



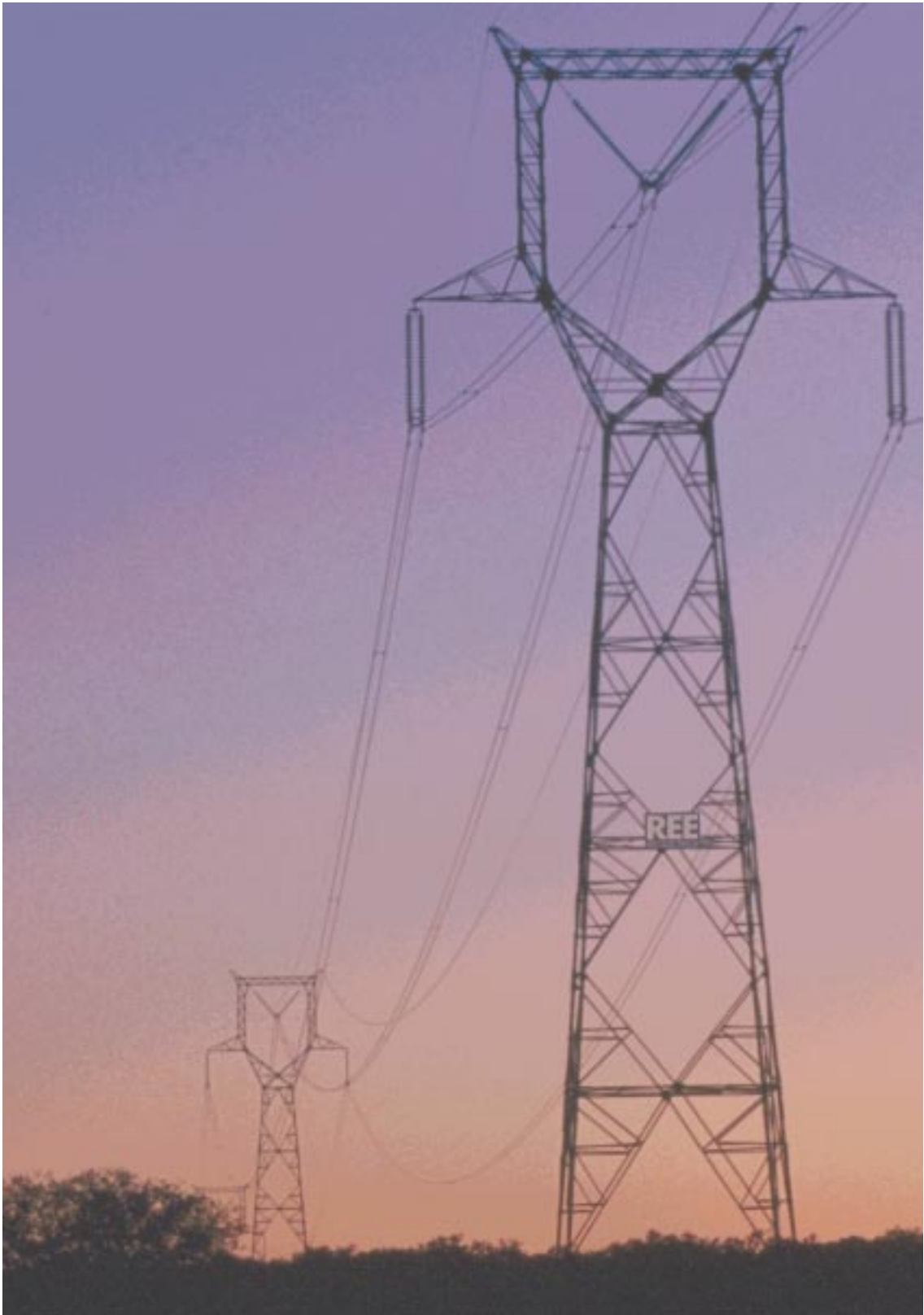
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RED ELECTRICA

