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CARBON EMISSIONS DECREASING DUE TO LOWER DEMAND AND RENEWABLE ENERGY DEVELOPMENT

As France prepares to host the 21st international climate conference, the 2014 edition of RTE’s Annual Electricity Report illustrates, once again, how sensitive power consumption is to climate conditions. In 2014, the hottest year on record since the beginning of the 20th century according to Météo France, gross power consumption contracted by 6% versus 2013 and ended the year at 465.3 TWh, the lowest level since 2002.

This decline was attributable in large part to weather conditions. With temperatures 0.5°C above reference temperatures and only dipping below 5°C very rarely in the winter, electric heating was used less during the year.

In the absence of any truly cold spells, power demand peaked at 82.5 GW on 9 December 2014. Peak demand had not been this low since 2004. That being said, the temperature sensitivity of demand in winter is still close to 2,400 MW/°C.

Such large swings in electricity consumption from one year to the next, both in annual energy and peak demand terms, underscore the need to make the power system adaptable to increasingly unpredictable weather patterns. Though underlying trends probably point to warmer average temperatures, it is impossible to predict the frequency and intensity of cold spells going forward, or the regional variability of these patterns. These elements of uncertainty are such that supply must be very flexible to keep up with swings in demand.

Along these lines, to assure continued coverage of the peaks in demand to which the power system is still exposed, RTE is introducing market mechanisms designed to consistently secure supply, such as demand response schemes and the capacity mechanism.

Electricity consumption was moderate in 2014, and CO₂ emissions in the power sector contracted by 40% from the year-earlier level. Emissions ended the year at 19 MtCO₂e.

One reason for this decline is that less use was made of fossil fuel thermal power plants (coal, gas and oil), which are used for backup generation. Their output was down 40% from 2013. Lower consumption has been impacting CO₂ emissions reductions in recent years as well. For instance, a 6% contraction in demand between 2010 and 2011, though offset in part by rising exports, went hand in hand with a 20% decrease in CO₂ emissions. This phenomenon confirms that demand-side management measures undertaken in France have positive effects on the environment.

At a more structural level, CO₂ emissions are decreasing due to changes in the energy mix and the fact that renewable sources are accounting for an ever larger share of generation. Wind and photovoltaic power development had slowed in recent years but began trending higher again in 2014, with close to 1,900 MW of new capacity installed. France is now home to more than 9,100 MW of wind power and almost 5,300 MW of photovoltaic capacity. With this growth, and the decommissioning of 1,300 MW of fossil fuel thermal capacity, the French energy mix continues to evolve in such a way as to support an energy transition designed to reduce carbon emissions.
As such, for the first time in 2014, more electrical energy was produced from renewable sources excluding hydropower (27.9 TWh) than from fossil-fired thermal plants. More than half of this total was wind power and the balance was split between photovoltaic, wood-energy and other solid biofuels. Wind production peaked on 27 December 2014 at just over 7,000 MW with a capacity factor of 80%. Photovoltaic generation peaked on 17 May 2014 at 3,700 MW with a capacity factor of 80%. New records were set in both cases.

In addition, runoff was fairly high during the year: hydropower generation reached 68.2 TWh, the second highest level in the past decade after 2013, which had been a truly exceptional year.

All of these favourable conditions combined to allow renewable energy sources to cover almost 20% of power demand in France. This in turn helped reduce carbon emissions.

This same phenomenon can be seen across Europe as a whole, where power demand is stagnating or even falling. Between mid-2013 and mid-2014, European electricity consumption fell 1.5% compared with the year-earlier period. Demand contracted by more than 4% in Germany and more than 2% in Italy and Switzerland, and by about 0.7% in Spain. Though these results have not been adjusted for weather effects, which are much less pronounced elsewhere in Europe than in France, they most likely reflect a structural trend.

In France, power consumption in heavy industry had contracted for three years but stabilised in 2014 at 67.4 TWh, the second highest level in the past decade after 2013, which had been a truly exceptional year.

All of these favourable conditions combined to allow renewable energy sources to cover almost 20% of power demand in France. This in turn helped reduce carbon emissions.

**Power Demand Excluding Weather Impacts Stabilised Again as a Result of the Economic Crisis as Well as Energy Efficiency Measures**

A weak economy and energy efficiency measures also combined to help keep demand in check. Adjusting 2014 figures for climate impacts to show results at so-called normal weather conditions, power demand in France contracted by 0.4% during the year. The slump in growth observed over the past four years now thus continued, confirming that electricity consumption in France is no longer trending higher.

In reality, the drop in overall power demand in France was driven by declining electricity consumption (including own consumption) amongst users connected to the distribution grids – SMI/SMEs, professionals and residential consumers – which account for a much larger share of demand than heavy industry. Demand had risen steadily for years and then showed signs of stabilising last year, but 2014 saw the first decline on record, with consumption falling by about 0.5% versus 2013. This decline reflects a general slowing of economic activity, which tends to cause consumption by SMI/SMEs and professional users to decrease, and could put some downward pressure on household demand as well. Energy efficiency measures put into place for equipment and buildings, together with the decreasing share of electric heating in new construction following the implementation of the 2012 Building Energy Regulation, undoubtedly played a role as well.
It was also a challenging year for fossil fuel thermal generation, which contracted on the whole. The coal segment was the most impacted, with output falling 58% compared with 28% for gas. Coal-fired plants, several of which were shut down, produced 6 TWh less than gas-fired facilities.

This shift from coal to gas, which emits less CO₂, also contributed to the sharp decline in carbon emissions. However, economic conditions remain worrisome for combined-cycle gas plants in France. Like last year, some facilities were taken offline during the summer months.

Due to a combination of declining demand and plummeting fossil fuel prices, average spot prices declined over the year in Europe and dropped to €34.6/MWh in France. Compared with neighbouring countries, French spot prices were among the lowest, with Germany alone posting lower prices on wholesale markets. Average annual spot prices in the Central West Europe zone, comprising Germany, France and Benelux, have remained within the €32.4 to €41.2/MWh range over five years.

As the energy transition continues, growing use of interconnections confirms the need to start working now to adapt the power grid to the challenges that lie ahead.

Because domestic consumption was weak and prices were relatively low in the French market, France was able to help cover needs in neighbouring countries by exporting more electricity. The export balance ended 2014 at 65.1 TWh, the highest level since 2002. Total imports and exports reached 119.8 TWh, which was 7.4% more than in 2013.

In terms of hourly power demand averaged over each month, export balances exceeded 5 GW throughout the year, including in winter. France was in an import situation during some 30 hours over the year and was not a net energy importer on any given day.

Analysis of exchanges at each border underscores the increasing impact of an evolving European energy mix and the growing share of renewable energy sources. Because wind power output varies between seasons and week to week and photovoltaic generation moves according to daily cycles, electricity flows between European countries are fluctuating more and more.

France imported more from Germany than it exported during the year, but exchanges were more balanced than in the past with the import balance ending the year at 5.9 TWh, down from almost 10 TWh in 2013, reflecting the relative weakness of French prices. This lower balance does not mean that exchange volumes contracted, but rather that periods of imports and exports were more balanced, though fluctuations continued to increase in magnitude. Interconnections between France and Germany were saturated in one direction or the other about half the time.

Exchanges with Belgium were significantly impacted by the unavailability of nearly half of Belgian nuclear capacity. France’s export balance with Belgium increased (16.5 TWh). Capacity for exports from France to Belgium was saturated most of the time.

Export balances with all other countries with which France shares a border increased. France exported to Spain two thirds of the time, importing only when renewable generation in Spain surged, causing prices to fall below French prices. Interconnections between
France and England showed high availability rates in 2014. This capacity was used for exports during more than 99% of total hours during the year, and was saturated 90% of the time. France once again exported much more to Italy than it imported, and export capacity to that country increased by 400 MW in October 2014 after the transalpine grids were reinforced.

This growing reliance on interconnector capacity to pool and optimise the use of different energy sources, based on where and when they are available and economically competitive in Europe, only strengthens RTE’s commitment to adapt the grid to meet the challenges of the future.

**RTE’S INVESTMENT PROGRAMME IS DESIGNED TO ASSURE QUALITY SERVICE FOR CUSTOMERS OVER THE LONG TERM AND TO PROMOTE NETWORK INTEGRATION**

In 2014, RTE invested a total of €1,374m within the perimeter regulated by the CRE, including €1,243m for grid infrastructure. These investments chiefly targeted the accommodation of renewable energies, ongoing construction of the direct current line to strengthen interconnection capacity between France and Spain via the Eastern Pyrenees, the replacement of conductors to make flows more secure on the 400 kV line between Montélimar and Lyon, and the enhancement of security of supply to the regions (PACA and Vendée). One highlight of the last quarter of 2014 was the final test phase of the “PACA safety net”, which is scheduled to be deployed early in 2015.

