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Challenges and Solutions for RES integration within the Spanish Power System. Red Eléctrica's role

Toledo, 18 June 2010

PhotoVoltaic TECHNOLOGY PLATFORM

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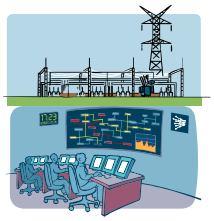
RED

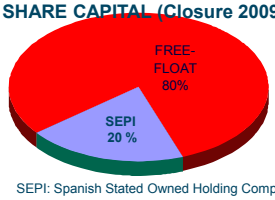
Red Eléctrica de España (REE): Mission and principles.

- The existence of **REE**, world pioneer **since 1985**, as independent and exclusively dedicated to **Transmission and System Operation**, has proved fundamental for the fast and secure implementation of electricity market and integration of RES



- Designs, builds and maintains the transmission network.
  - Since 2007 as exclusive transmission company
- Operates the system to guarantee the power supply.
  - Since 2006 also in the extra-peninsular systems

SHARE CAPITAL (Closure 2009):



SEPI: Spanish Stated Owned Holding Company

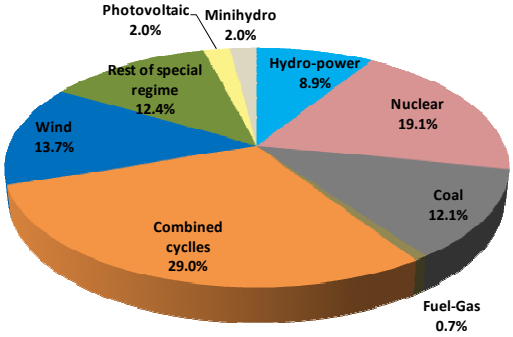
Transmission Grid Main magnitudes (SPPS)		Closure 2009 REE	vs. TOT
Lines	400 kV [km ct]	17 977	99,8%
	≤ 220 kV [km ct]	16 777	98,4%
Subst.	≤ 220 & 400 kV [nº bays]	3 385	96,8%
	Transformers 400/X kV [MVA]	66 259	98,8%

Contents

- Overview of the Spanish Power System
- Integration of Renewable Generation (RES) in Spain
  - past and prospects
  - sensitive aspects of RES for the power system
    - In System Planning and Access
    - Defining new technical requirements
    - In System Operation: the generation control
- Final Remarks and Possible trends

Yearly Demand supply and coverage 2009

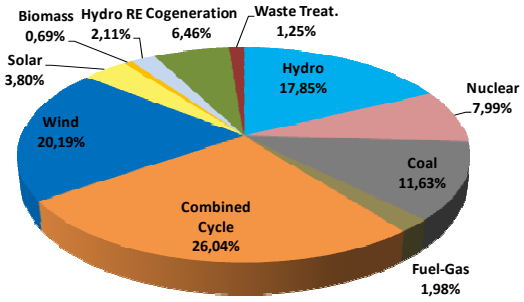
251.509 GWh = 181.614 Net Ordinary Regime
+ 81.785 Net Special Regime
- 3.770 Hydro-pump storage demand
- 8.120 International exchanges



Special Regime Generation

Renewable:	Non Renewable:
Minihydro	Cogeneration
Biomass	Coal
Wind	Fuel - Gas oil
Industrial waste	Refinery gas
Urban waste	Natural gas
Solar	

Installed capacity May 2010



Technology	MW	%
Hydro-power	16.657	17,85
Nuclear	7.455	7,99
Coal	10.856	11,63
Fuel-Gas	1.849	1,98
Combined cycles	24.294	26,04
Total (ordinary regime)	61.111	65,49
Wind power generation	18.842	20,19
Solar power	3.548	3,8
Biomass	647	0,69
Special regime hydro	1.965	2,11
Cogeneration	6.027	6,46
Waste treatment	1.170	1,25
Total (special regime)	32.199	34,51
Total	93.310	

3.268 MW Solar PV
280 MW Solar Thermal

Integration of renewables: prospects and challenges

Ambitious national objectives for RES (20% of final energy in 2020) require additional integration within the power system (>40% in the electric energy)