Annual Report 1997



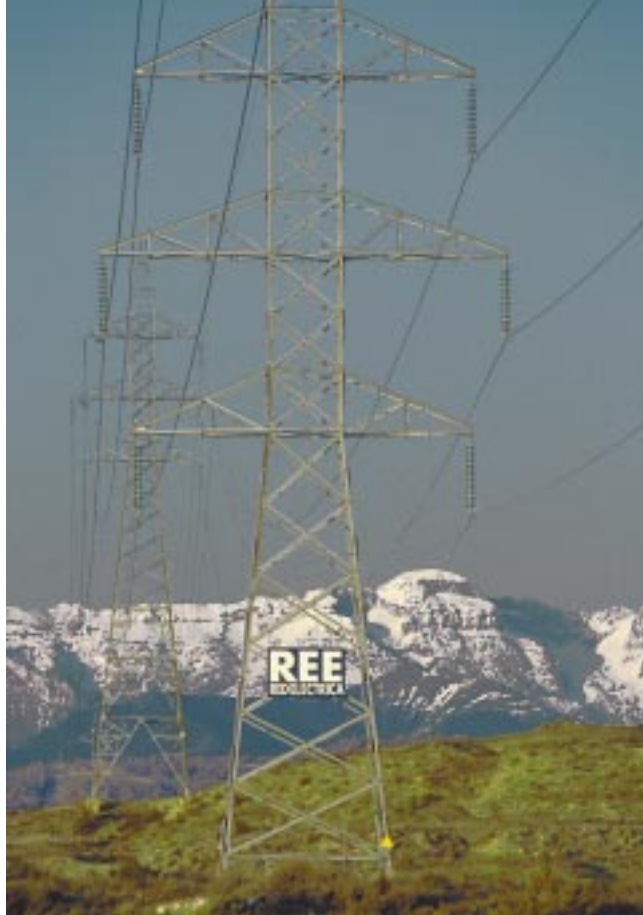
Development of the transmission network



Transmission network planning

Activities in 1997 related to the planning of strategic and operational issues in the transmission network included:

- Development of a new methodology to handle the studies corresponding to the Horizon 2008 Plan which incorporates the new control criteria for the power system and which takes into account the greater degree of uncertainty derived from the absence of overall development plans for the sector.
- A planning study corresponding to the horizon for the year 2020 in the Catalan Region as part of the group of guideline plans associated with the various autonomous regions to optimise the co-ordinated development of regional infrastructures.
- Studies associated with the evolution of new sources of generation in order to evaluate future requirements of the transmission grid related to right-of-ways and to determine the economic indicators which will guide the development of the power plants.
- An analysis of the potential features of the existing and of the planned network in the Levant area and in Catalonia to establish the optimum power factor for these markets, determine the supply capacities of the zones and to identify limitations. An operational plan for the areas of Tarragona and the Penedés was also prepared.
- A review of the capacity of the interconnection with France, a preliminary analysis of the 2004 Horizon for the interconnections with Portugal and a technical and financial analysis of the interconnection with Morocco.
- A general study of the power supply connections for new substations related to the Madrid-Valladolid and the Zaragoza-Lérida sections of the high-speed rail links.
- Studies and modelling were commenced on the impact of the wind-driven generation planned in various autonomous regions, especially in Galicia, covering transmission capacity, dynamic stability of the network, secondary regulations, wave quality and voltage control.
- Critical network studies on the conditions for eliminating defects (in terms of time and selectivity) at the substations with the object of avoiding significant repercussions affecting generation and/or the market. These were carried out by seven area work groups in which ENDESA, IBERDROLA, UNIÓN FENOSA, FECSA, HIDROCANTÁBRICO, the ENHER-HEC group, SEVILLANA, VIESGO and ERZ participated apart from RED ELECTRICA.
- The philosophy for the protection of the transmission network was updated.



- Development and installation of a new software application program for the support and handling of information related to the analysis of disturbances. This program is an improvement on the previous one due to its structure and the query interface for the end users and it includes the automatic loading of disturbances detected at the Control Centre, integration with the inventory of protection equipment and mechanisms for the automatic generation of reports and evaluations.

Transmission facilities under construction

The main projects in progress at the end of 1997 were:

- In the Northern Area: construction of the Soto-Penagos line and the studies for the installation of the Penagos-Güeñes and Güeñes-Ixaso lines, continue. The Soto-Penagos-Güeñes-Ixaso axis will improve transmission between Asturias, Cantabria and the Basque Country, reinforce power supply to this area and will notably improve the overall performance of the Spanish power transmission system.

- In the south of Andalusia, construction is being completed on the line between Pinar del Rey and Tajo de la Encantada, which will increase the reliability of supply in the area and will reduce transmission losses.

In the east of Andalusia, completion of the Litoral-Rocamora line is expected in the first half of 1998. This will connect the Centre and the Southeast of peninsular Spain and strengthen supply to the latter area and to the Levant area.