These developments are also intended to assure that electricity quality will meet high standards over the long term. In 2014, equivalent outage time for consumers connected to the transmission grid was 2 min 46 sec, which was below the average for the past ten years.

Outage frequency has also been factored into the incentive regulation since August of 2013. The average number of short or long outages experienced during the year by RTE’s distributor and industrial customers (excluding the energy and rail sectors) was 0.46 in 2014, below the average for the past ten years and within the 0.6 limit set out in incentive regulation.

Lastly, integrating infrastructure into landscapes remained a top priority for RTE, as was notably evidenced by the greater use of undergrounding technologies. At the end of 2014, the public transmission system had 105,331 km of circuits in operation. The length of underground circuits is steadily increasing, while the length of overhead circuits was stable over the year, after 2013 saw the VHV Cotentin-Maine line go into service. The undergrounding rate for new 63 kV and 90 kV infrastructure has averaged close to 92% over the past three years.
Part 1
Warmer temperatures resulting in lower demand
GROSS CONSUMPTION CONTRACTED SHARPLY IN 2014 DUE TO MILD WEATHER

Gross consumption in mainland France contracted by 6%, or 29.8 TWh, between 2013 and 2014, ending the year at 465.3 TWh. This was the lowest level on record since 2002.

The decrease was attributable to particularly warm temperatures throughout the year.

Though actual temperatures were on average 0.5°C above reference temperatures, they held at above 5°C nearly all winter, which depressed demand during the winter months because heating was not used as much. Conversely, relatively low temperatures in summer limited the use of cooling systems, and thus drove national demand down. Temperature differences between 2013, which was a cold year, and 2014, characterised by very mild weather, shaved 27.6 TWh from electricity consumption.
Warmer temperatures resulting in lower demand

WEATHER-ADJUSTED CONSUMPTION WAS UNCHANGED

Adjusted for weather, consumption contracted by 0.4% to 478.4 TWh.

Analysing weather-adjusted consumption trends requires excluding the energy sector from the calculation. Indeed, the adoption of a new uranium enrichment process at Eurodif severely impacted that sector in 2012 by, leading to a steep decline in consumption.

Stripping out the impact of weather and the energy sector, consumption contracted by 0.5%. This was the fourth year in a row that annual electricity consumption in France has shown signs of stabilising.

The monthly breakdown of consumption, excluding the energy sector, is similar to that observed over the past five years.

Source: Météo France
Warmer temperatures resulting in lower demand

Conversely, consumption increased in other sectors, including chemicals (+2.1%), which is still benefiting from buoyant exports, steelmaking (+2.2%), which is recovering after several years of declines, and metallurgy (+6.2%), which is notably benefiting from a vibrant aerospace market.

This stability is a reflection of mixed trends in different parts of industry. Consumption fell in some sectors. Examples include paper/paperboard (-7.1%) and car manufacturing (-4%), which were hurt by the economic crisis, as well as rail transport (-2.6%), which was impacted by social movements in June.

A more detailed analysis of sector trends can be found in the 2014 Generation Adequacy Report.
CONSUMPTION BY SMI/SMES, RESIDENTIAL AND PROFESSIONAL USERS DOWN SLIGHTLY

Customers connected to distribution grids, which include SMI/SMES and residential and professional users, along with any losses associated with energy withdrawn, edged down by 0.5% between 2013 and 2014. Growth had already begun to slow in 2013, after four years of annual average increases of 1%, as illustrated by the series below showing seasonally adjusted consumption on distribution networks.

This trend is a consequence of the downward pressure the economy has put on business levels for SMI/SMES and professionals and, to a lesser degree, household spending. New energy efficiency directives and regulations governing equipment and buildings are beginning to bear fruit. At the same time, the share of electric heating in new buildings decreased after the 2012 Building Energy Regulation went into effect, and the decline was amplified by a drop in new construction (for more information, please see the 2014 Generation Adequacy Report).

TRENDS IN ADJUSTED REGIONAL CONSUMPTION

Weather-adjusted electricity demand increased by an average 3% a year between 2006 and 2013 in France as a whole. Analysis of regional consumption patterns over that period reveals mixed underlying trends.

Adjusted consumption in Brittany, Lower Normandy, Poitou-Charentes, Pays de la Loire and Languedoc-Roussillon rose by almost 10% between 2006 and 2013, which was three times faster than the national average. The difference between consumption patterns in these regions and the country as a whole is explained primarily by demographic growth trends in these regions and the proportion of residential/professional users there.

Conversely, adjusted consumption in Alsace and Lorraine contracted sharply (by 6% and 11%, respectively), the economic crisis having taken a significant toll on heavy industry in both regions. Electricity demand for heavy industry has declined by 36% in Alsace and by 28% in Lorraine since 2006, compared with a national average of -14%. More details about these developments can be found in the Regional Electricity Reports and their executive summaries.
PEAK DEMAND THE LOWEST ON RECORD SINCE 2004

The highest level of demand recorded in 2014 was on 9 December, at 7pm, with 82,540 MW at a temperature of 4.3°C, which was 1.4°C below the reference temperature. This demand peak, the lowest on record since 2004, reflected the mild temperatures observed throughout the year.

These estimates are based on reference temperatures. They show that, under reference conditions, demand at the evening peak time has been flat since 2008.

Demand peaks at about 7pm because tertiary sector activities are still continuing at that time, while rail transport is spiking and evening domestic activities are getting under way. Every year, winter temperatures drive consumption higher as heating is switched on. However, the additional electricity consumed depends on whether winter temperatures are mild or cold.
Demand was at its lowest on 17 August, at 29,500 MW, a level that has been stable for ten years.

RTE uses a model that distinguishes between temperature-sensitive and non-temperature-sensitive demand to calculate weather-adjusted consumption. This model illustrates that it is the temperature-sensitive share that determines the overall demand trend.

The temperature sensitivity of power demand varies over the course of a given day. It is estimated at about 2,400 MW per degree Celsius in winter on average.

Insofar as this temperature sensitivity is primarily the result of electric heating, the types of heating systems installed in new homes can impact it. Indeed, since the 2012 Building Energy Regulation took effect, the share of electric heating in new build has plummeted. This shift is liable to keep the increase in temperature sensitivity in check going forward. However, new homes only make up a very small portion of existing housing stock, so this impact will only be visible over the long term.

Other end-uses besides heating can also contribute, to a lesser degree, to increasing the share of power demand that is sensitive to temperatures, including sanitary hot water production, cooking and cold production.

The opposite trend is visible in the summer months, when warmer temperatures tend to drive power demand up due notably to the use of air conditioning. In France, however, demand is much less sensitive to temperatures in summer than in the winter months.

Power demand in France is highly sensitive to temperatures, notably during the winter months, given the large installed base of electric convection heaters. This is why the warm temperatures of 2014 brought demand to such low levels.
LOAD SHEDDING AND LOAD CURTAILMENT SCHEMES GAINING GROUND

EcoWatt in Brittany and Provence-Côte d’Azur

RTE is continuing to promote the EcoWatt Brittany and EcoWatt Provence Azur schemes in partnership with local authorities. These schemes give residential consumers, local authorities and companies in Brittany and the PACA region an opportunity to proactively reduce their electricity consumption in winter, during hours when demand is peaking. The schemes proved efficient during colder winters by shaving some 3% from demand during peak hours.

During the 2013-2014 season, there were no EcoWatt alerts, thanks to exceptionally warm weather and high availability rates for generation resources and the grid. The scheme is continuing to attract more supporters with membership bases of 52,400 in Brittany and 26,000 in the PACA region.

Brittany generated enough electricity in 2014 to cover 13% of its demand. The balance was generated elsewhere and brought in over the grid. During peak hours in winter, the grid can reach its maximum transmission capacity. In this case the risk of power outages in Brittany is high, particularly if there is an incident on the network or at a generation facility.

Lastly, RTE has been managing the Tempo signal since 1 November 2014 along with its transposition to éCO2mix. Power supply offers like Tempo include different pricing levels that vary depending on the time and colour coding of the day. “Red days” correspond to the times of year when demand is very high, “white days” to times of moderate demand, and “blue days” to periods when demand is at its lowest. Prices corresponding to each type of day are set by the individual suppliers offering such plans. It will now be possible to receive messages about whether days are red or white on mobile devices. A special page devoted to these tariff signals has also been created on the Web.
Part 2

Wind and photovoltaic power development trending higher again
Wind and photovoltaic power development trending higher again

RENEWABLE ENERGIES ACCOUNTING FOR LARGER SHARE OF CONSUMPTION

Installed power generation capacity in France increased by 0.5%, or 662 MW, in 2014.

Renewable energies continued to account for a larger share of that capacity, with 1,889 MW of wind and photovoltaic power added and 1,296 MW of fossil-fired thermal capacity withdrawn.

