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RE Integration at High Penetration Levels. RE in Spain

Content

Energy Generation Context in Spain

- ✓ Size: 505,992 km^2
- ✓ Population: 40,847,371
- ✓ Currency: Euro
- ✓ GDP: $1,407 trillion
- ✓ GDP per capita: $30,412
- ✓ Annual energy: 255,179 GWh

Law 54/1997: *Liberalization of Electricity sector*

Law 17/2007: *Amends last law, erasing integral tariff and introducing TUR*

RD 661/2007: *Regulates renewable generation activity*

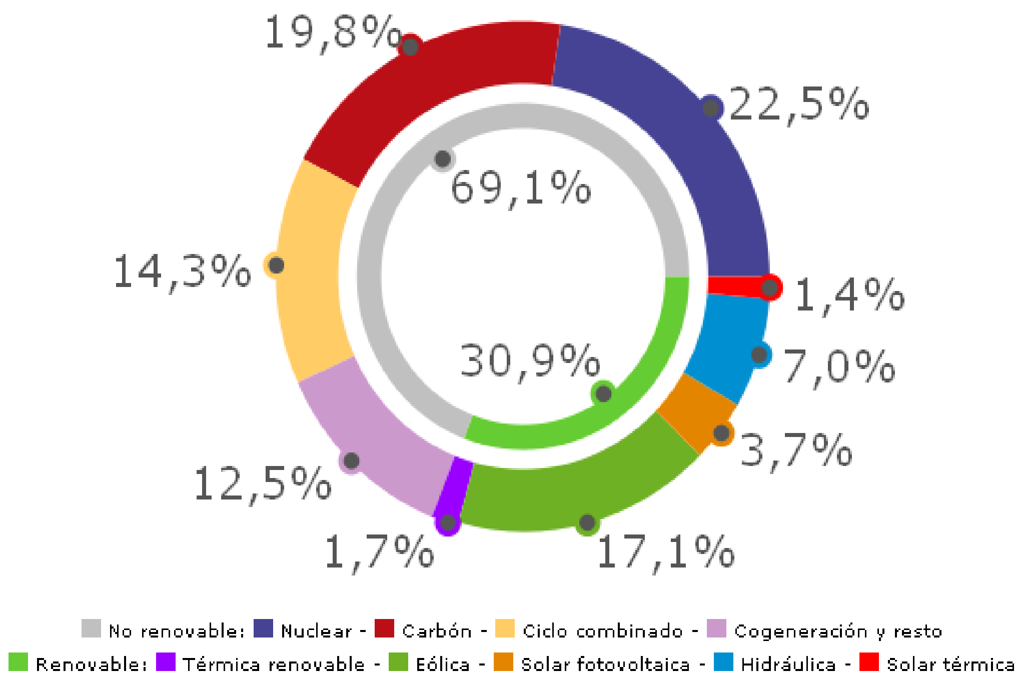
RD 1578/2008: *New remuneration for PV plants*

RD 485/2009: *Established how to set up TUR*

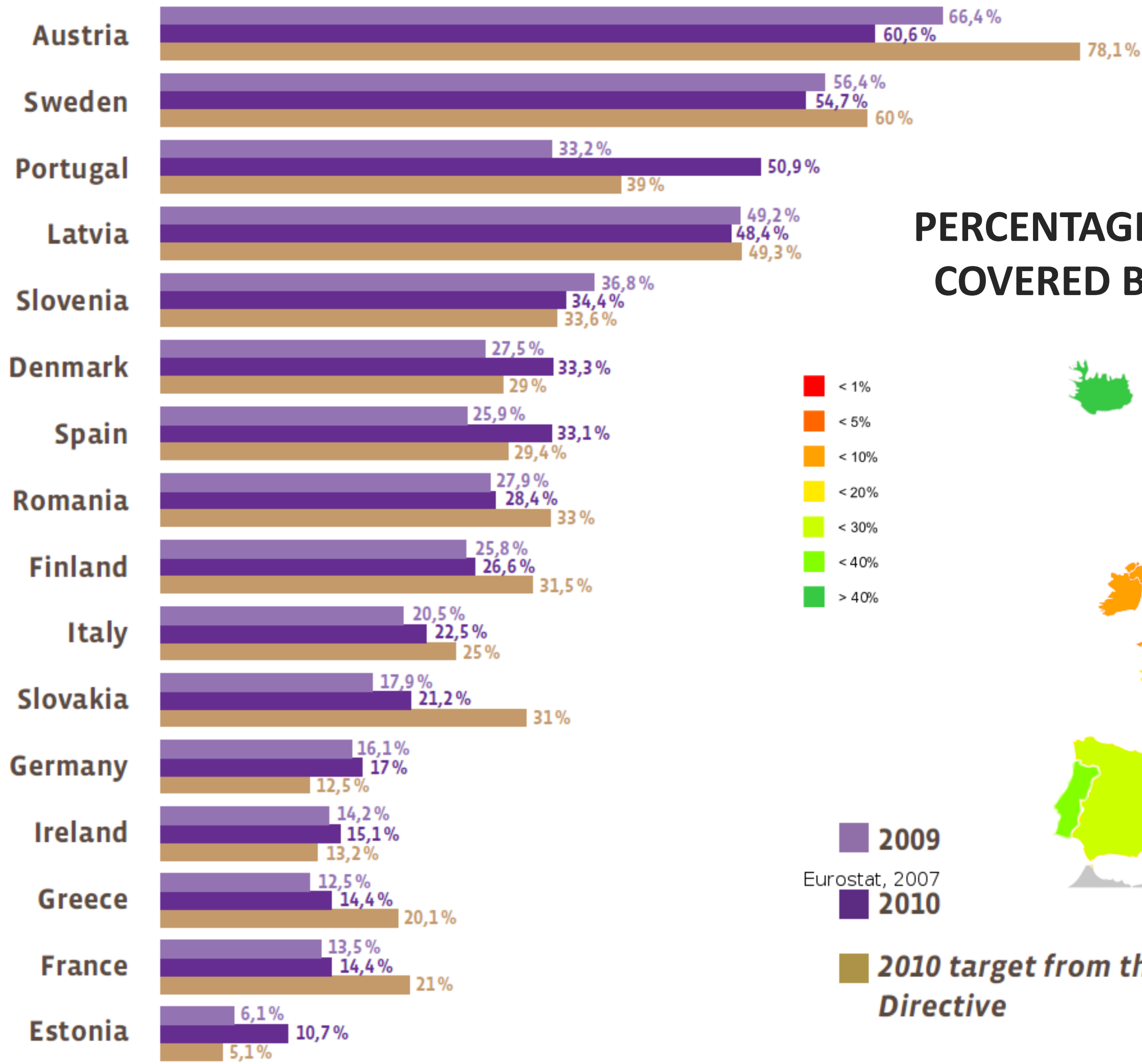
CNE 4/2009: *Regulated how to set up Equivalent bonuses other incentives addressed to renewable plants*

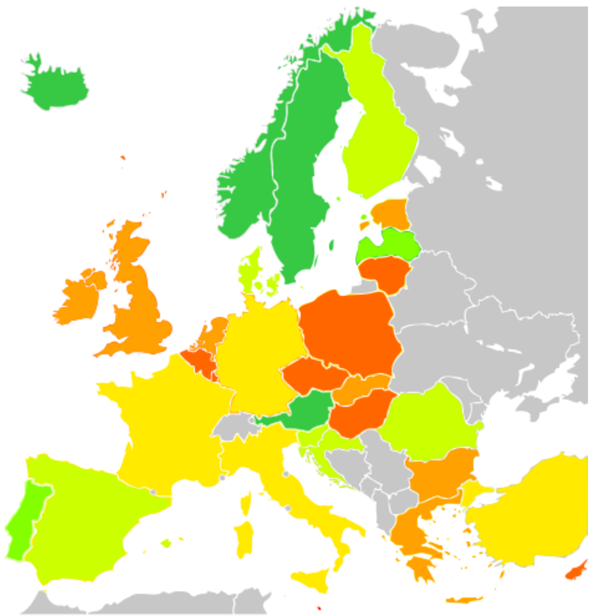
1997	1998	.....	2004	2005	2006	2007	2008	2009	2010	2011	2012	.....	.....	.....	.....

