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Reliability Report 2009

32 Pages

Summary:

2009 was marked by two important events. Firstly, the way in which the RTE grid stood up to European Windstorm Klaus striking the south-west of France, which turned out to be an excellent illustration of the pertinence of the transport & distribution network safety policy implemented as a result of the storms of 1999. The second event was an incident, which took place in Tavel, near Avignon on the 21st December. A total grid blackout, between Marseille and Nice, was avoided by a rapid load-shedding operation. In general, partly due to the difficult meteorological conditions, operations in 2009 were characterised by some tense situations, efficiently managed by RTE, and requiring the use of safeguard measures during the most difficult periods.

Significant progress has been made in terms of coordination by setting up CORESO, a Regional Coordination Service Centre to provide support to the TSOs of Central Western Europe.

The publication of this yearly report is in keeping with RTE's goal to promote timely monitoring of changes in reliability in all its various aspects. RTE aims to contribute to the development of a 'reliability culture', encouraging the various companies involved (RTE & Network Users) to improve their assessments of the roles they play in building reliability, and by advocating the integration of reliability and benchmarking into the European Network of Transmission System Operators.

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

From an operational point of view, partly due to the difficult meteorological conditions, 2009 was characterised by some tense situations, efficiently managed by RTE, and requiring the use of safeguard measures during the most difficult periods.

2009 was marked by several significant milestones on both a European and International scale.

- The European Network of Transmission System Operators for Electricity (ENTSO-E), founded in 2008, has drawn up and detailed its programme of work, forecasting increased levels of cooperation between TSOs in key areas with a direct effect on reliability;
- The Third Legislative Energy Package has been published by the EU. The texts define the joint responsibilities of the future regulatory agency, the Association of European TSOs and the Commission in terms of the drawing up of the principal market integration regulations and the safe, reliable running of the electrical grid network;
- RTE and the Belgian TSO (ELIA), joined by the British National Grid, have jointly set up CORESO, a Coordination Centre, which became fully operational in February 2009. Its first year of operations has confirmed the progress made in terms of the reliability of the Centre-West region of Europe;
- President Barak Obama announced the launch of a 3.4 Billion USD programme to renovate and improve the reliability of the American grid network, a programme based upon innovative technologies, grouped under an umbrella known by the moniker 'smart-grids'.

This 2009 report is aimed at underlining the principal points relating to electrical transmission system reliability controlled by RTE and integrated into the European electrical system.

2 Operating situations encountered

Controlling power system reliability is especially difficult when the operational situations encountered are not easy to deal with. Notwithstanding this, control over these situations is largely dependant on the capacity for operational planning.

2.1 Climatic conditions

With an average temperature 0.8°C higher than normal, the year has been the 9th hottest since 1900, a statistic which hides some important contrasts: Winter was cold, particularly in January – with the average temperature for the month being the lowest for 20 years, including a significant, yet not exceptional, cold spell between the 3rd and the 11th of January, in addition to a week-long cold spell in December. Rainfall levels were, in the main, down.

January was marked by the exceptional European Windstorm Klaus, which crossed the southwest of the country on the 24th of the month. Even if the area affected was smaller than the footprint of the storm of 1999, the recorded wind speeds were higher, winds of more than 140 km/h were observed across some 30% more woodland in the immediate vicinity of power lines.

The Operational Reliability of the Electricity Network

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 (*Access Publications*)

2.2 Supply / demand balance management

France's internal electricity consumption dropped by 8.1 TWh to 486.4 TWh total (-1.6%), notably due to the international economic crisis. From a reliability point of view, it should be noted that a maximum consumption level of 92,400 MW was reached on the 7th January at 19:00. This level, never before attained, was achieved with a mean temperature 7.8 °C lower than average climatic conditions. It clearly shows the increasing correlation between grid load and temperature gradient, which has become apparent over the last few years; achieving, in 2009, a level of 2,100 MW/°C.

The year was also marked out by a serious decrease in the balance of contractual exports, from 46.6 TWh in 2008 down to 24.7 TWh. This decrease is in-line with the structural changes, ongoing since 2003, but has undoubtedly been amplified by the various problems created by the availability of the French generating facilities, particularly during the second quarter of the year¹. In summary, electricity was imported for 57 days, against just 6 in 2008. During these periods the total imported electricity exceeded 5,000 MW over some 95 hours (0 hours in 2008) and 6,000 MW for 34 hours (between the 15th October and the 17th December), with a peak of 7,890 MW on the 19th October, in comparison with the maximum importation limits, which, under the best of circumstances, should be around 9,000 MW. The cumulative volume of export and import transactions was slightly down, with 111.7 TWh. The intraday market at the borders continues to grow and now represents 5.1% of the contractual exchanges at the borders (against 3.6% in 2008).

French electricity production reached 518.8 TWh, a drop off of 30.4 TWh. Wind power supplied 7.8 TWh (+39.9% - a rate of increase which is consistent with last year's figures and is a reflection of the progress in terms of infrastructure installations). Production from other renewable sources, excluding hydro-electric, increased by 7.5%, representing 4.4 TWh (mainly bio-mass generation).

The shortfalls between actual figures at peak period and the forecasts viewed the day before remained below 1,500 MW in winter and 750 MW in summer in 82.7% of the cases versus 82.3% in 2008 and 84.2% in 2007 (with a minimum objective of 80%). Two ESSs (Significant System Event - cf. §5.3) were declared at level A for a deviation of 3,500 MW (2 during 2008).

Operating margins

RTE monitors, in real time, the margins available to balance supply and demand, and, in case the volume falls below the specified level, restores this margin.

Whenever possible, the margins are covered by normal balancing offers. If this is insufficient, RTE turns to additional offers received following the transmission of a safeguard mode Balancing Mechanism message, then using emergency contracts with other TSOs. Finally, RTE can turn to 'exceptional' means which can only be used when the margin is negative. Should the normal and exceptional measures no longer suffice to ensure system reliability, RTE may have to resort to emergency means: Non-contracted emergency feeds from other TSOs, 5% drop in HVA voltage, consumer load-shedding, reduction in exporting physical linkages, etc.

Operating margins and reliability regulations

Reliability rules state that there is:

- 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 from the 15 minute threshold for the next 8 hours.

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.

¹ As an example, when compared with 2008, there was 2000 MW additional unavailable capacity in mid-October of 2009, 4800 MW in mid November and 4400 MW in mid December.

The load peak, a sensitive time of the day, was passed whilst respecting the requisite 1,500 MW margin at the 15-minute time period, except on 23 days (as opposed to 24 days in 2008 and 8 in 2007).

The 60 ESS (Significant System Events), two of which were at Level A, relating to a critical situation due to insufficient margin or to the activation of an alert message or Downgraded Mode via the *Balancing Mechanism* during D or D-1, remained at a relatively high level, as in 2008 (56 ESS level 0 and one level A, 24 ESS 0 in 2007, 36 in 2006).

For 2009, these principally involved the 42 ESS 0 for insufficient margin, mostly between May and July, and all gave rise to a warning message on D-1, followed by the Balancing Mechanism being shifted into downgraded mode on D-Day on 21 occasions. This is mainly due to insufficiently flexible and modular configurations, production plants which are unable to cope with the changes, as well as an increase in drop-offs during the night in comparison with previous years. It is interesting to note that for certain of the drop-off points, the insufficient standard offers have led to the activation of offers at a negative prices², creating 12 half-hour steps at zero price and 17 at a negative figure to counter the positive differences: It then became necessary for Balance Responsible Entities to pay for these excess injections.

There were 18 ESSs for insufficient margins (against 38 in 2008, 19 in 2007 and 32 in 2006), which correspond to the transmission of a 'S' order (Critical Situation), principally in February and October. In February, this was mainly due to the repeated unavailability of a large scale production facility which was suffering repetitive problems with its cooling water circuits.

5 % of the cases corresponded to a forecasted insufficiency for a time of fifteen minutes ahead, 28 % for a time of two hours ahead and 67 % for a period of over two hours ahead. 13 cases were accompanied by "Balancing Mechanism degraded mode" message.

In a few situations, large scale changes in the flows at the interconnections between the forecasts at D-1 and the final infra-daily transaction declarations were dealt with despite the difficult situation in terms of time-span margin. In at least one case, the Balance Responsible Entities (without injections or physical draw-offs from within their balancing zone) found themselves with a negative balance on the French grid by increasing their export sales without covering them, where the prices in a neighbouring market were particularly interesting.

It should be noted that the colder periods in January and December were managed without any major margin problems: The global supply & demand balance for these peak days was correctly managed, despite the reduced availability of certain production sites, this was achieved by large-scale imports by the market companies, with certain peak hours approaching the maximum admissible grid import levels. Provisional analyses of the 'start of the winter months' published by RTE at the end of October, forecast the probability of this type of operation.

Balancing Mechanism (MA)

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 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 ahead, 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

² In general, decreases in production activated by RTE are covered by a payment to RTE by the producer, the reverse happened in that particular case.

As of the 24th November, RTE modified the respective methods for the transmission of warning messages (in downgraded mode) for the Balance Mechanism and for the transmission of 'S' orders, depending on the timing of margin problems, with the aim of increasing notice to the balancing companies so that they can provide additional offers further in advance and save the transmission of an 'S' order for occasions where there is insufficient response from the market companies or when the timing is too tight.

Originally, the Swiss and German TSOs were involved with the Balancing Mechanism along the French borders; these were joined by the UK National Grid TSO in 2009, with the BALIT (Balancing Inter-TSO) agreement, further improving potential margins.

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

No ESS was issued for shortfalls in primary and secondary reserves of power in terms of the levels required for France. This is a repeat of 2007 (In 2008, one single ESS was logged).

Frequency stability

The observation of frequency control is also instructive, even if it must exceed the framework of French responsibility because of the European synchronous interconnection. Since 2001, reliability reports have drawn attention to unexpected frequency deviations observed across the European Interconnected Grid, which are proving to be significant in terms of what is stipulated by the application of the ENTSO-E reference. The following table, drawn up using CdP Prod (C.f. Section 5.4) gives the number of frequency deviations of greater than 100 and 150 mHz from the reference frequency.