<table>
<thead>
<tr>
<th>Installed capacity as of 2014-12-31 (MW)</th>
<th>Total France</th>
<th>Share of installed capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity (MW)</td>
<td>Change vs. 2013-12-31 (MW)</td>
</tr>
<tr>
<td>Nuclear</td>
<td>63,130</td>
<td>+0.0%</td>
</tr>
<tr>
<td>Fossil-fired thermal</td>
<td>24,411</td>
<td>-5.0%</td>
</tr>
<tr>
<td>Of which Coal</td>
<td>5,119</td>
<td>-19.5%</td>
</tr>
<tr>
<td>Oil</td>
<td>8,883</td>
<td>-0.7%</td>
</tr>
<tr>
<td>Gas</td>
<td>10,409</td>
<td>+0.1%</td>
</tr>
<tr>
<td>Hydropower</td>
<td>25,411</td>
<td>-0.1%</td>
</tr>
<tr>
<td>Wind power</td>
<td>9,120</td>
<td>+11.8%</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>5,292</td>
<td>+21.2%</td>
</tr>
<tr>
<td>Other energy sources</td>
<td>1,579</td>
<td>+6.2%</td>
</tr>
<tr>
<td>Total</td>
<td>128,943</td>
<td>+0.5%</td>
</tr>
</tbody>
</table>

Total generation in France reached 540.6 TWh in 2014, or 1.8% less than in 2013. This decline in generation, triggered by a decrease in power demand, drove the export balance up sharply for the year.

<table>
<thead>
<tr>
<th>Energy produced</th>
<th>TWh</th>
<th>Change 2014/2013</th>
<th>Share of generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net generation</td>
<td>540.6</td>
<td>-1.8%</td>
<td>100%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>415.9</td>
<td>3.0%</td>
<td>77.0%</td>
</tr>
<tr>
<td>Fossil-fired thermal</td>
<td>27.0</td>
<td>-39.6%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Of which Coal</td>
<td>8.3</td>
<td>-58.2%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Oil</td>
<td>4.4</td>
<td>-10.5%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Gas</td>
<td>14.3</td>
<td>-28.2%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Hydropower</td>
<td>68.2</td>
<td>-9.7%</td>
<td>12.6%</td>
</tr>
<tr>
<td>Wind power</td>
<td>17.0</td>
<td>+6.7%</td>
<td>3.1%</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>5.9</td>
<td>+27.2%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Other energy sources</td>
<td>6.6</td>
<td>+6.7%</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

Of which renewable 5.1 +8.4% 0.9%

SHARE OF RENEWABLE ENERGY SOURCES

In 2014, 19.5% of the power consumed in France came from renewable sources. This percentage was slightly higher than in 2013.

1 Calculation method drawn from EU directive 2009/28/EC: Production from pumped storage units less 70% of consumption for pumping, municipal waste incineration plants counted at 50%, in relation to gross consumption. This does not correspond to the calculation under the official methodology, which assumes that results are adjusted for weather.
Wind and photovoltaic power development trending higher again

**WIND POWER**

**Installed capacity**

Onshore wind capacity expanded in 2014, with an additional 963 MW connected to the grid. This represents an 11.8% increase from 2013. Total installed wind power capacity rose to 9,120 MW of which 414 MW is connected to the RTE grid and 8,706 MW to the networks of ERDF and local distribution companies.

Like in 2013, more than half of renewable energy generation excluding hydropower corresponded to wind power. Wind conditions were particularly favourable for that industry early in the year and during the summer. Photovoltaic generation increased by more than 27% from the 2013 level, rising to 5.9 TWh. Power generated by combustible renewables (municipal waste, paper waste, biogas, wood energy and other solid biofuels) rose 8.4% to 5.0 TWh.

All in all, renewable generation excluding hydropower increased in 2014 and accounted for 5.2% of total generation, or 28.0 TWh, which was higher than the percentage of fossil fuel generation. Adding in all hydropower generation, production from renewable sources reached 96.1 TWh.
Wind and photovoltaic power development trending higher again

Wind power generation

Wind power generation rose by 6.7% from the end-December 2013 level, to 17.0 TWh.

Output peaked on Saturday 27 December, at 4:00 am, with 7,238 MW produced, the highest level ever recorded. During this peak, the capacity factor of 79.8% was close to the level seen on 23 December 2013 (6,529 MW, capacity factor of 80.2%).

On average, wind power covered 3.6% of total demand as at end-December 2014, compared with 3.3% a year earlier. Coverage peaked at 16.0% on Sunday, 11 May at 4:00 pm, which was nonetheless below the record high of 16.2% observed on 27 October 2013.
Wind and photovoltaic power development trending higher again

Breakdown of wind power generation over a year

Wind power output depends on wind conditions and can thus vary from one day to the next, and over the course of a given day. Looking at the breakdown of wind power generation over 2014 by time of day, we see that 10% of the totals recorded at 7:00pm are below 509 MW. This result was more or less the same as in 2013. However, at that same time of day, 10% of totals are above 4,027 MW in 2014, implying an increase of almost 300 MW in this threshold compared with 2013.

The decile graph below illustrates this variability in wind power generation and shows that the lower decile changed little between 2013 and 2014, while the upper decile increased sharply at all times of the day.

Wind power generation at half-hourly intervals

Wind power facilities produced at an average 22.6% of their capacity in 2014, compared with 23.2% at the end of 2013.

Regional breakdown of coverage of consumption with wind power

RTE, SER, ERDF and ADEeF jointly publish a “Panorama of Renewable Electricity”. This document notably includes a detailed analysis of wind power development at the level of the administrative regions. Regions that have built the largest wind farms show the highest rates of coverage of electricity demand with wind power. These rates stand at 16% in Picardy and 19% in Champagne-Ardenne.

Wind capacity factor

% 100 90 80 70 60 50 40 30 20 10 0

31.9 30.9 30.8 31.7 31.6 31.5 31.4 31.3 31.2 31.1 31.0 30.9

Wind capacity factor

2 The top decile corresponds to the value that separates the data between the lowest 10% and the highest 90%. The bottom decile separates the 90% of lowest values from the highest 10%.
Wind and photovoltaic power development trending higher again

PHOTOVOLTAIC

Installed capacity

Installed photovoltaic capacity had contracted for two straight years but began trending upward again in 2014. With a total 926 MW added, installed capacity climbed to 5,292 MW of which 338 MW is connected to the RTE grid and 4,955 MW to the networks of ERDF and local distribution companies.

Photovoltaic generation increased by 27% between 2013 and 2014, ending the year at 5.9 TWh. Monthly output was higher in 2014 than in 2013 during every month except December. This growth reflected good sunlight conditions during the year as well as higher output at newly installed photovoltaic units. Photovoltaic generation is variable and fluctuates over a given day, depending on sunlight, and seasonally, depending on when the sun rises and sets and on cloud cover.

Output peaked on Saturday, 17 May at 1:30 pm at 3,700 MW, representing a capacity factor of 80.3%, the highest level on record to date.

Photovoltaic generation covered an average 1.3% of power demand in 2014, up from 1.0% in 2013. On 18 May 2014, at 2:00 pm, photovoltaic power covered 8.5% of demand, whereas in 2013 coverage had peaked at 7.0%.

Installed capacity exceeded 500 MW in the four southernmost regions of mainland France: Aquitaine, Midi-Pyrénées, Languedoc-Roussillon and Provence-Alpes-Côte d’Azur. All regions have at least 30 MW of installed photovoltaic capacity.
Wind and photovoltaic power development trending higher again

The Panorama of Renewable Electricity provides a more detailed analysis of growth in the photovoltaic industry, notably at the level of the administrative regions. It shows that four regions – Aquitaine, Corsica, Languedoc-Roussillon and Midi-Pyrénées – cover more than 3% of their consumption with photovoltaic power on average, and the Auvergne, Limousin, PACA and Poitou-Charentes regions boast coverage rates of more than 2%.

THERMAL RENEWABLE ENERGY

Installed thermal renewable capacity increased by 92 MW in 2014, to 1,579 MW. All new facilities installed during the year were on the distribution grid.

Installed capacity exceeded 100 MW in four regions: Aquitaine, Provence-Alpes-Côte d’Azur, Rhône-Alpes and Ile-de-France, which had more than 300 MW.

More than half (54.8%) of combustible renewable energy plants ran on municipal waste. Other fuels used were biogas, paper waste, wood energy and other solid biofuels. Municipal waste, wood energy and other solid biofuels accounted for a larger share of the total than in 2013.
Wind and photovoltaic power development trending higher again

**HYDROPOWER**

Installed hydropower capacity was unchanged in 2014. Hydropower generation remained robust during the year, totalling 68.2 TWh. This annual total was the second highest volume in the past decade, with output notably climbing in the early part of the year, between January and March. Generation was nonetheless 9.7% lower than in 2013, which had been an exceptional year in terms of precipitation with above-average rainfall across all of France.