Generation mix 2012



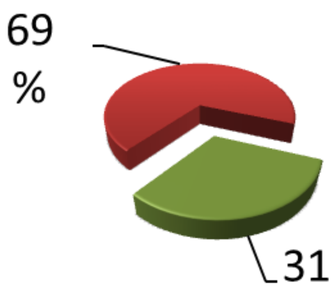
PERCENTAGE OF ENERGY DEMANDED COVERED BY RENEWABLE SOURCES

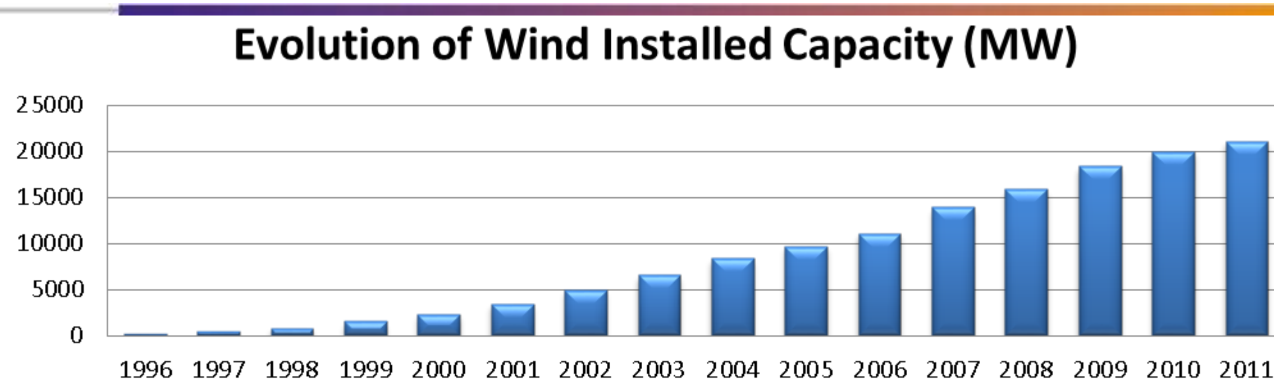


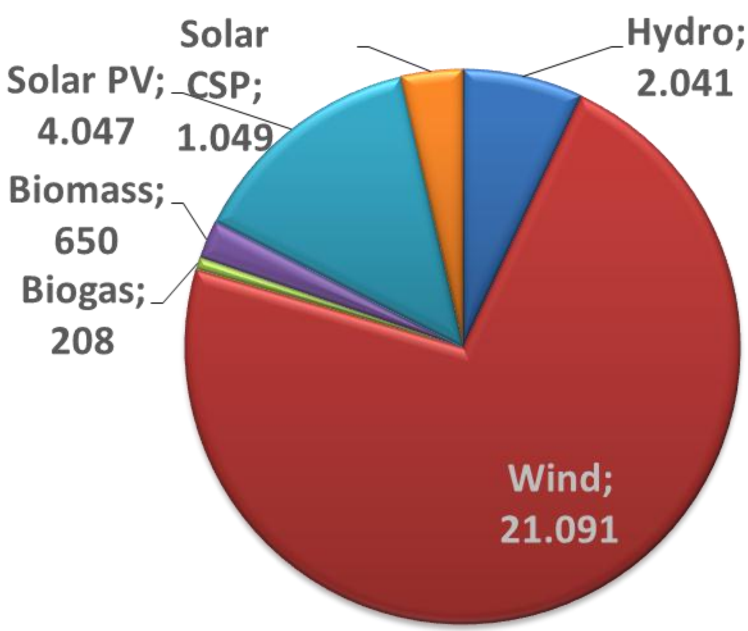


Eurostat, 2007

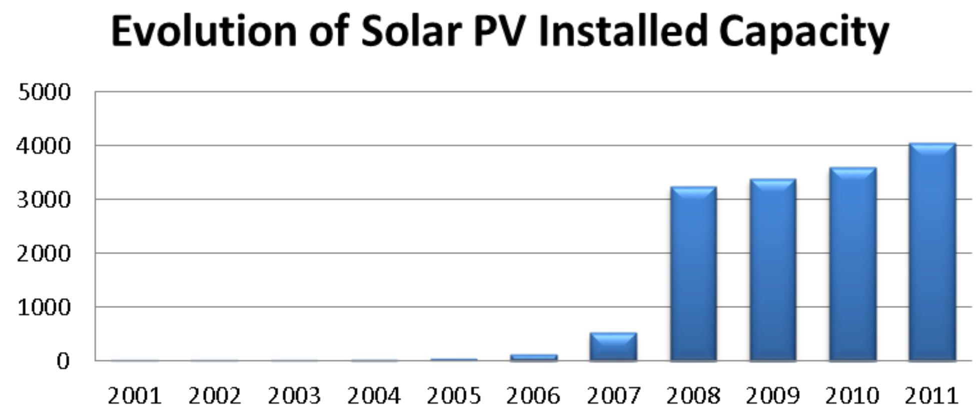
ENERGY GENERATION CONTEXT IN SPAIN. Nameplate capacity

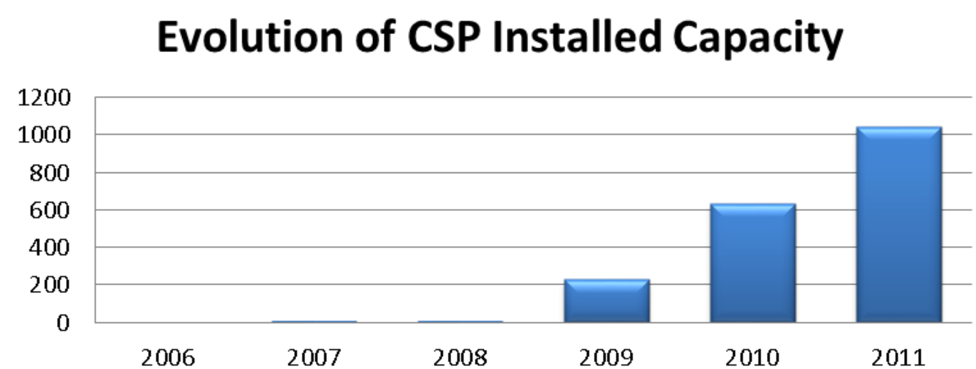






RE installed capacity Dec- 2011 (MW)