Primary and Secondary Control of Reserves of Power Frequency

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.

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

By examining the first two lines, the number of frequency deviations has dropped, the most critical point for the European grid in 2009 was, in-line with the 2007 and 2008 figures, still high, despite being less than 2006, which was in itself a particularly bad year. The average duration of these deviations was, however, limited to 39 seconds with the longest being 4 min 40 seconds, illustrating how TSO operators act in order to rapidly suppress these deviations.

On the 12th February, 4 units on a single production site successively tripped within a period of just 4 minutes, with a loss of 3,500 MW, due to problems relating to vegetable matter clogging the cooling intakes, probably caused by European Windstorm Klaus. On this occasion RTE transmitted an 'Increase to Max. Power' order via the Warning and Safeguard System, bringing on-line an additional 5,000 MW of production within a few minutes. The timing of the incident (end of the morning), meant that reserves were available in quantity, which wouldn't have necessarily been the case under other operational circumstances.

Voltage stability

As in previous years, voltage stability has again been shown to be a sensitive operating parameter. Feedback from previous years led RTE to carry out the required network reinforcement (lines, phase-shifting transformers, and reactive power compensation) and upgrade the situation management rules for high load conditions where there is a risk of voltage collapse, particularly in the Brittany and South-eastern zones. This involves, firstly, an accurate assessment of the reliability of the voltage plan using advanced simulations (dynamic system behaviour), including, in the simulations, preventive actions such as blocking HVB1 and HVA transformer on-load tap changers and a 5% drop in HVA voltage level. In addition, in October 2009 a load-shedding controller was installed for the Brittany area (See Section 4.1.2), which is designed to stop any voltage collapse caused by the loss of a production facility.

The overall trend for ESS, following the progressive application of specific control methods, an increasing reliance on preventive safeguard actions, situations under which the automatic load shedding controller would be activated, show that the voltage stability during cold snaps is a particularly sensitive point to be monitored carefully.

Thus, in the Southeast, on the 6th and 7th January, then again between the 17th and the 22nd December there were eight "-5%" drops in HVA voltage and 9 on-load transformer blocks were required, a fact which shows the structural limitations of the grid in this area, which is suffering from a lack of new compensation installations. On the 15th and 16th December, at the peak morning and evening periods, the Automatic Load-Shedding Controller was armed, and two '-5%' signals were transmitted over a wide Western and Lower Normandy region, with the structural problems in the western region supported by the presence of a single unit from the Flamanville site.

The use of '-5%' safeguard orders or transformer blocks helped guarantee that the system voltage was kept under control for an additional load, which was estimated at 3 to 6% over this wide area.

We should however point out that the word 'control' actually means 'avoid a widespread collapse on a regional scale': When RTE has to resort to safeguard measures; it is only because without them, the system would collapse over a wide area due to the occurrence of a relatively common outage (loss of connection or plant). Moreover, during these periods, the system is not always covered by the standard measures implemented to deal with potentially rarer events such as a busbar fault in a substation.

20 level A ESS (including 18 by National Dispatching) were logged for voltage reasons (a figure comparable to 2006 and 2007). The cover all situations during which RTE sent out one or more of the following messages: 18 'Low Voltage' Critical Situation Orders, mainly in the West, Southeast, Normandy-Paris region, but also in the North and East; 3 'Voltage Warning' messages, as well as the previously mentioned safeguard orders.

These periods of low voltage were made all the more difficult to manage by two factors:

- Firstly, towards the end of the year there were unexpected unavailabilities involving certain production units on two sites in strategic locations;
- Then, there were multiple, long-term reactive power supply limits, imposed across a large number of production sites, the majority of which were located in strategic points of the 400kV grid; On each of the sites concerned, several hundred MVar were unavailable or could only be used for restricted periods with specific protocols employed. This represented a total of approx. 6500 MVar for December. The measures in place as part of the Ancillary services Participation Contract are unsuitable to deal with problems of this amplitude.

Then, there were serious import situations in early July across the eastern borders, which in themselves were atypical for these periods of the year, as well as similar problems on our Northern borders in late August and September. These led to significant problems in terms of 400 kV voltage withstand capability, associated with transit constraints.

The voltage problems also required the implementation of actions to guarantee respect for High Voltage levels during low load periods: It is often necessary that low-load lines be de-energised, which means, until they return to service, there are difficulties in respecting the 'N-k' safety rules. Thus, it was necessary to de-energise up to 26 400 kV lines in early June. New measures were rapidly drawn up and implemented; they required high levels of coordination, in terms of voltage management, between the national dispatching system and the regions, the control over the overruns of certain construction limits for limited durations and the correct use of the evaluated voltage values provided by state estimator. These measures proved efficient as a maximum of 10 lines were de-energised through the summer; the measures themselves were backed-up by more structural actions in terms of reactive load management and the installation of new capacitors in the EHV substations.

2.3 Management of interconnections

The control over interconnections, and, in general, coordination of the actions undertaken by the TSOs playing a role in the reliability of the pan-European interconnected system was highlighted, on the 16th February, by the start of operations controlled by the Technical Coordination Centre (CORESO), founded by the Belgian TSO Elia and RTE, and later, in May, joined by the British TSO National Grid. CORESO is permanently operated, manned by mixed Elia/RTE teams. They use data fusion tools from all the European TSOs and, since February, have been performing security analysis ahead of real time. Their aim is to be able to detect, throughout the European Centre-West Zone (Benelux, France, Germany) any situations liable to create reliability problems, relating to energy exchanges between the various networks under the control of each individual TSO, which would be difficult for the TSOs to detect alone, and to propose coordinated corrective actions. These activities were widened towards the middle of the year to include real-time studies of system snap-shots every 15 minutes. The pertinence of the CORESO analyses, in conjunction with the operators from the 3 TSOs, was shown clearly on several occasions by the detection of unidentified restrictions within the studies of each of the TSOs, which were linked to energy flows created by the generation flow patterns across the north of Europe, or offering cooperative solutions to deal with the congestion created by the high levels of imports to the Belgian network or the Northern region.

The management of interconnections is based upon commercial capacity allocation mechanisms, determined bilaterally by RTE and each neighbouring TSO so as to get the most out of the physical capacities of the interconnected networks whilst assuring that reliability levels are respected. These mechanisms are regularly updated to improve efficiency in terms of the various markets, but also to increase inter-TSO coordination for capacity calculations. Thus, in 2009, improved, unified rules were brought into effect for the assignment of D-1 capacities throughout the Centre-West European Zone. New rules were also introduced across the other borders.

In order to assure reliability despite the random nature of potential operational problems, the interconnection capacities offered to the various users must be reviewed and interventions can be in real-time. It is thus instructive to follow these actions, initiated by RTE or their neighbouring TSO, using Reliability Reports.

For Great Britain, operational incidents have regularly had an effect on IFA DC connection components, resulting in various reductions, particularly during February and October. These incidents gave rise to 35 ESS level 0 (26 in 2008). It should also be noted that the work to replace and renew IFA equipment was ordered in 2008 and should start, for real, in Mid-2010.

With Spain, excluding the specific problems of European Windstorm Klaus, one-off reductions in exchange capacity, a few hours each, were noted in February, March, May, August, September, October and November.

With Italy, the flow of exports was altered on numerous occasions between April and September inclusive (activation for a few hours per day over more than 40 days), in application of the trilateral agreement involving RTE, Swissgrid and TERNA, or the five nation agreements which also involved the TSOs of Austria and Slovenia; these coordinated management procedures were, in the main, activated by TERNA, with Swissgrid being responsible on a few occasions.

Finally, we must highlight the determining importance of the connections with Spain in dealing with the problems in the Perpignan area following Klaus.

2.4 Management of internal congestion

Six level A ESS, relating to 400kV transit control problems were noted. Significant levels of internal congestion were noted, firstly in the sections of the network suffering from structural weaknesses in terms of production site location and network loops, that is to say, in the Southeast and Western regions. Moreover, serious congestion situations were also encountered in the North and East of France, due to large scale imports, mainly between July and November, combined, in certain cases, with voltage stability problems. Dealing with these problems involved cancelling planned outages for work on the 400 kV network.

In the Southeast, on the 30th July, a single-tower 400kV double line Tavel-Réaltor, supplying the southeast of the Provence-Cote d'Azur region, tripped due to a fire in the vicinity of the equipment. This trip led to multiple overloads and major voltage drops. Only the very rapid reactions (just one minute) of the control operator, load-shedding around 1300 MW via the Warning and Safeguard System, avoided a cascade of trips, which would have blacked-out the whole region. In addition, on the 21st December during a cold spell, a technical problem with a substation in Tavel caused a double 400 kV busbar fault (outside of operational parameters), with the same consequences: Loss of the whole 400kV section, start of a cascade trip, stopped by the decisive action of the operator who gave the order to load-shed 2400 MW. In both cases the chain of automatic equipment transmitting the orders to the distribution equipment functioned perfectly. The permanence of the '400 kV spur' situation in the region, the result of the cancellation of the Boute-Broc Carros loop project, had, in both cases, directly contributed to the development of the situations, without being at the cause. The 225 kV 'safety net' (associated with the development of local production and the achievement of ambitious electricity demand control targets), was decided upon at the end of 2008, with the aim of providing protection for the region as of 2015 against the loss of the double Realtor - Neoules line. This will undoubtedly attenuate the consequences of events similar to those of 2009, but will not eliminate them entirely.

In the West, the main problems were related to voltage collapse risks (C.f.: Section 2.2) during the winter. In 2009 these were made worse by an increase in regional demand peaks (+ 1,000 MW over 2008, and the same between 2007 and 2008) and by restricted reactive capacities or production unavailabilities. On the other hand, work carried out by the energy producer on the combustion turbines in Brittany, which are small in size but very well located, removed their operational limitations, which appeared in the previous report. In July, RTE started work on a 400/225 kV substation in the Lorient area, aimed at reducing congestion in the 225kV network in the Southern Brittany area during heavy-load periods.