**NUCLEAR SHARE OF GENERATION STABLE, CONVENTIONAL THERMAL POWER DOWN SHARPLY**

Nuclear generation capacity did not change in 2014. The availability of the nuclear power plants was particularly high, notably starting in the summer of 2014, such that nuclear power output increased by 3.0%.

Fossil-fired thermal plants represented installed capacity of 24,411 MW, or just under 19% of the total for all of France. Installed capacity shrunk by 1,296 MW. This decrease was chiefly attributable to the decommissioning of the Blénod and Cordemais 1 coal-fired plants.

Fossil-fired thermal plants provide backup power. Several factors contributed to the sharp decline in production in 2014: high hydropower and nuclear generation, rises in wind and photovoltaic power output, and a decrease in demand. Power generated by fossil-fired thermal plants thus ended 2014 39.6% lower. Coal-fired plants were the most affected, with production falling by 58%, while gas-fired plants only saw a 28% decrease. Gas-fired plants produced 6.0 TWh more than coal-fired units during the year, contrary to 2012 and 2013. Economic conditions nonetheless remain challenging for combined-cycle gas (CCG) plants in France where, like in 2013, some units were taken off line during the summer months.
Wind and photovoltaic power development trending higher again

In Europe, more than 35 GW of gas-fired capacity has been mothballed and the number of CCG plant projects has fallen to a ten-year low.³

Over more than half the year, monthly renewable energy generation excluding hydropower exceeded output at fossil-fired thermal power plants. Renewable energy generation remained high over the year during cold periods and when greater use was made of fossil-fired thermal plants.

VARIABILITY OF GENERATION FROM DIFFERENT SOURCES

To assure that demand is met and given the variability of some energy sources, the breakdown of coverage of consumption in France changes with seasons and also over the course of the day.

Because of its modular and seasonal nature, hydropower generation can cover between 5 and 28% of French consumption, depending on the period.

Another observation is that coverage of consumption with renewable energy sources excluding hydropower was higher than coverage with fossil-fired thermal generation over half of the year.

³ Source: Platts.
Wind and photovoltaic power development trending higher again

The ratio was reversed in October, when fossil-fired thermal generation covered up to 17% of consumption. Lastly, wind power output can vary from day to day and over the course of a given day. Coverage of consumption with wind power peaked at 16% in May, and held at 0.1% or more during each month of the year.

**CO₂ ÉMISSIONS**

The decline in CO₂ emissions observed in 2014 reflected the sharp drop in fossil-fired thermal generation, which was in turn due to mild winter temperatures and high availability rates for the nuclear power plants. As such, not taking into account own consumption, CO₂ emissions totalled 19.0 Mt, for a 41% decline. Moreover, the increase in the share of gas-fired versus coal-fired generation offset emissions stemming from the increase in thermal renewable generation.

CO₂ emissions resulting from own consumption added approximately 5.0 Mt to total emissions. These emissions are included in the carbon footprint assessments of the industrial sites in question.

<table>
<thead>
<tr>
<th>CO₂ emissions (millions of tonnes)</th>
<th>2014</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>19.0</td>
<td>32.2</td>
</tr>
<tr>
<td>Nuclear</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fossil-fired thermal</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Of which Coal</td>
<td>8.0</td>
<td>19.0</td>
</tr>
<tr>
<td>Oil</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Gas</td>
<td>4.9</td>
<td>7.4</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hydropower</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wind power</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other energy sources</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Of which renewable</td>
<td>3.9</td>
<td>3.5</td>
</tr>
</tbody>
</table>

4 CO₂ emission factors have been refined and historical data re-updated accordingly. They only represent CO₂ emissions generated by the consumption of the primarily fuel source. The different generation technologies contributed to CO₂ emissions as follows:
- 0.96 t/MWh for coal-fired units;
- 0.67 t/MWh for oil-fired units;
- 0.46 t/MWh for gas-fired units;
- 0.98 t/MWh for other thermal power plants (biogas, waste, wood energy and other solid biofuels).
These rates are calculated based on emission factors in g/CO₂ per kWh of thermal energy as reported by the Centre Intéprofessionnel Technique d’Etude de la Pollution Atmosphérique (Inter-professional Technical Centre for Studies on Atmospheric Pollution - CITEPA) and on RTE’s estimate of output between kWh of thermal energy and kWh of electricity.

In 2014, monthly CO₂ emissions were consistently lower than in the same months in previous years. However, these values can vary by a factor of up to seven or eight within a given month. In October for instance, CO₂ emissions fluctuated between 12 kg/MWh and 91 kg MWh. The profile of CO₂ emissions over the course of a day in winter shows a plateau between 6:00 am and 10:00 pm, while emissions in summer are fairly constant.
Wind and photovoltaic power development trending higher again

THE TRANSMISSION GRID CORRECTS IMBALANCES BETWEEN GENERATION AND CONSUMPTION

The map opposite matches electricity generation against consumption in each of the French regions in 2014. Because generation facilities are rarely located in the geographic areas where consumption is highest, there are major discrepancies between regions’ ability to cover all of part of their consumption with “local” generation. Some regions like Brittany, Pays-de-la-Loire, Île-de-France, Burgundy and Franche-Comté consume five times as much power as they produce, while others - Centre, Champagne-Ardenne, Upper Normandy, Rhône-Alpes and Lorraine – produce twice as much as they consume. These five regions alone are home to 70% of France’s nuclear power capacity.

Coverage rates can vary from one year to the next, depending on weather events and changes in installed capacity in given regions. For instance, the coverage rates of Pays-de-la-Loire and Franche-Comté declined between 2013 and 2014. This was due to the decrease in fossil-fired production in these regions, and to weather that was not conducive to hydropower generation in Franche-Comté.

The grid allows electricity to move between the regions to guarantee the security and safety of the power system.
Part 3
Consumption declining in Europe
Consumption declining in Europe

All data presented in this chapter are drawn from ENTSO-E\(^2\) and are calculated on a year-on-year basis. The data are for the period between July 2013 and June 2014, and changes are calculated relative to the July 2012 to June 2013 period.

GROSS CONSUMPTION LOWER IN MOST COUNTRIES

Gross annual electricity consumption declined in a large majority of ENTSO-E member countries. Consumption notably contracted by more than 4% in Germany. The trend in France was similar. Spain only saw a moderate decrease of around 0.7%, but consumption in Italy and Switzerland ended the year down by more than 2.4%.

All in all, annual electricity consumption in ENTSO-E member countries was down 1.5% relative to the 2012-2013 period, representing a decrease of around 50 TWh, equivalent to annual consumption in Greece.

This downward trend is attributable to the combined effects of the economic crisis and energy efficiency measures, and also to the fact that temperatures were more favourable in the 2013-2014 period. This was notably the case in France, where the sharp contraction in annual power demand reflected the high degree of sensitivity of demand to temperatures.

FRANCE, GERMANY, SPAIN, ITALY AND GREAT BRITAIN TOGETHER HOME TO 60% OF EUROPEAN POWER GENERATION

Between 2013 and 2014, Europe produced 3,304 TWh of power, or about 1.4% less than in 2012-2013, due to a decrease in power demand. France and Germany alone accounted for almost a third of total generation in ENTSO-E member countries.

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\(^2\) ENTSO-E: European Network of Transmission System Operators for Electricity. This association brings together 41 European transmission system operators (TSOs), including RTE. At this writing, data for Great Britain do not cover the entire country.
Electricity generated from renewable energy sources excluding hydropower continued to increase. It accounted for 14.4% of total annual consumption at the level of ENTSO-E in the 2013-2014 period.

Photovoltaic generation covered between 5 and 8% of consumption in Germany, Spain, Italy and Greece. The average for ENTSO-E as a whole was close to 2.8%.
Wind power covered between one fifth and one third of annual consumption in three countries: Denmark, Spain and Portugal. In Spain, wind power covered approximately 21% of consumption, compared with an average coverage rate of 7.7% in the ENTSO-E area.

Hydropower covers more than 50% of annual consumption in Austria, Switzerland, Iceland and Montenegro. In Norway, production actually exceeded consumption in 2013-2014, making exports to neighbouring countries possible, though other types of generation may be called upon to assure that power demand is covered continuously over the year.

Lastly, fossil-fired plants covered an average 42% of annual consumption in ENTSO-E countries. The share was above 61% in Germany. Coverage in France was closer to 7% due in part to the preponderance of nuclear power.

Indeed, nuclear power still covers about 85% of annual power consumption in France. Belgium and Slovakia also showed coverage rates of more than 50% for nuclear power in 2013-2014, whereas almost half of ENTSO-E member countries no longer have any nuclear plants in service.

The configuration of individual results by country was stable relative to 2013 with the exception of Slovakia, which had an export balance in 2012-2013 but an import balance in 2013-2014.