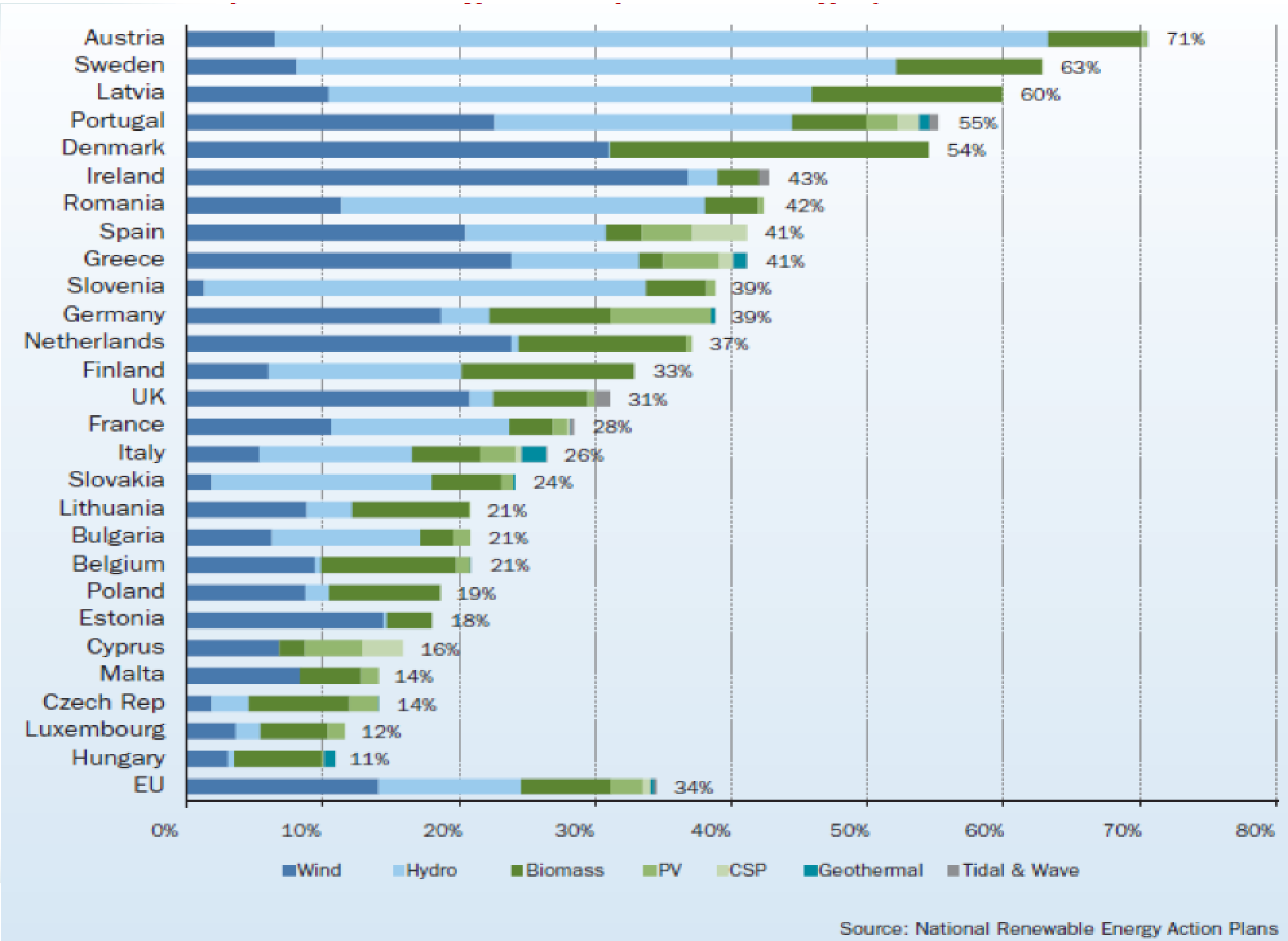




Some records in Spain

	Date	Value
Maximum Wind Generation	April 19th, 2012	14,889 MWh
Maximum Coverage Wind	Sept 24th, 2012	64.25%
Maximum CSP Generation	July 10th, 2012	1,363 MWh
Maximum Coverage CSP	July 10th, 2012	4%

ENERGY GENERATION CONTEXT IN SPAIN. Nameplate capacity



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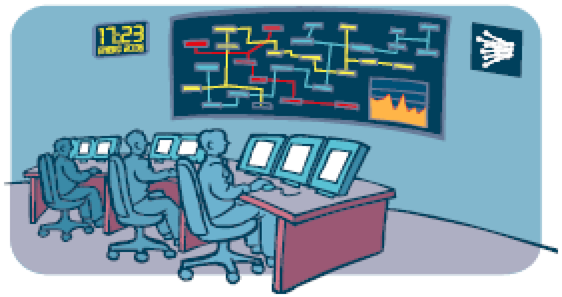
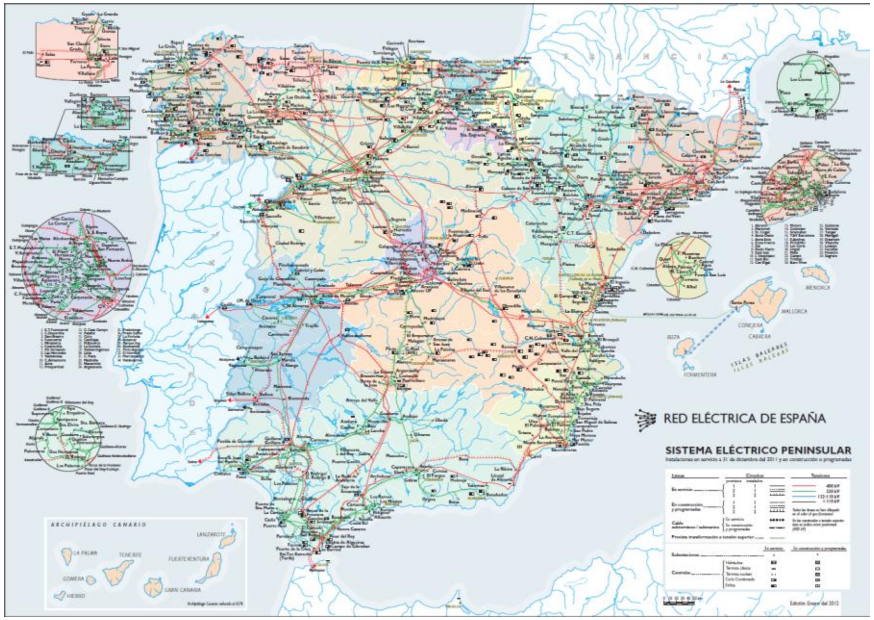
ENERGY GENERATION CONTEXT IN SPAIN. TSO

RED ELÉCTRICA DE ESPAÑA



REE is Spanish TSO

- Grid Operator: **assure power supply**
- Transport Grid Design, Planification and Maintenance.



TN	2010
Lines (HV)	18.576
Lines (MV)	17.221
Subs.	3500
Trans.	69.059

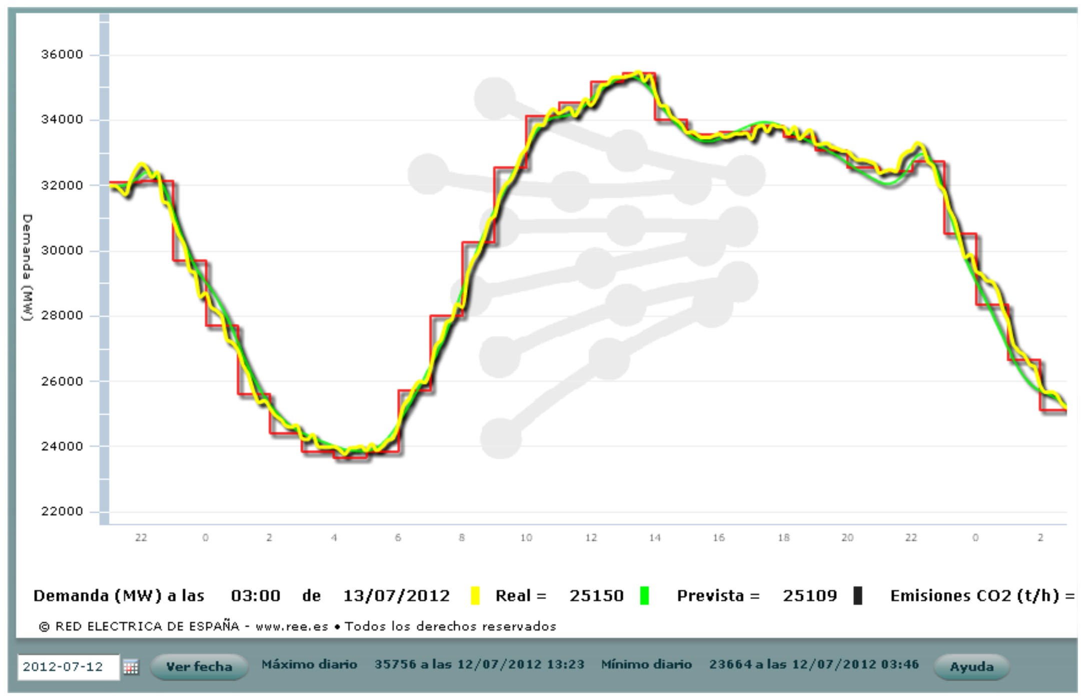
Renewable Energy Integration Issue

TSO must balance generation and consumption

- Stability of grid parameters: frequency, power, etc.
- Unbalance may lead whether to disconnection or to extra generation costs.

