within ENTSO-E. Hence, ENTSO-E continued to work on a unified real-time warning system "ENTSO-E Awareness System" for all the TSOs in the association. Its usefulness and functions were established in light of the lessons stemming from the European incident of November 4th 2006. An invitation to tender was launched in 2010 for this project.
In 2010, ENTSO-E published its first ten-year European network development plan. In the long term, the economic and environmental performance and the reliability of the electrical system will be impacted if the associated structures are not actually built, and ENTSO-E has called for a shortening of the corresponding permit procedure times.

RTE organized a joint simulator training session with the Italian TSO TERNA for operators of both TSOs, and prepared similar types of actions with the Spanish TSO REE. Exchange meetings between staff at an operating level took place with the Swiss TSO Swissgrid, the Belgian TSO Elia and CORESO.

RTE played a driving role in the actions undertaken to develop European R&D among TSOs. They led to the definition of a R&D programme for TSOs and DSOs, which was ratified during the first meeting of the "Grid Initiative", and then ENTSO-E established its R&D work programme for the years 2010-2018.
Among the operational R&D actions, RTE is participating in several European projects such as TWENTIES (technical feasibility of direct current networks -DC-), PEGASE (models of large grids) and SafeWind, and has also performed studies to cope with the main reliability issues.
New technologies are being tested (new low expansion cables to increase flow capacity) or are being introduced on the grid (DC line between France and Spain of the voltage source converter type, a technology that has proven reliability benefits compared with the previous one).

G- Management, control and audits

RTE management has committed the company to a "industrial project for sustainable performance" with different components linked to controlling reliability. In parallel, the company's overall internal control system is being developed, with each Unit identifying risks and the associated control actions.
The Reliability Audit Mission carries out regular in-depth audits. Three audits were performed in 2010 on the following topics: digital I&C in substations, operation of interconnection lines, network restoration following a generalized blackout. A flash audit was performed following malfunctions observed after the removal of a busbar differential protection in a 400 kV substation.

In summary,

From an operation standpoint, 2010 was marked by tense situations during cold spells that RTE was able to manage effectively, but which required issuing safeguard orders more than 15 times. These difficult situations, which reoccur from year to year despite regular improvements made in the reinforcement of compensation means and operational management, reveal structural weaknesses in the location of generation facilities in the West and South-East regions, as well as the impact of the growing thermosensitivity of consumption.
RTE's ability to handle severe meteorological incidents, as already proven in previous years, was confirmed during the management of windstorm Xynthia and the flooding in the Var on June 15th.

The incidents that affected electrical system reliability assessed in terms of ESS with a level A or higher, had increased significantly in 2009. 2010 is characterized by a return to the average trend from 2005-2008, even though the number of ESS level A and B remains higher, due to the increase in ESS A recorded during tense operating situations during cold spells. Vigilance with regard to reliability remains a timely issue and hence RTE must keep up its efforts to fully exploit feedback and to disseminate its lessons, even though, in a longer term perspective, we can underscore that the number of ESS level B and higher recorded since 2004 is significantly lower that at the start of the previous decade.

Some points of potential risk stand out in this reliability report: the difficulty in making headway in the reduction of occurrences and the consequences of human errors, some of which may be important in terms of reliability; the potential vulnerability of operations to data errors and the control of regularly adapted parameters; the persistence of lasting reactive production capacity limits affecting a certain number of units, even though in-depth discussions with the concerned producer made it possible in early 2011 to define a progressive management process to return to contractual capacities in the next few years.

As a counterpoint, significant evolutions were made to improve reliability and regularly improving operating and control modalities, adapting them to an ever-changing environment: the revision of the fundamental rule of reliability – the N-k; introducing a new method to determine overload temporary current levels to release additional operating capacities; noteworthy improvements in day ahead study methods, in particular for very tense situations; reinforcement of events feedback.
Given these evolutions, we must also ensure that operational teams have enough time to fully assimilate the changes, especially since the tools themselves are also changing.

Finally, like in 2009, progress was once again made in coordination at a European scale, including the increasingly important role taken on by CORESO in operational management and the evolution in calculation methods of capacities available to the markets, in the framework of the implementation of day-ahead market coupling in the Europe Centre-West region.

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1 Brief overview of the evolution of the internal and external environment

2010 was punctuated by some noteworthy achievements on a European level:
- The European Network of Transmission System Operators (TSOs) for Electricity ENTSO-E began drafting future European network codes in the framework of the third energy package adopted in 2009.
- The TSOs TERNA and 50Hertz joined ELIA, National Grid and RTE in the CORESO coordination centre, set up in 2009, thereby extending the scope of the analyses that the centre can carry out to benefit the reliability of the European electrical system.
- Markets and transmission system operators in the Central West Europe region jointly implemented a market coupling. This coupling, beyond its innate benefits for short term supply & demand balance optimisation, reveals the real need for increased (though still perfectible) coordination among TSOs.

Internally, RTE management has committed the whole company to the "industrial project for sustainable performance", whose different components are linked to reliability control.

This 2010 report highlights the main elements concerning the reliability of the electrical system managed by RTE and integrated into the European electrical system.
Its aim is to give those outside the company a vision of reliability that is of course concise but that nonetheless deals with all aspects of the question: the goal is not only to give a factual account of the incidents that may have affected the electrical system, but also and above all, to explain the actions undertaken by RTE to prepare the conditions for reliable operation in future, from several months to several years, and this both internally and in coordination with the other involved stakeholders that are European TSOs and network users.
It is furthermore a tool for in-house use that makes it possible to provide all employees with a global view of reliability control, one of RTE's fundamental missions, and hence to better understand the importance of their basic actions. The building of this national report is based on the information available in regional reliability reports, national operating reports and more generally those produced throughout the year. This is not a summary of the different regional reports.

NB: explanatory elements for the main concepts used in this report are found in the annex. They are identified during their first appearance in the text by the symbol "*Glos*" as an exponent (e.g.: reliability[Glos]).

2 Operating situations encountered

This chapter examines how reliability[Glos] was ensured throughout the main operating situations that RTE had to manage by examining them from the technical point of view – management of congestion, voltage profile, interconnections, frequency and margins – and from the external conditions point of view – climatic conditions, imports/exports, contingencies affecting the network.
There is better reliability control when future operating conditions are anticipated and well prepared, regardless of their intrinsic difficulty.

2.1 Climatic conditions

On average, 2010 was cooler than the last 20 years in France. January and December were particularly cold, with monthly variations[1] of -2.4°C and -3°C with respect to normal and giving rise respectively to record monthly cold levels for the last 20 and 40 years. February, March and the second half of November were also colder than average, while July was marked by temperatures higher than normal by +1.9 °C. The most notable weather disturbances that impacted the electrical system were windstorm Xynthia in late February with winds of 120 to 140 km/h, and even higher very locally, and the exceptional rainfall on June 15th in the Var, where in 12 hours they locally received 5 times the normal monthly rainfall.

[1] Source Météo France for §2.1; the other national temperature variations compared with normal values in the other chapters of the report were calculated by RTE

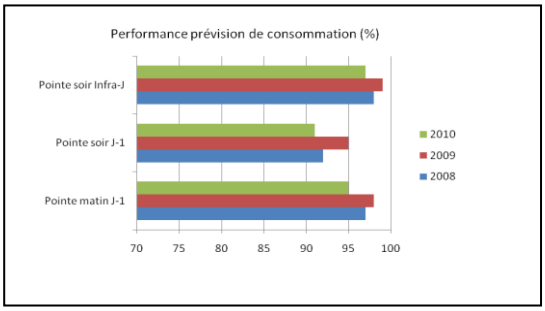
2.2 Supply / demand balance management

French domestic electricity consumption, including grid losses, reached 513.3 TWh, a 5.5% increase compared with 2009 due to climatic contingencies and a certain catch-up effect of the economic crisis. More significantly for reliability, maximum consumption of 96,700 MW was reached on December 15th at 19:00, with a mean temperature 6.3°C lower than average climatic conditions, or an increase of 4300 MW compared with the maximum of January 7th 2009, which had a negative variation of 7.8°C. Another peak was observed on February 2nd at 92,000 MW. The temperature gradient in winter reached 2300 MW/°C.
Though the annual balance of exports increased slightly to 29 TWh (24.7 TWh in 2009), due to a stabilisation of export volumes and a decrease in import volumes, we observed an increase in the number of import situations:

- 72 days required imports (57 in 2009, 6 in 2008);
- 161hrs with an import level higher than 5000 MW (95hrs in 2009, 0hr in 2008), during cold periods before March 11th and after October 19th, and 40hrs above 6000 MW.

In parallel, the export level was higher than 9000 MW for 660hrs, mostly in summer. Above 7000 MW, the export situations appear at variable times throughout the year (mid-November, late February, from March 20th to 30th, etc.), including weekdays.
The intraday market at the borders continues to grow and now represents 6.0% of contractual exchanges there (5.1% in 2009 and 3.6% in 2008).
The overall operating landscape is therefore characterized by contrasted import and export situations that vary rapidly from one day to the next or even on the same day, reflecting the specific sensitivity of French consumption to climatic conditions, the optimisation of production at a European scale, and the ever growing impact of intermittent generation that requires very short term buying and selling by the European market participants to ensure the balance of their physical shortfalls.
Wind power supplied 9.6 TWh, an increase of 1.8 TWh compared with 2009 (+2.2 TWh between 2009 and 2008), and photovoltaic supplied 0.6 TWh, for a total French production of 550.3 TWh, a 6% increase. Nuclear production increased significantly (+17.9 TWh) after an atypical year in 2009.

In this context of high total demand variability, linked particularly to growing thermosensitivity, it is important for system reliability to ensure the quality of consumption forecasts, specifically with regard to their impact on the margin calculations required for the supply & demand balance, which is a more significant indicator than the intrinsic performance of the forecast. This graph shows the frequency of situations (in %) for which the forecast variation is below the consumption forecast contingency used to calculate the required margin. Given an objective of 85%, the performance is satisfactory on an annual basis, with a slight drop in 2010, and the results are fairly average on an evening peak basis in February, May and September when the objective was not met. In terms of the evening peak, the graph illustrates the usefulness of intraday reforecasting, based on updated weather forecasts. 3 Significant System Events*Glos* (ESS) were declared at level A for forecast underestimations of 3300 to 3500 MW (2 in 2008, 1 in 2009). They can for the most part be attributed to climate contingencies (temperature and cloud cover forecasts, wind effect) but also to atypical days.



Operating margins*Glos*

RTE monitors the margins available to balance supply and demand over different periods in real time, and, should the volume fall below the specified level, restores this margin by calling on normal balancing offers available in the Balancing Mechanism*Glos* (MA). If this is insufficient, RTE turns to additional offers received following the sending of a degraded mode message in the Balancing Mechanism, and then uses back-up contracts with other TSOs. Should the margin become negative, RTE can turn to exceptional and then emergency means[2]

[2] Non-contracted emergency feeds from other TSOs, 5% drop in HVA voltage, load-shedding, reduction in exporting physical exchanges, etc.

The load peak, a sensitive time of the day, was passed whilst respecting the requisite 1500 MW margin at the 15-minute ahead time period on all but on 19 days (23 in 2009) for durations below 30mn, which did not lead to any recorded ESS.

There were 32 ESS relating to a critical situation due to insufficient margin, a real drop compared with 2009 (60 ESS, including 2 level A) and 2008 (56). However, in 2009, 42 concerned situations due to downward insufficient margin, which though awkward, are less critical for reliability. They were linked to the economic conditions of the generating fleet.
In 2010, 18 of these ESS were linked to upward insufficient margin, exactly the same as in 2009. These ESS gave rise to the issuing of 19[3] 'S' orders (Critical Situation), mainly between February 9th to 12th, March 5th to 12th and October 26th, November 25th and 26th and December 27th. Only part of these situations (e.g.: March 9th and November 26th) were characterized by major production problems. Generally, the situations were synchronous with cold spells and, from January 1st to mid-February, with a lower than normal fleet availability, corresponding to the end of the absorption of the situation seen in the second half of 2009. We also observed that these more tense margin availability situations were often correlated with consumption forecasting problems (one of the causes identified in 2/3 of the cases).

All of these ESS were accompanied by warning messages or Balancing Mechanism degraded mode messages. Only one concerned insufficient margin 15 minutes ahead, the 17 others concerned estimations for longer ahead time periods that were mostly reasonably reconstituted before the real time. The margin oversight observatory, set up last year by RTE, confirms this.
In addition, 14 degraded mode messages were sent, without the sending of an 'S' order – these correspond to situations that are improving as they reach the deadline – of which three for downward insufficient margin.
Finally, 7 Balancing Mechanism degraded mode messages and 2 S orders were sent during strikes on production sites.
We did not detect any non-virtuous opportunistic behaviour on the markets regarding the supply & demand balance, as opposed to some detected and reported cases in the 2009 report. In 2010, the spot market EPEX introduced the possibility of finalizing the hourly price of energy at negative values for the injection of production, in order to take into account tense situations with high production surpluses. This type of mechanism helps to avoid certain opportunistic positions.
In conclusion, there were no major difficulties in terms of overall supply & demand balance in 2010, excluding grid congestion, despite several more complicated very cold days and some delicate situations managed during the national strikes in October.

Primary and secondary reserves of power frequency control (f/P)

Similarly to 2009, no ESS level A were issued for shortfalls in the availability of reserves for primary and secondary control of power frequency*Glos* in terms of the levels required for France. This is an essential aspect of the contribution of the French system to the control of European power frequency.