Import and export capacities available for electricity exchanges, known as net transfer capacity (NTC), are calculated and published jointly by system operators. Their level depends upon the characteristics of interconnector lines, their availability, and internal constraints on the power grids of each country.
Centrally-located countries have the highest maximum NTC (Max NTC) values for imports and exports, since they are situated at the heart of exchanges. Examples include France and Germany, which have max NTCs of more than 10 GW in both directions. Sweden also has a max NTC of more than 9 GW for imports and exports.

There can be differences, however, between the max NTCs for imports and exports in a given country. One example is Italy, where the NTC for imports is twice as high as for exports.

FRANCE HAS THE HIGHEST TEMPERATURE SENSITIVITY IN EUROPE

A country’s electricity consumption is largely dependent on its temperature sensitivity. In winter, when electric heating is switched on, consumption increases as temperatures decrease. It is estimated that in France, power demand increases by about 2,400 MW with each degree Celsius drop in winter temperatures. Demand can increase when temperatures rise in the summer mainly because of air conditioning.

This sensitivity of power consumption to temperatures can be graphically visualised by representing daily demand as a function of the average daily temperature in the country. Non-working days have been stripped out, as have the Christmas holidays and the month of August, because demand is significantly lower at these times for obvious reasons not related to the weather.

Demand varies widely from one country to the next, though the phenomenon of temperature sensitivity in winter is always visible: when it is cold, consumption increases as temperatures drop.
Consumption declining in Europe

This phenomenon is the most noticeable by far in France; as a first approximation, temperature sensitivity is 2.5 times higher in France than in Great Britain, 4.5 times as high as in Germany and five times higher than in Italy and Spain.

In southern countries (Italy and Spain), the use of air conditioning when temperatures are higher is also visible.

On 5 January 2015, TSOs adhering to ENTSO-E began publishing fundamental data about the European electricity market on a joint platform called the Electricity Market Fundamental Data Information Platform, or EMFIP. This new platform, which complies with the EU Transparency regulation, is a big step towards harmonising power system data published across Europe and assuring that it is complete.
Part 4

Market prices trending lower across all of Europe
Average annual spot prices on power exchanges contracted sharply across all of Western Europe in 2014. This downtrend was fuelled by declines in demand in all countries, reflecting particularly mild weather conditions. Plummeting fossil fuel prices (oil, gas and, to a lesser degree, coal) also played a part. In France, which relies less on these fuels for power generation, a very high availability rate for nuclear power plants put additional downward pressure on prices.

Wholesale electricity prices in France remained among the lowest in Europe. The average gap with German prices narrowed and the rate of convergence between prices in France and Germany was of the same order of magnitude as in 2013. French prices were particularly low during the summer and held below those of all other countries most of the time. Prices were higher in Belgium than in France due to unscheduled shutdowns of several nuclear power plants there. The rate of convergence between prices in France and its neighbouring countries thus decreased.
Market prices trending lower across all of Europe

Two new extensions for market coupling in 2014

The integration of European power markets took major steps forward in 2014 with the extension of price coupling to the North West Europe (NWE) region on 5 February and then to the Iberian Peninsula on 14 May. The price coupling of day-ahead markets makes a significant contribution to the economic optimisation of the European power system.

It creates a single trading area, and therefore zones with identical prices when interconnection capacities do not limit cross-border flows. The convergence observed on the morning of Thursday, 15 May was remarkable: prices were exactly the same from Portugal all the way to Finland.

Prices within coupled area on Thursday 15 May 2014, 6-7:00 am

<table>
<thead>
<tr>
<th>Country</th>
<th>Price &gt; FR price</th>
<th>Price &lt; FR price</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB</td>
<td>€38.64/MWh</td>
<td></td>
</tr>
<tr>
<td>FI</td>
<td>€35.77/MWh</td>
<td></td>
</tr>
<tr>
<td>FR</td>
<td>€36.64/MWh</td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td>€33.33/MWh</td>
<td></td>
</tr>
<tr>
<td>ES</td>
<td>€35.77/MWh</td>
<td></td>
</tr>
<tr>
<td>NL</td>
<td>€41.57/MWh</td>
<td></td>
</tr>
</tbody>
</table>

Exports up sharply

Overview of contractual trades in 2014 (TWh)

<table>
<thead>
<tr>
<th>Country</th>
<th>Exports</th>
<th>Imports</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB</td>
<td>15.9</td>
<td>0.8</td>
<td>17.4</td>
</tr>
<tr>
<td>NL</td>
<td>0.8</td>
<td>27.3</td>
<td>20.5</td>
</tr>
<tr>
<td>FR</td>
<td>7.3</td>
<td>65.1</td>
<td>57.8</td>
</tr>
<tr>
<td>DE</td>
<td>13.2</td>
<td>19.1</td>
<td>6.0</td>
</tr>
<tr>
<td>AT</td>
<td>25.5</td>
<td>0.5</td>
<td>25.0</td>
</tr>
<tr>
<td>NO1</td>
<td>2.9</td>
<td>19.8</td>
<td>16.9</td>
</tr>
<tr>
<td>NO2</td>
<td>6.5</td>
<td>1.1</td>
<td>5.4</td>
</tr>
<tr>
<td>NO3</td>
<td>0.5</td>
<td>6.0</td>
<td>5.5</td>
</tr>
<tr>
<td>NO4</td>
<td>25.5</td>
<td>0.5</td>
<td>25.0</td>
</tr>
<tr>
<td>NO5</td>
<td>9.1</td>
<td>0.5</td>
<td>8.6</td>
</tr>
</tbody>
</table>

Difference between physical and contractual trades

Contractual trades between countries are carried out based on commercial transactions between market players. Physical exchanges correspond to the electricity actually carried over interconnector lines directly interlinking countries.

As such, on the France–Germany border, a commercial import programme might be “offset” by significant exports to Belgium, Italy or Switzerland, though from a physical standpoint the power will be carried part of the way from France to Germany.

For a given country, the balance of physical exchanges over all of its borders and the balance of contractual trades with all of its neighbours are identical.
Market prices trending lower across all of Europe

France showed an export balance of 65.1 TWh in 2014, the highest level since 2002.

In terms of hourly power demand averaged over each month, export balances exceeded 5 GW throughout the year, including in winter, thanks to the competitiveness of French prices.

France was in an import situation for about 30 hours during the year, spread over 11 days.

No full day ended with net energy imports.
France was a net importer from Germany on the whole in 2014. However, exchanges were more balanced, ending the year with an import balance of 5.9 TWh versus 9.8 TWh in 2013 due to relatively low prices in France. Exports were notably robust in July and August, and imports were lower in the first four months of the year.

Renewable energy generation in Germany had a significant impact on reversals of cross-border energy flows with France. For instance, analysis of hourly trends in the exchange balance with Germany in relation to the amount of photovoltaic and wind power injected into the German grid during a sunny week in March helps illustrate the influence these variable sources have on the direction of flows.

The saturation of interconnections between France and Germany was slightly lower than in 2013, but still remained at close to 50%.
Belgium

Trading with Belgium was greatly impacted by the unscheduled unavailability of nearly half of Belgian nuclear capacity. The country had experienced similar problems between mid-2012 and mid-2013. The Tihange 2 and Doel 3 reactors were shut down on 26 March 2014 to conduct safety tests, and then on 4 August Doel 4 was taken offline and was only restarted on 19 December. As of 31 December 2014, two reactors were still not back in service.

Belgium thus did without as much as 3 GW of generation, or up to a third of its capacity excluding renewables.

During the time the three reactors were offline, Belgium showed a very high net import balance. Export capacity from France to Belgium was saturated most of the time and the Netherlands exported to Belgium.

France’s export balance with Belgium increased to 16.5 TWh from 12.9 TWh in 2013.

RTE assessed the impact the shutdown of the three Belgian nuclear reactors had on the French power system. Its analysis showed that during the winter of 2014-2015, the shutdowns in question put downward pressure on operating margins in France, though they remained high enough to meet safety standards.
Spain

France exported to Spain 69% of the time in 2014, up from 62% in 2013. The export balance doubled to 3.6 TWh from 1.7 TWh in 2013.

Prices were extremely volatile in Spain due to the high percentage of variable renewable sources in the energy mix, which exceeded 50% during some months. When renewable generation in Spain peaks, local prices plummet, and fall below French prices; in this case flows are reversed, and France imports electricity from the Iberian Peninsula.

Interconnection capacity was saturated 67% of the time - 45% of the time in the France-Spain direction and 22% of the time going the other way. Exchange capacity between the countries will double in 2015 when the new Baixas-Santa Llogaia line (see Part 5) interconnection comes into service.

Sources: www.ree.es (figures as of 20/01/2015) for generation data, EPEX Spot and OMIE for prices
Market prices trending lower across all of Europe

**Switzerland**

Monthly exchange balances with Switzerland were again dominated by exports; they rose between January and August and dropped in the latter months of the year. The total annual balance was 16.5 TWh in 2014, the same as in 2013.