2.5 Contingencies affecting the transmission facilities

The transmission facilities sustained 9,494 short-circuits, a figure which dropped by more than 10 % in comparison with the values for the previous 3 years. Thus, the annual frequency for 100 km of overhead power line was 2.1 for the 400kV network and 6.5 for the

225kV, as opposed to 2.5 and 8.3 respectively in 2008³. 98.9% of the short-circuits were on connections and 1.1% were located within substation equipment involving transformers, busbars or compensation. 3.1% of the short-circuits involving connections triggered automatic recovery on the fault, which gives an estimate of the proportion of permanent faults. These latter faults are the only ones for which the permanent de-energising of the connection would result in lowering the network reliability until it could be restored by corrective actions undertaken by the operator.

Among the transient short-circuits, 56.8% were caused by lightning (as opposed to 52.4% in 2008), 8.9% by the wind and storms (an atypical level – 2.7% in 2008, due to the more than 400 short-circuits caused by Klaus), 1.9% due to frost and adhesive snow, 1.4% to pollution and 1.2% equipment problems (rather declining). One can see progress in terms of reducing undetermined causes, dropping to 26.7% from 36.2% (C.f.: Section 6.2 for actions undertaken), the rest (3.1%) comprises miscellaneous causes (human error, external aggression, etc.).

In terms of reliability, one should focus the analysis on faults with double 400kV lines and 400kV busbar faults. During busbar faults, all equipment connected to the bar or the section of bar is disconnected:

- 11 simultaneous faults on a double 400kV line were noted (15 in 2008), including 3 definitive, the average rate over 15 years of definitive double faults being 7%.
- 8 400 kV busbar faults, including 4 in metal clad substations.

Two of these busbar faults gave rise to 1 level B ESS and 1 level D ESS, a definitive double line fault also caused an ESS B.

The absence of short-circuits on the 400kV network following contact with vegetation, as in 2006-2007 (one in 2008) shows that the pruning work carried out by RTE, aimed at preventing this type of fault, has produced the expected results for this voltage level. Such a problem was one of the initiating factors of major incidents in North America, Switzerland and Italy in 2003.

3 Evolution of the reliability reference guide

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

In Europe

2009 saw the conclusion of the long process involved in drawing up the Third Energy Package: In the field of electricity, an EU directive (2009/72/CE) and two additional regulations (713/2009 and 714/2009) were published on the 14th August, with a corresponding impact on the organisation of markets and the reliability of the electricity network. These documents define the respective attributes of a single coordination structure for TSOs (ENTSO-E is designed to become this structure, it must, however, be authorised by ACER (ACER - European Regulatory Agency - to be founded in 2010). In terms of reliability, ENTSO-E is to be required to prepare network codes for questions relating to the integration of markets and operating an interconnected network. These codes, drawn up in cooperation with ACER and the Commission, are designed to be taken up by the Commission. It will also be the responsibility of ENTSO-E to develop shared tools for operational coordination, and to draw up a 10-year interconnected network development plan.

The EU has also published Directive 2009/28/CE covering renewable energy sources. It gives priority access to the network to these sources. The transposition of this directive into French law should highlight the actual consequences on operations.

³ Even though lightning intensity had clearly increased over 2008, one cannot draw the conclusion that the network was less sensitive as updates to the weather detection systems introduced uncertainties in terms of the continuity of the historic data on lightning strikes.

In France

In 2009 the French Ministerial Decision dated the 5th June 2009 was published in the Official Journal of the French Government, setting out the new tariffs for the use of the network (TURPE 3). These tariffs include, in particular, the recovery of RTE's expenses in the acquisition of ancillary services and for the work on the mechanical reliability programme planned until 2017.

In accordance with Article 35 of the standard specifications for a Public Transportation System, following consultations carried out within the framework of the CURTE (Electricity Transport Users Committee), in 2008, RTE published an initial version of the Reference Technical Documentation. After further consultations, updates were published in 2009. In addition to the introductory, chapters detailing the decrees published in April 2008, the chapters relating to the methodologies to be employed in connectivity studies and their respective diagrams, to normal and exceptional voltage and frequency ranges, to the secondary power-frequency regulation and metering were all reviewed.

A standard convention for production unit control and operations was also published; this stipulated the necessity that production units participate in providing ancillary services, either by an ancillary services participation contract, signed by the producer, or, by default, using group-specific requirements.

Standard contracts were also included for the provisional management of interactions between wind-farms and the network, as well as technical and financial propositions for user clients.

It should also be noted that RTE is involved in the work started by the Ministry for Environment, Sustainable Development, Energy (MEEDDM) in the autumn to implement European Directive 2008/114 covering critical European infrastructure; the work carried out during 2009 was aimed at identifying critical infrastructure to the energy network.

3.2 ENTSO-E

As shown in the inset, ENTSO-E took permanent control of the management and operations of those activities previously carried out by ETSO and UCTE on the 1st July 2009. This is why this reliability report covers the activities of these older associations along with the aspects covered by ENTSO-E.

The UCTE published, in early 2009, a study on the outlook for production capabilities looking forward to the 2010-2020 horizon. Its conclusion was that capabilities should be sufficient up as far as 2015 given confirmed investment, and up to 2020 using the most plausible scenario for announced investments.

In the shorter term, ENTSO-E has published provisional studies relating to the arrival of summer 2009 then the winter of 2009-10. These studies showed that, in both cases, the general capacities of the European Electricity System to deal with these passages, even when under stress (mainly due to the heat and drought in summer and the cold in winter), whilst highlighting the point that this result, for certain countries which were mainly importers during high load periods (including France), that this was dependant on the efficient use of interconnections.

Following on from the Public Consultation in November 2008, the UCTE published, in March 2009, new, final versions of the P1, P2 & P3 policies, dealing with the adjustment of frequencies and power, programming and the breakdown of international exchanges as well as operational reliability. Each of the TSOs is committed to applying the measures laid out in these policies as part of an inter-TSO contract (The Multi-Lateral Agreement) and declaring

any eventual shortfalls. RTE thus declared four shortfalls with respect to the P3 policy and agrees to re-absorb them.

The previous reliability reports explained the annual mechanism, in place since 2006, and used to verify that these policies were respected by the TSOs: The Compliance Monitoring and Enforcement Process (CMP). The statements of conformity to the rules, drawn up by the TSOs on a self-assessment basis, should have, since 2008, been backed-up by a list of applicable internal documents. In 2009 the verification campaign, led by the RGCE group, was based upon the P8 policy published in 2008 covering the real-time control of operators. RTE is one of the group of TSOs that fully conform. As an extension of the improvements introduced during 2008, on-site verifications (based upon Policies P3, 4, 5 and 6) were carried out by a team of experts from other TSOs, verifying volunteer TSOs, which were the Polish PSE Operator and Portuguese REN.

3.3 Contracting contributing to reliability

The year was marked by a dispute between POWEO and RTE concerning these obligations, POWEO contested the requirement to participate in the Ancillary Services with the payment conditions drawn up by RTE. CoRDIS, decided, on the 2nd October 2009, to dismiss the appeal by POWEO. POWEO then appealed against this decision.

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

RTE published a new version of the regulations covering the Balancing Mechanism applicable as of the 3rd March 2009, introducing the contractual mechanisms used by each market company to calculate the consumption suppression volumes activated on D-1 or on the same day to guarantee RTE's provisional consumption figures as and when required.

Following the change of SAS tool version (Safeguard & Warning System), the 'General Operating Rules for the SAS' were reviewed in depth, both internally within RTE as well as by in-depth discussions with the producers and distributors in order to define the precise operational commitments required by the addressees of warning and safeguard messages transmitted by RTE to the production and distribution control centres. These new General Operating Rules for SAS (RGE SAS) have been signed by all producers and distributors concerned (See Section 4.1.5).

The contractualisation, involving the distributors, covers various subject matters which have a direct link with system reliability. In 2009, consultation work was carried out aimed at managing compensation work and the reactive consumption of source substations. In the

ENTSO-E

ENTSO-E (European Network of Transmission System Operators for Electricity), founded at the end of 2008, has, since 1st July 2009, been the single body responsible for the European TSOs. It has replaced all the older regional organisations, including the ETSO and UCTE.

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 old ECTE, the SOC created a regional ad-hoc sub-group - The Regional Group Continental Europe (RGCE). See: www.entsoe.eu

same way as the reactive production capacities of the generating units, this element is essential to the control of low voltage problems, and RTE has noted over the last few years that there has been an alarming movement by the distributors to remove compensation means in light of the existing contractual conditions. A project for an addition to the Reference Technical Documentation has been tabled by RTE for discussion: The measures planned assure RTE of the availability of sufficient compensation means within distribution source substations, as well as applying a rule for dynamically energising and de-energising these systems to match changing loads throughout the day. The consultations with the distributors showed that these measures cannot be introduced within the financial framework of TURPE 3: Temporary conditions have been agreed with eRDF, accompanied by a commitment to implement the article in the Technical Documentation by TURPE 4. These temporary conditions are to stabilise the compensation levels. This agreement, drawn up in 2009, should be transformed into a contract by 2010 for each source substation. The question of an extension to other distributors remains to be answered.

3.4 RTE internal reference guide

The System Operations Reference has been improved to introduce documents covering the preventive use of the safeguard measures to warn of the risk of a voltage collapse (updated following experience in Winter 2008 and the introduction of the ADO Programmable Logic Controller (PLC)), the use of emergency means during supply-demand balance problems, the general operating rules covering safeguard orders, methods for using re-energising equipment, the control of the life-cycle of specific PLCs, short-term provisional consumption, capability of substations to resist to short circuit currents. Transitional arrangements for definition of maximum current levels in day/night mode have also been added.