Frequency stability

For several years now, the frequency stability of the European interconnected system, an asset shared by all of the companies and TSO's, has been and remains a serious concern. The frequency variations that we observe on the European interconnected grid with large amplitudes compared with what is provided for in the ENTSO-E reference guide are presented in the table below. It indicates the number of frequency deviations of greater than 100 and 150 mHz from the reference frequency.

	2005	2006	2007	2008	2009	2010
F-Fref < - 100 mHz	59	150	73	91	89	151
F-Fref < - 150 mHz	0	1	0	0	0	0
F-Fref > +100 mHz	106	202	82	191	302	270
F-Fref > +150 mHz	0	1	0	0	0	0

If we examine the first two lines, the number of downward frequency deviations, the most critical point for the European grid, 2010 has the poorest results with 2006 and January 2010 was the worst

[3] An ESS covering a period containing two S orders

month ever since the start of these observations. It should be noted that during these periods in which the frequency is lower or close to "Fref – 100 mHz", the European system has almost fully used up its primary reserve and can therefore not cope as planned with a sudden major loss in generation, with the associated risk of requiring an automatic frequency related load shedding operation to manage the consequences. The total duration of the exposure to this risk was 6400s during the year (3700s in 2009). Happily, the mean duration of these variations remains very limited at 43s (39s), illustrating the effects of the controls and the actions of the TSO operators to resolve them. The longest one did reach 6min and 20s (4 min 40s). These frequency variations are essentially the results of important changes in exchange programs at the interconnections between countries, on the hour, and are also due to the shutdowns/start-ups of the associated units; current practices don't make it possible to sufficiently reduce the impact. They also lead to large variations in physical flows on the interconnections: for example, on January 13th at 23:00, the flow from Spain to France was for a few minutes 1300 MW instead of the 530 MW planned. The operational implementation in 2010 of a European task force with members from the TSOs/Producers/Market companies, that made it possible to share observations and possible solutions with all the stakeholders, opens up new encouraging prospects to reduce this risk, but in late 2010, there weren't yet any tangible conclusions.

2.3 Voltage stability

The main operating challenge for RTE in 2010 remained ensuring reliability faced with the risk of voltage collapse, mainly during periods of high consumption. Previous reports have shown the structural difficulties for control in a large western region and in PACA (South-East of France): shortage of well-located production facilities in these zones, difficulties in building transmission facilities, and growth in regional consumption levels. The "Brittany electrical pact" agreed between the region, the State, RTE, the ADEME and the ANAH and signed on December 14th plans for investments (invitation to tender for a combined cycle power plant near Brest and reinforcement of the north-south 225 kV network) over the next few years to reduce these difficulties. For the time being, the structural difficulties were aggravated in the western region as of 2009 by major limitations in reactive power production capacities on generating units.

In line with previous years, RTE continued its on-going adaptation actions in 2010, by using the feedback from the last winters and by taking into account the expected lasting nature of reactive power limitations for certain generating units over the next few years:

- In terms of facilities
  - The installation of capacitors previously decided for Brittany and Normandy was continued.
  - For 2011-2014, a major programme to build new compensation means in the northwest quarter was initiated, for a total of roughly 1800 MVAr, including several static VAR compensators that provide continuous and automatic regulation capacities to the voltage profile. This programme also includes investments of 1750 MVAr of capacitors (of which 1200 in 400 kV) in the South-West, the reinforcement of the interconnection between France and Spain, and 320 MVAr in the North-East.
  - The passage to 400 kV of the second three-phase circuit of the only double line between Toulon and Nice (Néoules – Trans – Briançon - Broc-Carros line) was finalized in mid-2010.

- In terms of control methods, improvements to the tools (Convergence -cf §4.1.5) and the progressive adaptation of the organisations made it possible to make decisions in real time to call on safeguard means, by using dynamic simulations carried out on more precise data sets (instantaneous regional points included in a single complete data set) replacing less precise static criteria; in 2009, these dynamic studies were used on day ahead data. The methods and organization of day ahead forecasting studies were also improved -cf §5.6-.

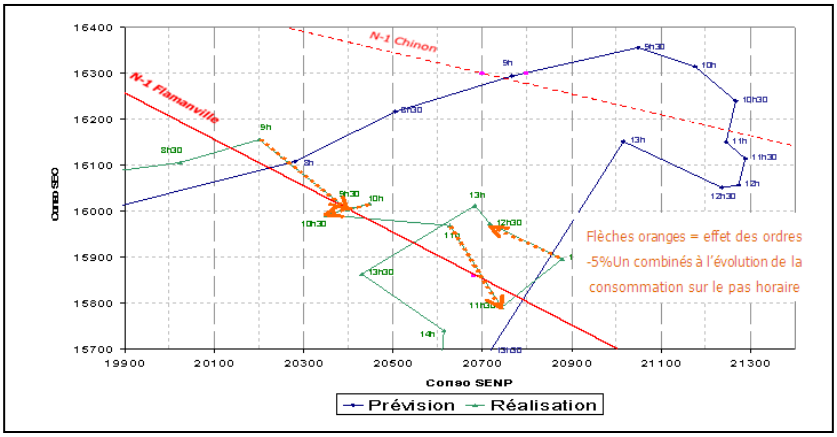
The development of the Ecowatt programme in Brittany and in the South-East also contributed to controlling these daily peaks by encouraging citizens to reduce their consumption.

From a factual point of view, in line with the end of 2009, the passage of consumption peaks during cold spells from January to March 2010 remained very tense. Many times, RTE had to resort to warning and then safeguard orders. These orders are activated so as to ensure electrical system capacity in order to avoid a large-scale voltage collapse (regional or more) during the occurrence of potential incidents that are fairly common (loss of a 400 kV line or a large production unit in the region) or quite rare but with very large consequences (loss of a busbar section in a 400 kV substation

or of all the production and transmission facilities connected to this section). Safeguard measures are activated when the expected consumption level exceeds the limit ensuring reliability only in case of more common incidents. These measures make it possible to reduce consumed power by several % points. In addition, the Automatic Load-Shedding Controller (ADO) installed in 2009 can act in a dozen seconds after an incident by load shedding consumption in Brittany.
During the cold wave in late November early December, which was severe without being exceptional, with a variation of 9°C compared with normal temperatures, new situations of this type developed, giving rise to similar decisions in more extensive zones.

In total, 31 ESS level A (20 in 2009) were logged for voltage reasons, including 23 during cold spells, each corresponding to at least one first level warning "low voltage critical situation" S order. During these periods, 16 S "voltage profile downgrading" orders were issued in the West and Normandy–Paris regions, but also less systematically in the North-East, South-West and East regions, illustrating the widespread nature of the voltage control problem, due to the meshing of the network and location of the main generation facilities. These orders let producers and distributors know that they should do their utmost to activate available reactive power reserves.

The "-5%"[4] safeguard orders were activated ten times in the North-West region (2 in 2009), for durations of 2 to 4 hours each time, from January 4th to 7th, then on January 26th, and from November 30th to December 2nd in fairly large areas. For example, an order was issued on December 1st from Picardie to Brittany and La Vendée, encompassing Ile de France and Normandy, for an estimated effect of 1200 MW. The Automatic Load-Shedding Controller (ADO) was put on standby 19 times (82 hours in total). Additional "transformer block[5]" safeguard orders were activated three times on January 4th, December 1st and 3rd. It should be noted that on several days, these safeguard orders were issued to deal with situations, that in the absence of orders, would have led to a voltage collapse not only in Brittany but also in the whole West region including Paris in the case of the loss of a single generating unit. To illustrate this, the associated chart concerning the consumption plan for the Normandy-Paris and West regions indicates the effect that safeguard orders have in maintaining the system's operating point close to the pre-collapse safety limit on N-1 unit (limits shown by red lines, the operating point must remain below it to guarantee that a collapse doesn't occur; without additional remedial actions).



The results of voltage profile control in the PACA region are also worth noting. In January and February, 4 "-5%" orders and 7 transformer block orders were issued for the eastern part of the region but none at the end of the year. This is due to the commissioning of the 400 kV double line to Nice (as well as the growing availability of generating means in the Fos area) that makes it possible to substantially raise the consumption limit before voltage collapse. The durability of this improvement will depend on the regional control actions that are taken to limit the growth in consumption and on the construction of the "225 kV safety net" decided in 2009.

This information, and in particular the number of safeguard orders, confirms the criticality of these situations and their presence from one year to the next: the improvements made by RTE each year

[4] Order sent to distribution network control centres to lower the set-point voltage of the delivery point substation transformers, resulting in a drop in consumption associated with passive loads
[5] Suspension of voltage regulation in HV2/HV1and HV1/MV transformers, which contributes to the stabilisation of voltage drop phenomena by using the natural behaviour of the loads

(reinforcements, study methods and means) have been up until now counterbalanced by the unfavourable factors (growing consumption, unit reactive power limits).

Generally, any event impacting the availability of means to act on the voltage profile is extremely penalizing during these periods and contributes to explaining the day-to-day variability of situations. This is particularly true for the availability of generating units in a large North-West region (with the absence of two units at Chinon during the cold spell in early December), including peak production means in Brittany and also the continuing limitations on generating unit reactive power (5000 MVAr late 2010 for 6500 late 2009, of which more than 4000 MVAr for units in the Centre, North and West regions).
We observed on December 15th, with a consumption of 96,700 MW and a favourable production plan, that safeguard orders weren't necessary. And on July 27th, with unfavourable production plan conditions in the Rhône Valley and following the triggering of the last generating unit on one of the sites in the valley, it was necessary to issue a "voltage profile downgrading" order (ESS A). This situation should however not be confused with previous ones in that it was due to the restoration of operating reliability after the occurrence of a first incident.

A new directive was issued for high voltages, based on the experiments in 2009, to foster the best technical & economic choices between different possible tools (including de-energizing lines). Their control in low load periods, which is less critical in terms of reliability than low voltages but which may nevertheless make it difficult to apply the N-k rule (on unit loss), was satisfactory during the summer but more complicated in the spring (several days during which ten 400 kV lines were de-energized, and up to 23 on May 30th).

2.4 Management of interconnections

Since 2009, the CORESO technical coordination centre has been providing reliability analyses and coordinated resolution proposals ahead of real time for the Central West Europe zone (Benelux, France, Germany), as well as real time monitoring of system snap-shots every 15 minutes. This activity continued in 2010. In November, the Italian TSO Terna and 50Hertz, the TSO in north-eastern Germany, joined Elia (Belgium), the National Grid (Great Britain) and RTE. This enlargement reinforces CORESO's ability to make pertinent diagnoses and to propose solutions for a larger portion of the European network
This major technical evolution, coupled with regular improvements in operational coordination between TSOs (see hereunder) and reinforcement of exchanges and their consecutive variability, is essential to move forward with the integration of the European markets and the growth of intermittent energies.
We note in particular that the attribution of day ahead interconnection capacities[6] in the Central-West Europe block has been ensured since November 2010 by a coupling of electricity exchange markets (Germany, Belgium, France, the Netherlands) whose algorithm ensures the best use of these capacities. The roll out of this system required reinforced technical cooperation between the different TSOs, in particular for the definition at the end of D-2 of a single set of merged data between the different systems and then for the calculation of the different capacities that may be available to the markets. For this, RTE itself uses the services provided by CORESO.
Moreover in December, RTE, the German TSOs Amprion and EnBW and the EPEX spot market set up a continuous intraday capacity allocation mechanism for the interconnection between France and Germany.

As concerns forecasting and real time coordination with its neighbouring TSOs, RTE bases this on contracts signed with each of them. There are only draft versions for the time being with Amprion and EnBW TSO since it was not possible to finalise them in 2010. Among the interesting events in operational management are:

[6] They are (virtual) exchange capacities between the systems of 2 different countries, proposed to market companies to facilitate the optimisation of production means to the continental plate; not to be confused with physical transmission capacities of the interconnection lines that are not elements used to determine these exchange capacities

- More than 25 activations (more than 40 in 2009) of trilateral and pentalateral agreements associating all the TSOs neighbouring Terna, including RTE, in order to facilitate the management of real time constraints resulting from exchanges, often impacting facilities on the Italian grid and sometimes on the Swiss grid. They are proof of the structural difficulties of the European system in this region but also of the need to improve forecasting coordination between all these TSOs. The need is great since it is probable that N-1 reliability was not always guaranteed on a line between Slovenia and Italy during the cold spell at the end of November. CORESO's support made it possible to facilitate the consolidation of a solution envisaged by Terna on its north-east network by evaluating its impact on the RTE network.
- Some forecasted or real time capacity reductions were organized by REE and RTE at the Spanish border (without any financial impact for the market companies) because of maintenance work delays or breakdowns.
- Many trippings affected the transmission capacities on the DC link between France and Great Britain, generally for very short periods, and without any impact on the market companies. This confirms the urgency of the renovation work that should be completed in 2011.

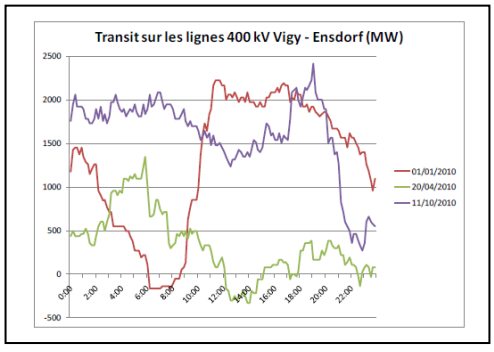
On the topic of the interconnection with Spain, we note that it essentially worked in an import direction, linked to the growth in renewable energies generation in Spain in 2010 (following excellent hydraulic flow coefficients and an increase in wind power generation, which covered 16% of Spanish demand), leading to lower market prices and high volumes of undispatchable energy.