**Great Britain**

The annual export balance with Great Britain rose sharply to 15.2 TWh. France-England interconnections showed good availability during the year. Interconnection capacity was used for exports during more than 99% of the hours of the year and saturated about 90% of the time.
Market prices trending lower across all of Europe

Italy

Exchanges with Italy were largely dominated by exports with a balance of 19.3 TWh, or 3.9 TWh more than in 2013. Export capacity toward Italy was increased by 400 MW in October thanks to the strengthening of the Alpine networks. During the spring and summer, Italy must limit its imports on days when demand is low. Indeed, given the significant photovoltaic capacity in place, it must keep in operation a number of thermal plants that can modulate their output and assure the stability of the power system.

The balancing mechanism allows RTE to modulate generation, consumption and exchange levels to assure that electricity supply and demand are always balanced. The mechanism involves the selection of offers submitted by Balancing Actors, based on their merit order.

Total balancing volumes declined between 2013 and 2014. Energy volumes activated upwards were notably the lowest on record since the mechanism was created. The use of fossil fuel capacity declined sharply.

Balancing volumes represented less than 1% of the total business volumes of balance responsible entities.
Market prices trending lower across all of Europe

ACTIVITIES OF THE BALANCE RESPONSIBLE ENTITIES

The balance responsible entity system allows consumers, generators, suppliers and traders to conduct all types of commercial transactions in the electricity market. Each balance responsible entity creates an activity portfolio and agrees to settle the costs resulting from imbalances between generation and consumption within it, as recorded after the fact.

There were 192 balance responsible entities with valid contracts in 2014, or 17 more than in 2013. Of these, 134 were actually active, and for 26 physical injections and withdrawals on the grid represented at least 10% of their total business.

An overall increase in transactions conducted by balance responsible entities was observed, with:

- A 10% increase in the volume of party-to-party transactions (block exchange notifications, or NEB) versus 2013.
- A 15% increase in volumes traded on the power exchange. This rise was notably visible on the day-ahead market starting in April 2014: weekly trades reached an all-time high in the week of 1 to 7 December 2014.
- An 11% rise in ARENH volumes to 71 TWh. This increase was primarily attributable to the fact that since 1 January 2014, energy delivered to offset system operator losses has been eligible for inclusion in the ARENH mechanism. On the other hand, the volumes requested at the end of 2014 for the first half of 2015 were down sharply.

* Supply is considered to be tight from a supply-demand balance standpoint when RTE generates one or more messages about insufficient offers on the balancing mechanism (alerts or degraded mode) so actors will submit additional offers.

Supply was rarely tight in the French power system in 2014.
Market prices trending lower across all of Europe

• Virtual Power Plants (VPP) continue to be phased out gradually pursuant to the European Commission decision of 30 November 2011. These products only represented 3.4 TWh, down from 8.5 TWh in 2013, and should be eliminated altogether in 2015.

NEW LOAD SHEDDING CAPACITY BEING DEVELOPED

The development of new load shedding and load curtailment capacity is continuing.

Load shedding allows more flexibility in managing the system and is an additional asset when it comes to maintaining the supply-demand balance and assuring security in the French power system at all times. Since 2003, load shedding capacity can be offered on the balancing mechanism and, since 2014, it can also be requested directly by a market player.

Load shedding involves consumers cancelling or postponing all or part of their consumption in response to a signal.

There are two main categories of load shedding that contribute to the supply-demand balance:
• Industrial load shedding, when production stops at one or more industrial sites.
• Distributed load shedding, which corresponds to the aggregation by an aggregator of individual load shedding actions involving smaller demand volumes, all carried out at the same time by residential or professional customers.

RTE uses a series of calls for tenders to contract industrial or distributed load shedding capacity that can be activated on the balancing mechanism. Through these contracts, players commit to offer to shed or shift loads under very specific conditions, in exchange for which they are compensated:
• Since 2008, RTE has been contracting load shedding capacity with balancing actors to guarantee the availability of these offers on the balancing mechanism.

Balance responsible entities are increasingly using intraday mechanisms, notably on interconnections (+20%) and the exchange (+17%).
Since 2011, RTE has been contracting load shedding capacity that can be activated on very short notice for the rapid and complementary reserves. Contracts resulting from the latest call for tenders have been in effect since 1 April 2014. Thanks to these tenders, RTE had up to 1,200 MW of load shedding capacity at its disposal in 2014, capacity it could activate under specific conditions.

Given that upward balancing volumes declined in 2014, the amount of load shedding capacity activated on the balancing mechanism decreased, falling to 12 GWh (-39% versus 2013).

Load shedding capacity representing 100 MW or more was activated on 14 days over the year, and a maximum of more than 500 MW was recorded on 15 April.

However, offers submitted increased sharply in 2014: though little use was made of load shedding capacity during the year, it contributed to the power system’s margins.
NEBEF
Since 1 January 2014, the new “NEBEF” mechanism (Block Exchange Notification of Demand Response) has allowed actors to realise value on load shedding capacity directly on the market.

The new mechanism was used for the first time when RTE was notified of 30 MW of load shedding on 8 January 2014 for two hours. RTE verifies after the fact that the loads shed correspond to the schedules submitted by actors. The monthly error (weighted by volumes declared by actors) typically ranges between 10% and 20%.

Over the year, a total of 347 MWh of load shedding was submitted to the mechanism by five actors. As of 31 December 2014, 12 actors had contracts with RTE to participate in the NEBEF mechanism.

RTE CREATING NEW MARKET MECHANISMS
From the beginning, RTE has been working with market players to create mechanisms that facilitate the opening of the French electricity market and its integration within Europe.

In 2014, market coupling expanded to Great Britain and the Nordic countries, and then to the Iberian Peninsula. The Italian market will be coupled in the first half of 2015. The areas coupled will subsequently represent more than 84% of total electricity consumption in Europe.

Due to the exceptional situation in Belgium during the 2014-2015 winter, the TSOs participating in the project opted to postpone flow-based power market coupling, initially scheduled for November 2014, until the spring of 2015. Flow-based coupling will involve introducing a new method of calculating and allocating power trading capacity for the CWE region. With this algorithm, cross-border flows will be aligned as closely as possible to the physical capacities of the network.
Part 5
RTE is investing today in the grid of the future
RTE is investing today in the grid of the future

RTE IMPROVING THE QUALITY OF ELECTRICITY

Equivalent outage time lower than in 2013

Equivalent outage time (temps de coupure équivalent - TCE) is an indicator used to measure the quality of the electricity supplied by RTE. It is calculated as a ratio between:

- Total energy not served during times when no power is delivered to RTE’s distributor and industrial customer sites (excluding the energy and rail sectors);
- The average power served annually by RTE to these same customers.

In 2014, the equivalent outage time for RTE customers was 2 min 46 sec, excluding exceptional events. This result reflects the actions RTE has undertaken to improve the quality of the electricity supplied to its customers. Further actions must be taken to move within the 2 min 24 sec limit set out in the incentive regulation.

Only one event was classified as exceptional in 2014, representing an additional equivalent outage time of less than 2 sec. It occurred when power was cut to three lines while fire services intervened in a fire zone under the lines. It is also worth noting that three events alone accounted for more than 38% of total equivalent outage time.

Outage frequency lower despite high lightning density

Since 2013, outage frequency has been factored into the incentive regulation created by CRE to encourage continuity of supply. It corresponds to the average number of short outages (between 1 sec and 3 min) and long outages (more than 3 min) experienced during the year by RTE’s distributor and industrial customers (excluding the energy and rail sectors).

In 2014, outage frequency excluding exceptional events was 0.46, which was lower than in 2013. This result was well within the 0.6 limit set out in the incentive regulation, and was even below the average of the past ten years (0.54).

Note that the exceptional event recorded during the year had a negligible impact on outage frequency (< 0.001).

3. The incentive regulation for electricity quality is based on two key indicators:
- Equivalent outage time;
- Outage frequency.
A financial bonus-malus system is applied based on the results observed during the year.
Of the numerous factors that determine outage frequency, lightning density has a major impact on the number of short outages observed during the year. In most cases, the regions that are hit by lightning the most show a high frequency of short outages. Conversely, in regions where there is relatively little lightning, short outage frequency is lower.

In 2014, lightning density reached 0.97 strikes per km² across France as a whole.

**Lightning density**

- LD < 0.60
- 0.60 < LD < 1.08
- LD > 1.08

**Short outage frequency**

- SOF < 0.20
- 0.20 < SOF < 0.59
- SOF > 0.59

RTE is taking action to reduce the environmental impact of its activities by utilising its resources more efficiently. In 2004, RTE launched a proactive initiative to reduce leakage of SF6, a gas with a strong greenhouse effect. SF6 is currently indispensable to the electrical insulation of RTE equipment, including substations inside buildings (Gas Insulated Substations, which are currently a societal expectation). In 2014, RTE met its target of reducing emissions to under 5.5 tonnes.