In terms of the Transport Operating Reference, it should be noted that there has been an update to the principles concerning document management, the publication of elements to define management methods following equipment outages or theft of earthing equipment and dispensations to maximum current operations within the framework of current tests (See Section 4.1.4).

The two divisions, Transport & Systems, are slowly developing a shared reference. It was enriched during 2009 by a modification to the doctrine used for the establishment and sharing of the electro-technical characteristics of installations.

4 Evolution of measures contributing to reliability in the equipment field

4.1 Intrinsic performances of components

4.1.1 Generating sets

The number of renewable energies generating units continues to grow. Wind-farm production, by the end of 2009, was 4400 MW, the rate of growth of approximately 1000 MW / year has continued. The mean load factor for wind-farm production (as opposed to installed power) was 22%, varying between 12% in August and 42% in November (with a peak of 78% on the 23rd November). Photovoltaic production took off during 2009, with more than 180 MW installed by the end of the year. The objectives of the '*Grenelle de l'environnement*' (French Environmental Policy Meetings in 2007) were 19000 MW of wind production and 5400 Photovoltaic by 2020.

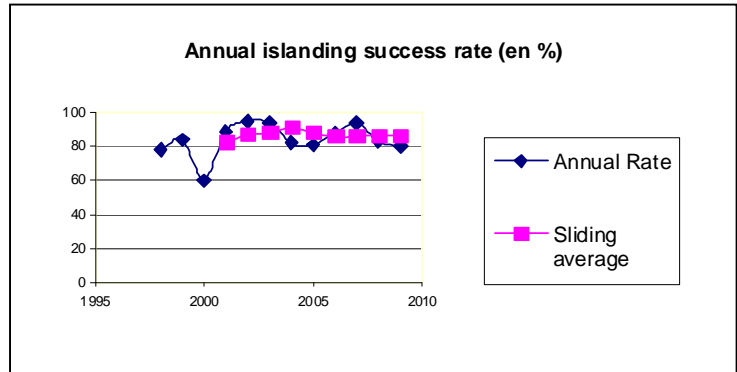
The CRE has sent out a call for tender for land-based solar power stations. Responses to the tender for biomass generating stations were still being analysed on 31st December.

It should also be noted that the Nuclear Safety Authority has given, in principle, its agreement to the extension to the service lives of REP 900 nuclear power plants (to be

confirmed on a reactor-by-reactor basis during 10 year inspections). New thermal generating sets with significant unit capacity must also be reported, with:

- In April, the coupling of a combined gas cycle (CCG) at 410 MW to the Pont-sur-Sambre power plant in the 'Nord' region of France and that during the second quarter of two 450 MW CCGs to the Emile Huchet plant in the East, as well as a 440 MW CCG in Gracieuse (Fos) at the end of December, no industrial commissioning had taken place by the 31st December;
- The industrial commissioning of a third combustion turbine of 185 MW in Vaires sur Marne in the Paris region.

For existing generating sets, a major point to be considered is the success rate of the islanding operations (i.e. disconnection to house load), in view of their importance when having to cope with a possible network restoration following a major incident. The performance levels are sufficiently stable as regards the rate required to apply the policy of restoring the network by the main structures. Seventeen scheduled tests were carried out 13 of which were successful. There were three unscheduled but successful islanding operations. This gave a global success rate of 80% for 2009 and 86% over a four year sliding period (stable).



The other major point in the event of a large scale incident concerned the voltage return scenarios which help guarantee a supply to the auxiliary systems of nuclear reactors after an emergency scram; they can also be used to reconstitute the network. The contract signed by RTE and EDF on this subject is covered by the framework of the "Steering Committee for Network Recovery Management and Voltage Returns" (CPRR). This committee plays a major role in the sharing between market companies and the resolution of problems. Moreover, there were a number of programmed tests delayed or cancelled during 2009. In detail, 16 out of 23 initially scheduled tests were carried out successfully. However, for two of them, the voltage returns were satisfactory but the corresponding sub-network could not be re-coupled to the network, which is unsatisfactory from a network recovery point of view.

Overall, the voltage recovery test success rate can be characterised, for 2009, in two ways:

- defined as the ratio between the number of successful and attempted tests, it is 100% (as opposed to 83% in 2008, 79% in 2007 and 95% in 2006); this rate is interesting with regard to what might happen in the case of a widespread incident;
- defined as the ratio between successful and initially scheduled tests, it is 69% (46% in 2007, 86% in 2006); this calculation mode allows one to include aborted scheduled tests, with regard to which a close watch must be kept so as to maintain an adequate periodicity of tests for each voltage scenario and for each target generation site.

The results are successful in terms of pass rates, but average in terms of the total number of tests carried out: 4 sites were not tested during the year and 9 tests were delayed. The performance in terms of tests completed, monitored by the CPRR, must therefore be kept under close surveillance during 2010.

4.1.2 Protection systems, operation PLC's, instrumentation and control

The year was marked by the roll-out of the Western Load-shedding PLC (ADO). This dedicated and complex PLC was developed rapidly thanks to feedback created during the winter of 2008 and commissioned on the 15th October thanks to the full commitment of all RTE, eRDF and EDF personnel involved. The ADO, in conjunction with the SAS, decides

upon load-shedding operations to stop a rapid voltage collapse caused by the loss of a plant; to do this it monitors a set of voltages in the VHV substations as well as, in a specific mode, the availability of the Cordemais plants. ADO is only armed when the situation becomes tense.

In terms of the 400 kV protection plans (plans 1975, 1983 and 1986) there were 54 LV anomalies which had an impact on the HV system, a number which, in general, remained stable. 39 of these anomalies occurred during the elimination of one of the 479 electrical faults. Note that this value has returned to the mean level of between 2003 and 2008 after the increase in 2008 (51).

These anomalies are broken down into 25 untimely circuit breaker trips, two late trips, 2 failures to close and one late closure.

35 of the 54 anomalies were technical in nature, including 11 due to equipment malfunctions, 9 due to operational limits - elimination of specific faults - and 21 from the telecommunications systems, an increase over 2 years (17 in 2008, 9 in 2007 and 2 in 2006), with a significant percentage of the total being concentrated around a few individual installations. 6 anomalies had a human cause, 1 was due to equipment damaged by an external factor and 6 were of an unknown cause.

The digitisation of substation instrumentation and control systems continued. This has almost reached its cruising speed, which will however be high as approximately 40% of the HVB1 400kV plants are going to need replacement technology by 2018. Malfunctions were noted during these first years, as is often the case with the roll-out of a new industrial tool level. RTE should consolidate its overall control of the operations and maintenance of this equipment in cooperation with its suppliers. A safety audit on this subject, scheduled for 2008-9 will conclude during the first quarter of 2010.

In an associated field, in 2009, RTE agreed to a renewal programme for the inter-substation remote control architecture, doing away with the proprietary protocols and replacing them with industry standard protocols, extending the current processing limits in terms of communications speed and quantity of remote data.

4.1.3 Automatic frequency and voltage controls

The rollout of the RST-N system, which concerns the renovation of Secondary Voltage Control, has been achieved in all the regions. Moreover, the tool has been improved to improve integration of the reactive power capacity diagrams for the various plants (which we considered could be the cause of major limitations) in order to use to a maximum the available capacity.

4.1.4 Transmission facilities

In terms of the area covered, the passage of European Windstorm Klaus, despite being stronger than the storms of 1999, caused damage to just half the number of lines, three times fewer substations were cut off and four times fewer towers were damaged. These results clearly show the effects of the rollout of the reliability policy started in 2000, and its pertinence; the rollout should be complete by 2017.

Changes to the 400kV network in 2009 were as follows:

- Replacement of the Avelin-Warande link conductors to improve the northern network, as well as those along the Tavel-Tamareau line (ACSS technology) to reinforce the link between the Rhone Valley and the southwest of the country;
- As part of a short-term reliability programme in the East-Provence Cote-d'Azur region, the second section of the double Néoules-Trans link was increased from 225 to 400 kV to increase its capacity, this was linked to the installation of a 225 kV phase-shifter transformer in the Boutre substation. With the increase of the second section of the link to Broc-Carros to 400 kV programmed for 2010, the whole link will have been improved.

One should also note the installation of various high voltage control equipment (3 HV capacitors in the southwest, in the Rhone-Alps regions and in the East) and low voltage systems (capacitors, including 225kV, in the West).

In terms of operations, under operating conditions approaching the limitations of the electricity system and taking into account the problems with reinforcement and development of exchanges, a lot of work has been carried out over the last couple of years to optimise the maximum admissible current levels on the lines.

Various measures have thus been put in place, including on the 400 kV network, to deal with temperature differences between day and night time or dynamically change the seasonal mode being applied to match the actual weather conditions on the day. In 2009, the regions invested heavily in the rollout of these measures, which have been regularly and profitably employed during stretched operating conditions, but they do highlight the operational rigour required to control these regular changes (in the overload protection PLCs and control tools). If this is badly managed this line of progress can create its own risks, which must be analysed in more detail. Thus, one level A ESS was logged for a situation in which a database in the calculatory tools for network states was fed with incorrect data for a period of 3 months due to successive manual updates.

The experimental monitoring system, installed on a 225 kV line in the West, with the aim of providing dispatchers with real time information on authorised transmission capacity was not sufficiently reliable to be really used fully in 2009. However, a different device of a similar type, being tested in the Southeast since the middle of 2009 has returned encouraging initial results. Other experiments are underway: One of them, in the Rhone-Alps region, is based on the evaluation of the correlation between the wind chill factor on conductors and the production levels of wind-farms, examining whether it is possible to employ higher loads because the production levels are higher and thus likely to overload the line. Another, in the Southwest, is examining the feasibility and possible gains from a day-to-day evaluation of admissible currents with regard to weather forecasts. These remain, however, just experiments and must be continued before genuine conclusions may be drawn from them.

4.1.5 Control systems

Behaviour of the National Control System (SNC) can be characterised by:

- The total unscheduled unavailability for the SNC of zero minutes (as in 2008);
- The outage time of the power frequency control level signal transmission (RSFP) from the SNC at midnight (taking into account the automatic backup provided by the National Mimic Board (French acronym - ASN).