- In Aragon, engineering is being finalised to join the Aragon-French Frontier line with the Sallente-Sentmenat, (Graus-Isona), line in order to improve power supply capacity in Aragon and Catalonia.

Lines, under construction		
	No. of circuits	Length (km)
400 kV LINES		
Pinar-Tajo	(*) 1	110
Litoral-Rocamora	(*) 1	186
Fuencarral-Línea Galapagar-San Sebastián de los Reyes	2	9
Lada-Velilla	1	96
Soto-Penagos	1	175
La Secuita-Línea Vandellós-Begues	2	1
Xistral-Línea Aluminio-Puentes de García Rodríguez	2	14
Sentmenat-Bescanó	2	77
Penagos-Güeñes	2	70
Graus-Línea Sallente-Sentmenat	2	41
Aragón-Frontera Francesa	2	187
TOTAL CIRCUITS DE KM		1,365
220 kV LINES		
Cartelle-Línea Pazos-Castrelo	2	8
TOTAL CIRCUITS DE KM		16

(*) Structures prepared for double circuit although provisionally a single circuit is installed.

Substations, work in progress	
Facility	Work
Cartelle	Extension of the 400 kV compound New 220 kV compound 400/220 kV transformer
Balboa	Extension of the 400 kV compound New 220 kV compound 400/220 kV transformer
Aguayo	New 400 kV circuit end at Velilla New 400 kV circuit end at Penagos
Fuencarral	New 400 kV compound 400/132 kV transformer
La Secuita	New 400 kV substation 400/220 kV transformer



- In Extremadura, engineering work is underway on the extension of the Balboa substation involving a new 400/220 kV transformer module, the construction of a new 220 kV compound and its connection to the Balboa-Badajoz line to strengthen and increase the reliability of power in south area of Badajoz.

Figures 1a and 1b give details of the installations under construction at December 31st, 1997.

Facilities completed

During 1997 construction of the following facilities was completed:

Lines

- Pinar del Rey-Estrecho, single circuit 400 kV line, 34.1 km long with structures prepared for double circuit.
- The Spain-Morocco interconnection between Estrecho and Ferdioua, by means of four underwater and underground cables of 400 kV, 26.2 km and 2.2 km respectively. This includes the terminal stations for the cables on both sides of the Straits.

These installations will allow the exchange of electrical power between Spain and Morocco and will also lead to an increase in technical, industrial and commercial co-operation with countries in North Africa.

New facilities in existing substations

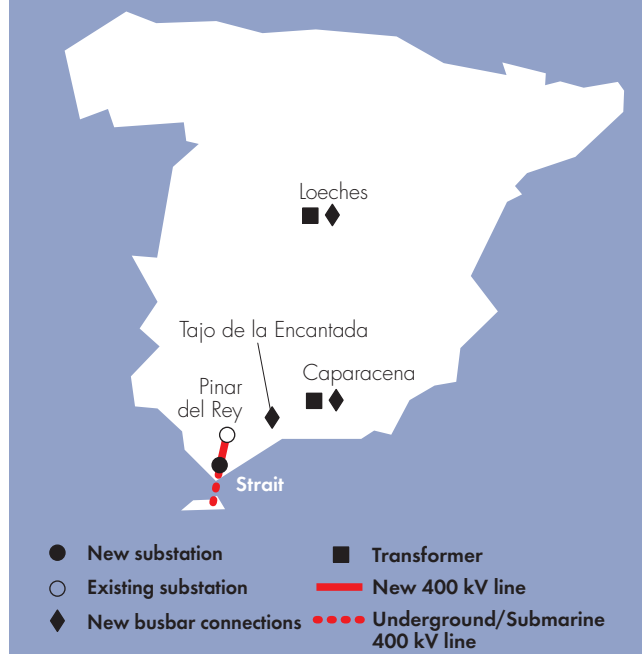
- Caparacena: New 400/220 kV, 600 MVA transformer bank which reinforces power supply to the area of Granada.
- Loeches: New busbar connection and new 400/220 kV, 600 MVA transformer bank which will allow more power to be injected into the Madrid ring.