RTE is also forging partnerships to turn its power line corridors into corridors of biodiversity. The fact is that most of RTE’s infrastructure is located in agricultural areas (70%) or wooded regions (20%), and some 15,000 km of power line corridors cross through protected natural areas.

Protecting and encouraging the development of biodiversity are the cornerstones of RTE’s environmental policy. Its commitment is recognised as part of the “2011-2020 National Strategy for Biodiversity” by the Ministry for Ecology, Sustainable Development and Energy.

In 2014, RTE set aside 582 hectares of land for biodiversity conservation.

**LOSS RATE STABLE IN 2014**

Line losses occur when electricity is being carried from generation to consumption sites, and loss volumes depend on the transmission distance and the characteristics of the grid. Nearly 80% of these losses are due to the Joule effect on high and extra high voltage lines. Other effects contribute as well, notably when current passes into transformer substations.

Losses are a function of the intensity moving through the infrastructure, and increase when consumption is higher. RTE works to minimise losses to reduce the impact of electricity transmission on the environment, by optimising the distance over which electricity travels and taking full advantage of the flexibility it has in operating the grid.

In 2014, losses reached 10.6 TWh, which corresponded to 2.08% of consumption.

**RTE INVESTED CLOSE TO €1.4 BILLION IN 2014**

In 2014, RTE’s investments within the scope of businesses regulated by the CRE totalled €1,374 million, of which €1,243 million was invested in grid infrastructure.

The bulk of these investments corresponded to the accommodation of renewable energies, the ongoing construction of the direct current line that will strengthen the interconnection between France and Spain through the Eastern Pyrenees, the replacement of conductors to make flows more secure on the 400 kV line between Montélimar and Lyon, and bolstering security of supply to the regions (PACA, Vendée). Moreover, nearly 35% of investments in grid infrastructure were for replacements designed to maintain service quality.
RTE has stepped up its investment programme for 2015, which should be in the region of €1.5 billion. This will ensure that the structural work planned (direct current line between France and Italy, through the service gallery in the Fréjus tunnel, and reconstruction of the 400 kV Charleville-Reims line) can be carried out in 2015. The programme also calls for additional actions to expand and update the information system.

These investments are being made bearing in mind that, over the coming years, rising to the challenges of the energy transition will require more and more effort. Indeed, the French transmission grid will play a key role in accommodating new generation sources (including offshore wind farms), integrating European energy markets (by strengthening cross-border capacity), and assuring the operational safety of the networks and quality of supply to the different consumption areas and regions.

UNDERGROUND NETWORK EXPANDED IN 2014

With 105,331 km of lines in service, RTE’s network expanded in 2014, and the length of its underground lines increased. The length of the overhead circuits did not change during the year, 2013 having seen the Cotentin-Maine EHV line go live.

All in all, the network in service was expanded by 348 km in 2014. New underground lines accounted for 345 km, much more than in 2013 (100 km). Lines scrapped or replaced in 2014 represented a total of 752 km.

Also in 2014, 22 new substations were connected, nine of which were extra high voltage. Examples included the 400 kV Oudon substation, where the Cotentin-Maine project ends, and the 400 kV Galoreaux substation in Pays de la Loire. Their purpose is to bolster power supply to western France and the southern part of Pays de la Loire.

As regards 225 kV substations, the Saint-Cyr-En-Val and Tivernon substations in the Centre region, Darcey in Burgundy and Saintois in Lorraine are all helping enhance grid security in these regions.
NEW 400 KV AND 225 KV LINES AND REPLACEMENTS

The “PACA safety net” was tested during the last quarter of 2014. This was the final step before it could be deployed early in 2015.

The PACA safety net involves three new 225 kV underground lines - Biançon-La Bocca, Biançon-Fréjus and Boutre-Trans – in the Var and Maritime Alps departments.

To enhance security of supply to the region, the PACA safety net will make it possible to avoid cutting power to the entire eastern part of the region if the main 400 kV line between Avignon and Nice is down. The Boutre-Trans link is almost 65 km long, whereas previously, the longest 225 kV underground line in France has a length of 21 km. With these new developments, RTE is pushing back the limits of the technologies and methods used until now to build underground electric infrastructure.

These innovative technical solutions will be incorporated into the safety net planned for Brittany, with its 80 km of 225 kV lines, all underground.

Another 55 km of new underground cables, in addition to the 106 km built for the PACA safety net, were also brought into service, notably in Lyon and Marseille. In this case underground technology was required due to the highly urbanised areas in which the cables were installed.

Conductor replacement work was also done on 468 km of 400 kV and 225 kV overhead lines. Examples include the Chaffard-Coulanges 400 kV line in the Rhône-Alpes region and several 225 kV lines: Barbuise-Les Fossés in Champagne-Ardenne, Margeride-Rueyres in Auvergne and La Mole-Sainte Feyre in Limousin.

NEW 63 KV AND 90 KV LINES AND REPLACEMENTS

Ninety per cent of new 63 kV and 90 kV lines were placed underground in 2014; this rate stabilised during the year and averaged 92% over the past three years.

In 2014, 252 km of new underground lines were brought into service, up from 110 km in 2013 and 208 km in 2012. The most important underground lines commissioned at these voltage levels were South Hill-Periers in Lower Normandy, Forges Les Eaux-Neufchatel in Upper Normandy, Grande Synthe-Ruytingen in Nord-Pas de Calais, Cantegrit-Mimizan in Aquitaine and Darcey-Poiseul in Burgundy.

Some overhead lines were also partially or totally undergrounded during the year, including Vitré-Piquage line in Bréal, Brittany and the Hourtin-Lacanau line in the Aquitaine region.

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All in all, the portion of the 63 kV and 90 kV lines located underground continues to rise steadily and represented 6.2% of the existing network in 2014. This rate varies from one region to the next depending on local population density, physical geography (flat or mountainous land), the existence of protected areas, or the additional cost to the community relative to building overhead lines.

Note that in 2014, 27 km of new 63 kV and 90 kV overhead circuits were also brought into service and conductors were replaced along 179 km. Examples of how the grid is being strengthened include Bellac-Maureix in Limousin, Barettes-Buquet in Upper Normandy and Gueugnon-Sornat in Burgundy.

DEUX NOUVELLES LIAISONS TRANSFRONTALIÈRES

Two new cross-border lines were commissioned in 2014. The first connects the Principality of Andorra with a direct 150 kV link built between Hospitalet (France) and Grau-Roig (Andorra). The Island of Jersey was already getting power from the Cotentin via two 90 kV subsea lines, and a third 90 kV underground connection that is partially immersed was added. This new cross-border line guarantees reliable and high-quality power supply to the Island of Jersey.
RTE is investing today in the grid of the future

To connect these different projects, RTE is proposing the creation of 225 kV double circuit lines, starting out underwater between the wind farm and the landing point, and then running underground between that landing point and the 225 kV substation where it is earthed. An existing substation can be used or one can be created under existing lines. The plotting of these different lines was the subject of a far-reaching consultation in 2013 and 2014.

In May 2014, the government announced the results of the second call for tenders for two wind farms with capacity of 500 MW each, one off the coast of Tréport in Upper Normandy and one in Noirmoutier-Yeu, in Pays de la Loire. Both projects went to the consortium formed by GDF Suez, Areva, Portuguese energy firm EDP Renovaveis and Neoen Marine, in partnership with Areva. As with the first tender, RTE is in charge of connecting the projects. Offshore studies and local consultations to help determine how they will be connected will kick off in 2015.

**France-Spain interconnector in the Eastern Pyrenees**

The decision was made to build this fully underground link between Baixas (near Perpignan, France) and Santa Llogaia (close to Figueras, Spain) in 2008. This 65 km link (35 km in France and 30 km in Spain) crosses the Albera Massif with an 8.5 km tunnel and uses direct current technology with AC/DC voltage source converters at each end. With a capacity of 2,000 MW and operating at 320 kV, the link will double interconnector capacity between France and Spain from 1,400 MW to 2,800 MW. This boost in exchange capacity between the countries will facilitate the further integration of renewable energies into the European grid.

The construction of the new interconnector between France and Spain has been entrusted to INELFE, which is jointly owned in equal shares by RTE and REE.

Construction work on the line has been completed and the first live tests have just taken place. The latter part of 2014 and early months of 2015 will be devoted to various tests on this innovative line.

**Accommodating offshore wind power**

The renewable energy development plan for France that resulted from the Grenelle environmental conference aims to boost annual renewable energy output so that it can cover at least 23% of final energy consumption by 2020. One aspect of the plan is the development of 6,000 MW of offshore wind and marine energy capacity in France by 2020.