*38.000 MW**


*8.367 MW**


*5.079 MW**

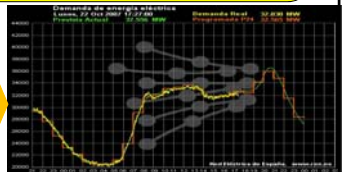
Particular features imply technical and management challenges for the power system and the generation:

Location far from load and grid
Vulnerability to incidents(voltage dips)
Primary energy: Lack of firmness and control

- **Grid development**
- **Technical Requirements**
- **Control by TSO and more dispatchable resources**

… without forgetting other organisational aspects

REE is working to maximise Secure Integration of RES in Power System



*** Draft of NAP to by submitted to EC in June10**

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Challenges for integrating RES generation. REE's actions

RED ELÉCTRICA works for **maximizing** the **secure** integration of RES generation in its different functions as **System Operator** and **Transmission company**:

- **Energy Prospective: access and grid planning**
  - Generation Adequacy Studies
  - Management of access and planning studies and proposals. Capacity Studies
  - Regulatory proposals (Grid Code) identifying technical and operational requisites
- **Management in real-time horizons**
  - Production forecast: Wind and recently solar
  - Management of Ancillary Services
  - Contribution to system dispatchability by the development of a specific control arquitecture for RES generation

- **Development and reinforcement of transmission grid**

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Managing Access and Planning the Grid

A good programming of new non-transmission facilities (e.g., generators) must take into account decision and commissioning processes in transmission grid:

- **Decision on transmission facilities**

Grid Planning
- **REE carries out the planning studies and proposals**
- **National Goverment, with the collaboration of Regional Administrations, approve the grid development plan**
  - **Every 4 years, new horizon (10 y)**
  - **Every year, review with same horizon**

Binding (unlike indicative planning for generation)

Access to the grid
- **Regulated process to assess the aceptability of a new non-transmission facility**
- **Continuous process**

- **The actual development of the grid (authorization, construction and ; from 1 to more than 10 years)**

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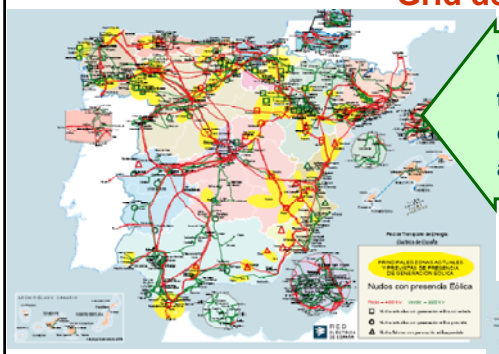
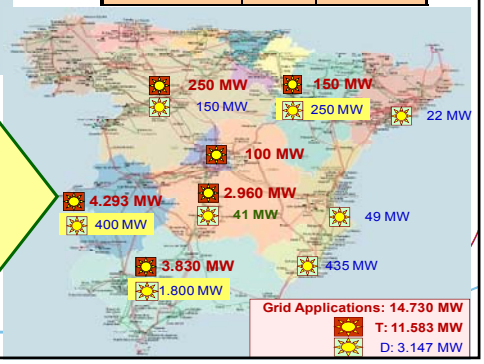
Grid development



WIND POWER: High presence in transmission (>60%, contrary to other systems with high penetration) and expected to increase

NºNodesRdT	Today	Future
220 & 400 kV	49	> 100



SOLAR POWER:

TS.- Majoritary in transmission (≈ 80%)

FV.- Minoritary in transmission(≈ 5% of existing; few new plans)

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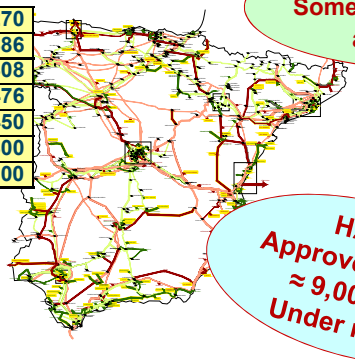
Main challenges: Grid Development

- RES generation does not avoid distribution grid but requires transmission expansion, where the majority of Wind Power (>60%) and Solar Thermal (>80%) is expected. RES is a relevant motivation in the current Plan:
  - new lines and reinforcements for avoiding constrains operation
  - facilities associated to physical connection

New substations and bays
Some 100 buses in 220 kV
and 50 in 400 kV

OH Circuit [km]	12.270
UG Cables [km]	386
Uprating lines [km]	8.308
SS [nº bays *]	3.476
Transformers [MVA]	52.450
Reactors [Mvar]	2.800
Capacitors [Mvar]	1.100



H2016
Approved may08
≈ 9,000 M€
Under review

- Particular significance: Spain-France interconnection

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Development of the Spain-France Interconnection: A priority

Spain –and Portugal- form a peninsula, also electrically, with weak electrical interconnections with the European Union.