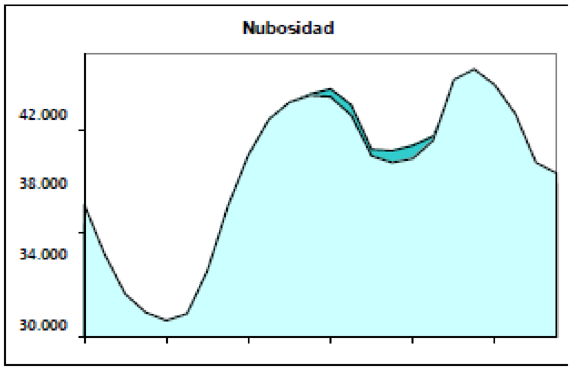
Demand

- Varies along time
- Depends on
  - Meteorology
  - Labor/Non-labor day
  - Day of week
  - Special events
  - Random data

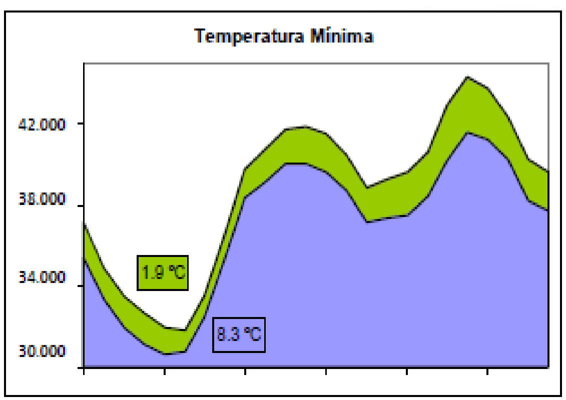


RENEWABLE INTEGRATION ISSUES. Demand Variability

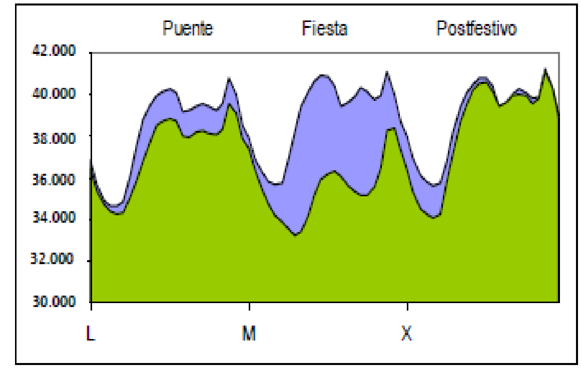
Cloudiness



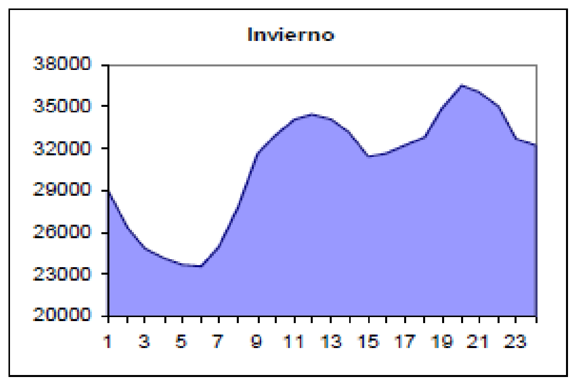
Temperature

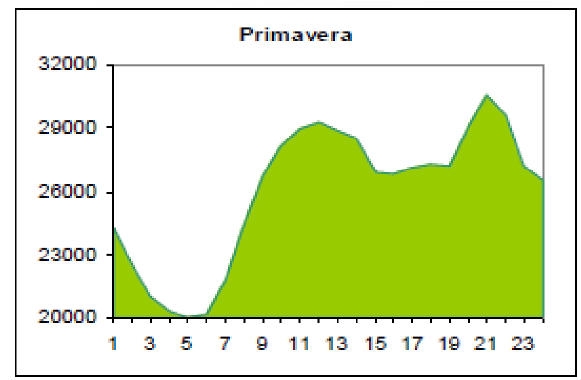


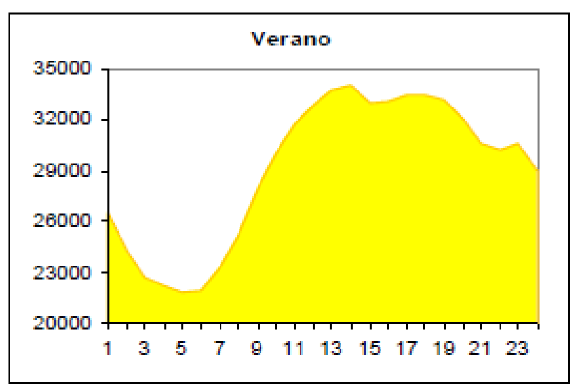