In 2009, the rollout of a new regional level network control tool (SRC) continued. By the end of the year, 5 out of the 7 regions were using it in day-to-day operations and the final two (Lyon & Toulouse) had started controlled operations. Due to the relatively young age of this platform, 7 level A ESS were logged, mainly due to performance-related problems or abnormal behaviour after a change to the database. The actual availability level was estimated at 99.97% (at the lower limit of the targeted threshold) for the last months of 2009, it will be closely monitored in 2010.

This platform improves ergonomics, increasing dispatcher efficiency and providing new functions, facilitating, for example, the broadcasting of remote operating commands to substations from the dispatching centre, an upgrade which was widely used in 2009.

Within this field of control tools, 2009 was notable for the industrial commissioning of the IPES wind-farm and photovoltaic production display, on a local, regional or national level, as an extension to the experimental tool used in 2008. Developed by RTE, with cooperation from eRDF and other distributors and producers, IPES acquires real-time data on individual power readings and provides a real-time estimate of performance and production provisions⁴ up to 48 hours ahead. The quality of the data produced is dependent on the quality of production data and observability rate, which, by the end of 2009, stood at 64.5%.

These forecasts have been found to be very useful for regional D-1 studies to improve understanding of actual congestion situations and the possibilities for short-duration work. In terms of feedback, the logs from the tool have, for example, allowed the Western region to start capitalising on the behaviour of wind-farms when a fault happens within their connection zone. IPES forecasts will become more and more important due to the increase in the quantity of renewable sources: It is essential that current efforts are maintained over the longer term to increase the percentage of remotely-monitored installations and assure that the database is of the highest quality.

The French Remote Control System

The size and complexity of the French Electricity System means that a hierarchical organisation of control and command systems is a necessity, with four levels of control:

- Nationwide: via the Centre National d'Exploitation Système (CNES – National System Operations Centre);
- Regionally: via the Unités Régionales Système Electrique (URSE – Regional Electricity Systems Units);
- Control and Command groups – from the PEXI (Computerised Control Desk) for sets of substations on transport installations, supported by centralised user control posts (producers, distributors, consumers, etc.);
- Locally: via power installations (transmission substations, production plants, etc.)

These control levels are linked by the 'Reliability Network', a communications system exclusively for operations, which allows operators to exchange orders and data under all conditions, notably when public communications lines are overloaded or unavailable.

The PCCP project (Production Centralized Control Point) was used to transfer RTE's current responsibilities to the producers, in terms of generation scheduling and balancing in day ahead, intraday and real time. After the transfer of responsibilities to D-1 in 2008, 2009 was a development year, both for the producers and for RTE. A set of tests on the new organisation and tools was carried out by RTE and EDF. The actual changeover is expected for 2010.

To support this important change to active production control modes, in October, RTE started limited operations of 'Scorpion' tool in two regions. This is used to let regional operators evaluate, in near real-time, that the production plants are actually respecting the programmes (power to be produced and assigned primary and secondary frequency regulation settings) and to intervene as quickly as possible if there is an undeclared shift from the production plants.

A renovated, unified platform, Convergence was developed to homogenise the network development study tools currently in use (long-term) and for preparatory studies for real-time operations. It improves the stability of the analyses carried out over various timescales and improves methodological coherence. The rollout of Convergence across the CNES and the regions started in 2009 and should be completed during 2010. Convergence has also been installed at CORESO.

⁴ Algorithm developed by RTE R&D division

In conjunction with the re-write of the General Operating Rules for an SAS, a new system version was rolled out in 2009. The reliability of this system is crucial to the safety and reliability of the network, as shown by the use of SAS during major incidents this year (in the PACA region, loss of 4 units, management of stretched voltage situations): The mean unavailability level of the function has been improved in 2009 to 0.25% (0.44% in 2008) in line with the replacement of certain computers and the end of EDF's rollout of the new RTE interconnection architecture (ARCHIPROD). The contractual relationships with distributors includes the completion of period tests of critical system backup functions (transformer setting locks, 5% HVA voltage drop, remote load shedding). The rigour of these tests, which can be variable, is progressing. However, these tests regularly showed that certain of the distributor's control centres were not operating in conformity, confirming the fact that one or more ESS are logged each year for varying levels of extended safeguard orders.

Concerning the telecommunications network, RTE has been running the ROSE project, which consists in modernising the *Security Network* by digitising it and further equipping it with optical fibre telecommunication cables, installed on the company's transmission structures, to accommodate high-level reliability-related applications: Teleprotection firstly, with priority to line differential protection, then, tele-control and telephone security.

In 2009, the fibre-optic network installed as part of the ROSE project reached 1290 km in length, the line laying programme should be completed during 2010, services on the general remote control network have been tested on a pilot loop.

In terms of tele-protection, 15 communications lines, between the ends of the 400kV line differential protection, were chopped to a ROSE system in 2009. Even though this figure is lower than 2008, the programme has already migrated more than 75% of these connections and should be fully completed by 2011.

For the classical microwave network, traffic on which is decreasing steeply, even if availability remains satisfactory the contractor's response levels in terms of the detection and repair of malfunctions is dropping, with a detection rate of 44% (for a contract commitment of 70%) and the number of guaranteed service restoration deadlines exceeded was 164, against 102 in 2008. The average downtime is also worsening, particularly in the Eastern region.

Reliability Communications Network

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.

4.1.6 Load / Consumption

Changes to this field, in terms of progressive advances in the development of demand actions, are facilitating control over the supply & demand balance, particularly during stretched periods. These actions generally involve reducing or temporarily offsetting the instantaneous demand.

In Brittany and the Southeast, RTE has continued development of the system to encourage private customers to limit their consumption during peak periods. In the West, the Ecowatt system, with 18,000 subscribers at the end of 2009, has sent out 3 orange alerts and 8 red during the year. In the Southeast the alert system has 17,000 subscribers and transmitted 8 alerts. These messages are repeated by local and national media as well as by private means. An initial estimate indicates that these alerts can reduce consumption at peak periods by 1 to 1.5% in Brittany and the South-east PACA, even though this evaluation needs more work.

Following a call to tender launched in 2008, RTE had an additional 100 MW available to the Balance Mechanism during the period between October 2008 and September 2009, this capacity was supplied, on request from RTE, by industrial contracted consumers connected to the transmission network (in the form of withdrawals). Even if this remains modest, the experience has been positive- the CRE considered it on the 29th October-, and has been extended to cover the winter of 2009-10.

Launched in 2008, the Balance Mechanism participation experiment involved the aggregation of withdrawals from various consumers, it hadn't really got going in 2009 due to a lack of useable offers: it should reach a contractual minimum of 10 MW, below this figure there is no measurable effect.

Regional demand management actions also continue, particularly those undertaken by regional authorities. RTE signed a partnership agreement with the Brittany region. Four areas of cooperation were covered by the regional agreement. Consultations and exchanges on new power plant sites, actions to limit electricity demand, the setting up of an energy observatory in Brittany and actions to create a shared vision of regional energy stakes. In the Southeast, RTE, a member of the Capenergies Competition Centre since 2008, has been closely following the PREMIO experiment (intelligent network combining consumption management, production and storage) in the community of Lambesc.

4.2 Structure of the system and its design rules

In 2009, RTE published its fourth provisional supply & demand balance report for electricity in France. The reliability of electricity procurement for France appears to be reasonably stable up until 2013, taking into account production facilities expected to enter service. The report, however, does warn of the increasing impact of cold snaps (sensitivity of 2,500 MW per °C is expected by 2025). Beyond 2015, the outlook remains extremely fluid in terms of supply & demand balance. The report also highlights the importance of the development of peak demand management and underlines the fact that the reliability of the supply to Brittany and the East of the PACA region should be studied carefully and will require new network investment, demand management and the development of local production.

This work has also aided the multi-annual production investment programme drawn up by the French Government at the end of 2009.

RTE played an active role in the working group 'Poignant-Sido' covering the management of peak electricity demand, launched by MEEDDM during the last trimester.

In addition, in 2009, RTE published the 'Connection Potential' for each zone, for each RPT voltage level (early 2010 for 400 kV). These values give producers, in particular those working with renewable sources, an up-to-date vision of the zones most suitable for

connection. They are defined as a maximum additional power level acceptable on the network, given that production withdrawals may be necessary under certain circumstance.

As announced in the 2008 report, given the fundamental changes over the last few years: restructuring of the market, Europe-wide outlook, increased local production power and new solutions (underground, DC), in 2009 RTE started work on the first steps of a project aimed at defining a new policy for transmission network development, providing technical targets and development strategies and drawing up associated study methods.

In terms of the decision-making study doctrine, it has been decided that studies will, as of 2010, integrate the modalities for the integration of N-1 double line operating rules (simultaneous loss of two lines from a single support). The objective of this change is to ensure that the long-term design of the network remains coherent with the operational reliability rules and to facilitate maintenance operations on an operational network.

In order to reduce the regular congestion in the 225 kV regional networks caused by border crossings and production injections at 400 kV - See Section 2.4 - the Northeast region has studied a re-structuring of its regional plan, to be rolled out in the years to come as and when the structure evolves.

4.3 Other material measures contributing to operation

The management of the profit margins required to assure the supply & demand balance is based upon a tool used to determine the margins required on a scale of 2 to several hours in order to deal with various possible random factors (impacting on expected demand, on the appearance of production restrictions and plant outages, on the level of de-centralised production). A new algorithm has been introduced to improve representation of the changes in wind-farm production.