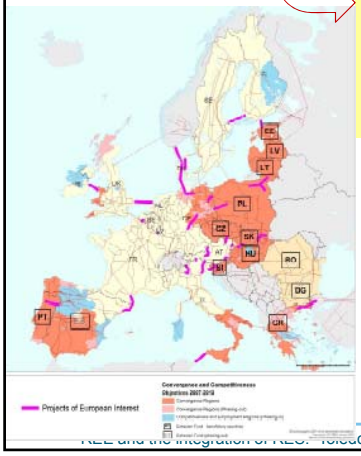
The development of Spain-France Interconnection with a new 2 x 1000 MW DC underground line

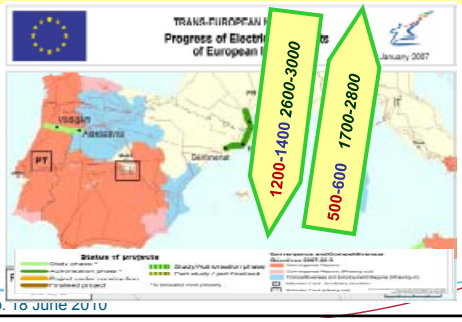
-Prioritary Project with "European Coordinator"

-1st step for objective of 4.000 MW of commercial capacity

-Necessary for building the IEM

-Fundamental for RES integration in Spain (& Portugal)





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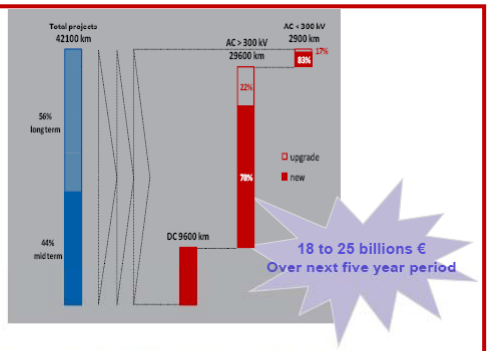
The transmission grid development in Europe

- **The Ten Tear Network Development Plan (TYNDP) is being elaborated by ENTSO-E**
  - **RES integration is a main motivation: representing > 25% of investment**



The final draft of the pilot TYNDP will be published on ENTSO-E web site on July 1

Presented by ENTSO-E at Florence forum

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Access and Connection : Overview

- **Procedures for Access and Connection are managed by REE**
- **Main Features**

	Main Perspective	Object - Scope
Access	System Operation	System behaviour
Connection	Transmission	Engineering and Physical Feasibility

- **Procedures**
  - **Access Application**
    - Connection to Transmission >>> SO (REE) — 2m
    - Connection to Distribution (> 10 MW.) > DO> SO (REE)

    REE issues a report evaluating access feasibility, fulfilling system security criteria
  - **Connection Application >>> Trans.Co.**

    Agent submits engineering Project and Programme
    - Trans.Co. elaborates Report of Technical Conditions for Connection — 1m
    - SO (REE) supervises and issues a report — 1m

Agent < TECHNICAL ACCESS CONTRACT> Transmission Company

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Planning and access studies for special generation

The planning and access studies are carried out with different analysis perspectives and different time horizons, resulting in connection capacities which enable location optimization:

TOPOLOGICAL SCOPE	NATURE OF LIMITATION
• Transmission node (and associated distribution)	➢ Load flow capacity ➢ Short-circuit power (Scc) ➢ Stability
☹ ΣCapNode > CapReg : Nodal capacities are not mutually compatible and resulting grid development needs are not coherent	
• Electric zones (and associated distribution) sharing constraint	➢ Load flow capacity ➢ Short-circuit power (Scc) ➢ Stability
😐 Regional and Zonal Capacities are the "reference" for Regional Administrations (competent for AA of SRG) and for access management	
• Power System	➢ Feasibility Balance P+jQ ➢ Stability

This scenario validates up to the regional level and avoids persistent constraints within this scope