Labor or Non-Labor days

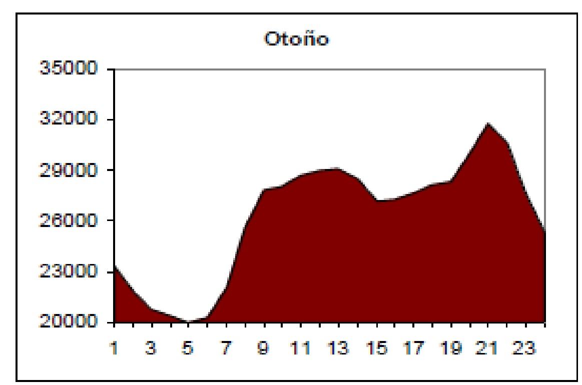


Seasons

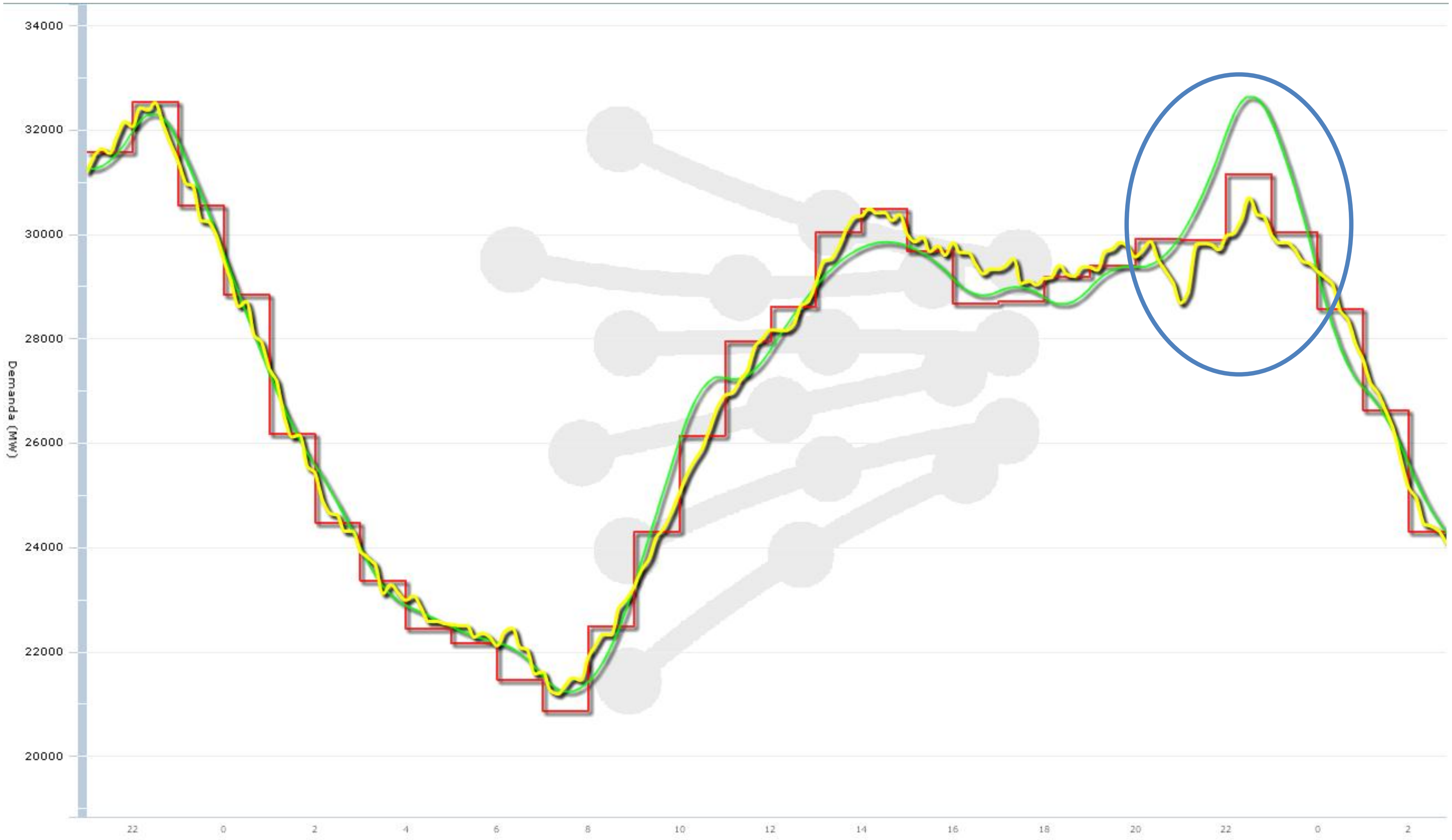




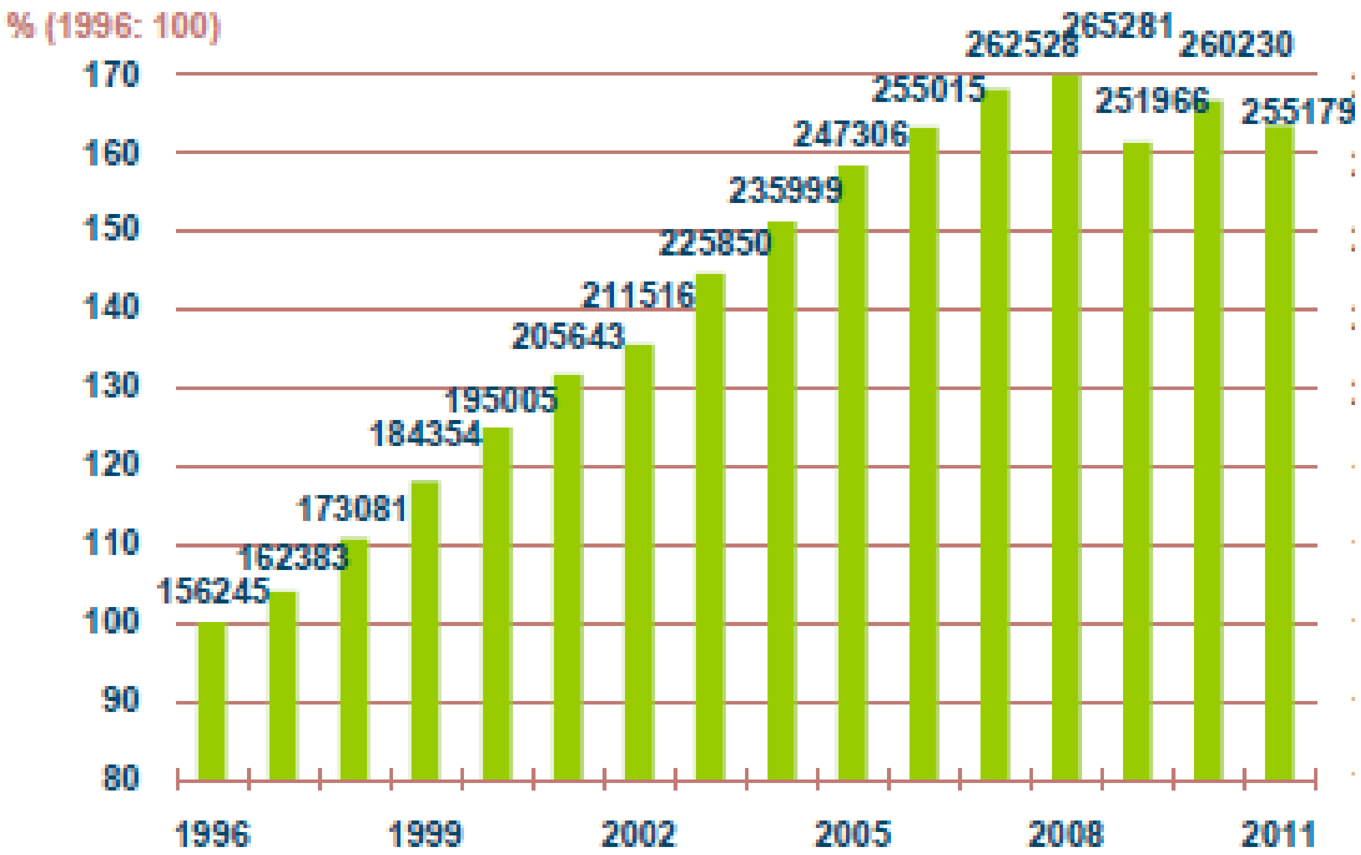




Special events!

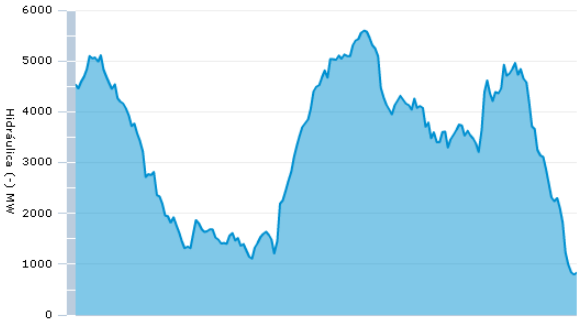


Evolution of energy demand in Spain



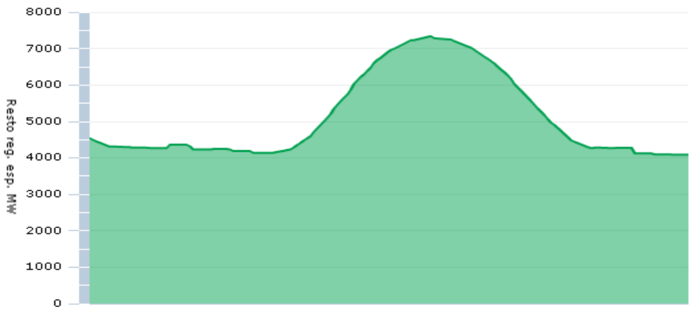
Renewable Energy Sources

- Availability depends on natural resource
- Intermittent vs non-intermittent
- Dispatchable vs non-dispatchable