2.5 Management of internal congestion

Seven ESS level A and one level B (Marlenheim zone– see §6.1) were recorded during difficult flow control situations.

Four of them demonstrate the structural difficulties in the South-East, which are regularly set out in RTE publications and illustrated here by N-1 management difficulties (or N-2 at specific times, such as during thunderstorms) on the Tavel-Realtor double line feeding the region from Marseille to Nice. When a first event takes place in the region (outage of a structure, late coupling of a unit "imposed" by RTE for congestion management, etc.), it is sometimes not possible to cover the hypothesis of the triggering of one (or two) Tavel-Realtor 3-phase circuit(s) without calling on a load shedding volume greater than 600 MW (63 cumulative hours in 2010). Different evolutions (development of generating capacity near Fos, passage to 2x400kV of the Toulon-Nice double line, construction of a "225 kV safety net" by 2015) associated with demand control actions are contributing and will continue to contribute to reducing these difficulties, without completely eliminating them.
The West region is also structurally weak, above all for voltage stability. In terms of regional 225 kV flow balancing, the integration of the 400/225 kV substation at Calan in the Lorient area, helped facilitate control.
A regional event (in 225 kV) near Nantes, recorded as ESS level A and caused by poor vegetation management, illustrates the risks associated with an incomplete analysis of a newly encountered operating situations and is a reminder[7] to all parties (forecast management, operations, etc.) of the importance of carrying out security monitoring and calculations.

Several regional events close to the borders (April 20th and October 11th in the East and May 5th in the North) showed difficulties already identified in 2009 concerning the correct forecasting of the impact of cross border exchanges in 400 kV and on regional 225 kV networks and the usefulness of reinforcing coordination between the CNES and regional dispatching centres for the preparation of projected situations (in day ahead or intraday) improving the effectiveness of the integration of CORESO studies within these evaluations. These improvements are expected in 2011 as a result of the organizational changes described in §5.6. Furthermore, CORESO is providing real assistance in terms of feedback from these situations by providing a more accurate vision of the



[7] in addition to the requirement for the strict application of the vegetation management policy.

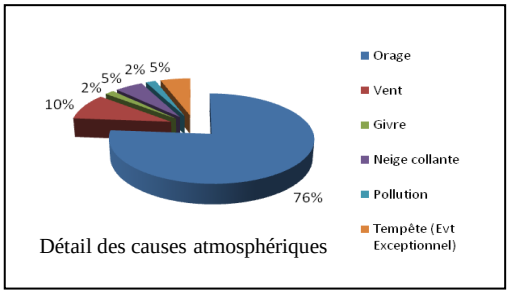
impact of flows in neighbouring networks on the RTE network. The rapid variability of flows in a single day is illustrated on the diagram opposite for an interconnection line between Germany and France; this variability naturally affects the domestic grid.

The examination of the reports analysing these events and of the regional reliability reports shows that a sensitive point for the preparation of day ahead and intraday operation concerns the analysis of the sensitivity of the studies to variations in hypotheses, in particular for expected consumption or exchange levels near the borders. This sensitivity increases with the development of the intraday activity of market companies, of intermittent energies and thermosensitivity. The "setting" of the coverage level required to deal with the uncertainties in hypotheses is a topic that required more detailed work in late 2010.

2.6 Contingencies affecting the transmission facilities

The number of short-circuits (7723) affecting transmission facilities is down by 18.6% compared with 2009, continuing a downward trend observed for several years now. The drop essentially concerns HV1 networks but also 400 kV lines (1.7 short circuits for 100 km versus 2.1 in 2009) and 225 kV lines (5.7 for 100 km versus 6.5), with a ratio roughly 6 times lower between 400 kV and HV1 links, which can be attributed to more protective construction measures.

97% of these short-circuits are transient and therefore do not affect the availability of facilities when the re-energizing equipment is functioning correctly[8].
61.9 % of these short-circuits are of proven atmospheric origin (68.9% in 2009). The number of lightning strikes in France decreased in 2010, but the number of short-circuits due to lightning dropped even more, confirming the trend of previous years.
The proven or presumed main causes of the remaining 38.1% are: bird activity (15.3%), construction characteristics (15.2%) resulting from optimisation choices that evolved depending on the construction period (recent structures take feedback into account), pollution (3.8 %), equipment breakdowns (1.7 %) and various other causes (external aggressions, human errors, etc.) for 2.1 %.



Détail des causes atmosphériques

In terms of reliability, it is important to focus the analysis faults involving double 400kV lines and 400kV busbars. During busbar faults, all equipment connected to the bar or the section of bar is automatically disconnected. Both types of incidents, but particularly the second, can cause large-scale incidents. In 2010 the following were logged:

- 12 simultaneous faults on a double 400kV line (11 in 2009), all transient (3 definitive in 2009)
- Three 400 kV busbar faults (versus 8 in 2009), two of which were due to the destruction of equipment and one to human error.

One of these busbar faults gave rise to an ESS level B. A 225 kV busbar fault also gave rise to an ESS level B.

The absence of short-circuits on the 400kV network following contact with vegetation shows that the pruning work carried out by RTE is effective for this voltage level. However, there was an incident of this type on a 225 kV line (ESS A, cf §2.5).

3 Evolution of the reliability reference guide

This chapter describes the evolutions in reliability reference guides, be they established outside of RTE or internally. It concerns all types of requirements and orders from all sources, contracts established by RTE with any type of party that may have an impact on reliability and also reference documents (studies, position papers, etc.) that concern this field.

[8] From a reliability standpoint, these transient short-circuits are without risk if they are cleared sufficently rapidly so as to not affect the dynamic stability of the units, which has been confirmed – see §4.1.2

3.1 External reference documentation: directives, laws, decrees, etc.

In Europe

There is nothing specific to speak of this year in terms of documents related to electrical system reliability.

In France

The "NOME" law dated December 7th 2010 introduces a major change for supply & demand balance reliability by establishing capacity obligations for electricity suppliers in the shape of "direct or indirect guarantees" of production or withdrawal capacities. It assigned RTE the task of ensuring their effective availability. RTE is also in charge of a consultation process with all of the parties concerned prior to proposing measures[9] to the Minister of Energy to enable the application of this principle. Finally, the law extends RTE's possibilities of contracting withdrawal capacities.

In another field, essential to guaranteeing the reliability of the electrical system, it is important to note the publication (expanding on the 2008 decrees concerning the connection of production units) of the order, dated July 6th, concerning the methods used to control the performance of these installations, both during connection and throughout their lifecycle; hence a verification is planned at least every 10 years. Nevertheless, the concrete expression of this measure for pre-existing units is still pending, requiring the review of the contractual provision linking RTE and the producers.
After consultation with the concerned parties, RTE updated the Reference Technical Documentation (RTD) by updating the list of data to be provided for the connection of a production facility (Art 1.1.2). The measures concerning the management of reactive power at the interface with distribution system operators (DSOs) were also reviewed in the RTD.

3.2 ENTSO-E

RTE's control of reliability, both for operational management and to prepare the electrical system of the future, is increasingly linked to results acquired on a European level, mainly by the ENTSO-E*Glos* association of European TSOs. RTE is very involved in these different topics.
In compliance with Regulation EC 714/2009 of the third energy package, and following an extensive consultation process, ENTSO-E published, in 2010, its first 10-year development plan for the European grid (TYNDP). It is based on production means location and type scenarios that were presented in the previous ENTSO-E report "*System Adequacy Forecast 2010-2025*", that put forward a rather confident diagnosis regarding the reliability of the overall European supply & demand balance for this period, and more particularly up to 2015[10]. This exercise can and will be perfected as the plan is to be revised every two years. It revealed significant reinforcement needs on the regional and trans-European levels due to the development of renewable energies and the growth in electricity consumption that is partly due to a transfer from other energies. In the long term, the electrical system's economic and environmental performance and reliability will be impacted if the planned new facilities are not built, and hence ENTSO-E has called for a shortening of the corresponding permit processing times.

To prepare supply & demand balance reliability at a seasonal scale, ENTSO-E published its evaluations for summer 2010 and winter 2010-2011, with conclusions that were consistent, for the French part, with those published by RTE in its seasonal forecast analyses, highlighting in particular improved production capacity availabilities compared with 2009 and the need for significant imports during long cold spells.

For the mandatory reference document, the ENTSO-E Continental Europe regional group approved the new versions of policies 4 to 6 making up this document, which all TSOs in the continental Europe interconnected system are contractually committed to applying in the framework of an inter-TSO contract, the *Multi-Lateral Agreement*. Policy 5 was reviewed in October with regard to electrical system incident conditions and the restoration phases required after a major incident. Its instructions

[9] The Minister assigned this mission to the RTE Chief Executive Officer in early 2011
[10] This study published in February 2010 obviously did not take into account the potential impacts of the nuclear accident in Japan in March 2011, such as the shutdown of nuclear plants in Germany. The identified impacts are evaluated in ENTSO-E's study "Summer Outlook 2011" and in RTE's study "Forecast Analysis Summer 2001"

were revised in light of the major incidents that occurred in the years 2000, in particular, given the difficulties encountered in terms of the overall diagnosis and restoration management of the incident[11] of November 4th 2006. The compliance review concerning the requirements of this policy needed to be finalized by RTE at the end of 2010.

TSO compliance with this reference guide has been verified by a regular mechanism since 2006. In 2010, it concerned policies 1 to 3, which involve the fundamental aspects of reliability that are frequency control (primary, secondary and restoration of reserves) and safe operation (incidents to cover, data exchanges, controlling impacts on external networks, etc.). This mechanism is based on a self-assessment followed by a cross-analysis of the declarations. The results obtained show that the implementation of the fairly complex operating measures adopted during the review of policy 3 after the incident of November 4th 2006 can be improved[12]. This supports RTE's analysis that an adequate solution is to assign a part of these activities to a structure such as CORESO.
In addition, spot audits were carried out on the previous year's topic of self-evaluation. In 2010, 6 randomly selected TSOs were audited by their peers in application of policy 8, concerning dispatcher training.
Although not perfect, the overall compliance verification process is useful and should serve in future as a basis to develop adequate verification measures with regard to the application of European network codes, once they have been promulgated by the EU.

3.3 Contracting contributing to reliability

Several points are worth noting with regard to Ancillary Services participation contracts.
In September, the Court of Appeal confirmed the decision handed down by CoRDiS in 2009 dismissing the POWEO case contesting its obligation to participate in ancillary services (cf 2009 report). By the end of the year, all of the producers who had previously refused to sign a participation contract did so.
Specific technical conditions were agreed, after an in-depth consultation, to take into account the technical limitations of gas combined cycle plants, whose characteristics make it impossible for them to participate in primary frequency control (or 'steep slope' secondary control) in conditions equivalent to other thermal units. The solution makes their effective participation in these controls possible, which is essential for the consolidation of future frequency control reliability, given the development of this generation technology. Tests must yet be carried out to actually confirm these control capabilities.

Moreover, RTE led consultation work to define provisions for the next Ancillary Services contracts as the current contracts are to be renewed in 2011. Subject to a finalisation in 2011 of the discussed changes, two points concerning reliability are worth noting:

- It will be possible to sign a contract for voltage or frequency control services only, which will make it possible to contract for the participation of certain specific units (wind power, photovoltaic) that can technically only provide a part of these services.
- In view of the problems arising from the lasting reduction in reactive power control capacities, the 2009 report underlined the inadequacy of the current contract penalties to ensure a return to nominal capacities when the corrective actions require major work for the producer (e.g.: repairing an alternator). The new version of the contract discussed in 2010 defines a more appropriate management of these situations between RTE and the concerned producer, including the setting up of an attractive absorption schedule for the producer, the intervention of third party expertise in case of disagreement and reinforced penalties in case of non-execution.

[11] Following differences in forecasted and operational planning in Germany, cascade triggering of facilities occurred, followed by the separation into several isolated sub-systems and frequency related load shedding (activated by a drop in frequency) to stabilise some of these sub-systems (including the French one)
[12] For example, for information and data exchanges allowing the monitoring of network reliability for each TSO in coordination with its neighbours, or the definition of "exceptional contingencies" to watch during the period a risk analysis justify it.

For primary frequency control, RTE has signed a contract with SwissGrid allowing the Swiss TSO to supply control capacities for French units in limited volumes, without impacting the reliability of the creation of primary reserves for France.

With respect to the stabilisation of reactive power compensation levels in HVA delivery point substations and in line with discussions mentioned in the 2009 report, RTE has signed a contract with ERDF and Electricité de Strasbourg Réseau ensuring availability and maintenance of HVA capacitors in operational condition, as well as the commitment to operate them. The contract sets new maximum reference thresholds for reference "phi tangents" per delivery point substation based on its history, beyond which penalties are triggered. This approach must contribute to limiting the impact of reactive power on problems of voltage stability, whose criticality was explained in §2.3.
RTE also signed a contract with ERDF regarding the conditions for making available descriptive and telemetered power information on the wind power sites connected in HVA to use them in the IPES system (cf §4.1.5).

As concerns network restoration and voltage recovery to power plants, the contract signed in 2006 with the producer EDF was extended to cover 2010-2012.