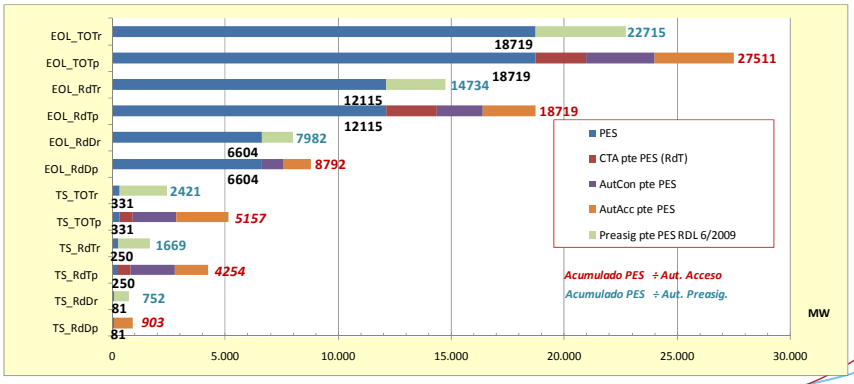
However, lack of national coordination does not prevent potential constraints when regional plans are developed up to their limits

Prospects for SRG. Recent regulation

- New national regulation oriented to gradual control of generation to be connected per year, securing economic and technical sustainability:

  Non PV: RDL6/2009 (7may09): Register and mechanism (9 requisites, incl A&C)

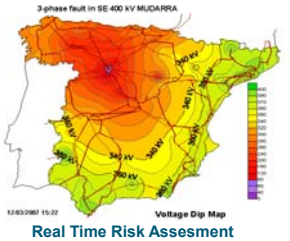
  ResMin 19Nov09 (CM Agreement13nov09): Identification of generation projects with annual contingents : for Wind Plants (≈ 1.700 MW) and Solar-Thermal plants (≈ 500 MW) {in adition, ≈ 500 MW in Solar PV }



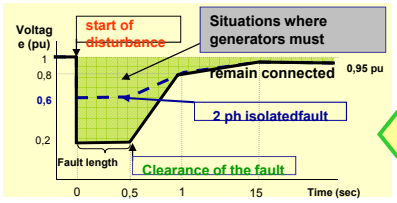
Main Technical Requirements

Need to identify and regulate requirements, carried out in coordination with the Wind power industry

- **Technological vulnerability (voltage dips leading to disconnections).**



Real Time Risk Assesment



Minimum Requirement proposed for Solar PV

The "grid code" (PO 12.3) establishes the required level for Low Voltage Through Capability

- **Very good response from the wind generators (adaptation except <1,000 MW)**
- **New requirements associated to the increasing need for contribution to stability: specially dynamic control of voltage**
- **Other challenges: protection equipment and philosophy**

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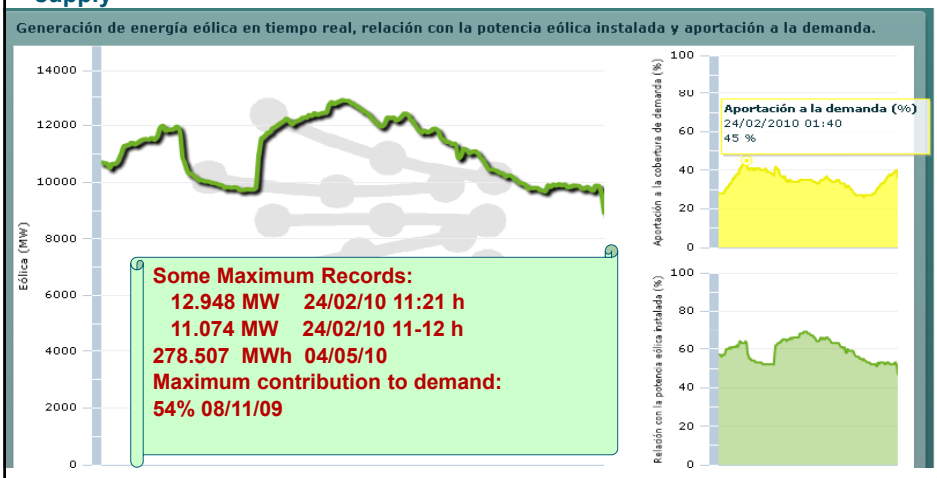
The contribution to power supply. Records in 2009 (i)