Hydro

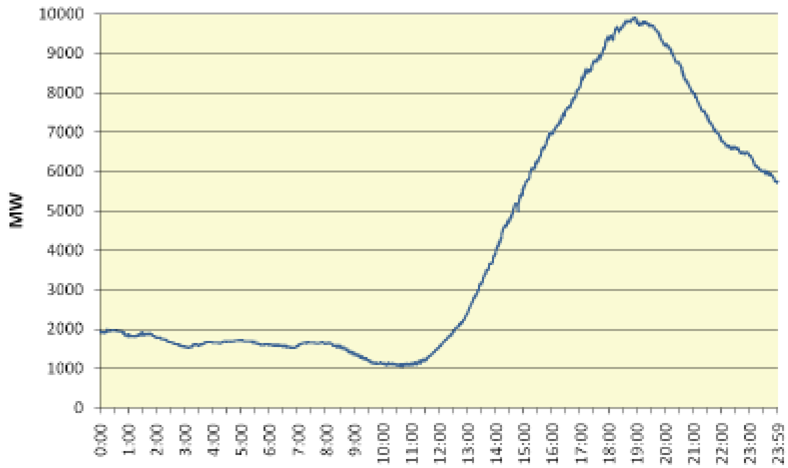
Wind

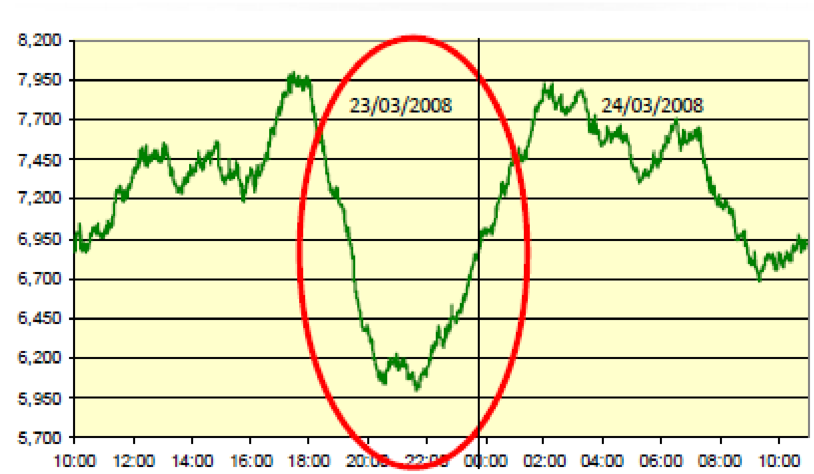


Solar PV, biomass, solar CSP,…

Generation not correlated to demand

Wind energy: typical situations



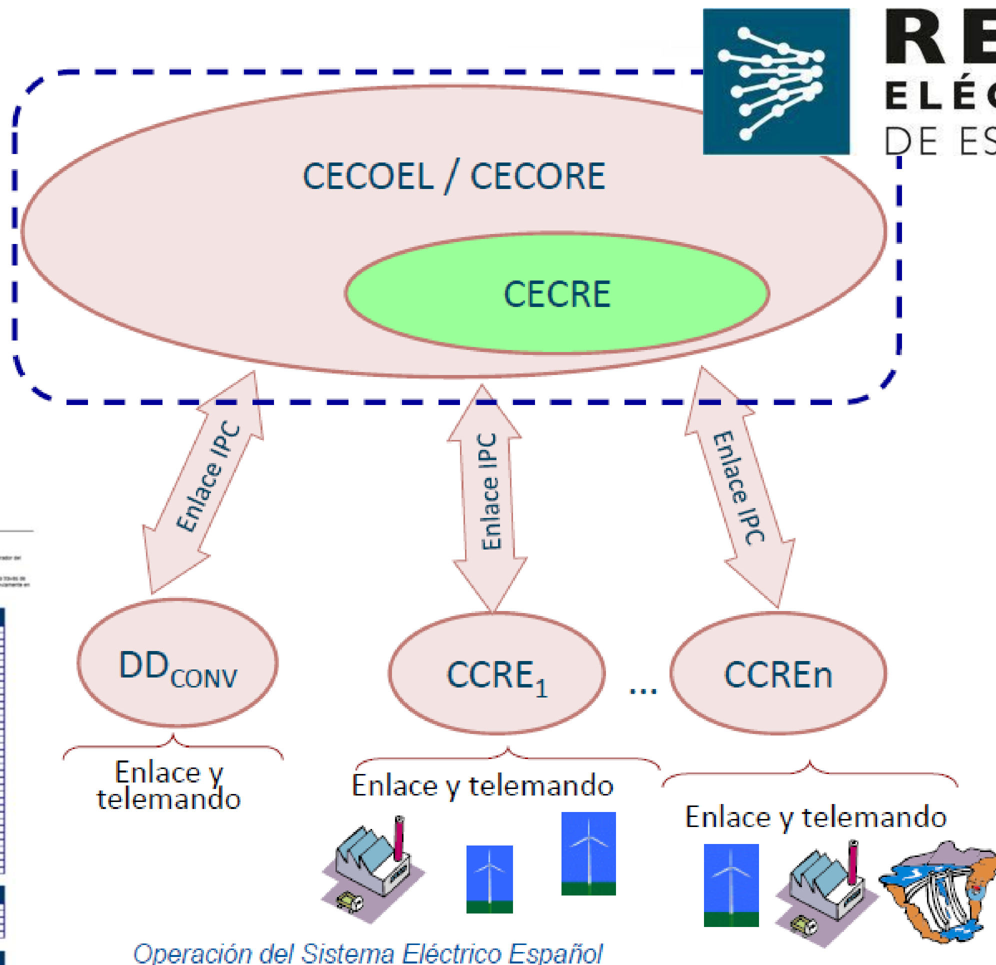


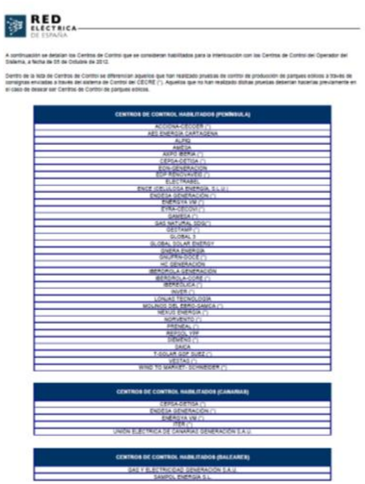
- Wind ramps -> High gradients of energy -> Scheduling efforts.
- Wind energy fall due to over-speed protection, wind speed is higher than 25 m/s.

- Forecasts can mitigate the effects of wind variability for System Operation.
- Larger forecast errors imply the use of reserves -> Increasing system costs.

Real Time Grid Operation

CECRE





RED ELÉCTRICA DE ESPAÑA

A continuación se detallan los Centros de Control que se consideran habilitados para la interlocución con los Centros de Control del Operador del Sistema, a fecha de 05 de Octubre de 2012.

Dentro de la lista de Centros de Control se diferencian aquellos que han realizado pruebas de control de producción de parques eólicos a través de consignas enviadas a través del sistema de Control del CECRE (*). Aquellos que no han realizado dichas pruebas deberían hacerlas previamente en el caso de desear ser Centros de Control de parques eólicos.