3.4 RTE internal reference documentation

The main changes in the System Operations Reference Document concerned:
- The revision of the "N-k" rule: *the basic rule that guarantees the security of operations, see §5.6;*
- Up-limit voltage management;
- Secondary voltage control management;
- The sizing of reserves for supply & demand balance;
- The management of short term reports on consumption results;
- Electrical supply guarantees for dispatching centres;
- Closing angle management procedures and re-energizing equipment;
- Technical leadership in the field of "short-term consumption forecasts".

In terms of the Transmission Operating Reference Document, one should note:
- The revision of the methods used to determine temporary overload intensities in facilities: *a revision that may optimize the quality and reliability of operations, see §4.1.4;*
- The dealing with acts of theft of earthing equipment in substations;
- National professional drive for equipment operators;
- The definition of the dispensations enabling the experimentation of new measures to re-energize a structure that was put off line accidentally.

Finally, the shared reference document was revised in terms of:
- The method for the multi-year planning of work: *construction and/or maintenance activities will guarantee future reliability but must be scheduled correctly to not compromise today's reliability;*
- The telecommunications network operating code: *electrical system reliability cannot be dissociated from the control of the telecom services that it requires.*
- Recommendations for feedback management*, see § 5.3*.

4 Measures contributing to reliability in the equipment field

4.1 Behaviour of the equipment making up the electrical system

4.1.1 Generating sets

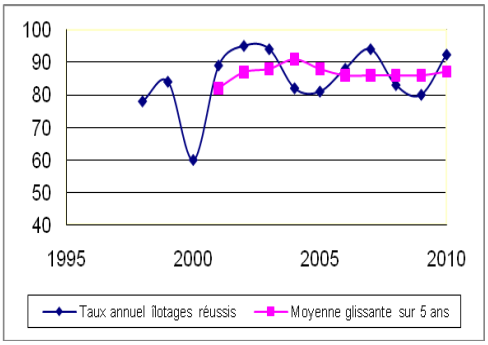
Evolution of the generating fleet
The number of renewable energies generating units has continued to grow.
Wind power production reached 5700 MW installed capacity by the end of 2010; the growth rate of approximately 1000 MW/year has continued, and we note a 78 MW HV connection in the East. The mean load factor (compared with installed power) was 21.9 % (2009: 22%), varying between 12.9 %

in July and 33.6 % in March. The maximum production level varied over the months between 2400 and 4200 MW. During the year, the distribution of produced power shows a first decile at 333 MW and a ninth decile at 2178 MW. Though there is high variability throughout the year, the annual performances are stable.
The number of photovoltaic generation units has grown considerably, with roughly 800 MW installed at the end of the year.

For thermal units, we have logged the industrial commissioning of three 440 MW gas combined cycle units (GCC) connected in 2009 (2 in the East and one at Fos), confirming that the expected performances for these units have been checked and contracted with the producers. A GCC was connected at Grande-Rivière, near Montoir-de-Bretagne, which will help to control the voltage problems in the West. Finally two 180 MW peak power units (combustion turbines) were commissioned at Montereau.

Risk of multiple trippings at close intervals
In the past, different cases of simultaneous or very close trippings of several generating sets (e.g.: February 2009), particularly nuclear, for a same reason usually linked to problems with cooling water intake (waste in the river following a storm, floods, tide flows, etc.) resulted in serious problems for the electrical system (ESS level B or C). Feedback on these incidents, as concerns the interface between the producer and RTE, mainly focused on reinforcing the warning systems. The existing system worked well in 2010 and was built up in the Rhône Valley with the commissioning of a warning system, feeding through to RTE and jointly coordinated by EDF and CNR.

Voltage return tests
An important point to consider for nuclear reactors is the success rate of plant islanding, given their importance when coping with a possible network restoration following a major incident. Performance levels remain extremely satisfactory: 10 out of the 11 scheduled islanding operations were successful and there were 2 unscheduled but successful operations.



The other major point in the event of a large scale incident concerns the voltage return scenarios that constitute an additional source of independent means for power plants to supply the auxiliary systems of nuclear reactors; they can also be useful for network restoration. The contract signed with EDF on this subject plans annual tests on each site and the testing of each scenario once every 3 years. In 2010, 19 out of 26 initially scheduled tests were carried out, 16 successfully (in 2009, 16 out of 23 initially scheduled tests, all successful). One of the three failed tests corresponds to the first test of a scenario that was changed following developments in the network. The two others gave rise to ESS level A, one of which is RTE's responsibility (return accomplished but not in the given time limit).
In terms of the ability to achieve these returns during a large scale incident, the 84% success rate for the attempted tests is similar to past years (100, 83, 79, and 95% from 2009 to 2006). However, the difficulty in reaching a level very close to 100% every year shows that achieving the return of these sub-networks is not insignificant: these tests contribute to the technical verification of restoration procedures and to regular training of the different EDF and RTE teams involved.
The ratio between successful tests and those initially scheduled is also similar to previous years (62 %). Hence, the objective/result gap remains stable: 4 untested sites, like in 2009 and 8 delayed triennial test scenarios (9 in 2009).

4.1.2 Protection systems, operation PLCs, instrumentation and control

A complex PLC system is being set up in the southern part of the network to cope with a simultaneous tripping of two double lines on a major link, which could cause a critical stability incident in certain configurations. The PLC acts in approximately a hundredth of a millisecond to trigger production tripping in the Rhône Valley. Its creation requires special attention to ensure its operating reliability; it applies the principles decreed in the design and maintenance directive published in 2009 relative to

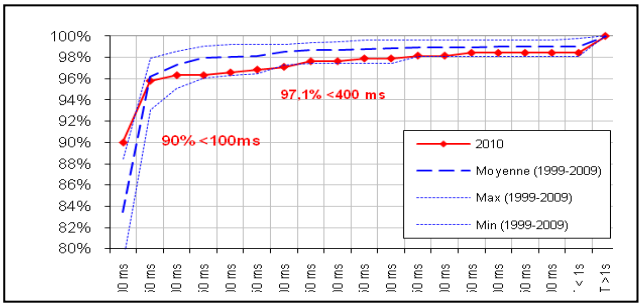
this type of PLC. The main components were installed in 2010, for a trial usage run over a significant observation period in 2011.

With a large increase in the number of generating sets in the Fos zone connected in 225 kV, it seemed necessary to implement a specific protection plan for these zones, similar to the one for 400kV, including a differential protection and a distance protection for each link ensuring the same, sufficiently short clearing times. The corresponding equipment will be qualified at the end of 2011 however and, in the meantime, the region has prepared the installation of a remote signal indicating that the only current protection ensuring these times is not operating, so that preventive measures to ensure the stability of these sets can be taken.

It is important to note the continuation and scheduled completion in 2011 of the programme to replace the 225 kV distance protections in high risk zones, of the same model as the one whose functional limits aggravated a serious incident in the PACA region, on November 3rd, 2008 (classified ESS C).

As regards the operating results of the isolation fault protections for 400 kV lines, various aspects must be followed closely: does the observed operation comply with the expected result in terms of selectivity (i.e.: are the circuit-breakers used to eliminate the fault as few as possible and well located?) and automatic service restoration? Does the fault elimination time comply with the expected one to ensure generating set stability? Are there untimely trippings when there is no fault?

The analysis of the elimination of the 386 short-circuits on the 400 kV network by the protections and PLCs provides elements concerning the evolution of the adequacy of the protection plan and protection maintenance, of the communication links between protections and of the circuit breakers. As this elimination needs to be about 100 ms to guarantee the dynamic stability of 400 kV sets, we note that 90% of the short-circuits were eliminated in less than 100 ms in 2010, a value which is making steady progress from one year to the next, and 96% were eliminated in less than 150 ms, a value that has gone down slightly. These results are satisfactory. We should note, however, the elimination, in times over 300 ms, of two polyphased faults in 400 kV and one in "close 225 kV"; two of them could have potentially harmed the generating set stability[13].



In 2010, there were 51 LV operational anomalies in the protections which had an impact on the HV system, a number that remained stable. The 20 anomalies that occurred when there was no electrical fault all resulted in an untimely trip. 31 anomalies (39 in 2009) happened during the elimination of one of the 386 electrical faults, including only 9 cases where the elimination conditions were degraded: 8 untimely trips, 1 late trip, which is a satisfactory result.
The fact remains that these protection systems are critical for system reliability: therefore, efforts to further reduce the occurrence of anomalies are useful, even if some of them are without consequence, as the above results show, due to the doubling of the protection system. Among the main causes of these anomalies, 10 are due to malfunctions and 6 to functional limits. Functions monitored by telecommunications systems are a main cause of the 16 anomalies: this result, although it improved compared to 2009 and 2008 (21 and 17) remains significantly higher than in earlier years (9 in 2007 and 2 in 2006). Aside from the action plans already implemented, the gradual transfer of these telecommunication lines to the ROSE network should reduce this type of anomaly. There are also 4 anomalies due to rodents (in 2009, this phenomenon caused the total loss of a substation, classified ESS level B).

For 400 kV and 225 kV busbar differential protections, which play a major part in the selective, rapid elimination of busbar faults (admittedly very rare, but among the most dangerous for the electrical system), fault behaviour was satisfactory. The number of unscheduled unavailability incidents rose to

[13] The loss of effective stability depends on the operating conditions and fault characteristics

54, compared to 40 in 2009, but with a much lower total duration: 475 hrs compared to 714 hrs in 2009 (7 incidents of over 20hrs). Specific plans or constrained reactive or active power operation modes must be used when these unavailability incidents occur in substations that could jeopardize set stability.

Many substation instrumentation and control systems are currently being digitized so that, by 2020, 40% of plants will be using this technology, the initial objective having been pushed back by two years. The operation of the converted substations has revealed difficulties concerning the thoroughness of the specification of the functions expected in each substation, the often general nature of the results of a failure concerning observability and controllability, and the need for rigour in the management of upgrades. Short-circuit elimination regulations have always been respected. The measures decided or implemented on the basis of this feedback, some of which stem from a reliability audit on the subject, and the overall ramping up of the skills of all the personnel (RTE and suppliers) together with the repetitive nature of the work, will help to correct these deployment problems which are inherent to any change in technology.

4.1.3 Automatic frequency and voltage controls

Coordinated Secondary Voltage Control is a more advanced version of secondary voltage control, deployed in the west of France where voltage management is particularly important. It is the subject of a gradual renovation programme that comprises in 2010, the adaptation to the new regional control system, the setting up of a redundant computer to improve robustness, and the commitment to replace the telecommunications interfaces for remote equipment.
The control parameters of the standard version called RST-N, used in the Rhône-Alpes region, have been revised to improve dynamic performance.

4.1.4 Transmission facilities

The passage of windstorm Xynthia confirmed what was noted in 2009 during windstorm Klaus, that the network controlled by RTE showed satisfactory strength 75% of the tripped links were restored to service and 42 out of 43 substations were re-energized within the day. This result is linked to the on-going implementation of the reliability policy decided in 2000, which will end in 2017. Its "foundation safety" and "forest trench enlargement" aspects were virtually completed at the beginning of 2010. The impact in terms of reliability was low: tripping of two 400 kV lines and 25 HV2 lines, in the West, South-West and East.

The most significant progress on the 400 kV network, from a reliability point of view, reinforcing the interconnection capacity between regions (or with the neighbouring TSOs) or supplying the more fragile regions, are the following:

- Completion of the replacement of the Tavel-Tamareau link conductors (between Avignon and Montpellier) by high capacity conductors (ACSS low expansion technology) to strengthen the link between the Rhône Valley and the South-West (transmission capacity in winter increased by around 60%).
- Reinforcing the network in the North region in the context of increased connected production in the region and exchanges with northern Europe: Avelin-Mastaing-Lonny and Avelin-Warande-Weppes links and 225 kV Moulaine-Aubange link with Belgium.
- Reinforcing the link with Italy in the Maurienne valley (the Italian sector must be upgraded in 2011).
- Completion of the passage to 400 kV of the second line of the Toulon-Nice double link, from Néoules to Broc-Carros in 2010;
- for the West region's supply, the reinforcement of the Avoine-Distré link in the Loire Valley and the building of Calan 400 / 225 kV substation near Lorient.

The continuing installation of compensation means should be mentioned, mainly in 225 kV. They are needed to reinforce network stability with regard to problems of low voltage (160 MVAr in the South-West, 155 MVAr in the West, 80 MVAr in Ile de France), and high voltage (two 64 MVAr reactors installed in the Paris region).

In 2010, in addition to improved equipment, an essential point for network operation involved the revising of the methods used to calculate the overload temporary current levels of different types of links. The new probabilistic method takes into consideration the statistical distribution of flow values on a link, as well as the representative cooling condition values, to assess the different rescue values that must be respected to ensure safety of third parties and equipment. By improving calculation precision, it makes it possible to significantly increase of maximum values (with or without work) for most 400 and 225 kV links or imposes a reduction on a small number of links, mostly HV1. These changes may increase the optimised use of the existing network, reduce congestion costs, simplify maintenance scheduling, and improve the quality of the electricity supplied in certain cases by allowing additional looped operations and occasionally pushing back the limits of network reliability. The deployment of this new policy started in November 2010 to make winter 2010-2011 easier, and will continue over the next two years. A significant effect on voltage management during cold spells is highlighted in the reports from those regions that are the most concerned: West, Normandy-Paris, and North-East. The effective savings in operational costs remains to be detailed, particularly as the possibilities of additional looped operations also depend upon other actions carried out in 2010, such as the new N-k rule or the improvement of study methods.