5 Evolution of measures contributing to reliability in the organizational and human domain

5.1 Reliability culture, management of the Human Factor, Training

The Human Factor

As in 2008, an analysis of human factors as part of operational events, with or without consequences, is, within operational units, covered by constant logging, analysis by the teams concerned and, sometimes, reused by organisers of training sessions. This activity is based upon a variety of approaches. One strong point in the efforts undertaken over these last few years is the increase in the self-declaration of events: Transparency is becoming more and more the norm and seen as a way forward. In summary, the overall results remain mixed, at least as far as concrete results are concerned, as patient and constant work is required over time to make progress. The average level of events having an impact on operations but with a human factor involved has remained stable over several years now, one explanation for this being that the types of cause noted are multiple and no one cause is dominating the others. At the end of 2009 the CNREX (See Section 6.2) ended its push to strengthen the approach using a coordinated vision.

Training

Initial and refresher training for the various professions involved are organised at a national or regional level in accordance with the planned programmes.

Beyond the training syllabus for real-time operators on the electricity network, the regions also organise additional training for their personnel to strengthen and maintain skill levels, particularly in terms of those questions rarely encountered during operations: Voltage returns, human factors, hazard risks, etc. Awareness sessions are also regularly organised for personnel whose work has a direct impact on reliability (development, provisional management, protection adjustment, etc.).

Specific training was tried out in Lyon for network operators training new arrivals in the trade by 'doubling-up' on a post, it should be widened in coverage over 2010.

Training to cover short-term consumption provisions had its first pilot session.

In line with the roll out of the Convergence studies platform, the studies training syllabus, currently shared with network and operations development studies, has been redefined.

In the Northeast region an experiment was carried out on a joint training programme for operators of the electricity system and transport equipment to develop understanding of their interactions during changes and the management of incidents. The Southwest, Normandy-Paris and Eastern regions have also undertaken actions in this area.

Reliability Culture

As each year, RTE has offered external companies (notably producers and distributors) regional training sessions entitled 'Together assuring reliability'. These training sessions are the main way of improving these companies' understanding of the risks to reliability and the phenomenon that occur during incidents impacting on the electricity network. The sessions are all the better as the participants are from a number of origins. It is a pity to note, however, that, as in 2008, participation levels were mixed: The number of sessions actually held goes from zero (Southwest, Northeast) to 4 (Southeast) depending on the region, the participation of distributors is highly variable, in addition, and this is a pity, a single 'mixed' session took place.

Forums organised for those companies involved at a regional level to meet up may be the perfect occasion to share a few reliability awareness messages, but they can in no way replace the aforementioned training programmes.

Other exchanges aimed at supporting the diffusion of a reliability-based culture should also be noted:

- The Western region organised a dedicated distributors forum in November to prepare for the onset of winter (focussing on the installation of the ADO)
- Training personnel and operators from the Northeast region met their opposite numbers from a nuclear plant to share experience and examine on their respective simulators serious incident situation.

5.2 ISO 9001 certification – management system

System reliability benefits from the measures set up by RTE for its management system (which has earned it ISO 9001 V2000 and ISO 14001 certification). The certifications were renewed in April 2009 following an audit carried out by the AFAQ-AFNOR. The auditors highlighted the progress RTE had made in the analysis of risks at a company-wide level, the improvements to activity scheduling and the progress in cross platform links.

Supervision of the enterprise process entitled 'Assuring a balanced flow' was, in 2009, the responsibility of the CNREX in line with its re-direction (see below).

5.3 Feedback (organisation of feedback, evolution of the ESS scale)

The feedback process is driven at an RTE-wide level by the National Feedback Committee (CNREX). In 2009, the number of séances it held was increased to confirm its role of being responsible for reflection and orientation on the subject of operating methods, improving operational performance, reliability and quality of service.

With this in mind, the weekly feedback meeting was reviewed to improve responsiveness and the global coherence of the process: The two weekly operating reports drawn up from different points of view were merged as from the 1st September. Based on this report, a national 'short loop' mechanism was defined and tried out: It is capable of collecting initial data from operational events quicker than before, analysing the causes and risks and determining the follow up between regions and national entities. This measure, to be generalised in 2010, could be evaluated towards the end of 2010 to confirm its efficiency and ability to improve experience sharing.

Significant System Events (ESS)

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.

Work was undertaken in 2009 to determine possible solutions aimed at accelerating, where necessary, the re-energising procedures for equipment tripped by isolation fault protection devices. This means, in effect, reconciling personnel and equipment safety requirements during voltage restoration with the fastest possible restoration of network integrity; the safety of the electricity system and the supply to customers may, under certain circumstances, be seriously compromised by the loss of 400 kV links, as shown in the examples of the incidents on the 30th July and 21st December in the PACA region. The work was aimed around improving the means used to rapidly locate an initiating fault at a distance and determining a list of sensitive points for each link to be check visually before re-energising, noting that the conditions for the implementation of this accelerated process were studied in 2009. Work should continue throughout 2010.

The CNREX has launched a number of other subjects based upon feedback and covered in this report, such as: Preparation for the onset of winter 2009-10, using data from last winter; management of High Voltages; Analysis of human factors in operations; European Windstorm Klaus; Major ESS.

The classification grille for Significant System Events (ESS) used to provide feedback on the reliability of the French electricity network has not been changed since 1st January 2004; This stability means that a multi-year comparative vision is possible, looking at the occurrence and treatment of both minor and major events impacting upon the electricity system. However, the feedback obtained, as well as changes to the architecture of certain control systems, suggests that the grill could do with a few minor updates. This work is programmed for 2010.

Drawing from these principles, applied by RTE in 2008, as shown in the Reliability Report for last year, some initial steps have been taken aimed at monitoring events impacting on the interconnected European network, with the application of an incident classification grille used jointly by the German, Belgian, Dutch, Luxembourg, Swiss and French TSOs. Analyses of the events logged in this way by the TSOs concerned, supported by CORESO, mainly deals with events impacting upon a minimum of two TSOs and shows that this new practice is starting to take hold (486 events logged). Even if no major incidents impacting on two or more TSOs were logged it should be noted that violations of voltage threshold levels doubled, this is particularly due to the problems of different TSOs managing HV situations.

5.4 Performance monitoring

According to the ancillary services participation contract for 2008 to 2010, the performances monitored regionally by the CdP Prod tool are the following:

- In the frequency / power domain: generating set supply of the expected primary reserve and its maintenance for 15 min during a frequency excursion, conformity with schedule for generating set participation in primary control (reserve, static gain) and secondary control, the correct scheduling of the contribution to primary and secondary control, and the response times to these control requests.
- In the voltage / reactive power domain: availability of the totality of the contracted domain, participation in secondary voltage control, time and speed of response to the control requests.

Verifying the performance of Production Installations

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 against frequency-power controls (droop, participation, etc) as well as voltage levels via the situation of the operating point of the set in the U/Q diagram.

All of the regions have applied the generation unit performance monitoring with its associated technical and financial aspects. Beyond this, in response to the recommendations of an audit on the subject, carried out in 2008, RTE's regional teams aimed for the target of at least one meeting with producing sites and their management a year to analyse, in-depth, the performance shortfalls noted, their causes and any possible remedial actions. The regional reliability reports quote several examples where the regularity of the tests and the awareness and technical analysis carried out during meetings have jointly highlighted and corrected shortfalls (offset of stator voltage limits, dynamic performance, etc.). On the other hand, it was confirmed that the permanent nature of a technical limit meant that it was impossible to respect the contractual dynamic figures for reactive power variations by adjusting the secondary voltage on two units which were essential to hold the voltage stability in the Western region.

However, as noted in Section 2.2 'Voltage Stability', RTE has, over time, had to deal with a high volume of problems with reactive capacity, for which, taking into account the financial and technical aspects of their correction, the financial incentives in the ancillary services

contract seem insufficient. Beyond the various managerial actions undertaken to establish a plan for the absorption of these shortfall with the producer, something should be done in the upcoming round of contract modifications.

With the rollout of Scorpion (See Section 4.1.4) quasi real-time verification of participation in primary and secondary rules is possible, which will benefit electricity system safety.

Verification of the performance levels attained by distributors remains less well structured than for producers. The completion of ever-increasingly complex and regular operating tests on the SAS is a step forward. The verification of safety-critical points and the respect for the contractual elements currently being finalised for reactive power compensation are yet to be defined.

5.5 Crisis organisation

Several Crisis Cells have been activated for real, on a national level during Klaus, regionally for the Quinten storm and for two load-shedding operations in the Southeast.

The ORTEC plan organisational note was revised in 2009 based upon feedback.

The national load shedding exercise overseen by MEEDDM, scheduled for the second quarter of the year, was put off until 2010 on request from the Minister responsible.

A crisis management exercise, crossing national borders, was carried out for the first time; it involved the Belgian TSO Elia and CORESO and showed the ability of these two TSOs to take coordinated decisions in terms of load shedding to assure the stability of a seriously compromised network situation.

Amongst the various regional exercises one should highlight the remote network control system outage for the East and Northeast regions.

The ORTEC plan

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 the DTE 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.

5.6 Other organizational measures contributing to reliability

The management of large scale construction or renovation work on the network is an important part of operational reliability and performance: In the short term, it is necessary to lock out the equipment required for the work without changing the reliability levels, on longer term, future investment work⁵ (new works) or maintenance on existing equipment must be carried out within deadlines and without delaying any investment work. 2009 was the first year during which this task was carried out in accordance with a multi-year schedule (3-year horizon), used to improve the efficiency and reliability of the process.

One of the essential operating principles in terms of electricity system reliability is the rule known as 'N-k'; this is used to guarantee that system upgrades are managed after the loss of one or more components by comparing the relative levels of risk⁶ for the various incidents to be taken into account as it is economically impossible and technically unrealistic to cover against all improbable incidents. In 2009, an experiment in the adaption of the application of this rule was carried out. On the 400 kV network this involves, taking into account the normally extremely low probability of this event, to guarantee the ability to deal with the

⁵ Investments announced by RTE have increased greatly: more than 1 billion for 2009

⁶ The risk is defined as the product of the probability of the incident by the gravity of its consequences.

simultaneous loss of two circuits on a single support only when there are unfavourable external conditions (weather conditions, risk of fire, identified common mode, etc.) which increase the risk (with the exception of certain permanently covered equipment). The experiment showed the pertinence of this approach: It provided additional possibilities for the locking out of equipment and savings in congestion costs. The definitive conclusions should be published during 2010.

