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05 SUSTAINABLE ENERGY

CONNECTED TO THE PROVISION OF A SECURE AND EFFICIENT ELECTRICITY SERVICE OF THE HIGHEST QUALITY

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CORNERSTONES FOR ACHIEVING SUSTAINABLE ENERGY

The value of a secure, efficient and sustainable energy supply

INTERCONNECTIONS BETWEEN SYSTEMS

Strengthening of interconnections to improve the security of supply, achieve a greater integration of renewables and reduce costs for the electricity system as a whole.

Commissioning of the Majorca-Ibiza double link

ENERGY EFFICIENCY

Development of initiatives aimed at achieving a more efficient management of the electricity system in the fields of demand-side management, energy storage, smart grids.

Carrying out projects for the improvement of system efficiency (PERFILA, ALMACENA,...)

43,664
km
OF LINES IN SERVICE

INTEGRATION OF RENEWABLES

The safe integration of renewable energies to contribute to the reduction of air pollutant emissions, and to reduce Spain's dependence on foreign energy.

40.8% of the electricity demand covered with renewable energies

SUSTAINABLE DEVELOPMENT OF THE TRANSMISSION GRID

Construction of new facilities in order to increase transmission capacity, strengthen grid meshing and facilitate connections between electricity systems.

674 km of new lines and **61 new** substations bays

TECHNOLOGICAL INNOVATION

Incorporation of new innovative technologies in order to increase the security, efficiency and sustainability of the electricity system.

76 R&D+i projects
8.6 M€ in investment

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QUALITY AND SECURITY OF SUPPLY / G4-DMA

The objective of the European Union's strategy on the 'Energy Union' is to boost energy security, sustainability and the competitiveness of the energy market.

Red Eléctrica, as transmission agent and operator of the Spanish electricity system, is responsible for helping to make the objectives of the energy policy viable in regard to providing a secure, efficient and sustainable electricity supply.

For this reason, all our actions are aimed in some way at realising the commitment of the European Union to the energy targets and the fight against climate change. In this regard, noteworthy is the legislative proposal announced in 2016, known as the 'Winter Package', for achieving clean energy for all European citizens. This regulatory proposal is a further step in the transition, started in 2015, towards clean energy with the definition of the European Union's strategy on the 'Energy Union'. A strategy broken down into five closely related dimensions, the ultimate goal of which is to boost energy security, sustainability and the competitiveness of the energy market.

Dimensions of the strategy on the 'Energy Union'

1. **Reduce** energy dependence and increase energy solidarity.
2. Achieve a fully integrated **European energy market.**
3. **Foster energy efficiency** as a means to moderate demand.
4. **Decarbonise** the economy.
5. **Increase research,** innovation and competitiveness.

LEGISLATIVE PROPOSAL 2016

WINTER PACKAGE FOR ACHIEVING CLEAN ENERGY

Included in the EU's commitment against climate change

In the 'Activities' section of the corporate website.

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Sustainable development of the transmission grid

Electricity infrastructure planning / EU10

The current infrastructure planning, approved by the Council of Ministers in October 2015, covers a period of 6 years and is binding in nature for Red Eléctrica.

This planning includes the projects for new transmission grid infrastructures necessary to guarantee the electricity supply nationwide, considering the aspects of economic efficiency and sustainability of the electricity system. In addition, physical, technological and environmental feasibility has been taken into account in the analyses carried out, prioritising among them those alternatives that allow a better use of the existing grid. As a new development, the planning also includes an annex, non-binding, for those infrastructures deemed necessary with a horizon for post-2020, so that it can begin its administrative permitting process.

A fundamental aspect of this planning is the development of the i**nterconnections between electricity systems:** international interconnections, links between island systems and connections between the Peninsula and non-peninsular electricity systems.

CORNERSTONES OF THE
TRANSMISSION GRID PLANNING (2015-2020)

THE 2015-2020 **PLANNING**

4,554
M€
TOTAL ESTIMATED INVESTMENT

In the development of new electricity infrastructure

ELECTRICITY INFRASTRUCTURE PLANNING

Approved in October 2015 for a period of six years and is binding in nature for Red Eléctrica.

In this scope, the **Spain-France interconnection** is noteworthy for its great influence on the quality and security of the Spanish system, and the integration of renewable energies in the Iberian Peninsula. In addition, the need to increase the capacity of this interconnection is one of the priorities for the European Commission in the field of electricity, with a view to achieving the energy targets that allow access to sustainable, competitive energy under safe conditions.

In this regard, to improve the Spain-France interconnection, a phase shifter for the 220 kV Arkale-Argia line (planned for 2017) is included in the 2015-2020 horizon. Nevertheless, the set of actions that will allow a significant increase in exchange capacity is set out for beyond 2020 due to the great magnitude of the following projects: a submarine interconnection in direct current through the Bay of Biscay and two interconnections through the Pyrenees, one via Navarra and another via Aragón. Regarding the **interconnection with Portugal,** a project is included in the area of Galicia between Fontefría and Vilafría for 2017.

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As for the **interconnections between island systems,** eleven new links between islands are included that will allow the connection of isolated systems, or the strengthening of existing connections, which will represent an increase in the security of supply and the reduction of generation costs. Of the links indicated, eight correspond to the period 2015-2020: five in the Balearic Islands (of which, the two links between Majorca and Ibiza) have already been commissioned and three in the Canary Islands.

Finally, with regard to the **Peninsula's interconnections with non-peninsular electricity systems,** a link with Ceuta is planned for 2020 and a second link with Majorca post-2020. Both facilities will reduce generation costs and significantly improve the guarantee of supply in the systems of Ceuta and the Balearic Islands.

INFRASTRUCTURE PLANNING
2015-2020

NEW
INTERCONNECTIONS WITH FRANCE AND PORTUGAL

Increase in exchange capacity

PLANNING
includes eight new links between islands for the 2015-2020 period: five in the Balearic Islands and three in the Canary Islands; In addition to a link between the Spanish Peninsula and Ceuta.