Wind generation may have a very relevant contribution to the power demand supply



Some Maximum Records:
12.948 MW 24/02/10 11:21 h
11.074 MW 24/02/10 11-12 h
278.507 MWh 04/05/10
Maximum contribution to demand:
54% 08/11/09

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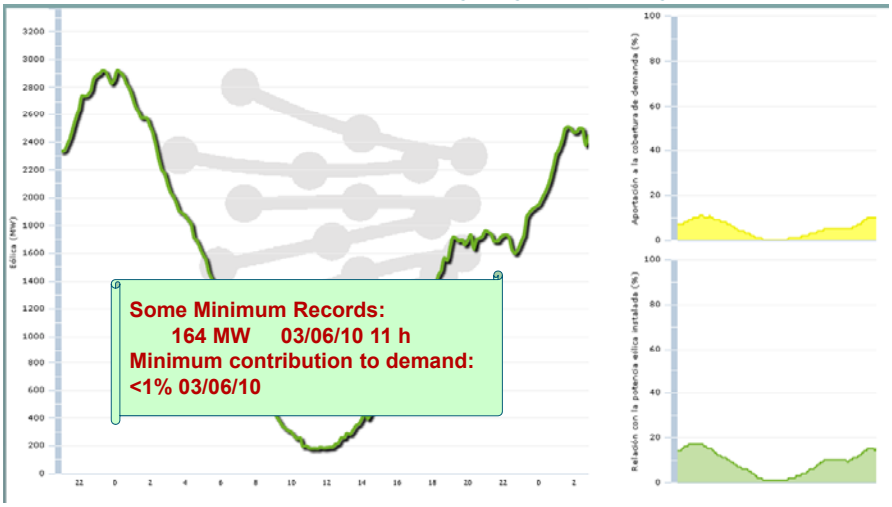
The contribution to power supply . Records in 2009 (ii)

… but the contribution to demand supply may also be very low



Some Minimum Records:
164 MW 03/06/10 11 h
Minimum contribution to demand:
<1% 03/06/10

In consequence, fluctuating nature of wind power is translated in a low contribution to power supply guarantee

Needs for real time operation

Dispatchable Generation is *required* to:

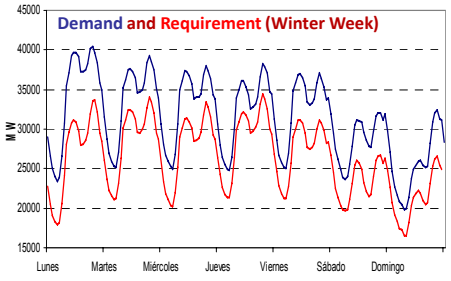
- supply the demand (D)
- compensate for nondispatchable gener. (NDisG) +€
- prevent contingencies

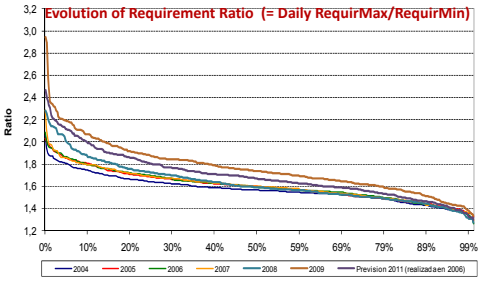
, what implies sufficient and fast enough **reserves**

System Operability depends on

- **managing power resources:**
  - **Forecast**
  - **Observability and Control**
- **existance of resources**

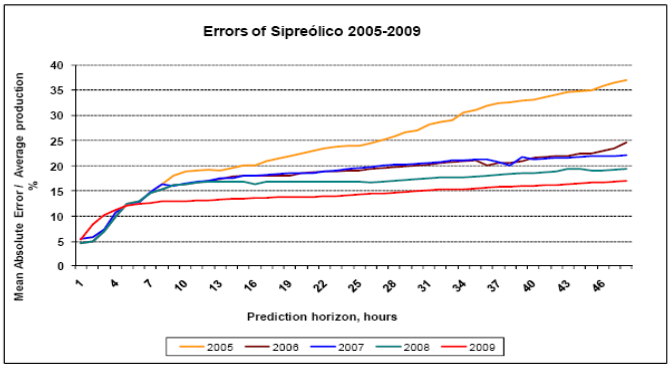
Disp.Gen.Requirement= (D+€$_D$) - (NDisG+€$_{NDG}$) +/- Contingencies





