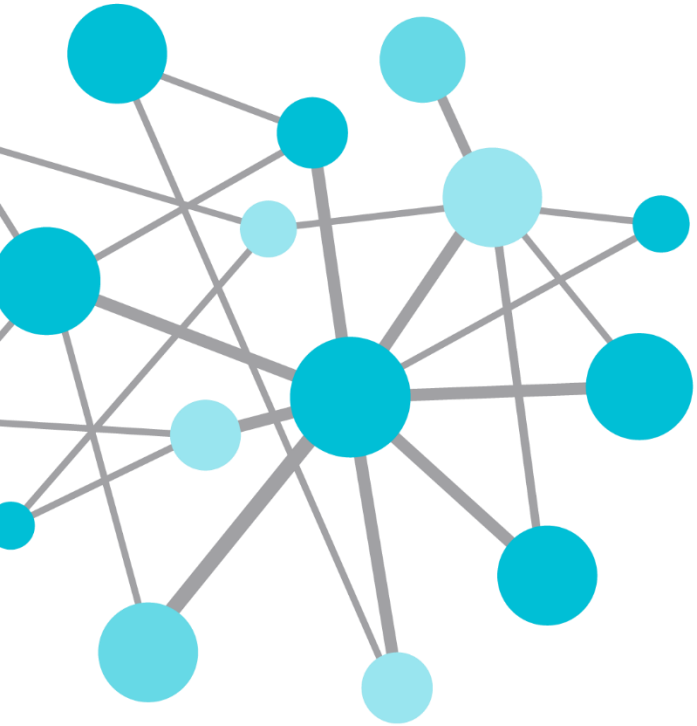

Big Data Analytics and Real Time Data Awareness at CECRE (Control Center for Renewable Energies)

Presented by **Alberto Gil**

RED ELÉCTRICA DE ESPAÑA

Index

1 Red Eléctrica de España (REE)

1 Red Eléctrica de España (REE)

System Operation:

- *Operates the grid and coordinates its uses with the generation facilities in order to ensure the security and continuity of the electricity supply.*

Transmission (since 2007 as exclusive transmission company):

- *The development and the maintenance of the transmission facilities*
- *~ 41,000 km of lines and 78,000 MW of transforming capacity*