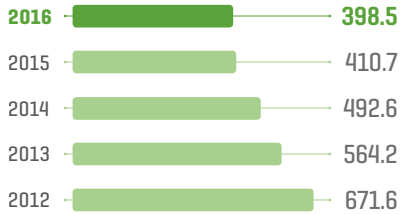
On the other hand, this planning includes, on an indicative basis, both the electricity consumption forecast in the 2015-2020 planning period as well as the **demand coverage analysis,** which assesses whether the forecasted generation allows this demand forecast to be met. In this regard, the structure of the generation mix will continue the transformation registered in recent years, increasing the predominance of both renewable energy and natural gas, in comparison to coal and nuclear energy, with a significant improvement in the associated efficiency, in terms of primary energy.

Regarding the reliability of the coverage of the peninsular demand, a minimum coverage ratio of 1.1 (calculated as the quotient between the net power available in the system and the forecasted peak average hourly demand) is adopted as a figure that adequately guarantees the coverage of the demand of the system in an extreme situation, considering the main uncertainties such as the variability of renewable generation. Under these assumptions, planning does not foresee the need for additional power to cover the peak demand in the 2015-2020 horizon.

Construction of the transmission grid / EU4

In 2016, investment in the transmission grid has basically addressed the resolution of technical constraints, grid meshing, the execution of unique international interconnection projects and submarine interconnections between islands, and the need to guarantee the security of supply and the reliability of the grid.

INVESTMENT IN THE TRANSMISSION GRID M€



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In this fiscal year, 674 km of new line and 61 new substation bays have been commissioned, and transformer capacity has also been increased by 600 MVA, with an overall investment in the transmission grid of 398.5 million euros.

The actions by which the improvement of the transmission grid is carried out are classified into two types: structural and connection, which are triggered as a result of the following reasons:

Structural actions

- Resolution of technical constraints.
- Security of supply.
- Reliability.
- International connections, interconnections between islands and connections between the Peninsula and non-peninsular systems.

Connection actions

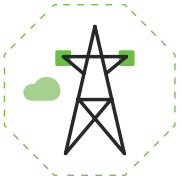
- Grid development associated with the high-speed rail network programme.
- Support for the distribution and new demand of large consumers, mainly industrial.
- Evacuation of conventional and renewable generation.
- Connection of energy storage facilities.

During 2016, the most significant **structural actions** undertaken regarding the development of the transmission grid were, by large axes, the following:

- **Asturias-Galicia axis:** the purpose of this axis is to guarantee the quality and security of supply, creating a 400 kV transmission infrastructure by incorporating 361 km of line, 46 substation bays and 3 transformers. The main objective is to connect northern Galicia and western Asturias in order to meet the foreseen consumption in this area, and facilitate the evacuation of new generation in the upcoming years. This actions will complete the Cantabrian axis, so that areas of surplus, such as Galicia and Asturias, can evacuate their energy into regions with a deficit. Much of this axis was commissioned before 2011. In 2016, the 163 km Boimente-Pesoz line was commissioned.
- **Aragón-Levante axis:** This axis aims to resolve the technical constraints and allow the evacuation of wind energy from Aragón into Castellón. The axis links the Aragón Fuendetodos, Muniesa, Mesquita, Morella and Mudéjar substations by means of a network of 414 km of line,

The major investments in the electricity transmission grid were earmarked for connecting the islands and for grid security and reliability.

GRID CONSTRUCTION
2016



674
km
OF NEW ELECTRICITY LINE

61 new substation bays

ASTURIAS-GALICIA AXIS

The 163 km Boimente-Pesoz line was incorporated in 2016 into the axis connection between northern Galicia and western Asturias.

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31 substation bays and 1 transformer. In 2016, the 243 km Mezquita-Morella line was commissioned.

- **Godelleta axis:** has the purpose of resolving 400 kV and 220 kV technical constraints in the province of Valencia. The construction of the Godelleta substation and the associated incoming/outgoing feeder lines will facilitate the evacuation of generation from Aragón, while allowing a new point of support from the 400 kV grid to the 220 kV grid that will feed the city of Valencia. In 2016, the Godelleta 400/220 kV substation and two of the three associated incoming/outgoing feeder lines that form this axis were commissioned.

- **Torremendo axis:** its objective is to resolve the lack of grid meshing at a 220 kV level in Murcia and Alicante, and thus to solve the risk of loss of supply. This infrastructure will strengthen the 220 kV coastal axis, which runs parallel to the coast, from which numerous nuclei are fed, which has experienced a significant increase in demand in recent years. The strengthening of the axis will be undertaken through the existing San Miguel de Salinas substation, which already belongs to the axis, through the construction of the 220 kV Torremendo-San Miguel de Salinas line and the 220/400 kV Torremendo substation that will connect the coastal axis to the already existing 400 kV Nueva Escombreras-Rocamora line. In 2016, progress has been made on the construction of the axis through the commissioning of the Torremendo substation, the associated incoming/outgoing feeder lines and the Torremendo-San Miguel de Salinas line.

- **Sabinal axis:** The strengthening of this axis enables the security and guarantee of supply to be increased and the reliability of the electricity system of Gran Canaria to be improved. In 2016, the Sabinal substation and the associated incoming/outgoing feeder lines were commissioned.

- **Interconnections with France:** In 2016, three new interconnections were designed with the objective of increasing the capacity of energy transmission with Europe through France: a submarine interconnection through the Bay of Biscay and two trans-Pyrenean interconnections Cantegrit-Navarra and Marsillon-Aragón. All these actions have an expected commissioning date post-2020.

- **Majorca-Ibiza interconnection:** this link aims to eliminate the electrical isolation of Ibiza, in addition to saving costs for the system and promoting competition in electricity generation on the islands. In 2015, the first cable of the link was commissioned and in 2016 the second cable of the interconnection was also brought into service, helping to consolidate the process of electrical integration of the entire Balearic archipelago and its connection with the Peninsula.