On this same topic of the most precise evaluation of admissible flow limits, RTE continued two types of experiments concerning their real time or very short term evaluation, according to actual operating conditions. The 2010 report on the first approach, using real time assessment tools for overhead line sag, show that the techniques are reliable but only of limited practical use (except to hone prepared decisions in real time) since the information contains no forecasting. In 2011, the possibility of including forecasts for the next few hours will be examined with the designers of this approach. The second type of approach is based on the use of short-term weather forecasts to hone the calculation of overload current levels, in day ahead or intra-day. The results are more promising with one of the two methods tested (South-West), operating gains are tangible even if they remain moderate. It has been decided to continue the experimentation of this method in another region and to see through the experimentation of the second method of this type, which could not be carried out in 2010 in Rhône-Alpes.

4.1.5 Control systems

National and regional control systems and Safeguard and Warning System
Like last year, total unscheduled unavailability of the National Control System (SNC) and power frequency control level command signal transmission, deployed at CNES, was zero.

The new regional network control tool (SRC) was in standard operation in all regional dispatching centres at the end of 2010. Like the SNC, its availability is a crucial element to guarantee reliability. Of the 7 installations, we note network observation losses over the year totalling 7 hours and 12 minutes (1hr/yr. region, which is better than the minimum expected performance of 2hr/yr. region), and 17 hours and 8 minutes for loss of controllability. The most penalizing incident was a 1 hour loss of observability and controllability. 5 ESS level A were logged, compared to 7 in 2009, the first year of deployment; this mainly reflects the insufficiently reliable operating measures for maintenance operations. Corrective measures have been taken. An upgrade with significant improvements has had to be delayed following an unsatisfactory trial operation period.

An experiment has been started to assess the possibilities of taking back the control of a region using the control tools and operators of another region. The positive results of a first test open up the way to a more detailed study of this alternative to current operational activity maintenance measures in the event of the major and long-lasting failure of a regional dispatching centre. This maintenance is currently provided by a fall-back dispatching centre, which is costly and, due to its wholly operational nature, weaker than that of installations that are used all the time.

The 'Système d'Alerte et Sauvegarde' or SAS (Safeguard and Warning System) is a crucial tool in the control of risky (warning) or downgraded (emergency) situations, as its regular use shows (in 2010:"-5%" or transformer block orders, request for an "emergency drop" on a unit to reduce an overload

resulting from a double busbar fault). Its rate of unavailability[14] is assessed at 0.21%, confirming the progress resulting from the computer overhauls carried out in the past few years. The SAS General Operating Rules include the carrying out of periodic tests of critical system safeguard functions, particularly with the distributors (transformer blocks, 5% drop from the HVA voltage set point, remote load shedding). The regional reports show that these tests are now more complete, including the remote load shedding test. Their pertinence can be seen in what they reveal when the test does not conform, 5 ESS level 0 were logged this way. In a real situation, an ESS level B was logged when a distribution control centre incorrectly carried out a "-5 %" safeguard order. As it was a case of the tool being used incorrectly, a back-up training course was organised. Two ESS level A were logged for the incomplete or non-processed resending by a regional dispatching centre of a warning order sent out by CNES.

Forecasting tools

Use of the IPES system to estimate wind power and photovoltaic production and to forecast local, regional or national wind power production is now well established, not just for real time control but also to prepare day ahead control, at least in the most involved regions. The forecasting algorithm, based at the beginning solely on wind forecasts and meter records, has been improved, by adding terms of correction using active power values measured remotely or estimated by IPES. The quality of the data coming from IPES depends on the production observability rate; this was 74.6 % at the end of 2010 (up from 64.5 % in 2009) for wind power and 10 % for photovoltaic. At the end of 2010, on the basis of formalized relations, RTE was receiving data from 16 out of a possible 20 ERDF distribution control centres and from three intermittent production monitoring centres managed by producers.

Consumption estimates and forecasts were used in 2010 to improve the quality of the day ahead studies, with practical measures that must be industrialised in 2011. Certain regions are using wind power forecasts for following day to better assess planned outages possibilities in zones where flows are strongly influenced by these injections. During a period with high restraints (cold spells), the setting of the safeguard order activation thresholds is also more precise thanks to the forecasts. Consumption assessments, performed in real time using draw offs from the transmission network and fee-based estimates for certain non-measurable values (HVA injections, auto-production, etc.) also improved in 2010 by taking into consideration actual wind power production estimates. Increased use of the tool for control requires unfailing availability. The total availability rate was 98.6%. Application availability was lost for over 30 hrs during windstorm Xynthia, following damage to a non-doubled microwave link. The securing of these links has since been implemented.

Use of the PREMIS consumption forecast tool has been extended to all regions to draw up better weekly and day-ahead forecasts. This should improve the robustness of the weekly studies to prepare facility shutdowns and short term studies. On this point, maturity levels from one region to the next still vary considerably between those that started using it in 2010 and those that have used it for longer and help to analyse its performances with the department responsible for the algorithm.

Production programme monitoring

The PCCP project (Production Centralized Control Point) was completed in the middle of 2010 with the producers taking full responsibility for passing on production programme modification orders to the power plants, including the adjustments requested by RTE. This change re-centres each actor on their core business and reduces the minimum time limit that producers have to review the production programmes during the day from two hours to one, which facilitates their short term optimisation and reducing their imbalances. Technical measures were defined with care to not affect reliability, integrating in particular direct access possibilities for the dispatcher to the unit operator within the context of safeguard actions. RTE has given the regional dispatchers access to CNES's EMMA tool so that they can appreciate the impact programme modifications have on flows as soon as they are declared. They can also check virtually in real time if unit generations follow correctly their programmes, using Scorpion, a tool that came into industrial use in 2010.

[14] For the 227 linked computers making up the SAS

Study tool
The deployment of the Convergence study platform, developed to standardize the study tools used for network development (long term) and the preparatory or real time studies for operation, was finalized in 2010, with a common training programme for both professions. Convergence is at the centre of functional changes currently being made to improve the precision of short term studies and to update them to intra-day -see §5.6- in particular by providing a process whereby "fixed points" are merged to give a single, shared vision of network situations and a more ergonomic and dynamic simulation module.

Safety Telecommunications Network[Glos]
RTE is running project ROSE, which consists in internalising and modernising the Safety Network by digitizing and further equipping it with fibre optic telecommunication cables fitted to existing transmission structures, to host high-level, reliability-related applications: teleprotection firstly, with priority to line differential protections, then tele-control and telephone security. This project is expected to provide better service availability and reliability than previous solutions.
In 2010, given the critical impact of this new telecommunications network on reliability, the project was subjected to a detailed review by high-level outside experts before deciding of its industrial deployment.
The Telecommunications Network Operational Code was published, to ensure the network's operational management as of now and with a view to ROSE being commissioned. Using a similar approach to the Transmission Networks Control Code, it stipulates expected service levels (restoration time), organisation, responsibilities and actions to achieve the forecasted management of the back-up telecom network maintenance, and how it should be supervised, monitored and administered.
As regards tele-protection, the migration of communication lines between the ends of the 400 kV line differential protection to ROSE was near to being completed at the end of 2010: 13 lines are still to be migrated in 2011.

For the classic RF network, progressively being phased out, 2009's report can be repeated: traffic is still decreasing steeply, availability remains stable, the contractor's response levels in terms of the detection and repair of malfunctions is stable, way below contractual commitments. Maintaining the availability of equipment still in service must be closely monitored until the service is closed down.
Beyond the behaviour of telecommunications media, such as the RF network, in terms of reliability, it is interesting to consider the services provided: remote control success rate is 98.5% and the telemetering outage level is at 0.19%, these results are in line with required performances. The teleindicator outage rate increased to 0.23% (for a desired max. threshold of 0.20%), linked to an incorrect interface specification for the new digital substations, which should be corrected in 2011. For the links between the two ends of the line differential protections, still ensured by the RF network, average outage time was 2hrs24mins (for a contractual objective of 8hrs45mins maximum).

4.1.6 Load / consumption

In a context where attention is focused on the smart-grid[15] concept, it is interesting to look at the specific actions carried out by RTE to create or use load withdrawal, favouring overall margin management or regional congestion control in the framework of contracts or cooperative consumer behaviour.
At the start of the year RTE contributed heavily to the work of the "Working group on management of peak electricity demand" chaired by Mr Poignant and Mr Sidot, the conclusions of which were largely used in the NOME law, see §3.1.

RTE is keen to heighten consumer awareness regarding the impact of their behaviour on moderating consumption peaks. In Brittany, the Ecowatt scheme's notoriety has been reinforced, with significant support from local municipalities and associations. The same is true in the South-East where Ecowatt replaced a previous similar scheme in December. In the West, there are 30,000 registered members (compared to 18,000 at the end of 2009), who got 3 orange and 3 red alerts in January, then 5 orange and 2 red at the end of the year. In the South-East, 12 orange alerts were sent out at the

[15] A concept that goes way beyond simple load management, see for example: "RTE major smart-grid agent", Michel Bena, REE n°10, Nov.2010

start of the year and one on December 16th. It is important to support and develop this process in the long term.
More generally, in its "Brittany electricity pact", RTE has favoured distributed load adjustment experimentation in the St Brieuc area.
In the South-East, RTE is participating in different regional energy control experiments (Premio, Reflexe) through which the Var and Alpes-Maritimes departments have been able to analyse their regional consumption.

To increase the availability of industrial consumer withdrawal offers on the MA, and considering the limited but positive results of contracts signed in 2009 and 2010, RTE renewed the contracts for this type of product at the end of 2010 so that a volume of 110 MW, that may be activated 20 times in 2011 and 120 MW, that may be activated 12 times from May 1st 2011, would be available during tense situations.
For the MA, the volume available from offers made up through the aggregation of withdrawals from small consumers is low, between 10 and 15 MW; these were essentially activated in the last quarter.

In order to assess the potential of having adjustment proposals for products that can be activated rapidly, within a few minutes, which would be completely appropriate to help manage the problems posed by frequency variations on the hour (see §2.2), for which it was interesting to examine the withdrawal potentials, RTE organised a test tender. 3 one month contracts were granted for 51 MW for industrial or distributed withdrawals. Feedback, showing the pertinence of the approach, was taken into account in the technical and financial definition (attribution of a bonus in the interfiling of responses to the tender) of the requested products in the context of the tender for "rapid and complementary reserves", sent out at the end of 2010 in view of renewing the contract ending in April 2011.

4.2 Structure of the system and its design rules

In 2010, RTE updated the 2009 provisional supply & demand balance report for electricity in France. Its conclusions were confirmed: the reliability of electricity procurement should be stable until 2013, taking into account production facilities expected to come on line, and the increase in consumption peaks during cold spells is a cause for concern.

RTE has continued the work started in 2009 aiming to revise the network development policy and study methods, to adapt them to the context of coming years: new technical solutions, European grid, generation flow pattern, objection to projects, etc. The framework for a multi-criteria analysis must be defined, to be a credible response to the multi-dimensional problem of assessing possible development strategies, using as inspiration the theoretical conclusions from the European project Realisegrid. Work in 2010 led, for example, to a definition of the determining parameter values (costs of loss and undistributed energy, etc.). In parallel to this, a 400kV target grid project has been defined for 2030, but remains to be detailed in relation to the corresponding work at ENTSO-E level.

As concerns decisional studies, the different RTE teams concerned are working on bringing together both development and operating methods and tools to further take into account future operational constraints in development decisions (operation during planned outages, voltage management, withdrawal PLCs). This can be seen in the introduction of a single study platform (Convergence) and the gradual setting up of common training programme. However, this progress which is important for network reliability in years to come, is far from complete; in 2010, an analysis of low voltage problem study methods was started, but needs to be continued. Similarly, the late identification of the issues arising from the integration of new current level limits in development studies shows the need to strengthen coordination.

As concerns network development in the coming years, we see that RTE has worked in close collaboration with the government services to identify the constraints that will be created on the transmission network given the locations considered for off-shore wind power production installations in the call for tender prepared by the public authorities.

4.3 Other material measures contributing to operation

As already highlighted in last year's report, control is moving towards an increasingly dynamic short term constraint management, using different means, such as: studies that are closer to real time, dynamic simulations, refined realisation assessment and consumption forecasts integrated into the short term studies, N-k constraint cover using remedial solutions, operation of maximum current levels in dynamic mode[16] (using Day/Night or "Winter 2" thresholds during periods when the temperature is low enough). In this context, rigorous data management (in study tools) and parameter adjustment (in PLCs, including overload protections which ensure that maximum current levels are respected) are essential[17].
Some detected incidents show that there is an effective risk, even if it is low in relation to the number of actions of this kind that are carried out: on January 6th, overload protections on a PLC were set to "Summer" instead of "Winter 2"; on February 3rd, a considerable underestimation of actual consumption, caused by the inadequate management of the injection level for a generating set, led to an underestimation close to the limit of reliability, in a critical cold spell situation; on July 19th, a 400kV structure was put back into operation following works on "interseason" instead of "Summer" mode. Improvement works started, for example in the Eastern region or at the CNES, following a similar incident in 2009 (ESS A), show that operators are aware of this vulnerability. All operational teams and their managers must continue to be aware of this.