- In Catalonia, work continues on the installation and engineering for the future Sentmenat-Bescanó line and the La Secuita substation. These facilities will reinforce supply to the Gerona and Tarragona areas, respectively.
- In Galicia, engineering work is underway for extending the Cartelle substation with a new transformer module of 400/220 kV and installing a new 220 kV compound connected to the Pazos-Castrolo line. This will facilitate the transfer of hydraulic and wind-driven generation and cogeneration out of the south of Galicia. Work is also being carried out on the layout and preliminary studies for the future substation at Xistral and its connection to the Aluminio-Puentes de García Rodríguez line, to reinforce the network capacity for shifting power from the wind farms in the area.
- In the Central Area, engineering work is being finalised on the installation of the future 400 kV compound at the Fuencarral substation and its connection to the Galapagar-San Sebastián de los Reyes line. These facilities will improve the supply of power in the north of Madrid.

- Pinar del Rey: Connection of the Mellousa busbar connection which is part of the new facilities for the exchange of power with Morocco and the preparation of the Tajo de la Encantada circuit end for its connection to the new Pinar del Rey-Tajo de la Encantada line.
- Sabiñánigo: A new connection bay which will facilitate improvements in the safety and reliability of the facility.
- Tajo de la Encantada: A new Pinar del Rey busbar connection which will allow power supply to the Malaga market to be reinforced by means of the Pinar-Tajo line which is soon to be commissioned.

Figure 2 shows the facilities in operation which were owned by RED ELECTRICA on December 31st, 1997.

RED ELECTRICA network facilities constructed in 1997



Communications systems

During 1997, the following activities were carried out:

- **Communication circuits:** Commissioning of 981 circuits for telephone, remote control, remote protection, management, etc., bringing the total number of circuits used by RED ELECTRICA to 4,318.
- **Mobile radio systems:** Installation of 14 new repeater stations under the Adjustment and Improvement Plan for Mobile Communications, bringing the total at the end of the year to 106 mobile radio repeater stations. The notable improvement in coverage has increased the usefulness of the mobile radio system for line maintenance activities.
- **Fibre-optic systems:** Installation of compound earth-optic cable (a fibre-optic cable attached to the earth wire), underground cabling on 563 km of existing lines plus 154 km of new lines and the commissioning of 13 fibre-optic tie-lines during the year. This brings the total cable laid to 8,245 km and the fibre-optic tie-lines to 134. Installation was also completed on the Synchronous Digital Hierarchy (SDH) loop running at 622 Mbps between Madrid and Barcelona consisting of 19 nodes and the corresponding management system, with automatic restore capability for traffic in the case of failures.