TRANSFORMER CAPACITY

600 MVA

More in 2016

TORREMENDO AXIS

Will strenthen the coastal axis between Murcia and Alicante whose demand has increased in recent years.

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The Majorca-Ibiza submarine link, completed in 2016 eliminates the electrical isolation of the islands of Ibiza and Formentera.

TRANSMISSION GRID (PENINSULAR AND NON-PENINSULAR) / EU4

	2012	2013	2014	2015	**2016** [1]
km of 400 kV line	20,109	20,639	21,094	21,184	**21,620**
km of 220 kV line	18,779	19,053	19,192	19,386	**19,496**
km of 150-132-110 kV line	272	272	272	398	**523**
km of <110 kV line	2,014	2,014	2,014	2,022	**2,025**
Total km of line	**41,174**	**41,978**	**42,572**	**42,989**	**43,664**
400 kV Substation bays	1,319	1,374	1,394	1,441	**1,458**
220 kV Substation bays	2,936	3,026	3,077	3,124	**3,150**
150-132-110 kV Substation bays	52	52	52	84	**90**
<110 kV Substation bays	743	745	769	779	**791**
Total substation bays	**5,050**	**5,197**	**5,292**	**5,428**	**5,489**
Transformer capacity (MVA) [2]	**78,629**	**81,289**	**83,939**	**84,544**	**85,144**

[1] Provisional data pending audit - in progress.
[2] 2016 solely includes the MVA transformer capacity declared in that year.
Cumulative data as at 31 December.

TRANSMISSION GRID KM OF LINE [1]

Cumulative data as at 31 December 2016

	Peninsula	Balearic Islands	Canary Islands	Total
Overhead lines (km)	39,757	1,061	1,080	41,898
Submarine cable (km)	265	540	30	835
Underground cable (km)	516	171	244	930
Total	**40,538**	**1,772**	**1,354**	**43,664**

[1] Provisional data pending audit - in progress.

SUBMARINE CABLE

835 km OF LINE IN TOTAL

Peninsular system and non-peninsular systems

The connection activities carried out in 2016 include: the installation of two feeder bays in the Regoelle substation and one feeder bay in the Cristobal Colón substation, all of which are necessary for the evacuation of renewable generation.

In addition, work has continued on other relevant projects such as: the phase shifter in Arkale (Basque Country), the Campanario-Ayora line of 34.3 km and the Gavarrot substation of the Begues-Santboi line of 4.3 km.

Transmission grid maintenance

Red Eléctrica's mission is to guarantee that the facilities of the transmission grid are always in optimum condition in terms of availability and reliability by establishing adequate implementation of responsible, efficient and safe maintenance policies. To do this, according to the strategic plan of the Company, a maintenance programme is established annually, which includes all the activities and resources necessary to guarantee the continuity of the electricity supply.

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During 2016, the most important actions have been the following:

- The establishment of **cybersecurity tools** to improve secure access to electronic equipment in the transmission grid has continued.

- In addition, several **technological innovation** projects have been undertaken:
  - > An analysis of the resilience of transmission infrastructures in order to evaluate the Company's ability to deal with unforeseen risks or situations in a dynamic, flexible and creative way, giving a positive response to phenomena that could seriously affect capacity of supply and the recovery of facilities.
  - > Installation of dual-purpose remote devices to control fires near electricity lines and also to act as an ultrasonic nesting deterrent.
  - > The Inspection of electricity lines for their upkeeping by means of photogrammetric methods from images obtained from an aircraft.
  - > The design of tools for the optimisation of the treatment of vegetation and the use of unmanned drones for the inspection of overhead lines.

- In the scope of our commitment to **excellence in the development of activities:**
  - > Efficiency in facilities maintenance has been further improved through the implementation of intelligent maintenance techniques, monitoring and analysing the most relevant technical parameters of equipment and systems to ensure the reliability of the facilities.
  - > Continued operation of the 24x7 shift for the permanent attention of external customers related to the telecommunications business.

- Within the **commitment to sustainability,** in order to increase the reliability and quality of our facilities:
  - > Thermographic inspections have been carried out in all facilities, as well as monthly visual inspections to ensure the good condition of the substations. In addition, 100% of underground lines have been inspected annually to ensure that there are no negative impacts on their environment.

MAR Project (Improvement of Grid Assets)

Within the maintenance activity, the action of adaptation of the integration of the assets acquired from the electric utility companies, especially those acquired in the island systems, is carried out, providing them with the quality standards established by the Company. At the close of 2016, 80% and 89% of the assets acquired in the Balearic Islands and Canary Islands systems respectively had been integrated. In addition, it has been established that the commissioning of the telecommunications fibre optic system for the Majorca-Ibiza submarine interconnection has substantially improved the telecommunications network of the Balearic Islands system.

TECHNOLOGICAL INNOVATION

IMPLEMENTATION OF **INTELLIGENT MAINTENANCE** TECHNIQUES

monitoring the most relevant technical parameters of the facilities

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> A large number of towers have been replaced, both on the Peninsula and on the islands.

> Continuation of the long-term plan for the installation/ replacement of composite insulation in overhead lines.

> Serious investment has been made to incorporate environmentally responsible coatings on the premises.

Service quality / EU28 / EU29

The service quality indicators highlight for yet another year the high level of security and quality of supply provided by Red Eléctrica's facilities, being well within the benchmark established in the current legislation.

However, in the case of the transmission grid of the Canary Islands electricity system, a number of incidents have occurred which have led to an increase in the quality of service indicators associated with continuity of supply (Energy Not Supplied ENS and Average Interruption Time AIT).

SERVICE QUALITY

98.32 %
AVAILABILITY

In the peninsular transmission grid

This increase in these indicators is mainly associated with two incidents that took place on the island of Fuerteventura, which due to the grid topology of the area, have been of greater impact, with an energy not supplied of 374.77 MWh, which represents, 82 % of the total of the ENS and AIT in the transmission grid of the Canary Islands. In any case, 2015-2020 transmission grid planning incorporates new developments aimed at minimising the impact of the potential disturbances in the transmission grid regarding the continuity of supply in the Canary Islands electricity system.