5 Measures contributing to reliability in the organizational and human domain

5.1 Reliability culture, management of the human factor, training

The Human Factor

On the subject of human errors (whether they contributed to an actual incident or could have, in more unfavourable situations), the reader could go back to the corresponding § in 2009's report, where he will find the same trends: increase in the self-declaration and incidents logged and analysed, transparency being used to improve progress, team-based analyses, a frank lack of improvement, difficulties in assessing the efficiency of corrective actions, etc.
Going beyond this first observation, the increasing involvement of both employees and management to log and analyse these incidents and try to re-use them in training sessions, must be noted.
The different methods of analysing logged errors are applied as much to controlling or preparing the control of the electrical system as they are to equipment operation and maintenance. Although the activities are quite different, the conclusions are quite comparable. A significant share of the errors come from procedures not being obeyed (operation orders, CCRT[18], missing or incomplete work preparation, unobserved stopping points, etc.), and a significant share comes from oversights (operations not completely carried out, lack of tracing, etc.). Finally, confusion (equipment to operate, applicable procedure, etc.) are also on the list and often have very visible consequences. The relative distribution of these different causes of error is hard to assess with any precision (skills insufficiently acquired, complex and evolving reference guide, over-confidence in skills acquired in repetitive situations, etc.). The exogenous factors (inappropriate measures, perfectible tool ergonomics, etc.) obviously play a part but are not a predominant factor.
For control operator traced human errors, about 50 % had consequences, 10% of which resulted in an ESS. The cause of three ESS level A and one ESS level B was predominantly "human error".

Training

As in previous years, initial training and refresher training for the different professions concerned were carried out nationally or regionally according to the programmes.
Regular adaptation of training courses to the changes in the network control and operation linked professions is carried out:

16 regions in the East and Rhône-Alpes highlight, for example, the growing use of these measures. On the 400 kV network, dispensatory regime changes are frequently requested
17 As are remote control and equipment reliability for application of solutions
18 Code de Conduite des Réseaux de Transport (Transmission networks Control Code)

- New training courses were set up: network studies with Convergence, including dynamic studies on voltage stability and short term consumption forecasts (particularly on a regional level), connection to the network, etc.
- After the experience of 2009, joint training for substation group operators and dispatchers was set up to develop understanding of their interaction, with a session in every region.
- The professional capacity-building syllabus for substation group employees who can provide aided-operation services for dispatchers has been restructured to adapt to the changes in their activity caused by changes in the control systems (remote control using SRC, carrying out periodic operations from the dispatching centre, increasing needs for rapid incident diagnoses, etc.). It will be implemented as of 2011.
- A new skills reference guide has been drawn up, shared by control, forecast management and network development activities; its use should allow homogeneous identification of individual skills and a stronger overall vision of available skills and their management.

Reliability culture

Several reliability audits have highlighted, more especially for the DTE Units' regional teams, an insufficient perception –at least in the long term following initial awareness- of the strong, direct potential impact of their activities on reliability, particularly certain tasks (calculations, maintenance, and tests). Certain regions show more concern about it, such as the Rhône-Alpes region which has developed a specific awareness programme. It must be a shared concern, resulting in regular refresher actions, for which many opportunities exist: professional activities, using feedback, specific incidents, etc.

RTE organised, as it does every year, regional training sessions "Ensuring reliability together" for external companies (particularly producers and distributors). Even if other occasions to raise awareness exist (operator meetings, contract monitoring meetings, etc.), these training sessions are the main vector for strengthening their understanding of reliability stakes and the phenomena occurring during incidents that affect the electrical system. Participation remains fairly unbalanced, as in past years: 0 to 3 sessions according to regions, with in addition a trend to hold specific sessions, particularly for new producers. It's unfortunate that some companies refuse to participate because the training is not free.

We also note awareness raising actions with different State technical departments, in operational liaison with RTE: training sessions for DREAL employees, meetings with departments in the southeast and southwest that fight forest fires.

5.2 Steering, management system

RTE's general management has committed the entire company to their "industrial project for sustainable performance". Different elements of the project concern reliability control, particularly through the themes of the durability and renewal of industrial facilities, preparation of innovative technical solutions for tomorrow's network and R&D for the electrical system, management evolution and development of the European dimension.

Alongside the implementation of this project, the identification of company internal control as a tool to manage and check process efficiency is being significantly developed. Every year, each Unit re-examines its main risks and associated control actions and then updates the list of control measures, on every level, that should be applied. Reliability issues and black-out occurrence are clearly part of the main risks examined by managers and their operational Units during this process.

Within this context, RTE has stopped trying to get ISO 9001 certification for its activities since 2010. At that time and during the establishment of RTE, the certification process made it possible to reinforce the control over activities impacting reliability. It is important to verify over time that the company's new direction and the internal control system are building on these assets and reinforcing reliability control.

5.3 Feedback: organisation, ESS scale *Glos*

The feedback process (REX) is driven at an RTE-wide level by the National Feedback Committee (CNREX). In 2010, it held 6 meetings dealing, for example, with:

- incidents relating to quality of service or reliability (e.g. ESS level D on December 21st 2009, 2 ESS level B, flooding in the Var, virus risks in operational tools) and what can be learned from them;
- evolution of operation/control conditions (feedback from winter periods, experimentation, etc.);
- progress of action plans engaged based on feedback or national reliability audits;
- examining reports (protection, remote control).

This list shows that CNREX activity is balanced between overall and occasional analyses and the reinforced monitoring of actions with a national reach, which should be consolidated in 2011, particularly through the examination of the results of the national action plan following the incident at Tavel on December 12th 2009.

At an operational level, the feedback process has been significantly revised, with weekly national steering co-ordinated with regional steering, to improve first level efficiency, in the form of a "short loop" of a few weeks, to collect the first lessons about operational incidents, to analyse the causes and risks and to jointly determine the follow-up between regional and national entities. This evolution does not seem to be incompatible with the continuation of longer "in-depth analyses" in complex cases. The revision also aims at better managing shared operations (intra-regional and inter-regional) which, historically, have always proved to be difficult to carry out (lack of time, problems with obtaining external information, etc.) but which are an important source of progress.
This feedback process is essential for building future reliability: it concerns not only events that involved the reliability level (ESS) but also those, the majority moreover, related to operation and control, from equipment faults to human errors, and whose feedback is a significant source of corrections, changes to maintenance and operation methods and policies, organised sharing of information, which will all contribute in the future to better control of the electrical system.

Moreover, in the spirit of the recommendations of the national audit on "Reliability Feedback" in late 2009, most regions mention in their reports any changes in the Transmission and System Units' regional processes, to improve coordination and to allow a closer working relationship with all of the parties involved in feedback.

The Significant System Events (ESS) classification scale, used to guarantee feedback on the reliability of the French electrical system, had some slight changes made to it at the end of 2010, to remedy a few application ambiguities, take into account control evolutions (increased use of remote control corrective solutions from the dispatching centre to obey the N-k rule) and the redundant nature of network observability ensured by image walls with control systems.

5.4 Performance monitoring *Glos*

According to the Ancillary Services participation contract for 2008 to 2010, the performances defined for frequency-power and voltage control are monitored regionally using CdP_Prod tool. As in 2009, all the regions applied generating unit performance monitoring, with its associated technical and financial aspects. RTE's regional teams all organise at least yearly meetings with the production sites and their management to carry out an in-depth analysis of the performance shortfalls noted, their causes and any possible remedial actions. The regional reports show the result of these monitoring actions with anomaly corrections after long periods of contractual performance shortfall (reactive capacity, inaptitude for specific functions such as synchronous capacitor mode operation, adjustment speeds, aptitude for primary frequency control, etc.) or corrections of an incorrect diagnosis, but also of situations where contractual shortfall persists without being corrected, such as not providing voltage/reactive power diagrams defining the whole usable operating domain, for standard thermal units belonging to two producers.

Long term persistence of significant, uncorrected shortfall naturally concerns limitations in generation capacity or reactive power absorption, affecting a significant number of large sets over many months, already evoked in §2.3. Last year, the report indicated a deficit volume of 6500 MVAr, and underscored the unsuitable nature of the ancillary services contract clauses to encourage a producer to solve the problem rapidly, considering the financial stakes required for repairs (e.g. generating set repair or replacement, stator winding replacements, etc.) and appealed to the producer concerned to act as quickly as possible considering the reliability stakes linked to these limitations. In 2010, the figures improved slightly (over 5000 MVAr of deficit at the end of the year), in as much as the possibility of calling on protocols authorising the exceeding of permanent limitations for a few hours per year has been reduced to just one unit. This actually disguises various situations: work has been completed on certain units, bringing them back to nominal capacity, but other units have been declared in long-term limitation and new limitations have been declared for certain refurbished units, giving RTE less visibility on the forecasted situation for the next year or two, despite the fact that the producer has provided information on their work schedule. Given this situation and RTE's request, the latter agreed in January 2011 to implement new reactive power activation protocols on the limited units and to define a "multi-year plan to bring the units back to conformity", awareness of this plan is essential for RTE to decide on additional investments in reactive compensation. There was also an agreement made to work together towards a better understanding of equipment ageing conditions.
Finally, compared to last year's reports, we should remember that new measures concerning long term performance limitations management were adopted in the new version of the Ancillary Services supply contract (cf §3.3), whose incentive effect remains to be assessed in the future.

5.5 Crisis organisation*Glos*

Several crisis cells were activated in real conditions, particularly during Xynthia and the flooding in the Var.
After a first crisis exercise with Elia and CORESO in 2009, RTE and the Portuguese TSO REN participated in a crisis exercise organised by the Spanish TSO REE, simulating the coordinated management of a black-out affecting Portugal, northern Spain and RTE's South-West network. The ambitious scenario (up to 10 separate networks managed up to European recoupling, 5 hours of simulation) showed good coordination between REE and RTE with regard to the management of voltage and separate networks.
RTE participated in the national load shedding exercise under the aegis of the Ministry of Energy.
Amongst the regional exercises linked to reliability carried out, one should note a remote network outage exercise for the Normandy-Paris region and a seriously damaged voltage system management exercise in the West, to test the coordinating methods between the West and Normandy-Paris regions, the CNES and distribution control operators.

5.6 Other organizational measures contributing to reliability

There are two important points regarding organisation and policies contributing to reliability to be highlighted.

The first point was the revision of the "N-k" directive, a rule that determines which potential incidents should be studied (loss of a facility or production…), which consequences are included, when (on a preventative or remedial basis) and how to guard against them. The revision of this fundamental rule for system reliability had several aims: to optimise network use (cost reduction and reinforcing looped network operation, to benefit quality and reliability), to improve the management of very restricted situations, to facilitate safety shutdowns, get in line with the measures of the new version of policy 3 dealing with the safety of the continental interconnected system.
The new rule confirms the essential character of risk assessment[19] and comparisons for reliability. We can now distinguish normal contingencies (fairly common) that must be covered at all times, and exceptional contingencies, which, after checking that they cannot cause a major incident, are usually only covered in situations that favour their occurrence (e.g. weather conditions, a major cultural, sports or industrial event, etc.). The means to be used to cover these contingencies have been

[19] The risk here is defined as the product of the probability of occurrence of an incident times its potential gravity (resulting consequences and possibly required safeguard actions).

repositioned and the use of remedial measures is reinforced, thanks in particular to the advanced remote control functions supplied by the SRC (which requires very good facility and control equipment reliability). In addition, for ensuring reliability facing major events even in a favourable situation, a list of exceptional contingencies[20] is regularly monitored by CNES. Finally, the measures for data exchange and coordination between monitoring regions (RTE and neighbouring TSOs for the 400 kV network or between regional Units for the 225 kV network) have been improved, to better assess the impact of an incident on neighbouring regions.

Important preparation work with the teams in charge of applying the rule (training, common analyses of regional implementation) has been carried out and must be highlighted. It has helped to facilitate the appropriation of complex measures that have changed significantly from the previous version of the rule, making its application possible at the start of winter 2010-2011. Detailed feedback will be required in 2011 (programmed as of the application of the rule) to appreciate the overall impact, ensure that it is fully understood and applied, and that it is adequate for all situations.

The second point concerned changes in work organisation to allow better preparation of forecasted reliability analyses, in particular for voltage profile security calculations using static tools (simulating the final state reached after loss of one or several facilities) and "maximum consumption" calculations using dynamic simulations, beyond which safeguard orders are activated as a preventive measure (see §2.3). Detailed work has defined new day-ahead exchange and organisation methods between CNES and the regional dispatching centres[21] to have a single set of shared data (the whole HV3/HV2/HV1 network) providing a better forecasted vision (consumption, renewable energy injections, regional network topology, etc.) than with past methods, where differences between these forecasts could lead to conservative decisions, difficulties of real time analysis, or taking uncontrolled risks. The new system was put in place before winter 2010-2011 to benefit the most concerned regions[22]. The process also resulted in the improvement of certain decisions to impose certain units for network requirements: the imposing of a Cordemais unit was avoided and the need for another was revealed. This change is still incomplete and it is to be hoped that it can be brought into general use (in all regions, all year) and extended to data exchange for intra-day studies, particularly to improve the forecasting of the evening peak situation.

The setting up of a database shared by all the control centres for the logging of unit performance limitations (sometimes of short duration) and more generally volatile data that is not dealt with in the reference databases, should also be highlighted as it remedies a weakness that came to light in earlier reliability reports.

Finally, in 2010, the CCRT was completely re-written to bring it up to date, make it easier to read and more operational. A training programme for this new CCRT was set up and started. The new version was implemented on April 1st 2011.