Announced within the 2008 report, the margin oversight observatory was completed in 2009. The aim was to improve information on the impact of the behavioural activities of several types of market participants in terms of the margins available to the Balance Mechanism, which is also influenced by physical factors impacting on the production sources (hydraulic, temperatures, availability, etc.) Variations from one year to the next (See 2.2) in the number of S orders transmitted due to an insufficient margin illustrate the complexity of the analysis.

6 Lessons drawn from the year's events

6.1 Lessons drawn from the ESS and from their analysis

The number of ESS at level A or greater has clearly increased, reaching a total of 67. Breaking down these ESS into fields provides similar results to the previous years, with the increase being predominant in the 'System Operations' field.

It should be noted in particular that there were 8 ESS level B, 1 level C and 1 level D. One should not be too hasty in drawing the conclusion that the reliability levels reached are lower on a long-term basis, various conjunctural elements (rollout of a new control tool for regional dispatching, storms) and structural elements (problems with the PACA zone supply) must also be taken into consideration. However, these facts alert us, and in 2010-11 particular attention should be paid to the actions undertaken as a response to the feedback from these events, and the general actions undertaken by RTE as part of its constant and regular updates and changes, assuring that they are efficient in stopping this tendency.

Their breakdown per scale level and domain is listed below.

| ESS | 2005 | 2006 | 2007 | 2008 | 2009 |
|----------------|------|------|------|------|-----------|
| A | 65 | 45 | 41 | 37 | 57 |
| B | 4 | 4 | 2 | 2 | 8 |
| C | 1 | 0 | 0 | 1 | 1 |
| D | 0 | 1 | 0 | 0 | 1 |
| E | 0 | 0 | 0 | 0 | 0 |
| F | 0 | 0 | 0 | 0 | 0 |
| Total \geq A | 70 | 50 | 43 | 40 | 67 |

| ESS \geq A | 2005 | 2006 | 2007 | 2008 | 2009 |
|-------------------|------|------|------|------|-----------|
| Network | 9 | 6 | 8 | 13 | 9 |
| System Operations | 34 | 36 | 23 | 17 | 37 |
| Control Systems | 18 | 3 | 5 | 7 | 15 |
| Production | 6 | 4 | 5 | 1 | 4 |
| Distribution | 3 | 1 | 2 | 2 | 2 |
| Total \geq A | 70 | 50 | 43 | 40 | 67 |

The level D ESS is for the load shedding in the PACA region on the 21st December following a double busbar fault; in terms of the actual damage it was a level C, but was classified as a level D due to the potential impact it could have had without the efficient and rapid interventions of the control room operators.

The ESS C is for the 12th February and the tripping, within a four minute period, of 4 units in a single site, causing a drop of 3500 MW, which gave rise to a limited frequency drop (-75 mHz) and which, was controlled without impact on consumers; a really simultaneous trip would have exceeded the rated absorption capacity of the interconnected European network and could thus have led to a frequency related load shedding operation. Feedback has let us define a warning system, helping RTE to anticipate the management of this type of situation, which, nevertheless, remains very delicate.

The B-level ESS concern:

- The 1300 MW load shedding in PACA following the tripping of two 400 kV supply lines in the region, between Avignon and Marseille, following a fire under the lines and the intervention of the civil emergency services;
- The consequences of Klaus;
- A de-energising of a 400kV substation, caused by an equipment failure following abnormalities in the protection system, elimination of the fault would have meant that just half the substation would have had to be isolated;
- The inappropriate clearing of a busbar fault in a 400kV substation, processed as a double busbar fault, leading to the de-energising of 3 400 kV links and the outage of a nuclear plant;
- A lack of respect for the N-k safety rule for two ESS: One, lasting one and a half hours, relates to voltage control in the Northern zone, following a conjugation of stress on the supply & demand balance, large-scale imports and a high consumption level, the other, lasting a total of 400 hours, relates to a failure in a PLC adjustment system, detected at a later date;
- The delayed response of the distributors concerned by a -5% Un safeguard order on certain HVA substations, , mainly due to the fact that the SAS function was used inappropriately, and, for one case, the absence of an automatic device;
- The 2 hour loss of remote control capabilities from a regional dispatching centre without losing sight of the network status, the network remained controllable using PEXI equipment in the main substations with downgraded action times.

In addition, 1286 0-level ESS were declared (10% increase over 2008). Their declaration is encouraged because it is invaluable to improve feedback even though they have little effect on reliability⁷, and to carry out theme analyses.

Also, in 2009, the CNREX examined an ESS 0 caused by a malfunction in the remote control system assuring the secondary voltage and frequency configuration settings for a regional dispatching centre. The actions undertaken involved, in the main, improving training. This ESS also shows the importance of improving the sharing of feedback across regions, particularly in the field of remote controls.

The regions were also involved in operations involving the ESS 0. In addition to dealing with the ESS A and over, the majority dealt with some of the ESS 0 in depth, mainly those relating to incidents involving remote control tools or 400 kV losses.

The systematic exploitation of the data drawn from this ESS remains, to RTE however, a potential pointer for progress, strengthening their ability to warn of the more serious incidents, which, as the records of serious incidents show, are generally the result of a combination of events which are minor when considered individually.

Thus it is interesting to examine changes in production reliability and the efficiency of the ancillary systems; the ESS 0 provide an initial evaluation and a few trends can be seen: Over the period 2005-9, the number of trips of units of more than 120 MW has remained stable (around one a day) whereas we can see that outages of primary reserve supply and secondary voltage regulation participation have virtually doubled, albeit to a limited level

⁷ Thus, any unexpected tripping of a generating set and any tripping of a 400 kV line are declared as 0-level ESS, whereas such contingencies are covered by compliance with operating rule N-k

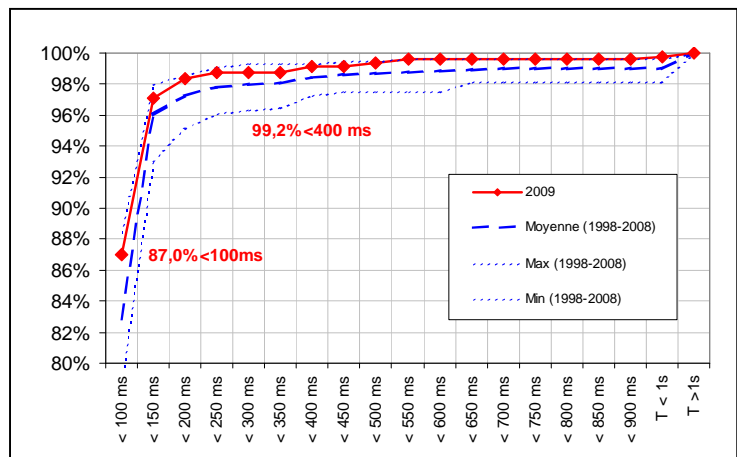
(respectively 80 and 95 in 2009 for all units of more than 120 MW); outages in secondary frequency-power control participation remain stable enough. Although these levels do not reach an alarming threshold this shortfall due to the number of outages is challenging. In summary, close communications with the producers concerned, on a site-by-site basis within a pre-defined contractual setting, must be used to closely study the potential causes.

6.2 Feedback other than ESS

RTE and its DSE and DTE divisions analyse problems that are not confined to ESS occurrences at both the regional and national levels (in particular within the scope of the CNREX and the Transmission Technical Committee).

The CNREX has continued its examinations of day-to-day work, which was initially covered in the 2008 report, to reduce the number of short-duration short-circuits of indeterminate source (37% in 2008), a necessity before actions can be defined to reduce the sensitivity of certain equipment to short-circuits. The suspected causes are mainly pollution related to morning humidity levels and avian activity. Experiments to reduce avian pollution in the proximity of the insulators were started in June 2009 and a help guide covering the potential causes, to be used when inspecting the lines, has been distributed. In addition, to make the most of the on-the-ground experience of the operators, the SIQUAEL database was updated in October 2009 to include the various presumed causes of short-circuits.

The analysis of the clearance by protections and PLCs of the 479 short-circuits sustained by the 400 kV grid provides an indication of the trend concerning protection plan efficiency. 87.0 % of the short-circuits were cleared in less than 100 ms (2008: 83,3 %, 2007 : 85,9 %, 2006 : 88.5%), and 97.1 % in less than 150 ms (2007: 93,1 %, 2007 : 96,5 %, 2006 : 98,0 %). These results seem to correct the initial slide which was noted in 2008, as shown by the curve of the time taken to eliminate the faults for 400 kV.



For all of the 367 lines at 400 kV, the unscheduled outage rate was 0,08 % and the scheduled outage rate 1,97 %. Amongst the 400 kV lines, there are 175 which are classified as 'sensitive', an outage on which in real-time will create a significant problem along the whole electricity network and for which RTE has set up appropriate measures (e.g.: improved maintenance plan, improved breakdown sets, quick-reaction equipment inspections even out of working hours in the event of a trip, etc.), their unscheduled unavailability rate stood at 0.09%. Also to be noted are 65 "strategic" 400 kV links, of which the absence in operation causes inconvenience such that measures have to be proposed so that the need to shut them down for lock-out purposes is reduced; the unscheduled unavailability rate for these links was 1,65 %.

Moreover, the contracts signed between RTE and the Producer EDF with respect to reliability are followed up by a specific committee. Among the topics examined in 2009 are frequency analyses, the methods for dealing with reactive power limitations, the application of the contract concerning network restoration and voltage recovery to power plants, the ESS concerning generating sets and those having affected generation.