QUALITY OF SERVICE INDICATORS

	2012	2013	2014	2015	2016 (*)
Peninsular grid					
Grid availability (%)	97.78	98.20	98.18	97.92	**98.32**
Energy Not Supplied (ENS) (MWh)	113	1,126	204	53	**67**
Average Interruption Time (AIT) (minutes)	0.238	2.403	0.441	0.112	**0.141**
Balearic Islands' grid					
Grid availability (%)	98.07	97.96	98.00	96.86	**96.92**
Energy Not Supplied (ENS) (MWh)	7	80	13	29	**0.30**
Average Interruption Time (AIT) (minutes)	0.678	7.366	1.205	2.662	**0.027**
Canary Islands' grid					
Grid availability (%)	98.91	98.30	98.37	96.74	**98.09**
Energy Not Supplied (ENS) (MWh)	224	72	148	150	**457**
Average Interruption Time (AIT) (minutes)	13.250	4.380	9.040	9.078	**27.436**

(*) The values for 2016 are pending external audit. As of 2012, the continuity of supply indicators includes the valuation of the impact of incidents that are subject to administrative proceedings currently underway.

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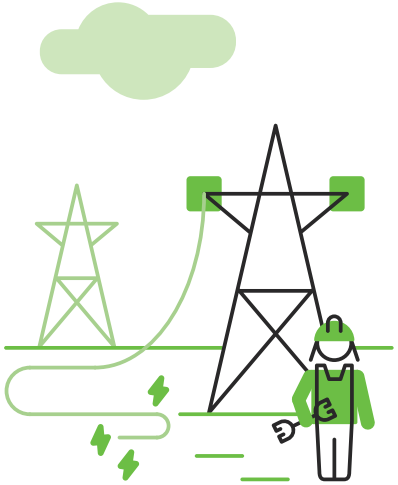
Red Eléctrica has mobile response units capable of responding immediately in any area of the national territory.

Contingency management / G4-DMA

Planning and response when faced with emergencies and disasters

Red Eléctrica has in place systems and methodologies to efficiently manage the contingencies that may occur in the Company.



These systems are set out in a series of policy documents governing actions in the case of operational emergencies. Their application in crisis situations are complemented through mobile response units capable of responding immediately in any area of the country, aimed at guaranteeing the quality and continuity of supply.

These actions are complemented with electricity system contingency action plans, called Service Restoration Plans, which detail the precise actions to be taken to restore the electricity supply, under safe conditions for the electricity system.

Similarly, the Company also has a dedicated training centre called the Operation School, where staff from the electricity control centres are trained by means of system restoration and service recovery simulations. It also carries out safety awareness campaigns for general dissemination and drafts specific training courses on security for certain employees.

OPERATION SCHOOL

TRAINING CENTRE SPECIFICALLY FOR CONTROL CENTRE EXPERTS

Conducts awareness campaigns and training courses on security

SERVICE RESTORATION PLANS

Specific actions regarding system operation to restore the electricity supply under safe conditions for the system.

International simulation for the restoration of the electricity supply service

On 15 November 2016, the system operators of Spain, Portugal and France jointly carried out a drill to restore the electricity service following a widespread blackout simulation in the south of France. The simulation has made it possible to validate the plans for service restoration of the peninsular electricity system, in addition to the joint support plans of the Spanish system with the Portuguese and French systems, as well as training the teams involved under highly exceptional situations.

In addition to the operators of Red Eléctrica de España (REE), Redes Energéticas Nacionais (REN), Portugal and Réseau de Transport d'Électricité (RTE) in France, operators from fifteen generation and distribution companies took part, such as the National Centre for Critical Infrastructure Protection (CNPIC), the Permanent Centre for Information and Coordination of the office of the Secretary of State for Security (CEPIC), and the state security forces.

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On 30 June 2014, at the request of the Secretary of State for Security, Red Eléctrica was designated Critical Operator according to procedure 1/2014, instructed by the National Centre for Critical Infrastructure Protection (CNPIC). As a result, and to comply with Law 8/2011 on Critical Infrastructure Protection and the regulations for its implementation, the Company undertook the creation of the plans required by said Law:

- **Operator Security Plan (OSP),** which sets the guidelines to be followed by the Company in the protection of these facilities.
- **Specific Protection Plan (SPP),** developed by the Company for each of the facilities designated by the Secretary of State for Security.

Within the system of protection of critical infrastructures, the Secretary of State for Security has drafted instruction nº 5/2011, which establishes a communication protocol between electricity operators, state security forces and the office of the Secretary of State for Security, in the case of a terrorist incident in facilities classified as critical.

The drafting of the Specific Protection Plans for each of the critical facilities is made without prejudice to the mandatory compliance of that set out in the Technical Construction Code, approved by Royal Decree 314/2006, of 17 March, Royal Decree 393/2007 of 23 March, which approves the Basic Rules for Self-Protection of the centres, facilities and premises dedicated to activities that can be focal points of emergency situations, or any other specific regulation applicable to the aforementioned. For this reason, and as an additional measure, the Corporate Security and Occupational Health and Safety department drafts other documents that complement the coverage of operational contingencies, and encompass the entire spectrum of possible contingencies such as those that affect people and / or the environment. These other regulations contemplate actions when faced with situations caused by pandemics, the evacuation of buildings and facilities of the Company, as well as self-protection plans for Company buildings, facilities and substations.

In 2014, Red Eléctrica was designated Critical Operator by the National Centre for Critical Infrastructure Protection (CNPIC).

PROTECTION
OF CRITICAL
INFRASTRUCTURE

RED ELÉCTRICA HAS SPECIFIC
PROTECTION PLANS

In the case of serious incidents or emergency situations

SECURITY PLAN

The Operator Security Plan establishes the guidelines to be followed by the Company for the protection of facilities.

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Transmission grid losses / G4-DMA / EU12

The transmission of electricity inevitably entails a loss of energy in the grid. This means that in order to satisfy a given final consumption, it is necessary to have a higher level of generation. Therefore, losses in the transmission grid are the difference between the energy generated and the energy demanded for distribution.