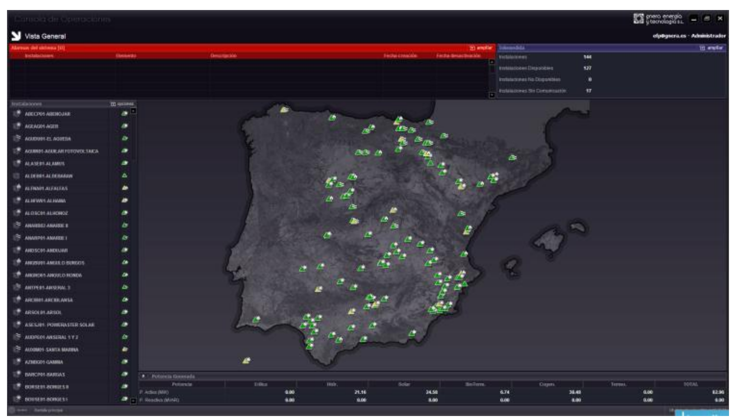
CENTROS DE CONTROL HABILITADOS (PENÍNSULA)
ACCIONA-CECOER (*)
AES ENERGIA CARTAGENA
ALPIQ
AMEGA
AXPO IBERIA (*)
CEPSA-CETGSA (*)
EON-GENERACION
EDP RENOVAVEIS (*)
ELECTRABEL
ENCE (CELULOSA ENERGIA, S.L.U.)
ENDESA GENERACION (*)
ENERGYA VM (*)
EYRA-CECOVI (*)
GAMESA (*)
GAS NATURAL SDG (*)
GESTAMP (*)
GLOBAL 3
GLOBAL SOLAR ENERGY
GNERA ENERGIA
GNUFFIN-DOCE (*)
HC GENERACION
IBERDROLA GENERACION
IBERDROLA-CORE (*)
IBEREOLICA (*)
INVER (*)
LONJAS TECNOLOGIA
MOLINOS DEL EBRO-SAMCA (*)
NEXUS ENERGIA (*)
NORVENTO (*)
PRENEAL (*)
REPSOL YPF
SIEMENS (*)
SAICA
T-SOLAR GDF SUEZ (*)
VESTAS (*)
WIND TO MARKET- SCHNEIDER (*)

CENTROS DE CONTROL HABILITADOS (CANARIAS)
CEPSA-CETGSA (*)
ENDESA GENERACION (*)
ENERGYA VM (*)
ITER (*)
UNIÓN ELÉCTRICA DE CANARIAS GENERACIÓN S.A.U.

CENTROS DE CONTROL HABILITADOS (BALEARES)
GAS Y ELECTRICIDAD GENERACIÓN S.A.U.
SAMPOL ENERGIA S.L.

CCRE GNERA

- 149 facilities
- Nameplate capacity: 430 MW
- Multitechnology: wind, PV, CSP, biomass, cogeneration.
- 24 x 7 x 365
- HW High availability
- Multiprotocol: IEC-104, Modbus TCP
- 2 ICCP redundant point-to-point links to CECORE y CECOEL (REE TSO)



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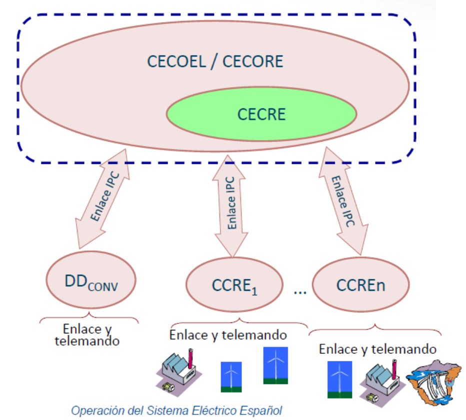
RED ELÉCTRICA DE ESPAÑA

CECORE

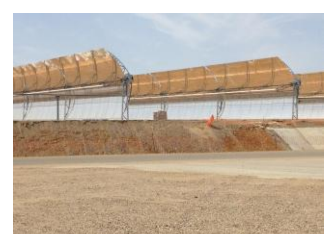
CECOEL



CECRE

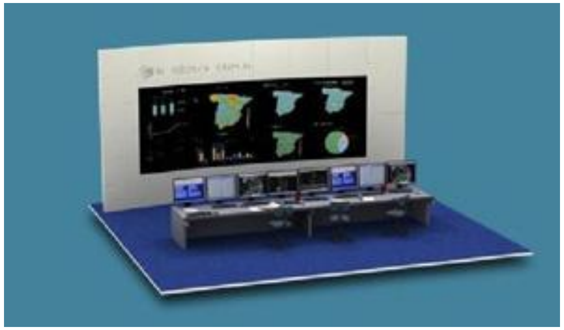
CCRE Gnera

gnera energía



Signals sent to CECRE:

CECRE SIGNALS



<u>**P < = 10 MW**</u>

- Active Power

<u>**P > 10 MW**</u>

- Active Power
- Reactive Power
- Connection Status
- Voltage

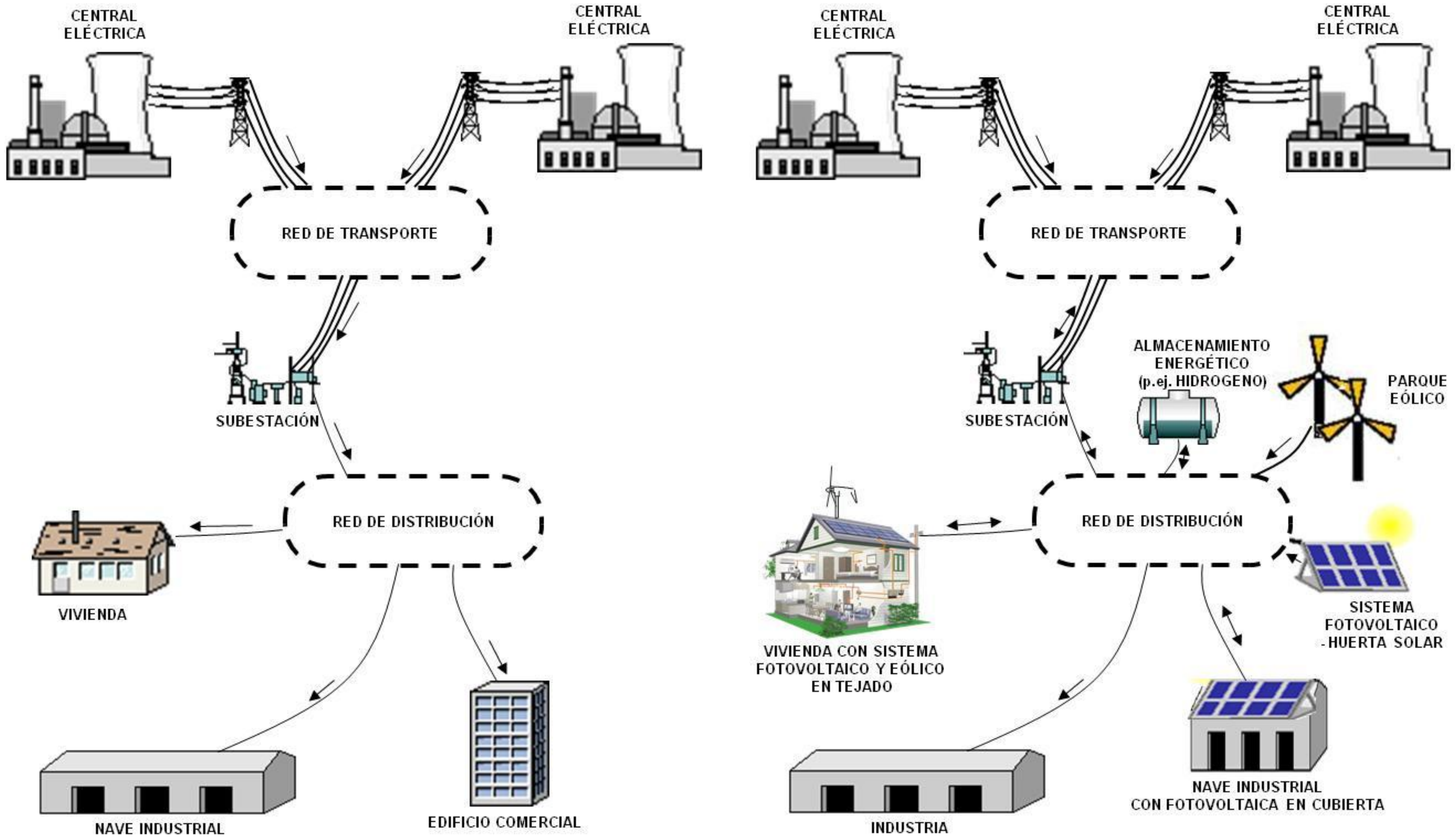
Wind Farms

- Wind speed
- Temperature

- Signals are sent every 12 seconds
- P>10, Control Signals to limit to a Max Operation Power in 15 minutes.