6 Lessons drawn from the year's events

6.1 Lessons drawn from the ESS and from their analysis

The number of ESS level A or higher incidents equalled 60 and comprised 55 level A and 5 level B, the result is quite high although better than 2009 (57 level A and 8 level B). It is strongly marked by the ESS A caused by safeguard orders given during cold spells.
Last year's reliability report highlighted that, while it was not a major cause for concern, there was an observed increase in ESS level A and particularly of ESS level B, as well as the presence of an ESS level C and an ESS level D, showing a downward trend. In 2010, we can highlight the absence of ESS of a level greater than B, and a lower number of B, although this does stay relatively high compared with 2007-2008.

[20] In particular: the loss of a busbar section is covered for most 400 kV substations (and cases in 225 kV), and the loss of certain common support lines in 400 kV.
[21] In 2010, limited to the regions: West, Normandie-Paris, North-East, South-West.
[22] For example, in Mayenne, making it possible to loop a network pushing back local maximum voltage limits.

In a longer term perspective, one should highlight that 18 level B and 2 level C were counted in 2000, 12 level B and 2 level C in 2001, 14 level B and 3 level C in 2003, a significant improvement appearing as of 2004. In short, 2010 is quite close to, although higher than, the general trend observed over 2005-2008. This improvement in comparison to 2009 should be noted; however, an observation over one year does not allow us to distinguish what is due to RTE's overall rigour and the benefits of the feedback process from what is just luck. Vigilance and rigour must therefore be maintained.

ESS breakdown per scale level and domain is listed below.

ESS	2006	2007	2008	2009	**2010**
A	45	41	37	57	**55**
B	4	2	2	8	**5**
C	0	0	1	1	**0**
D	1	0	0	1	**0**
E	0	0	0	0	**0**
F	0	0	0	0	**0**
Total ≥ A	50	43	40	67	**60**

ESS ≥ A	2006	2007	2008	2009	**2010**
Network	6	8	13	9	**8**
System operations	36	23	17	37	**43**
Control systems	3	5	7	15	**7**
Production	4	5	1	4	**1**
Distribution	1	2	2	2	**1**
Total ≥ A	50	43	40	67	**60**

Level B ESS concerned:

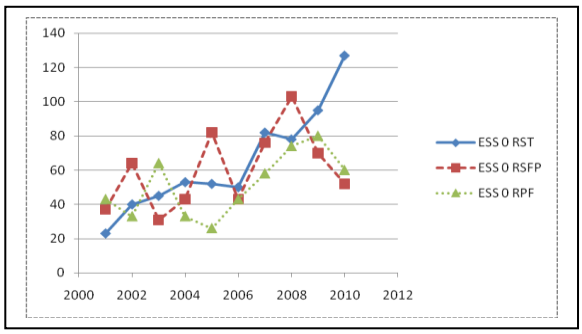
- A double busbar fault (loss of two sections) at the 400kV Granzay substation, causing the tripping of four 400 kV links and two autotransformers, without consequences for the clients or risk for system stability, thanks to the speed with which the strong constraints were resolved (5 mins). The incident was due to the destruction of a voltage measurement transformer, of a type that is known to be risky and is monitored, but where the warning signs could not be treated in time because of another concomitant incident.
- A double busbar fault at the Latena 225 kV substation, following a mechanical breakdown on a busbar switch disconnector, causing the loss of the substation; this incident demonstrates the difficulties in applying a conditional procedure to use corrective measures on this type of equipment.
- A loss of N-k security guarantee, on a 400kV busbar fault at the Marlenheim substation, in a context of high flows caused by German and Swiss interconnection exchanges; the occurrence of the fault would have caused a cutting off of 900 MW (600 MW admissible), but it must be highlighted that this weakening of operation reliability was limited to a duration of 1hr30, for which the probability of this type of busbar fault is extremely low, especially as the weather conditions were good.
- A risk of loss of a significant production volume, greater than 3000 MW, on a 400kV busbar fault at the Warande substation, during part of the week when the busbar differential protection was on planned maintenance, due to the incomplete application of the scheduled measures ahead of this outage. Here again, the probability of this fault occurring during this period was extremely low; this ESS was the subject of a flash audit ordered by RTE management.
- A fault in carrying out a "-5%" order issued to a distribution control centre, following a handling error; the scope of the failure remained limited because the order was correctly carried out by the 4 other centres it was sent to.

Regarding the 55 ESS level A, their high number (43) in the section on "system operation" is largely due to the ESS logged during the sending of the 31 warning or safeguard messages linked to the voltage stability problems mentioned earlier.

Finally, 1110 ESS level 0 were declared (-10% compared with 2009). It is important to record these incidents, even if they only moderately affect reliability[23], because the information is valuable to improve feedback and to carry out theme analyses. The analysis of these events is also instructive because some of these incidents could, in other conditions, be an elements setting off a serious reliability incident.
In 2010, the CNREX therefore examined several ESS level 0 concerning the uncontrolled loss of two telecommunications links, one of which is needed for rapid clearing of short circuits on the "close" 225 kV or 400 kV links[24], for a duration of a few hours to a month. These problems are mostly linked to a lack of rigour and communication between the multiple participants concerned by unavailability management (unscheduled or scheduled), sometimes lasting a long time, that can affect one and then both of the remote transmission links required for the associated protections (line differential and/or stage acceleration for distance protections). In addition to the decided improvement actions, which are partly linked to the recommendations of the flash audit mentioned above, these malfunctions, potentially serious for reliability, require long term vigilance by regional management.

The evolution of ESS level 0 also highlights the growing trend of non-operability of the 400kV structures' busbar switch disconnectors, detected during operating manoeuvres or periodic operations carried out for preventive maintenance (OMF). The incomplete operation of this equipment can have a serious impact on electrical system reliability with the risk of double busbar fault if the fault occurs when a busbar change for a given equipment is performed (as happened on December 21st 2009 at Tavel). Moreover, operating restrictions that may be imposed before repairs following the observation of a fault reduce the possibilities of action in the concerned substation when there is an operating problem to deal with. Different actions are being pursued to control these faults, in the short and long term: a replacement and securing programme in the South-East, development of corrective actions for a category of equipment, study of a future renewal programme. The critical nature of this equipment for reliability requires sustained, long term action and the process followed must be complete.

Among the production-related ESS level 0, the graph below presents the number logged since 2001 for generating unit control withdrawals of more than 2hrs in secondary voltage control (RST-N and RSCT), in secondary frequency-power control (RSFP) and in primary frequency control. It shows an upward trend in unit control losses in secondary voltage control, already indicated in last year's report. These withdrawals of control should be connected to the increase in reactive power capacity limitations; they result in difficulties for system control to efficiently manage variations of the voltage profile inherent to injection, consumption and flow variations, or unit trippings.



Since 2010, events affecting the European interconnected network on the Central-West Europe zone have been logged by the German, Belgian, Dutch, Luxembourg, Swiss and French TSOs according to a common classification grid, similar to RTE's. The number of logged incidents has gone down significantly: 264 level 0, 18 level A, 8 level B, compared to 418 level 0, 46 level A, 19 level B, 1 level C, 2 level D in 2009.
The published report indicates that two incidents of non-compliance with the 400 kV N-1 rule were logged (including the one on April 20th in the eastern France), for short durations and without any potential impact for the neighbouring TSOs. This result may be considered to be satisfactory, on the condition that these situations are correctly identified by all the TSOs. The report highlights that this important point should be related to progress in the development of operational cooperation between the TSOs concerned, based on different ad-hoc structures, such as CORESO, favouring risk identification and the implementation of concerted solutions (as already noted for CORESO, §2.4). In

[23] Hence, we declare as an ESS level 0 for any untimely tripping of a generating unit and any tripping of a 400 kV line, although these contingencies are covered by the application of the N-k operating rule.
[24] In the 3 cases, this concerns lines whose short-circuit elimination times must be short enough to guarantee the dynamic stability of high capacity units.

addition, amongst the level A and higher incidents, and if we set aside high voltage overruns on the 400 kV network declared mainly by Elia, which hardly affect system reliability, the potentially worrying events are: two losses of the main power-frequency regulator by a TSO and 11 non-concomitant losses of observability of the 400 kV network by different TSOs, for levels (scope and duration) more or less serious.

6.2 Feedback other than ESS

RTE teams perform reliability-related feedback analyses that are not limited to ESS occurrences, on a regional as well as a national level, particularly in the context of the CNREX and the Transmission Technical Committee. Different annual technical reports – telecontrol, line and substation equipment, and protections – are drawn up and examined by these committees to monitor underlying evolutions.

Thus, following the infection of different industrial systems worldwide by the "Stuxnett" virus, an analysis looking at the vulnerability of RTE's digital instrumentation and control methods was carried out. The CNREX approved the conclusions reached: though this virus did not infect the equipment, other relatively harmless viruses were found in different installations, but the regions were not affected; the measures set up therefore seem to protect the equipment properly if they are strictly applied. They were strengthened nevertheless and regular awareness raising actions are required.
The CNREX also examined the learnings from the flood on 15th June in the Var. Confronted with a water level much higher that the 100-year flood level, the 225 and 63 kV Trans substations were badly damaged, but the recent 400 kV substation was not harmed, in accordance with the requirements established for construction[25]. The preparations for the event announced by the weather forecast meant that the right decisions could be made, in particular for load shedding conditions to avoid the propagation of the incident to a wider electrical zone than the one affected. The efficiency with which the crisis was managed should be highlighted. In terms of corrective actions, apart from the upgrading of the damaged substations with a higher level of protection, preventive actions in case of future flooding on a regional level have been undertaken: updated inventory of the vulnerability of the region's substations, analysis of the possibilities of "bridging" the 400 kV links, so as to be able to bypass flooded substations and thus reduce the risk of spreading the incident to the whole regional network.

For all the 380 lines at 400 kV, the rate of unscheduled outage was 0.06 % (0.08 % in 2009) and the rate of scheduled outage for work was 2.16 % (1.97 %). Amongst the 400 kV lines, there are 181 "sensitive" ones in these 400 kV facilities, whose unscheduled absence in real time leads to significant problems for the electrical system and for which RTE implemented specific measures (improved maintenance sets, quick-reaction equipment inspections even out of working hours in the event of a trip, etc.); their unscheduled outage rate stood at 0.04 %. Also to be noted are 67 "strategic" 400 kV links whose absence in operation causes inconvenience such that measures are required to reduce the need to shut them off for maintenance purposes; the unscheduled unavailability rate was 1.47 % (1.67 %).
These results are among the best annual ones for sensitive links and reasonable considering the last ten years for strategic links. They are clearly better than the results observed for the links overall, which is to be expected but has not always been the case. These results are by nature quite variable according to network incidents (small number of lightning strikes in 2010) and the type of work to carry out for scheduled outages.

Moreover, contractual commitments between RTE and the producer EDF regarding reliability are monitored by a specific committee. The main themes examined were the methods of dealing with the unit reactive power limitations, the monitoring of actions taken on one side or the other following an incident, application of the contract on network restoration and voltage recovery.

[25] Within the scope of the Flood Risk Prevention Plan

6.3 Noteworthy facts concerning other power systems

There were no major incidents reported in 2010 (comparable to the Brazil-Paraguay incident on 10th November 2009 for example), but significant incidents did occur on the network of a town or a region, two of which were started by the same atmospheric cause:

- on March 8th, the accumulation of frost and snow led to the falling of several electrical lines in Catalonia, resulting in power cuts that lasted nearly all day for more than 200,000 homes in the Gerona and Barcelona provinces; the damaged lines on the plain were really not designed to mechanically resist this type of event;
- on December 26th, power cuts affected more than 100,000 customers in the Moscow region, with identical initial causes (cables breaking following the formation of layers of heavy snow); the Nijni-Novgorod region was affected to a similar degree;
- on July 7th, power to 250,000 people in Toronto was cut, following a fire in a transformer station supplying the city centre.

7 Reliability-related indicators

For external communication purposes, the factual indicator to be used comprises the numbers of ESS issued for levels A to F, hence for 2010: 5 B, 55 A.

However, a few figures alone cannot account for the reliability level, and ESS declaration, although it is extremely valuable, only accounts for incidents but says nothing of improvement processes or trends. It is therefore the present yearly Reliability Report which is the ideal tool for external communication on reliability, insofar as it gives an account, in coherence with the power system reliability policy, of all the important aspects of operating reliability and of the role that each party plays in building reliability.

8 Progress Actions

8.1 Cooperation actions (TSO, Users, etc.)

RTE initiates or contributes to many progress actions, directly or indirectly, in the short or medium term, to reinforce electrical system reliability. These actions are increasingly being carried out at a European level, within ENTSO-E.
Hence ENTSO-E continued with its work to create a unified real-time alert system for all TSOs members, called "EAS" (ENTSO-E Awareness System). An invitation to tender was launched for this project in 2010 for a commissioning planned before late 2011. The system, whose usefulness and functions were established in light of the lessons stemming from the European incident of November 4th 2006, will allow each TSO to view the alerts issued by its neighbours, the flows at the borders and the frequency of some network nodes. This will facilitate a shared and quick diagnosis, in particular in case of the separation of the network into several independent sub-networks, a situation which proved difficult on November 4th 2006.
In the medium term, within the framework of the third energy package adopted in 2009, ENTSO-E will draw up European "network codes", in consultation with all of the stakeholders. These codes are intended to eventually acquire the status of a European law. To prepare the official production activity that should start in 2011, ENTSO-E defined a draft code concerning the connection of units to the network, chiefly the expected technical performances, and has starting drafting a code of rules for the operation of European transmission networks. RTE actively participates in the drawing up of these codes.