There are several factors that generate losses: the Joule [1] effect, the corona effect and the own consumption of electricity substations which is required for their correct operation. Of these, the most important is undoubtedly the Joule effect associated with the flow of current through the conductors.

Losses in the electricity transmission grid depend on the distance between generation points and consumption points (primarily), the generation mix, the size of the transmission grid, voltage levels, international exchanges and the behaviour of the demand (amount of energy demanded and shape of the demand curve).

Red Eléctrica works to improve aspects that depend on their management and that can have an influence in reducing these losses. Among them noteworthy are the following actions:

- **Development and meshing** of the transmission grid.
- **Increase** in the number of conductors per circuit.
- **Use of technologies** and systems with the best performance (conductors with lower resistance, efficient equipment ...).
- **Maintaining** facilities in the best conditions possible to ensure their good operation.

The first two measures seek to create parallel paths to circulate the same intensity, which reduces resistance and thereby the losses.

However, all these improvements have a remarkably little impact on the evolution of losses, with other aspects, not controlled by Red Eléctrica, having the greatest influence.

TRANSMISSION GRID LOSSES WITH RESPECT TO PENINSULAR DEMAND

[1] **Joule effect:** the effect whereby, when an electrical current flows through a conductor, part of the kinetic energy of electrons is transformed into heat which thereby raises the temperature of the conductor.

Joule effect losses are proportional to the intensity flowing through the conductor and the resistance thereof, the greater the length of the line the greater this resistance is. In view of this, it can be understood that the losses are mainly related to the distance between points of generation and consumption.

ENERGY LOSSES IN THE GRID

1.38
%

With respect to peninsular demand in 2016

JOULE EFFECT

Key factor in energy losses in the transmission grid associated to current passing through conductors.

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The increase in losses in the Spanish electricity system is linked to the share of renewable energies in the generation mix.

Losses are usually proportionate to the distance between points of generation and consumption – the greater the distance, the greater the losses. The structure of the electricity generation mix depends on the rules of the electricity market, regulated by an independent body. The role of Red Eléctrica as electricity system operator should be performed according to specific and mandatory operating procedures. According to these procedures, it is not possible to operate the electricity system based on the criteria for reducing losses, so the Company has little capacity to act in relation to the reduction of said losses.

Moreover, it is important to note that in the case of the Spanish electricity system, the increase in losses is closely related to the share of renewable energies in the generation mix. Typically, increases in hydro and wind generation are related to an increase in transmission distances (this type of generation is located far from consumption points).

PENINSULAR DEMAND
2016

246.7
TWh

+0.7%
Compared to 2015

RENEWABLE ENERGY
Has increased its share in the coverage of the peninsular demand by almost 4 percentage points.

Electricity system operation

For yet another year, the fundamental objective of the operation of the electricity system has been to guarantee the security and quality of the electricity supply, maximising the integration of renewable energies. Demand for **peninsular electricity** in 2016 has grown by 0.7% over the previous year. After factoring in the seasonal and working patterns, demand stands at the same level as in 2015.

During 2016, the share of renewable energies in the coverage of the **peninsular demand** represented 40.8%, which is 3.9 percent more than in 2015.

It is worth noting the significant contribution of wind power generation, whose contribution

COVERAGE OF PENINSULAR DEMAND WITH RENEWABLES [1]

[1] Renewables: hydro, wind, solar photovoltaic, solar thermal, other renewable and 50% of urban solid waste. Excludes pumped-storage generation.

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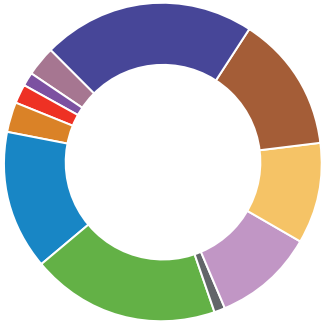
has reached 19%, which ranks this technology in second place, behind nuclear energy, in terms of share among the different types of energy in the coverage of demand. Also in January, February and March, wind generation was the technology with the greatest contribution to the total energy production of the peninsular electricity system, reaching 26.7%, 30% and 25%, respectively.

COVERAGE OF PENINSULAR DEMAND 2016

%

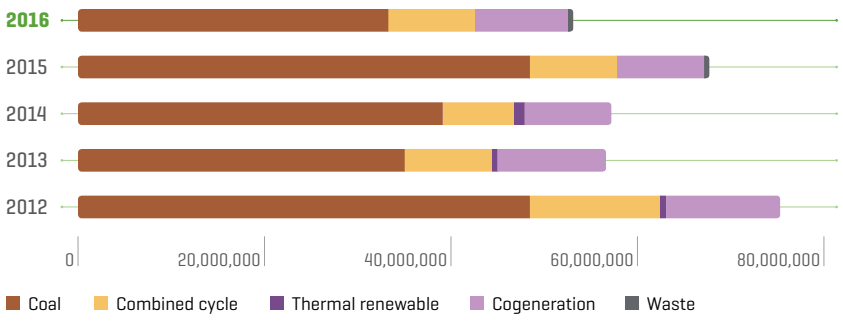
Nuclear	22.2
Coal	13.9
Combined cycle	10.2
Cogeneración	10.3
Waste	1.2
Wind	18.7
Hydro (1)	14.1
Solar photovoltaic	3
Solar thermoelectric	2
Other renewable	1.4
Importer balance international energy exchanges	3



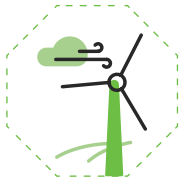
(1) Excludes pumped-storage generation.