Table 2

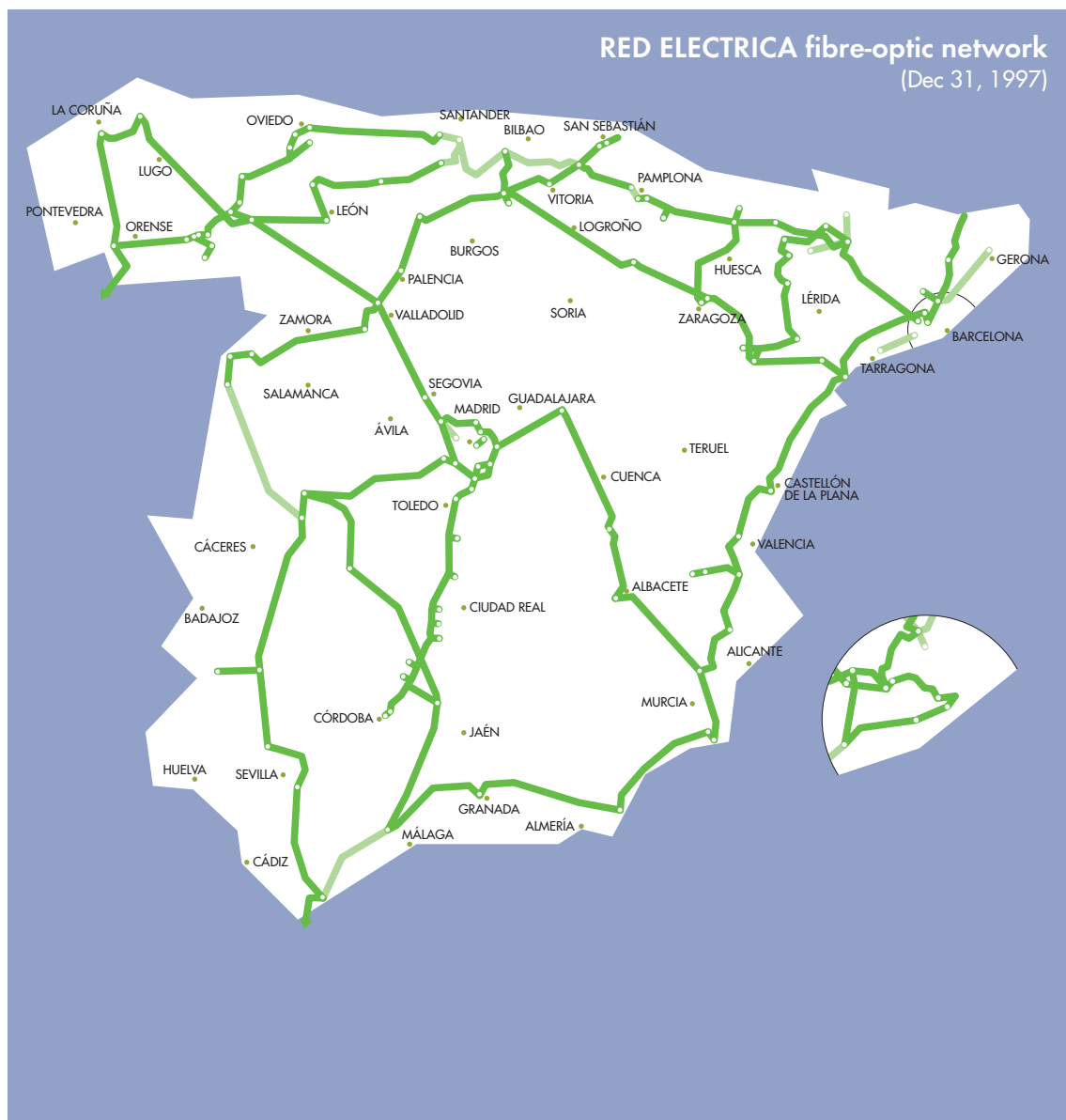
Facilities in use owned by RED ELECTRICA (Dec 31, 1997)	
Aerial lines (km)	
400 kV	13,969
220 kV	4,276
110 kV & less	75
TOTAL	18,320
Underground lines (km)	
400 kV	2
Underwater lines (km)	
400 kV	13
Busbar connections	
400 kV	455
220 kV	174
110 kV & less	3
TOTAL	632
Substations	
TOTAL	127
Auto-transformers	
Number	34
Total power (MVA)	17,051
Reactor units	
Number	28
Total power (MVA)	3,410

- **Carrier and Remote Protection Systems:** Installation and commissioning of 10 carrier wave links and 31 remote protection links. Eight high frequency remote protection links have been disconnected and this means that there is a total of 506 carrier wave links and 725 remote protection links.
- **Switching systems:** Installation and commissioning of one digital exchange and 13 remote exchange modules, thus improving the quality of connection at 14 network centres. This brings the total number of digital exchanges and remote modules to 52 and 32, respectively.
- **Cross-connects:** Installation of 10 cross-connect units for the network, providing flexibility for the communications network and improving operating capacity.
- **Management of the communication network:** Installation and commissioning of the Supervision System for the Communication Network which includes access by the regional centres to data on the network status in their respective areas.

Energy control systems

At the end of 1997 there were 124 substations adapted for operation by means of the remote control systems. The remote control includes not only the substations and compounds owned by RED ELECTRICA but also the installations of those utility companies which have signed a specific remote control agreement.

1997 saw the commissioning of the new energy control systems at the Power Control Centre (CECOEL) and at the five Regional Operation Centres of RED ELECTRICA (CEORE). These systems, which have a client-server architecture, use RISC technology computers and software with advanced features based





Renewal and improvement of the Installations

The priorities for the Renewal and Improvement Program for the installations and equipment are established based on an analysis of their real condition and taking into account the overall criteria of safety, quality, cost and external factors. This analysis is supported in a systematic way in the case of substations by the computer tool known as Decision Aid for Renewal of Substations and which, at the current time, is being adapted for application to the power lines.

The most important activities related to the modification, adjustment and rearrangement of equipment and facilities, were:

Lines

- Replacement of the transmission towers on the Sangüesa-Sabiñánigo, Mudarra-Montearenas y Siero-Puente de San Miguel 1 lines.
- Replacement of the earth wire on the Aluminio-Puentes de García Rodríguez 1 and 2 lines.
- Change of wires on the Montearenas-Mudarra and Sabiñánigo-Escalona lines.
- Completion of operations to increase the transmission capacity of the Vic-Baixas, Biescas-Sabiñánigo and Biescas-Pragneres lines in order to maintain adequate capacity for the power exchange with France.