2 CECOEL: Electrical Control Center

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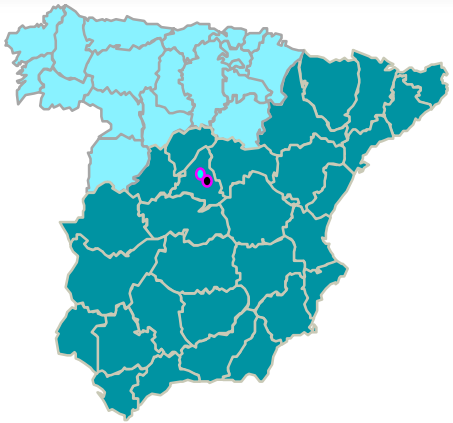
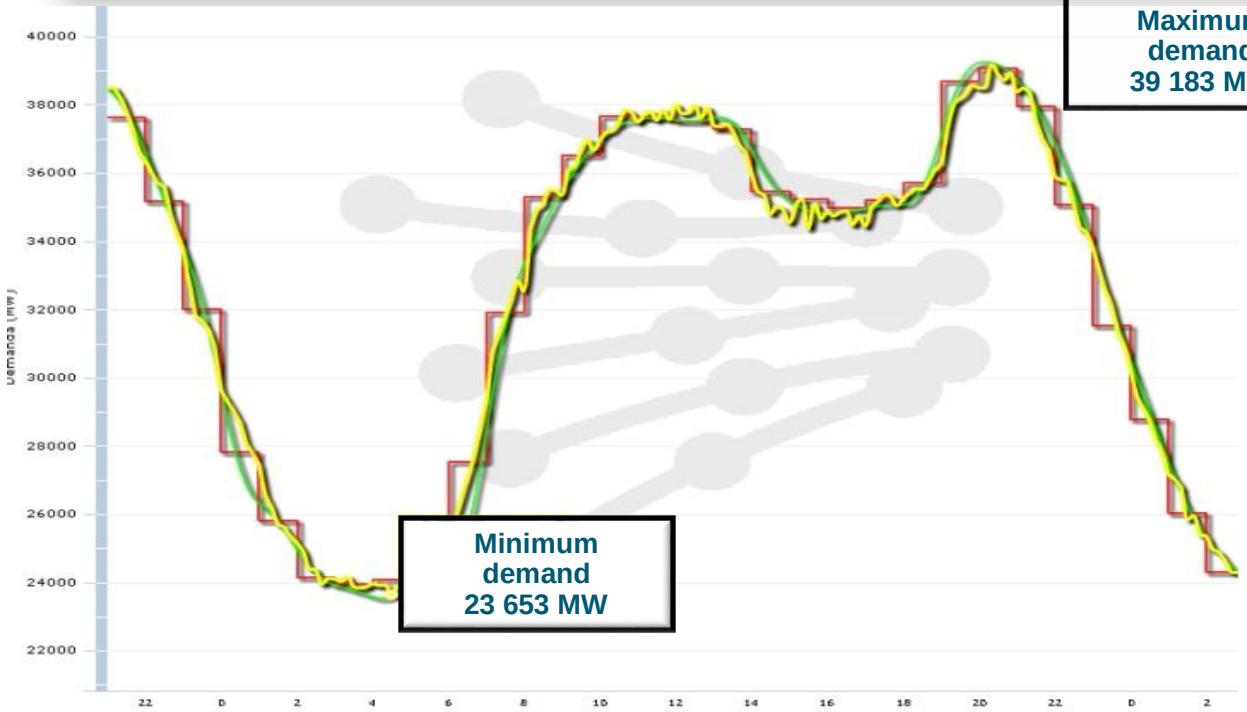
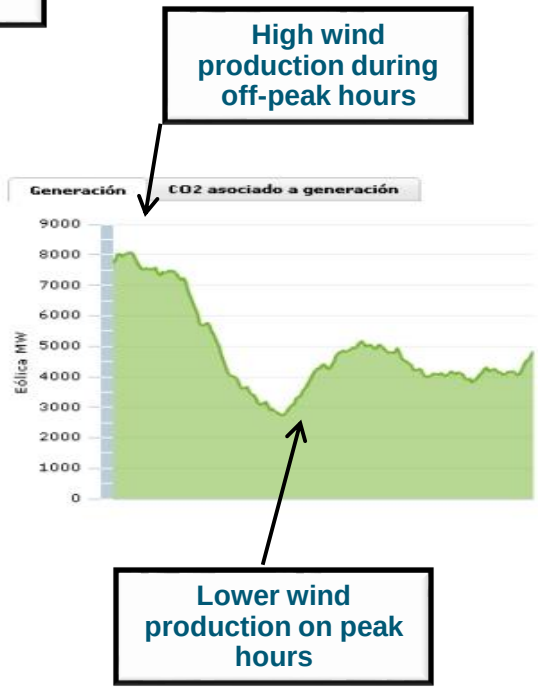


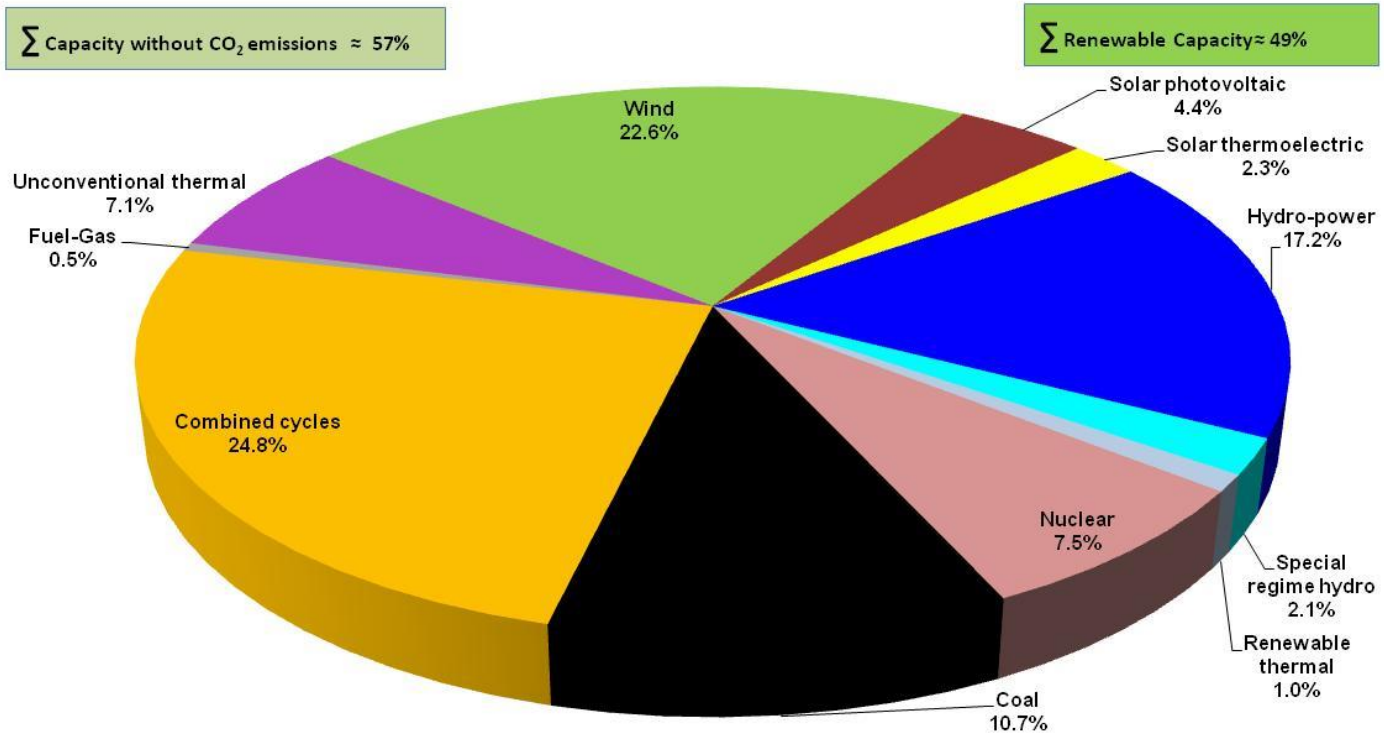
- Control Centres' permanent availability
- Two Control Centres with symmetrical backup capability
- Redundancy of computer equipment, telecommunication and electrical supply in each Control Centre