CO_2 EMISSIONS ASSOCIATED TO GENERATION OF ELECTRICITY ON THE PENINSULA

tCO_2



RENEWABLE ENERGIES



SHARE OF WIND POWER GENERATION

19 %

Ranked in second place in demand coverage, behind nuclear energy

On the other hand, on 11 January, 2016, a new all-time high of hourly energy was registered, reaching 17,390 MWh, and on 12 February, 2016, there was a new all-time high of daily energy reaching 365,348 MWh. To achieve these maximum values and to make the operation of an electricity system possible with such a high penetration of renewable energies under safe conditions, the control and supervision work carried

CORESO (COoRdination of Electricity System Operators)

In October 2016, Red Eléctrica joined CORESO, the coordinating body for regional security, which already includes several European TSOs.

The increasing proportion of variable generation produced mainly by renewable energy and increased cross-border energy flows require greater coordination among European TSOs in order to maintain the high-quality standards of the electricity system.

In this regard, regional security coordinators are entities created by the TSOs with the objective of providing certain coordination services to maintain the security of the electricity system at all times.

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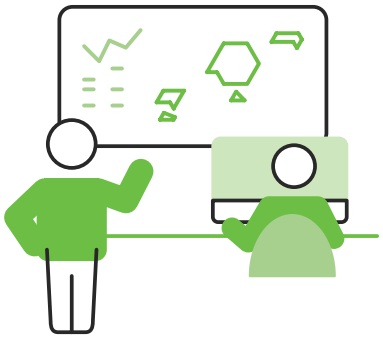

21% of demand on the Balearic Islands has been covered by energy transferred through the link that joins the Spanish Peninsula with the Balearic Islands system.

out by CECRE is fundamental. In this regard, CECRE continues to be a pioneering centre which is of reference worldwide.

Regarding the **Balearic Islands electricity system,** the 132 kV double link between Majorca and Ibiza has been commissioned, which has made it possible to connect the two electricity systems of the Balearic archipelago, Majorca-Menorca and Ibiza-Formentera, to form a single electricity system. This infrastructure, together with the link between the island of Majorca and the peninsular electricity system, represent a substantial improvement in the quality and security of the electricity supply for the Balearic Islands, as a whole, avoiding out-of-range frequency deviations and power outages caused by loss generation.

In 2016, the energy transferred from the Peninsula covered 21% of the demand of the Balearic Islands, reaching peaks that exceeded 30% of the hourly consumption. This has meant savings of 18% in the costs for the coverage of the Balearic Islands system and has avoided the emission of approximately 350,000 tonnes of CO_2 in the Balearic Islands territory.

In the **Canary Islands electricity system,** renewable generation - wind and photovoltaic - represented 8% of the total generation in 2016, reaching 29% in Gran Canaria and 35% in La Palma throughout the year, particularly challenging values in small isolated electricity systems.

Similarly, the hydro/wind power station of Gorona del Viento has been operating regularly throughout 2016, increasing the integration of renewable energy in the El Hierro electricity system. Thus, 43% of the total annual generation of this system came from renewable energy sources and in 2016, for more than 500 hours, this system was supplied with 100% renewable energy.

SPANISH PENINSULA BALEARIC ISLANDS **LINK**

SAVING OF

18

%

IN THE COVERAGE COST OF THE BALEARIC ISLANDS SYSTEM

REDUCED EMISSIONS

The Spanish Peninsula-Majorca link has avoided the emission of approximately 350,000 tonnes of CO_2 in the Balearic Islands in 2016.

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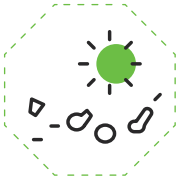
Pumped-storage power stations such as that of Soria-Chira allow energy storage and favour the integration of non-manageable renewable energies.

Energy storage in the Canary Islands

In order to reduce the vulnerability due to peaks in demand, or when facing certain situations of lack of generation, in small and isolated electricity systems such as that of the Canary Islands, it is crucial to introduce energy storage systems, such as pumped-storage power stations, which serve as tools for system operation to improve the guarantee of supply, security of the system and integration of non-manageable renewable energy. It is also essential to develop new interconnections between islands that allow for mutual support between systems and improve grid meshing to provide alternative supply routes in case of incidents.

In this regard, the construction of the pumped-storage power station between the Soria and Chira reservoirs, whose permitting process began in 2016, is an essential tool to progress towards the sustainability of the new energy model in the Canary Islands, as it will make a greater development and use of renewable energies possible on the island of Gran Canaria.

EL HIERRO **ELECTRICITY SYSTEM**



DURING MORE THAN

500

HOURS

Supplied by 100 % renewable energy

THE SORIA-CHIRA pumped-storage power station will have a turbine power capacity of 200 MW and pumping power capacity of 220 MW.

Benefits of the Soria-Chira pumped-storage power station for the electricity system of the Canary Islands

Greater GUARANTEE of supply

The power station will have a turbine power of 200 MW (around 36 % of the current peak of the island's actual demand), so it will increase the guarantee of the electricity supply in Gran Canaria.

Greater system SECURITY

The control capacity provided by this power station will make it possible to compensate for the variability of wind production foreseen on Gran Canaria and to maintain the frequency values stable, thus guaranteeing the security of the system.

Greater INTEGRATION of renewable energies

With this power station, Gran Canaria's electricity system will have an essential facility to take advantage of renewable energy surpluses and to integrate a greater amount of local energy and that energy which produces zero CO_2 emissions.

Greater ENERGY INDEPENDENCE

This facility will help reduce the costs of the Canary Islands electricity system by reducing the import of more expensive and polluting fossil fuels, which in turn lead to greater energy efficiency and a reduction in polluting emissions.

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ENERGY EFFICIENCY / G4-DMA

Red Eléctrica works actively on the promotion, development and dissemination of demand-side management initiatives as one of the tools necessary to improve the efficiency and sustainability of the electricity system.

In this respect, demand-side management initiatives seek to contribute to the maintenance of the guarantee and security of supply by promoting the integration of renewable energy sources, reducing the polluting emissions and promoting the sustainable use of energy in order to achieve a greater efficiency for the entire electricity system.

Among these initiatives, noteworthy are, on one hand, those aimed at achieving a more balanced consumption profile and, on the other, those aimed at providing greater flexibility to the operation of the system.