Generation Forecast

- **Despite production programs/forecasts from generators, REE must elaborate own preditions as a guarantee for security of operation, in particular for RES:**
  - **WIND: : REE has improved forecasting accuracy for wind by evolution of SIPREOLICO, although there seems to be limitations due to the difficuties of metheorological predictions**



- **SOLAR: REE is using a very approximated estimation tool based in irradiation forecasts. Shortly, a specific tool using real time meteo data and real time generation measures**

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Control Need and Actions upon Special Generation

- **Special Generation has to be dispatched with priority over Ordinary Generation.**
- **Consequently, whenever possible the SO must solve the technical constraints by issuing instructions to Ordinary Generation:**
  - **Power Output Reduction**
  - **Disconnection of Plants**
- **However, it may be necessary to issue Control Actions on Special Generation, by :**

a) Production Constraints (reduce or disconnect):

- Local zonal congestions (transmission or distribution)
- System Stability (instruction depending on technical compliance of plants)
- G-D balance in power and regulating reserve (specially off-peak and transitions)

b) Q/V Management: Set-point from SO substitutes reference for cosφ (established RD661)

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Generation Control requirements

Control of RES Generation Plants (GP) by TSO is necessary for maintaning system security and to maximize RES production by reducing preventive restrictions and delay upto real time. This involves in real time:

- **Observability for "all" plants:** GP ⇨ REAL TIME INFO ⇨ TSO
  (production, voltage, connectivity, …)
- **Operability for "all significant" plants:** TSO⇨ INSTRUCTIONS ⇨ GP
  production control (active power)
  provision of system services (reactive, regulation,)

For security and efficiency, this interlocution between TSO and GP should not be individual (several hundreds of plants) but via Generation Dispatch Centers with control capability over a number of plants

- **Human and technical resources (24 h)**
- **Secure and redundant Connection Dispatching Centre <> REE CC (computer<>computer, telephone)**
- **Connection Dispatching Centre <> Wind Farms-Generators**

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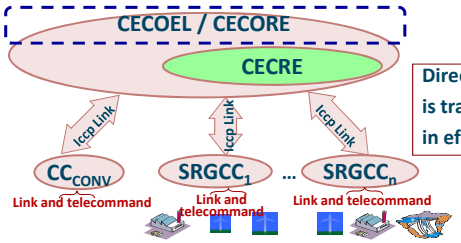
REE's Solution: CECRE

CECRE: Created by REE in 2006, is a control centre devoted to Special Regime Generation and *especially* to Wind Power:

- Integrated in REE's control structure
- Communication with generation Control Centres (SRGCCs) for supervision and control instructions.
- According to RD661/2007 all special regime plants >10 MW must be connected to a SRGCC.
- CECRE issues generation instructions through the SCADA system to the Control Centres.



Direct Link CECRE-SRG where Setpoint Instruction is transmitted automatically to be converted by plant in effective action, was a scenario non used

SRGCC: Special Regime Generation Control Centre
CC_{CONV}: Control Centre for conventional generation

686 WPP
326 nonWPP

via 16 GCCs
via 21 GCCs

25 SRCCGs
(June 2010)

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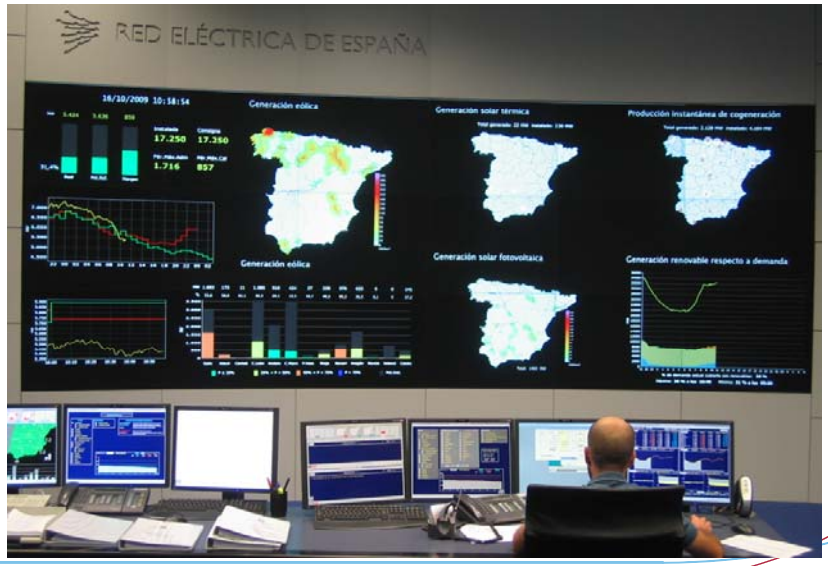
INTEGRATION IN CECRE OF OTHER GENERATION TECHNOLOGIES