Substations

- Replacement of 155 high voltage items: 14 circuit breakers, 41 isolators, 36 current transformers, 52 voltage transformers, 7 line traps and 5 lightning conductors.
- Replacement of various items of low voltage equipment in the substations at Begues, Vandellós, Vic and Villanueva de Gállego.

on UNIX, relational databases, standard communication protocols and user interfaces of the «full-graphic» type. Their modular character and their open architecture design will facilitate development and adaptation to future technical advances. Spare capacity of the elements covers the simple failure of any item and the system permits access to the information from any remote workstation.

In addition, at the CECOEL, the control room was rearranged and fitted with a real-time display comprising an 8 x 3 panel of video back projectors using LCD. The display is a complementary tool for the control system, it provides a global image of the power system and allows changes in status or invalid parameter values to be rapidly detected. It also allows the grid status to be checked or the extent of an incident to be determined, without the need to access specific parts of the network available on the system. Moreover, it contains multiple general schemes which make it possible to identify any zone where service has to be restored, down to the level of circuit breakers, and allows any important aspect in the operation to be highlighted at any time with great flexibility of use.

- Transfer of the control panel from the centre to the compound at the Ribarroja and Mediano substations.
- Remodelling of the compressed air installations at the La Lomba and Montearenas substations.

Protections

- Complete renewal of the protection systems at 26 busbar line connection, 2 busbars connections and 3 busbar transformer connection and partial renewal of those at another 63 busbar connections on the transmission network.
- Completion of renovation work at the Pont de Suert substation which affected the Mediano, Pobla, Rubí, Auto 1 and Auto 2 busbar connection.
- Renovation of the protections on the Vic-Baixas interconnection (including a change in the layout), and the Biescas-Pragneres, Arkale-Mouguerre and Cedillo-Pego lines.
- Commissioning of the protection system for the underwater cable between Estrecho and Ferdjoua on the Spain-Morocco interconnection.

Remote control

- Adaptation of three compounds of RED ELECTRICA at Almaraz CN, Trillo and Cofrentes, under the Substation Remote Control Adaptation Program. In addition the 400 kV compound at Compostilla has been adapted to the RED ELECTRICA remote control specification.
- Installation of the bi-directional remote monitoring system on the Spain-Morocco link with equipment installed at the terminals in Tarifa and Ferdjoua. Four new remote control stations entered service. The one installed at the Melloussa (Tetuan) substation forms part of the remote control system for the link between power systems of Spain and Morocco.
- Fitting of remote monitoring facilities to 25 digital control systems and remote control stations which brings the total number of units fitted with this function to 119 at the end of the year. Remote data loading, which allows the databases to be remotely updated, was fitted to 25 digital control systems and remote control stations - making a total of 103 remote control units which are fitted with this option. This function has allowed 187 engineering and maintenance operations to be carried out at the remote stations.



- Installation of the communication alarm distribution system at 9 units with their databases at the remote control stations and in the regional offices. At the end of 1997 a total of 99 substations had been fitted with the communication alarm distribution system.
- Synchronisation of disturbance recorders at 19 compounds of the transmission network equipped with digital control systems, based on the time synchronising unit installed in the digital control systems. At the end of 1997, 43 substations had been fitted with the disturbance recorder synchronising system. Purchase and installation of 50 new time synchronising units for remote control equipment was completed, bringing the number of items equipped with time synchronising units to 95.
- Preparation of a plan to fit hardware terminals for local operations at eight new remote control stations and their installation.

Documentation of the installations

The use of the Computer-Based Management System for Technical Documents, which was implemented in 1996, was extended to practically all the potential users during 1997 and, consequently, the number of terminals from which the program is accessible has doubled. At year end the system already covered the complete documentation of the substations and work will continue during 1998 on the inclusion of the drawings.



The standards for the preparation of drawings of the electrical installations have been adapted and entered in the CAD program. This facilitates their application by RED ELECTRICA personnel as well as by external engineers and results in unified technical documentation of a high quality.

In 1998 a new system will be developed which will integrate the current system with the documentation and details of the RED ELECTRICA power lines.