Main actions

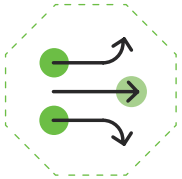
Demand-side management initiatives undertaken by Red Eléctrica seek to address demand, as a whole, carrying out specific actions for the residential sector and the industrial sector. Furthermore, other initiatives that have a global impact on all consumers in Spain are also carried out.

Active Citizen

The electricity system is in a phase of transition towards a new dynamic energy model in which the role of the citizen as a key player in the operation of the system is increasingly relevant. For this reason, Red Eléctrica promotes demand-side management initiatives aimed at making information available to the citizen about the situation of the system, or disseminating recommendations on best practices for an efficient consumption.

Demand-side management initiatives seek to achieve a balanced consumption profile and provide greater flexibility for system operation.

INTERRUPTIBILITY SERVICE 2017



AWARDING OF **2,975** MW OF INTERRUPTIBLE RESOURCE FOR THE SYSTEM

IN THE RESIDENTIAL SECTOR,

Red Eléctrica promotes consumer involvement as a key player in the new energy model.

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One aspect of the new energy model that is materialising is self-consumption. Aware of this new reality, during 2016, Red Eléctrica has carried out forward planning and analysis studies to adapt the operation of the system and anticipate its impact.

Interruptibility Service

This service is an industrial demand-side management tool provided by large consumers that provides a fast and efficient response to the needs of the electricity system at any given time. In this regard, the industrial consumers who provide this service reduce, at the request of the system operator, their consumption up to certain predetermined values.

In 2013, a new allocation mechanism was introduced for the demand-side management interruptibility service based on a competitive auction procedure. During 2016, Red Eléctrica, as administrator of the auctions, has managed the holding of these auctions for the allocation of the interruptible resource for the year 2017. Specifically, large industry of the country has competed in auctions held between 14 and 17 November, 2016, which have resulted in the awarding of 2,975 MW of interruptible resource for the system during the following year.

PERFILA **PROJECT**

ANALYSIS
OF HOURLY INFORMATION

From a panel of consumers with smart meters installed

Red Eléctrica leads the PERFILA Project that seeks **to introduce improvements in the profiling service** through a panel of approximately 20,000 consumers.

Profiling Service

Currently, many of the households in Spain do not yet have smart meters and, therefore, do not have hourly measurements. However, because in the electricity market all energy is settled hourly, it is necessary to make an estimate on the hourly behaviour of those consumers that do not have smart meters installed for hourly metering. Said forecast is carried out through the so-called 'settlement profiles', which Red Eléctrica drafts and which assign to each consumer a typical demand behaviour according to their contracted power and the voltage levels (access tariffs).

With the objective of improving the current profiling service and having a greater knowledge of the hourly consumption of households and a significant part of small shops and services, since 2013 Red Eléctrica has been spearheading the PERFILA project, which counts on the participation of the most important distribution companies. This project is based on the analysis of hourly information from a panel of consumers who already have smart meters installed. The information collated was already applied in the consumption profile proposals for 2015 and 2016 and is being applied in those for 2017.

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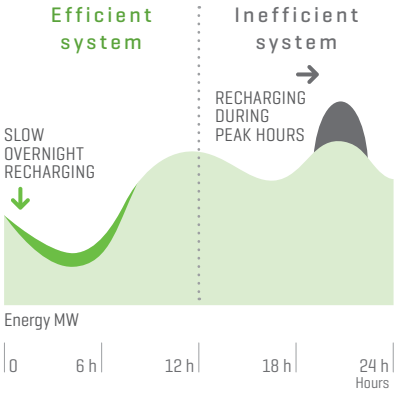
In addition, during 2016, work was undertaken on the management and use of hourly residential consumption information to identify average hourly consumption patterns in each type of household, with the idea of transmitting information about these patterns to consumers in the future, so that it serves as a reference when managing their consumption.

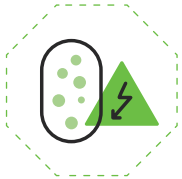
Electric Vehicle

The introduction of the electric vehicle promises to evolve the mobility models of our society, thanks to the possibility of recharging during the night-time valley hours, allowing it to become an ally that will provide greater flexibility and efficiency to the operation of the system.

THE RECHARGING SCHEDULE
OF THE ELECTRIC VEHICLE



ALMACENA **PROJECT**



POWER OF
1
MW

Electrochemical electricity storage system

ELECTRIC VEHICLE

The efficient management of the electricity demand for the electric vehicle is an opportunity for the operation of the electricity system of the future.

Future outlook

Red Eléctrica will continue to respond to the challenges posed by the evolution of the electricity system through the promotion of demand-side management measures that allow greater flexibility in the supply of electricity and a paradigm shift where electricity is not just a product that is consumed, but that the actors of the system can associate this product with services demanded by the end users. Therefore, the Company will continue to drive actions via the 'Active Citizen' initiative that allow the consumer to assume a role not only as a main player, but as an active participant in the electricity sector.

In addition, another challenge to be addressed in the near future, is the incorporation of new flexibility measures in the service sector through demand aggregation. For this reason, during 2016 the foundations were laid for the creation, next year, of a forum where the key agents in the development of the figure of the aggregator can share both their vision and the barriers and opportunities that are identified in its development, and to consolidate a framework, related to the demand, that can provide services to the system through aggregation.

Almacena Project

The Almacena Project consists of the field installation, and subsequent operation, of an electrochemical energy storage system, specifically a lithium-ion prismatic battery with a power output of 1 MW and a storage capacity of at least 3 MWh in the Carmona substation (Seville). During 2016, the behaviour of this innovative system has been further analysed and a comparative analysis has been carried out with other electrochemical storage systems encompassed within a project with EPRI (Electric Power Research Institute of the United States), in order to enrich the experience acquired, both in its integration into the electricity system as well as in its operation and maintenance.