- In 2009 new information and functionalities have been incorporated



Risks of Insufficient Control: Observability

In Spain, an unexpected magnitude of Photo-Voltaic generation (close to 4 GW) has been connected. However, the plant fragmentation (≤ 100 kW modules due to retribution conditions) has avoided real time tele-measurements and the plants are "hidden behind " the demand.

Lack of observability involves inefficient reserve programming and may become a serious risk for system operation

Same forecast from generators 9D and 10D

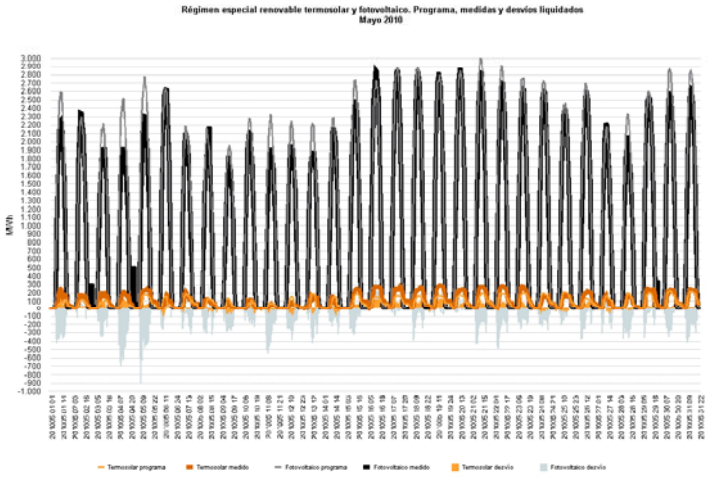
Expected

Unexpected

No real time observability and unreliable programmes

Unavoidable errors when programming Requirement Needs

Production mismatch (production vs. forecast)



Integration of RES: Final Remarks and Possible Trends

The many advantages of renewable energy lead to maximize installation.

In this context, REE works in the solution of the drawbacks of RES generation (technical, organisational, regulatory) in order to preserve the security and quality of supply in the power system.

- In particular, for Solar PV controllability and technical adequacy

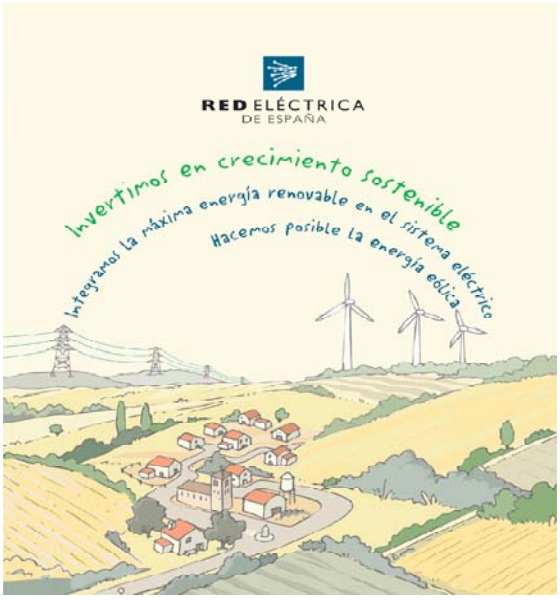
However, still a number of challenges remains:

- *Dispatchable* Gen: very demanding regime and decreasing running time

RES will be submitted to operating conditions including production constraints; specially related to off-peak situations and transitions

In the solution, a significant leap forward is needed based on:

- New flexible generation and enlarging energy storage possibilities
- More active participation of the demand side
- Incorporation to the electric sector energy consumption currently in other sectors: Electric Vehicles



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