6.3 Noteworthy facts concerning other power systems

There were relatively few major incidents in 2009, as was the case for 2008. The most important were:

- 16th January: 70% of the Ecuadorian landmass was without power for approximately 4 hours. The malfunction was down to a failure of a main line between the centre and the north of the country at a peak period;
- 20th January: Winds of 130 to 170 km/h damaged the lines of the Irish grid, either directly or by falling trees, cutting off approximately 110,000 households;
- 26th March: Tenerife in the Canaries was victim of a total black-out. A storm seemed to be the cause;
- 10th November: Quarter of the 190 million inhabitants of Brazil, and virtually the whole of Paraguay were cut-off following a lightning strike triggering the protective systems of the Itaipu power plant. Itaipu is the second largest hydroelectric dam in the world, currently supplying 40% of Brazil's power and 90% Paraguay's. This incident was the fourth major incident to affect Brazil since 1985. It took approximately 4 hours to restore services.

On Sunday 9th November, during an off-peak period, Spain logged a record wind-farm production level, for a period of 5 hours it exceeded the symbolic level of 50% of the country's consumption. This example shows the absolute necessity of supporting the increase in wind-farm production by regulatory and contractual means, highlighting its controllability, its capacity to participate within the limits of its technology, the controllability of frequency and voltage, its ability to remain connected during voltage drops following short-circuits on the EHV networks.

7 Reliability-related indicators

The management of each RTE unit is permanently monitoring its performance using various indicators. A significant number of these indicators are related to reliability. This is the same for the cross-processes of the management system.

RTE also passes on data used by the CRE to draw up indicators for the Ancillary services contracts.

In keeping with the recommendations defined in the 2003 report, the indicator to be used for external communication concerning reliability expresses the number of ESS for levels A to F, i.e. for 2009: 1 D, 1 C, 8 B, 57 A.

However, a few figures cannot account for the reliability level, and ESS declaration, although it is extremely valuable, only accounts for incidents and not improvements, trends or work being carried out to make improvements. It is therefore the 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 one plays in building reliability

8 Progress actions under way

8.1 Actions with the partners concerned (TSOs, Users, etc.)

The ENTSO-E has set up its operational organisation. It should also be noted that the association has opened its 2009-10 Works Programme up to public consultation, which will include the drawing up of projects for a code to cover operations and a code to cover the connection of units, as well as the publication of the first 10-year interconnected network development plan .

Concerning ENTSO-E, it should also be noted that the association has prepared a multi-year R&D working programme, opened up for public consultation in 2010. This noteworthy

advance shows the willingness of the TSOs to invest jointly in actions for the future. Preparatory work on this programme is based on an initiative by the 7 TSOs and 7 GRDs, helped by RTE, to define an R&D programme for the next 9 years with the aim of developing a 'Smart Electricity System'.

Concerning the Central West Europe region, in addition to the services assured by CORESO, 2009 was marked by important progress in the setting up of a project to interconnect the various markets across the zone: Firstly, an improved coordination process was defined and tried out by TSOs to calculate the available capacities at interconnections; then, they developed, in consultation with the various PXs concerned, IT systems and operational procedures used to couple the markets, which should be operational by September 2010.

In the framework of the application of policy P8 "Operational Training" of the ENTSOE reference guide, RTE's national dispatching centre pursued joint training actions with Terna operators, and joint training actions with Elia were set up. In addition, RTE hosted CORESO operators during in-depth training sessions covering RTE's problems and operating modes.

RTE and the Spanish TSO (REE) signed a contract defining the modalities to be employed in the coordinated management of both interconnected systems, covering the major operating fields: Maintenance work scheduling, capacity calculations, real-time data, voltage control, monitoring interconnection line data. RTE, the Swiss TSO (Swissgrid) and the Italian Terna updated their convention defining the real-time management restrictions at the borders.

RTE is an active member of the VLPGO group of power network operators of greater than 50,000 MW. Among the various themes studies one should look at work carried out on electrical vehicles, with constructors sharing information and points of view with the TSOs on the limitation of the impact of their development on the load curve, reliability improvement work (vulnerability, best practices for restoration following a black-out).

RTE is involved in the consultation, chaired by GRTGaz, dealing with the conditions of insertion for the CCGT into the gas network. The technical limitations in terms of gas supply, for certain areas, will likely mean that during the years to come there will be limitations on rapid modifications to the production of electricity. This will create constraints in that the warning notice to the Balance Mechanism must be longer than the timescales built into the equipment or on the delay before calling up these generation units (for example, via the Warning and safeguard measures), requiring the development of compromise technical solutions.

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 to take 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. RTE therefore has to be able to anticipate new power system operating conditions and to lead research actions.

The organisation of RTE R&D has been improved by the establishment of a three-year programme. On a European scale, with ENTSO-E as a partner, RTE has made active contributions to the construction of a shared R&D structure, with the main objectives being the construction of tomorrow's smart grids, facilitating the integration of renewable energy sources (including via the off-shore DC networks), by constructing solutions to promote the coordinated management of the electricity systems, in particular in terms of study tools, by joint management, by all those parties concerned, of the supply and demand balance (including TSOs, producers, withdrawal clients, etc.).

RTE has also contributed to the setting up of the Twenties⁸ project, grouping 26 TSOs, Industrial companies and Universities, all working towards the networks of the future (off-shore DC networks, improved system flexibility through coordination). RTE has also taken part in the European PEGASE project covering simulation methods and state estimations of very large electricity systems.

In addition to the above mentioned projects, other work carried out in 2009 includes:

- The development of renewable energy production and its integration into the electricity system, work to improve forecasting algorithms, the participation in the European EWIS and SAFEWIND projects (dealing with extreme weather);
- In the field of consumption forecasting, continuation of the background work into the use of new methods and the improvement of existing tools, essential work on the French system due to the variability of the loads and the willingness to develop means to control the load curve;
- For the supply & demand balance: improved understanding of the load curve, evaluation of the future impact of electrical vehicles on this curve, active management means for the load curve.
- Concerning voltage control: work on the dynamic behaviour of the dreaded network collapses requiring the use of the ADO PLC, on the management of the RPT/RPD interface, on the integration of advanced functionalities into Convergence to facilitate the operational use of dynamic calculations;
- Concerning network safeguards: reviews of the synchronisation-loss protection plans used by other TSOs, which have not, as yet, highlighted any attractive alternatives to the current defence plan;
- Concerning the balance mechanism: the updating of the algorithms used to monitor margins provided by market participants and the behaviour of balance responsible entities.

9 RTE regulation and monitoring system

Reliability audits are carried out at the request of RTE management within the framework of the internal audit measures set up within 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.

Four Reliability Audits were carried out in 2009, on the following subjects:

- RTE & RGCE (ex. UCTE) reliability rules;
- Quality of daily consumption forecasts;
- Margin and rapid reserve management;
- Working and efficiency of reliability-related feedback.

In addition, towards the end of 2009, a new set of reliability audits were defined for 2010-11, bearing on the following subjects:

- Network restoration aptitude following general black-outs;
- The application of equipment and systems maintenance policies;
- Operation at equipment limits and reference guides;
- 400 kV and close 225 kV protection function;
- The impact on reliability of operation supported by the ROSE network.

⁸ Chosen by the EU as part of its 7th R&D framework plan.

The definition of these audit programmes is methodological. They are based upon an analysis of the main risks to the company, on the information gained from feedback and on the progress and efficiency of plans of action defined by prior audits. On the basis of these elements, the programme is defined to cover, over the years, all parts of the field of reliability, as well as all those other areas covered by RTE's reliability policy. Taking into account the time required for each audit, the depth of the analysis and the geographic coverage, the objectives are reached over periods of around 7 years, which is judged reasonable by the Reliability Audit Mission.

10 Conclusion and recommendations

From a reliability point of view, 2009 was marked by two major events: Firstly, during European Windstorm Klaus in the Southwest of the country, the level of resistance shown by the electricity transport network showed that the reliability policies implemented after the storms in late 1999 worked; then, a double busbar fault in the Tavel Substation on the 21st December started a network collapse between Marseille and Nice, only limited by the rapid load-shedding operation implemented by RTE. In addition to these events, changes in operational conditions in terms of structure and certain conjunctural situations meant that the electricity system was, at times, being run close to its limits. RTE showed its ability to respond efficiently in these periods and, during some of the most at-risk periods, called upon certain safeguard measures to limit the risk of a network collapse. The measures implemented were directly based upon detailed dynamic simulations, in order to establish the regional consumption levels above which activating the safeguard measures was required.

Even if the number of notable ESS was higher than the annual mean, the steps taken to control these incidents showed their efficiency. We must be vigilant to assure that actions undertaken as a result of feedback are efficient, to reduce, during 2010-11, occurrences of comparable incidents.

In addition, significant progress has been made, firstly with the introduction of CORESO, an operational instance of TSO service coordination across the Centre West Europe region, and also through the renewal of contractual commitments to the Alert and Safeguard System, with yet unfinished progress on the stabilisation of the HVA capacitor banks. In the future, the increased power of ENTSO-E is a potential trigger for positive advances in operational efficiency and the reliability of the European Electricity System, a statement which will only be confirmed in the years to come.

In this context, the Reliability Audit Mission, noting that operational decisions will be more and more reliant on dynamic simulations and adaptive measures based on operational conditions (in particular, the weather), has recommended:

- For the operational use of the results of dynamic models, that the margins needed to deal with the different uncertainties be documented and quantified, particularly the dynamic load configurations, local reactive and active loads and equipment protection settings, and, if necessary, work should be continued in greater depth to reduce these uncertainties.
- For adaptive measures, that the operational control protocols be improved to make sure that the parameter values shown on the PLCs and those used by the security evaluation computing tools conform to expected values.

Finally, it goes without saying that it is of the utmost importance that discussions between RTE and producers be actively engaged in order to restore the constructive capacities expected from power production plants where reactive power levels are extremely limited. The Mission underlines the importance of drawing up new contract clauses to efficiently deal with long-duration shortfalls and invites the producers concerned to carefully consider the impacts of their decisions concerning their industrial equipments on system reliability.

For further information about the principles on which the annual System Reliability Report is drawn up, please see: "The Reliability of the French Electricity System: Annual Auditing and Reporting" J.M. Tesson. REE, N°8, September 2006