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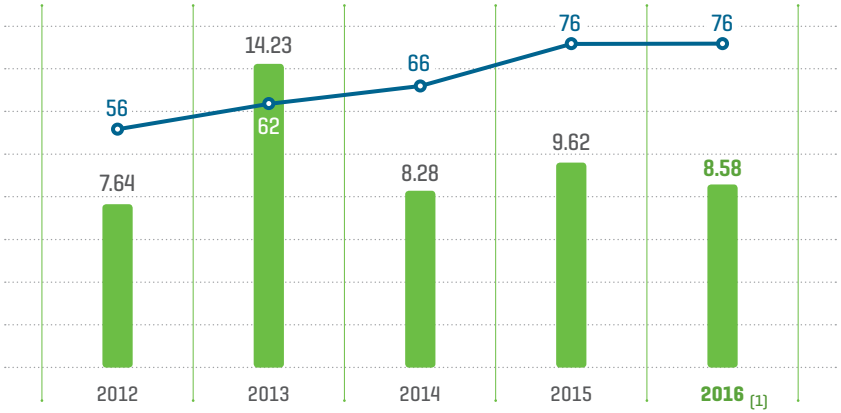
TECHNOLOGICAL INNOVATION / G4-DMA

In 2016, Red Eléctrica approved a new innovation strategy with the purpose of boosting innovation as a lever for growth, cultural change and improvement of the Group's sustainability. This initiative aims to extend innovation to all areas of business activity, focusing mainly on four vectors: digitalisation, people, sustainability and technology.

In this new strategy, the figure of the vector coordinator, who channels innovative ideas and proposals, participates in their evaluation and supervises the execution of the plans and programmes of its vector, transferring information on the progress of the various actions to the Innovation Committee. These coordinators belong to different units of the organisation. As a first step in promoting the culture of innovation, an award has been created for the most innovative initiative of 2016. In this first edition, 23 proposals were presented, among which the Innovation Committee chose the following as winners: MoviMAN (Mobility Solution for the Maintenance of Facilities), CONBANK (System of electronic authorisation of payments and financial transactions from mobile devices) and PORCT (Forecast and Optimisation of Resources for the Control of Voltage).

R&D+i EXPENDITURE /



R&D+i Expenditure (M€) — Nº of projects

(1) Includes the projects and actions of the four vectors defined in the innovation strategy.

MOST INNOVATIVE INITIATIVE 2016

23 PROPOSALS PRESENTED

Three were chosen as winners by the Innovation Committee

VECTOR COORDINATOR

Is the figure who channels, evaluates and supervises innovative ideas and proposals to later pass them on to the Innovation Committee.

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Similarly, Red Eléctrica has continued to undertake projects in the international arena, in particular those carried out under the framework of ENTSO-E. In 2016, the update of the 'R&D Roadmap 2017-2026' was published. Also in 2016, the R&D Monitoring Report 2015 was published, a report evaluating the progress of the ENTSO-E R&D+i Plan from the analysis of the results of more than 70 innovation projects, with the noteworthy participation of European TSOs. Collaboration has also continued with the European Platform for Technology and Innovation in Electricity Grids (ETIP) within the SET Plan of the EU, in which Red Eléctrica is a member of the Governing Board as part of the representation of European TSOs.

EPRI Award

The EPRI (Electric Power Research Institute), an organisation dedicated to research in the field of the electricity sector and involving many companies from around the world, has presented Red Eléctrica with one of its awards: the 2016 PDU 'Transfer Technology Award' for its collaboration in the analysis of the integration and impact of energy storage in electricity systems and, in particular, for the development of a model to maximise the integration of renewable energy in island systems. The awards will be presented in February 2017.

Main R&D+i projects undertaken in 2016

During 2016, Red Eléctrica has dedicated 8.6 million euros to innovation projects; projects that have had the participation of 280 employees dedicating a total of 39,926 hours. The most noteworthy projects that have been worked on in 2016 are listed below:

National projects

- **Monitoring of underground cables** using DTS (Distributed Temperature Sensors). ***Completed in 2016.***
- **Inspection of electricity lines** for their upkeeping by means of photogrammetric methods from images obtained from an aircraft. ***Completed in 2016.***
- **Monitoring and control system** based on synchrophasor measurements installed on the islands of Lanzarote and Fuerteventura. ***Completed in 2016.***
- **Study of surges** due to ferroresonance in high voltage grids. ***Completed in 2016.***
- **Use of drones** to capture geographical information and to inspect electricity lines. ***Completed in 2016.***
- **Optical current sensor** for the identification faults in the underground sections of the mixed lines. ***Completed in 2016.***
- **New forecasting tool** for peninsular and non-peninsular demand. ***Completed in 2016.***
- **Automation of the drafting of technical drawings** for substation plans in accordance with Civil works. ***Completed in 2016.***
- **Prototype to monitor real-time** recharging points for electric vehicles in Palma de Mallorca. ***Completed in 2016.***
- **Development and approval of the technique for the recovery** of Posidonia oceanica seagrass meadows, using seeds germinated in the laboratory and fragments of the species obtained due to natural fragmentation. ***Completed in 2016.***
- **Approval of the use of natural ester fluids** as a refrigerant in standard power transformers. ***Completed in 2016.***
- **Methodology for the optimum management** of the entire vegetation treatment cycle of the 'safety corridors' of lines. ***In progress.***
- **Methodology that allows the emptying of the oil pits** of the high voltage transformers and its treatment in situ. ***Completed in 2016.***

Projects related to national programmes

- **Design of a prototype** to improve the stability of frequency and voltage in small isolated systems (AMCOS-Stability FACTS Project). ***In progress.***

International projects

BEST PATHS

Analysis to overcome the various technical barriers that the current pan-European electricity grid could encounter to safely and efficiently integrate reliable quantities of energy from renewable sources such as solar or offshore wind. Project coordinated by Red Eléctrica. ***In progress.***

MIGRATE

Improved understanding of the behaviour of the electricity system with high penetration of devices based on electronic power (generators, loads, HVDC links, FACTS...). ***In progress.***

In the 'Red 21' section of the corporate website.