Quality assurance items

Apart from activities related to the design and construction of power lines, which were certified in 1996, RED ELECTRICA has implemented quality assurance systems for activities related to the design, installation and maintenance of fibre-optic lines and for the design and construction of substations. These are currently undergoing certification for the ISO 9001 standard.

Maintenance of the transmission network facilities



Lines maintenance

The periodic inspections carried out on foot were supplemented by 510 hours of helicopter inspection. They resulted in preventive or corrective maintenance actions.

Urgent improvements were carried out on 203 towers following the checking of earth wires at 3,815 towers and a study of the resistance to earth at another 240 towers.

With the object of reducing line faults due to fires and the potential danger of contact with trees, work was carried out on more than 250 hectares of forest, which represents 0.6% of the area under the power lines.

The use of helicopters for cleaning insulators was extended to 1,639 strings, which represents 38% of the 4,312 strings involved.

Other important preventive maintenance operations included the application of anti-corrosion protection to 114,000 square metres of transmission towers with significant corrosion problems, resurfacing of tower bases, re-tensioning of wires and replacement of insulator strings, in order to improve the reliability of the lines.

Corrective maintenance included the replacement of towers on the D. Rodrigo-Pinar, Caparacena-Litoral, Badajoz-Elvas and Siero-Puente de San Miguel 2 lines due to problems caused by the terrain.

Public works were the basic reason for 14 modification projects (changing the layout or increasing the height of structures) which were carried out at the request of third parties. Moreover, reports were prepared on 123 requests for the clarification of technical restrictions and areas of influence, made by official and private organisations.

Substations maintenance

Following evaluation of the results of 186 analysis of oil carried out on power equipment, oil was filtered at 7 units and other minor defects were identified which did not require any action.



The insulation was measured at 37 items of equipment and potential problems were detected at 5 terminals. This triggered continuous monitoring of their status. Frequency response analysis techniques were used in the diagnosis of 16 units.

The accuracy monitoring program for the measurement transformers included 209 comparisons carried out on capacitance transformers.

With regard to the program for the prevention of breakage failures in current transformers, 246 partial discharge measurements, 43 oil analyses and 12 insulation measurements were carried out. These, together with the thermovision inspection of all the units, helped to detect 8 defective units which have been decommissioned in order to avoid risks to personnel and the installations.

The remote diagnosis of 196 circuit breakers and the thermovision inspection of 124 substations detected a total of 167 hot spots.

Routine preventive inspections carried out on all the installations resulted in 587 complementary disturbances reports and the correction of 67 potential disturbances.

Synchronised closing relays for the reactor circuit breakers were installed at the Mudarra and Olmedilla substations, as a continuation of the corresponding program.

As part of the scheduled operations for complying with regulations, the resistance of the earth wire at 29 substations was checked and the compressed air tanks at 12 busbar connections were adjusted to conform with the applicable standards.



Maintenance of protection and measurement systems

Following a programmed review of the protection equipment at 194 busbar connections of 400 kV and 77 of 220 kV, operating defects were detected and corrected at 32 busbar connections. In addition, 194 defects in the protection and measurement systems were corrected.

The integrated measurement equipment fitted at 107 circuit ends of the Spanish Mainland Joint Regulation System was verified. Seventeen of these correspond to international interconnections.

Scheduling, testing and commissioning of the protection systems at 98 busbar connections were carried out. Of these, 4 are new busbar connections, 31 are complete renewals and 63 are partial renewals.

The verification of 250 measurement converters improved the quality of the measurement figures transmitted to the regional operation centres and has increased the number of measurements falling inside the expected range from 92.2% to 96%.

Remote management of protection equipment has reached a total of 525 items which are connected to the protection management control post. A new Digital Protections Information Management software application was installed which handles automatic recovery and the querying of the records of the recording oscilloscopes and digital protection operations.

Field monitoring and evaluation testing was carried out on the prototype of the Integrated Control and Protection System installed in the right of way at the Villaviciosa de Odón substation.

The corresponding specification was prepared and a real-time digital simulator was purchased for tests on protection systems and other equipment in the laboratory.

Maintenance of remote control systems

Specialised maintenance on the remote control systems generated more than 100 databases related to remote control stations and digital control systems.

Quality assurance items

Towards the end of the year the AENOR Certificate under the ISO 9000 standard was granted for the maintenance of lines (ISO 9001) and substations (ISO 9002) and the latter includes the maintenance of remote control systems. During 1998 a quality assurance system is going to be implemented for operations at our installations and the certificate is expected in 1999.