In the framework of the application of "Operational Training" policy, RTE and the Italian TSO TERNA organized a joint training session on simulators for operators of both TSOs, and prepared similar types of actions with the Spanish TSO REE (carried out in January 2011).
Several meetings between staff at an operating level took place with the Swiss TSO Swissgrid, the Belgian TSO Elia and CORESO to reinforce reciprocal understanding and operational coordination.

RTE, an active member of the VLPGO group of operators of power networks greater than 50,000 MW, pursued its participation in the on-going work, such as the analysis of the impact of electrical cars on the networks.

8.2 Main lines of research

Assuring power system operating reliability means knowing how to identify the risks against which one wants to protect oneself and taking the necessary measures in good time. Feedback, although it is invaluable, does not suffice, because major incidents are seldom similar to those that occurred before them. It is with this in mind that RTE manages or contributes to different research actions, increasingly within the framework of cooperations. The reinforcement of these activities is one of the goals of the "industrial project for sustainable performance".

RTE plays a driving role in the actions undertaken to develop European R&D among TSOs. They led to the definition of a R&D programme for TSOs and DSOs, which was ratified during the first meeting of the "Grid Initiative", then validated by the European Electricity Grid Initiative (EEGI) set up by EU. In line with this initiative, ENTSO-E established its R&D work programme for the years 2010-2018, structured into 4 themes: innovations and breakthroughs in network architecture; assessment of the benefits provided by the extensive deployment of the most advanced available technologies; development and validation of tools to monitor and operate the electrical system of the future; development of electricity market simulators.

In a more operational way, RTE is participating in the ambitious TWENTIES[26] project that really got underway in 2010, and for which RTE is managing the work on the technical feasibility, architecture and performances of direct current networks. RTE is also making a strong contribution to the European project PEGASE covering methods for the simulation, state estimations and optimization of very large electricity systems; the partial results already available are encouraging with regard to the possibilities for the improved operation of large European scale networks. Finally, RTE is participating in the SafeWind project to forecast wind power production during extreme weather events.

Other noteworthy reliability-related R&D projects carried out in 2010:

- Evolutions in network calculation models enabling the integration of modelling adapted to DC lines in view of their upcoming arrival in the heart of the continental network (France-Spain and France-Italy interconnections);
- The demonstration of the operational feasibility of the modelling of network physical congestion constraints in market coupling algorithms[27], to prepare for the switchover to the "flow-based" coupling technique in the CWE zone;
- Concerning voltage control, first projects carried out with an external laboratory to build up knowledge on the load response to voltage, which merit being continued and widened, in view of the criticality of voltage management for the French grid;
- In the field of consumption forecasting, work jointly performed with academics concerning alternative forecasting methods (including the climatic hazard).

Finally, in the equipment field, major innovations are also being prepared for the RTE network:

- A new type of low-expansion cable (ACCR[28]), whose properties offer new much higher backup intensities, is currently being tested on a section of the 400 kV line in the West in order to evaluate its performances in real conditions, to then decide on possible usage conditions for this cable, knowing that RTE already uses another type of low-expansion cable (ACSS[28]);
- For the building of a new interconnection between France and Spain, an underground DC line over 60 km long, in 320 kV synthetic cables, will provide a transmission capacity up to 2000 MW. RTE and REE have chosen to use voltage source converter technology in the DC/AC

[26] bringing together 26 TSOs, industrial companies and academics to work on the networks of the future (off-shore DC networks, reinforcement of the flexibility of electrical systems via coordination)

[27] In the coupling commissioned in 2010, the calculation of capacities proposed to market is done ex-ante, and is hence sensitive since based on flow hypotheses reputed to be conservative. The flow-based method allows the elimination of this preliminary stage.

[28] ACCR: Aluminium Conductor Composite Reinforced ; ACSS: Aluminium Conductor Steel Supported

substations enabling the integration of this link into the electrical system. This technology presents real advantages for network reliability, thanks to its operating flexibility and its capacity to provide voltage backup services. This choice was already made in 2009 for the future Savoie-Piémont interconnection.

9 Reliability audits

Reliability audits are carried out at the request of RTE management within the framework of the internal audit measures set up in the company to ensure that its policies are complied with, to assist it in pinpointing and making recommendations correcting any organisational weaknesses, and to advise management. These audits are performed according to periodical programming, which may be supplemented by other management requests, referred to as "flash" audits.
Actions undertaken by RTE in response to these audits are monitored by a Reliability Audit Mission, reporting to the RTE Board.

Three Reliability Audits were carried out in 2010, on the following subjects:

- Development of digital I&C on substations;
- Operation of cross-border interconnection links;
- Ability to restore the network after a generalized incident.

A flash audit was also carried out following malfunctions observed during the switch off of a 400 kV busbar differential protection for maintenance (cf ESS B).

10 Conclusion

From an operating standpoint, 2010 was marked by tense situations occurring during the cold spells, which were well handled by RTE but which required issuing safeguard orders more than 15 times. These delicate situations, occurring yearly despite regular improvements made to reinforce compensation means (HV and EHV capacitors) and operational management, show the structural weaknesses that exist in terms of production site location in the West and South-East regions, as well as the impact of the growing thermosensitivity of consumption.
RTE's ability to deal with severe weather incidents, already demonstrated in the past, was confirmed in the management of the Xynthia storm and the flooding in the Var on June 15.

The incidents affecting the reliability of the electrical system, assessed in terms of Significant Systems Events[29] with a level higher than or equal to A, had increased significantly in 2009. 2010 is characterized by a return to the average 2005-2008 trend, although the number of ESS levels A and B remains higher, due to the increase in ESS level A recorded for tense operating situations during the cold spells. Vigilance in terms of reliability remains topical and RTE must keep up its efforts to fully exploit all feedback and to disseminate its findings, even though, from a longer term standpoint, we can note that the number of ESS level B and higher recorded since 2004 is significantly lower than at the start of the previous decade. Over the last few years, the stabilization of a high number of ESS of the lowest level "0" reveals the maturity of this recording and feedback system.

Some potentially risky points emerge from this reliability report: the difficulty in further reducing the occurrence and consequences of human errors, some of which may be important in terms of reliability; the potential vulnerability of operations with regard to errors in data, assessed in real time or frequently modified, and the management of dynamic parameters, in particular the current level limits applicable at a given time; the continuing lasting limitations of reactive power production capacities affecting a certain number of generation units, even though we must underscore that in-depth discussions with the concerned producer made it possible in early 2011 to outline a progressive management process to return to contractual capacities in the next few years.

As a counterpoint, significant evolutions were made that participate in the reinforcement of reliability and the regular adaptation of operating and control methods to a changing environment: the revision of the fundamental security rule – the N-k; starting the use of a new method to determine overload temporary current levels to release additional operating capacities; noteworthy improvement in day ahead study methods, in particular for very tense situations, making it possible to perform increasingly accurate diagnoses of the effective risks of voltage collapse using dynamic simulations; reinforcement of events feedback.
Given these evolutions, we must ensure that operational teams also have enough time to fully assimilate them, especially since the tools themselves are also changing, like the "Convergence" unified study platform.

Finally, like in 2009, progress was once again made in coordination at a European scale, including the increasingly important role taken on by CORESO in operational management and the evolution in calculation methods of capacities available to the markets, in the framework of the implementation of the day-ahead market coupling in the Europe Centre-West region.

For further information about the principles on which the annual System Reliability Report is drawn up, consult: "Reliability of the French electrical system: annual audit reporting". J.M. Tesseron. REE, n° 8, September 2006

[29] ESS are ranked according to their level of gravity on a scale commencing with the most minor level 0, then from A to F.

APPENDIX: Subject Glossary

Identifier	*§*	*Concept*
The operational reliability of the electrical system	2	System Reliability is defined as the ability to: - Assure normal electricity system operations; - Restrict the total number of incidents and stop the occurrence of major incidents; - Limit the consequences of major incidents when they do occur. Reliability is at the heart of RTE's responsibilities as defined by the French Law of the 10th February 2000 in its role as the French Transmission System Operator. Should you wish to learn more or clarify any terms, see the *Reliability Memo* available via: www.rte-france.com *(Accueil > Mediatheque> Documents > L'électricité en France : données et analyses > Publications annuelles ou saisonnières)*
Operating margins and reliability rules	2.2	The reliability rules require: - A minimum safety margin, which can be called upon in under 15 minutes, of greater than 1,500 MW; this figure is calculated to be sufficient to compensate for the instantaneous loss of the largest unit coupled to the network; - A minimum safety margin, requiring more notice, for a gradual increase in volume from the 15 minute threshold to the 8 hour threshold. If these conditions are not met, RTE must transmit, depending on the individual situation, either an alert message via the Balancing Mechanism or a 'Critical Situation' S message.
Balancing Mechanism (MA)	2.2	French law states that producers must make available, to RTE, the technically possible power levels required to balance supply and demand. This is carried out using a Balancing Mechanism, used by RTE to make the most of the means held by the market companies in a permanent, open manner and by the market companies to valorise their withdrawal capacities and production flexibility. RTE will make the necessary adjustments, based on price-volume offers, accepting offers in price order until the demand is fulfilled. Certain measures are implemented to deal with shortfalls: - At 8 hours, RTE will request additional offers by alert message; - Prior to the 8 hour deadline, a 'downgraded mode' message allows RTE to mobilise, beyond any additional offers, exceptional offers and other means not covered by the balancing mechanism
Primary and Secondary Control of Reserves of Power Frequency	2.2	Primary control is automatic, triggered by any deviations between production and consumption and by the commitment of those involved in the synchronised interconnections, and assures virtually instantaneous restoration of the balance. The regulations are laid down by ENTSO-E's regional 'Continental Europe' group to ensure that frequencies are held within pre-defined limits. Following on from this, secondary control by the company responsible for the problem will automatically cancel out any residual deviations from the reference frequency, as well as any deviations from the programmed exchanges between the various control zones.

Identifier	*§*	*Concept*
ENTSO-E	3.2	ENTSO-E (European Network of Transmission System Operators for Electricity), founded at the end of 2008, is, since 1st July 2009, the single body responsible for the European TSOs.. ENTSO-E is tasked to improve cooperation between TSOs in key areas, including the drawing up of network codes for technical and operational aspects, operational coordination and development of the European Transport Network as well as for research activities. According to its statutes, all major decisions are taken by a General Assembly. An executive board is responsible for the general steering of the organisation and the preparation of strategic objectives. Operational work is overseen by three main committees and their sub-structures: The Markets Committee (MC), the Systems Development Committee (SDC) and the Systems Operations Committee (SOC), supported by a legal analysis group. To assure technical coordination of those TSOs connected on mainland Europe and to provide an evaluation of reliability-related commitments, defined in 8 policies and agreed upon as part of the Multi-Lateral Agreement signed by the members of the previous UCTE association, the SOC created a regional ad-hoc sub-group - The Regional Group Continental Europe (RGCE). See: www.entsoe.eu
Reliability Communications Network	4.1.5	The aim is to put together a secure network built around a dedicated telecommunications infrastructure for all types of traffic (data, voice, etc.) required for remote operations. These systems will provide the following functions: - 'Low level' transmission of control data for all remotely controlled substations and a limited number of telephone connections between major transport substations and substation groups; - 'High level' transmission of remote control data and telephone connections between Substation groups and dispatching centres; - Remote control data transmission and telephone conversations between power plants and dispatching centres; - Radio transmission of voice communications between mobile teams and their base. The RTE networks are evolving to meet the opportunities offered by new technologies, looking to improve reliability and safety, prioritising the idea of shared systems through technological advances.
Significant System Events (ESS)	2.2 5.3	The detection of events impacting on the reliability of the system is based upon pre-established criteria, grouped into a Significant System Events Classification Grille. The grille is used to assign an event an accurate indication of the effect on reliability, using a 7-level scale. Level 0 assigned to the lowest risk events to be logged; Levels A to F correspond to increasing severity of events, all the way up to a generalised, widespread nationwide incident. The classification method is based on an assessment of the seriousness of the event using two types of input: - One input logs the incidence of elementary events impacting on an operational function in a certain number of fields (transmission, production, systems ops, control systems, distribution); - One input logs the level to which system functionalities are downgraded.

Identifier	*§*	*Concept*
Verifying the performance of Production Installations	5.4	Taking into account the criticality of the services provided by production plants when connected to the grid, these should be subjected to performance monitoring. This monitoring, implemented in such a way as to limit the quantity of work and expenditure incurred by both RTE and the users, is aimed at ensuring that the grid remains operational for all and assuring system reliability. The principal is that the levels of performance are checked at the point of delivery from the installation, meaning a single test is sufficient to assure that performance levels are being met. The test checks the behaviour of the production units with respect to primary and secondary frequency-power controls (static gains, programmed reserves, response times, etc.) as well as for primary and secondary voltage controls (availability of the contractual domain in U/Q diagram, response dynamics).
Crisis management	5.5	The ORTEC Plan (RTE Crisis Organisation) was set up in response to the storms in late December 1999. It defines the measures to be taken and the organisation to be used both nationally and regionally in the event a serious crisis is declared by RTE. In addition to the provision of human resources and technical resources, it also covers the introduction of communications associated with crisis management. Concretely, Crisis Units are rapidly mobilised in all Units and in RTE Headquarters. In addition, Priority Intervention Groups (GIP) were created for each of regional Units. Their main objective being to assure the restoration of any seriously damaged lines of particular importance to system reliability in less than 5 days.