A glance to the future

"A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies"



Characteristic	Today's Grid	Smart Grid
Enables active participation by consumers	Consumers are uninformed and non-participative with power system	Informed, involved, and active consumers - demand response and distributed energy resources.
Enables new products, service sand markets	Limited wholesale markets, not well integrated - limited opportunities for consumers	Mature, well-integrated wholesale markets, growth of new electricity markets for consumers
Operates resiliently against attack and natural disaster	Vulnerable to malicious acts of terror and natural disasters	Resilient to attack and natural disasters with rapid restoration capabilities

A GLANCE TO THE FUTURE. Investments on Smart Grids

- FORECAST SMART GRID INVESTMENTS
  €56 billion by 2020
- FUNDING FOR SMART GRID DEVELOPMENT
  €384 million
- NUMBER OF SMART METERS DEPLOYED AND/OR PLANNED
  45 million installed
  240 million by 2020

- FORECAST SMART GRID INVESTMENTS
  €71 billion
- FUNDING FOR SMART GRID DEVELOPMENT
  €5,1 billion
- NUMBER OF SMART METERS DEPLOYED AND/OR PLANNED
  360 million installed by 2030

- FORECAST SMART GRID INVESTMENTS
  €238-334 billion by 2020
- FUNDING FOR SMART GRID DEVELOPMENT
  €4,9 billion
- NUMBER OF SMART METERS DEPLOYED AND/OR PLANNED
  8 million installed
  60 million by 2030

SMART GRID PROJECTS IN US MAP

- Supported by DOE seeks transform electrical distribution system, integrating a system of mix distributed resources and including renewables, improving efficiency reliability achieving Zero Energy District
- 30 distributed generation, 5 customer locations, 3.5 MW

CITY OF FORT COLLINS

- Will prove the effectiveness of integrating multiple distributed energy resources with advanced controls and communications
- Integrates PV, Biodiesel-fuel, energy storage along AMI
- 50MW

BEACH CITIES MICROGRID BY SAN DIEGO GAS&ELECTRIC

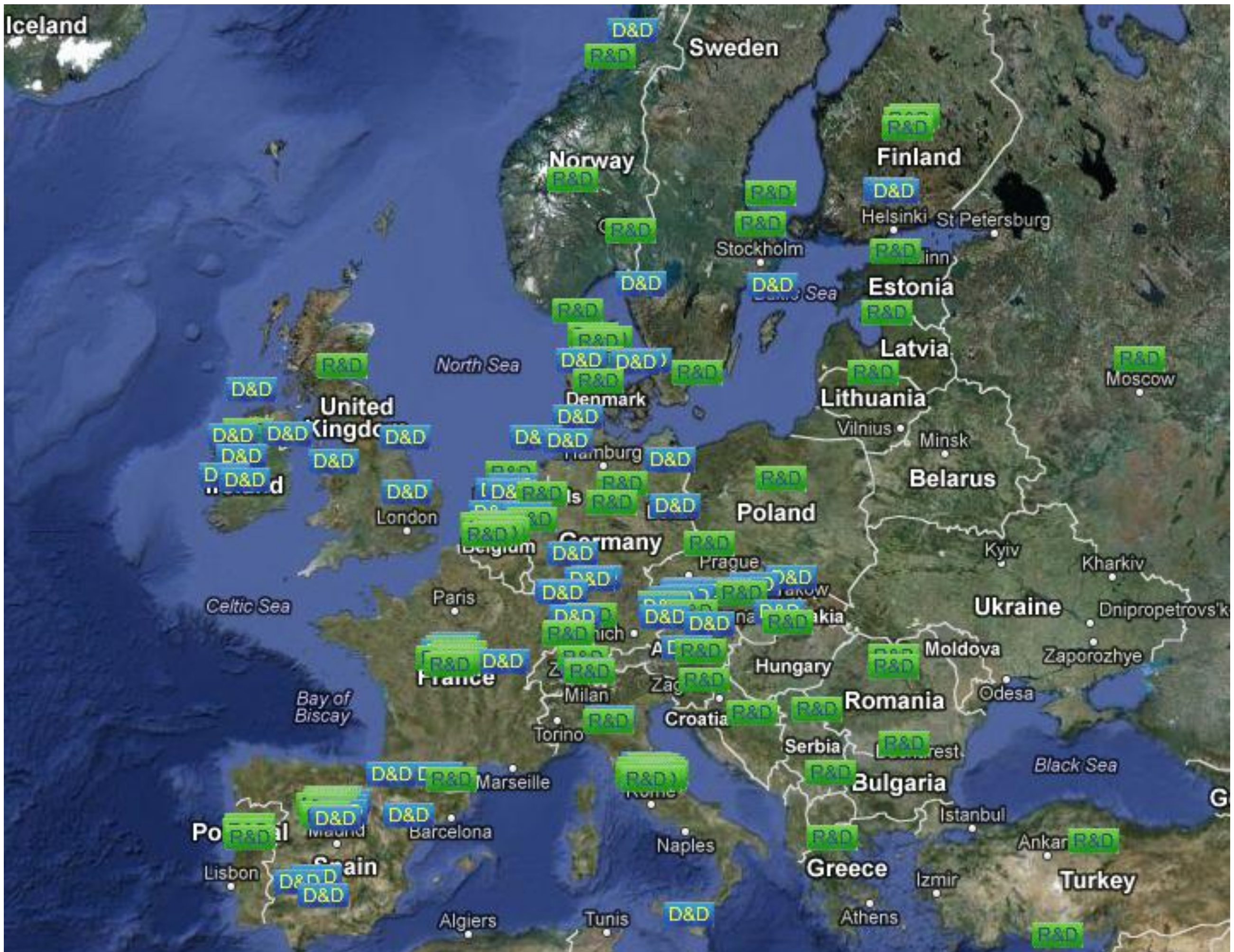
- Will integrate AMI as a home portal for demand response
- Home automation for energy conservation
- Optimal dispatch of distributed generation, storage, and loads in the distribution system
- Controls to make the distribution system a dispatchable entity to collaborate with other entities in the bulk grid.

DISTRIBUTED MANAGEMENT SYSTEM, UNIVERSITY OF HAWAII

- DOE demonstration project. Sophisticated system that responded to simple instructions set in place by a consumer in his or her preference profile
- Consumers saved 10% on their bills
- Peak of load reduced 15%

WASHINGTON OLYMPIC PENINSULA

SMART GRID PROJECTS IN EU MAP



A GLANCE TO THE FUTURE. Smart Grid Projects

- Connects small producers, storage and controllable loads (smart meters) through remote terminals units with a Control Center
- Platform connected components: 11 MW intermittent power, 300 MW controllable power
- Domestic consumer has access to variable tariffs

WEB2ENERGY PROJECT

- Electric vehicle integration project
- 50 customers and 100 recharging stations (50 public stations and 50 home stations) pursues an open access approach..
- Electric vehicles are used as storage devices to provide ancillary services in presence of a high level of

MINI-BERLIN PROJECT

- Develops embedded intelligence and integration technologies that will directly optimize energy use in buildings and enable active participation in the future smart grid environment
- Integrate energy brokerage module

- 5 countries participating
- 11 companies (small, large, universities)
- 4 demonstration locations
- €6,3 million budget
- 20% less energy needed
- 20% savings

ENCOURAGE PROJECT

Thank You!

www.gnarum.com