Under the contract terms of the first call for tenders, RTE will act as the contracting authority and project manager for studies on and the building of connections between the four production areas in Fécamp (Upper Normandy), Courseulles-sur-Mer (Lower Normandy), Saint-Brieuc (Brittany) and Saint-Nazaire (Pays de la Loire). This project calls for 350 wind turbines representing combined capacity of 2,000 MW and split between these four sites.

The contract for these offshore wind farms was awarded in April 2012 to the Eolien Maritime France (EMF) consortium formed by EDF Energies Nouvelles, Dong Energy Power and Alstom for the Courseulles-sur-Mer, Fécamp and Saint-Nazaire farms and Ailes Marines SAS – comprising Iberdrola, EOLES-RES SA and Areva – for the Saint-Brieuc farm. Together, these projects represent more than 300 wind turbines and capacity of about 2,000 MW.
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MAIN NEW CONNECTIONS IN 2014

EXISTING GRID

- 400 kV line
- 225 kV line

PLANNED ADDITIONS TO GRID

- Line strengthening
- Creation of new lines
- Project being considered
- Plans to create or adapt substations

Purpose

- Security of supply
- Low voltage management
- High voltage management
- Short circuit current control
- Grid stability

New generation capacity

- Combined-cycle gas
- Renewable energies
- Marine turbines

Source: Ten-year Network Development Plan
France-Italy (Savoy-Piedmont) interconnection

The Savoy-Piedmont project, led by RTE and TERNA, involves building an underground 320 kV direct current line between Chambéry and Turin. Completion of this 190 km double circuit underground line will boost interconnection capacity between France and Italy by 2,000 MW. Construction started on the French side in 2014 and the interconnector is scheduled to be in service in 2019.

France-England (IFA2) interconnection

Since 1986, France and England have been interconnected by the IFA France-England direct current interconnector with a capacity of 2,000 MW. But additional transmission capacity has become necessary. A consultation on the new IFA2 link kicked off in 2014 and it should be in service by 2020.

Running under the sea for 200 km and underground for about 30 km, the new interconnector will link Lower Normandy to the central south coast of England. This direct current, 1,000 MW line will increase exchange capacity between the two countries. RTE is handling this project in partnership with National Grid Interconnectors Limited, a subsidiary of its British counterpart in charge of developing interconnector capacity.

Power supply to the Haute-Durance

Power is supplied to this region primarily via a single 150 kV line built in 1936 and capable of carrying up to 220 MW of electricity. The Haute-Durance now finds itself in a vulnerable position, particularly when power demand peaks in winter. All regional players’ analyses concur that the energy situation could become critical in 2016, and that the region could need an estimated 250 MW in 2020.

RTE has thus designed a programme that is staggered over time and divided into six projects. It involves creating a 225 kV network to replace the existing 150 kV line and upgrading the 63 kV network (undergrounding, reconstruction or strengthening). All of this would be done making maximum use of existing corridors in order to conserve and even enhance the environment in the Haute-Durance.

The first two “Declarations of Public Utility” for the Haute-Durance project have been signed. Work got under way in September 2014 and the new infrastructure should be in service in 2020.

Plan to rebuild a 225 kV overhead/underground line between the Upper Loire and Loire regions (2 Loires project)

Some major urban and industrial hubs of the Upper Loire and Loire regions are concentrated between Le Puy-en-Velay, Yssingelais and Saint-Étienne. Power is provided to these areas by a 225 kV line that has been supporting the region’s industrial and economic growth for almost 70 years. The line was built in 1941 and has now reached its technical limits.

A “Declaration of Public Utility” was published for the 2 Loires project in the Official Journal in August 2014, after four years of consultations between RTE and regional stakeholders (elected officials, government services, associations, local residents, socioeconomic representatives, etc.) to determine the best possible path for the line.
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Source: Ten-year Network Development Plan
GLOSSARY

ADEeF: Association of Electricity Distributors in France.

Adjusted consumption: Power that would have been consumed if temperatures had been the same as reference temperatures, and if there was no 29th day in February for leap years.

ARENH: Accès Régulé à l’Électricité Nucléaire Historique, or Regulated Access to Incumbent Nuclear Electricity. Refers to suppliers’ right to buy electricity from EDF at a regulated price, in quantities determined by French energy regulator CRE.

Balance responsible entity: An electricity market player that has a contract with RTE under which it must settle the cost of any differences between energy injected and withdrawn, as recorded after the fact, across the entire portfolio for which it is responsible.

Balancing mechanism: Mechanism designed to assure that, at any given time, RTE has sufficient power reserves it can activate if their power consumption in response to a signal.

Capacity factor: Ratio between the electrical energy effectively generated over a given period and the energy that would have been produced at nameplate capacity over the same period.

Coverage rate: Ratio between power generated and gross domestic consumption at a given time.

CWE: Central West Europe, region including France, Belgium, Germany, Luxembourg and the Netherlands within which electricity market prices have been coupled since 2010.

ENTSO-E: European Network of Transmission System Operators for Electricity, which has 34 member countries and 41 transmission system operator (TSO) members. Its purpose is to promote important aspects of electricity policy such as security, renewable energy development and the power market. ENTSO-E works closely with the European Commission and is the backbone of the European electricity market.

“Equivalent outage time”: Energy not supplied as a result of customer power cuts and load shedding, expressed as a ratio to the total annual power supplied by RTE to its customers.

ERDF: Électricité Réseau de Distribution France.

Exceptional events: High impact, low probability atmospheric phenomena as well as cases of force majeure.

Generation: • The “Hydro” category includes all types of hydropower stations (poundage, run of river, etc.). Consumption resulting from pumping at “STEP” (pumped storage stations) is not deducted from generation. • The “Nuclear” category includes all nuclear power plants. Consumption by auxiliary generator sets is deducted from generation. • The “Fossil-fired thermal” category includes fuels like coal, oil and gas. • The “Thermal renewable” category includes biogas, paper/paperboard waste, municipal waste, wood-energy and other solid biofuels.

Gross consumption: Power consumed across France, including Corsica and factoring in losses.

Heavy industry: Final customers getting electricity directly from the transmission system operator.

Intraday: Refers to electricity trades conducted on very short notice, almost in real time.

LDCs: Local Distribution Companies. These are, along with ERDF, the operators of the distribution system, intermediaries between the transmission grid and final customers. There are approximately 150 LDCs across France.

Lightning density: Number of times lighting strikes per year and per square kilometre in a given region.

Load shedding: Mechanism by which consumers cancel or postpone all or part of their power consumption in response to a signal.

Market coupling: Process by which electricity supply and demand are matched across different markets, within the limits of the interconnection capacity between these markets. An algorithm simultaneously determines prices and implicitly allocates available cross-border capacities, resulting in identical price zones when interconnection capacities do not limit cross-border trades.

NCT: Net Transfer Capacity, the transfer capacity made available to the market for imports and exports, calculated and published jointly by the system operators. Transfer capacity depends on the characteristics and availability of interconnection lines and internal constraints on the individual countries’ power grids.

Outage frequency: Ratio between the number of outages and the number of distributors and industrial customer sites supplied by RTE. An outage is considered to be short if it lasts between 1 sec and 3 min and long if it lasts more than 3 min.

Power line circuit length: Actual length of one of the conductors that form a power line or the average length of the conductors if they differ substantially.

PTS: Public Transmission System, over which electrical energy is carried and transformed, linking generation sites to consumption sites. It includes the primary transmission and interconnection grid (400 kV and 225 kV) as well as the regional distribution networks (225 kV, 90 kV and 63 kV). This very high voltage and high voltage grid provides electricity to heavy industry and the main distribution system operators.

Reference temperatures: Averages of past temperature series considered to be representative of the current decade. Based on Météo France data, the temperatures are calculated by RTE for France as a whole thanks to 32 weather stations throughout the country.

Residential and professional customers: Final customers to which distribution system operators provide low-voltage power, with contracted power of 36 kVA or less.

Seasonally-adjusted data sets: Chronological series from which the seasonal component has been removed. Changes in statistical series can usually be characterised as reflections of trends, seasonal components, or irregular components. Adjusting for seasonal variations is a technique used by statisticians to eliminate the effects of seasonal fluctuations on data, thereby revealing fundamental trends.

SER: “Syndicat des Énergies Renouvelables”, France’s renewable energy association.

SMI/SMEs: Final customers to which distribution system operators provide medium- and low-voltage power, with contracted power of 36 kVA or more.

Spot price: Average electricity price negotiated for delivery the following day in 24 one-hour timeslots.

Water reserves: Filling rate (expressed as a percentage), corresponding to the relation between the storage volume recorded the previous Monday at midnight and the maximum storage volume, in aggregate.

Source of data: The information in this publication is based on metering data collected by RTE on the public transmission network and on data obtained from the distribution system operators, notably ERDF and EDF Systèmes Énergétiques Insulaires for Corsica and from ENTSO-E, the European Network of Transmission System Operators for Electricity. Temperature data are provided by Météo France.

Data as of 31 December 2014

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