2 CECOEL: Demand Coverage





2 CECOEL: Installed Generation Capacity September 2014 - 100 GW



2 CECOEL: Real Time Data

- *Every telemetry is linked point to point*

EMS System

- ***Observability**: 47 000 analog and 223 000 digital telemetries updated in less than 12 s*
- ***Controlability**: 40 000 remote control signals*

More than 2.5 billion data values every day

- *23.000 telemetries available for retrieving using PI System*

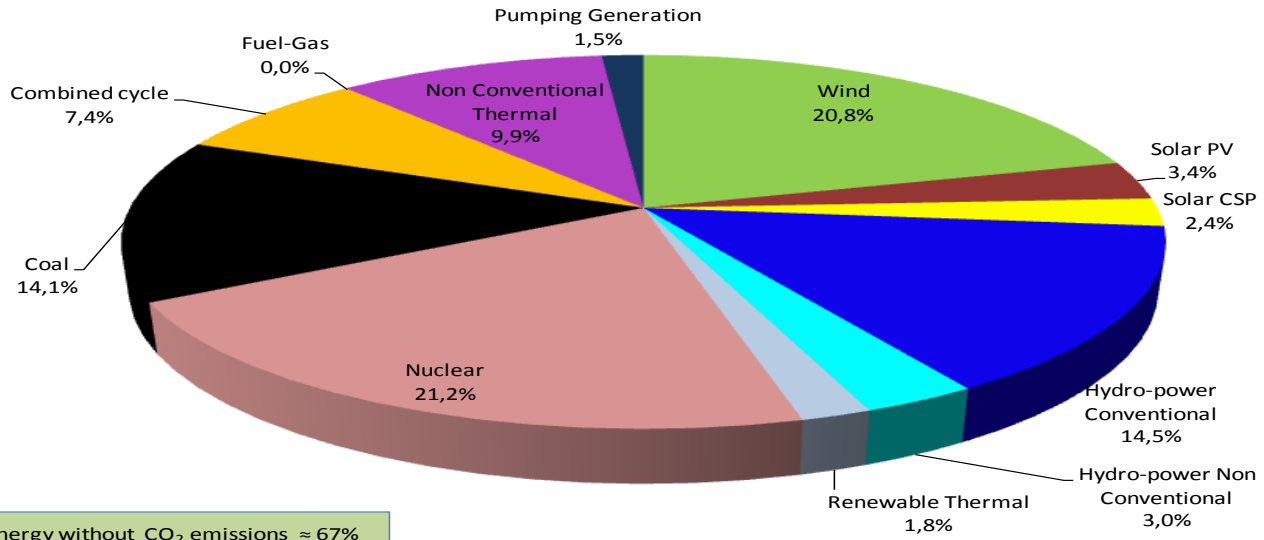
3 CECRE: Control Center for Renewable Energies

3 CECRE: Control Center for Renewable Energies

3 CECRE: Structure of the accumulated net generation 2014 (*)

	GWh
Wind	35.296
Solar PV	5.693
Solar CSP	4.087
Hydro-power	24.525
Hydro-power Non Conventional	5.116
Renewable thermal	3.124
Nuclear	35.887
Coal	23.859
Combined cycle	12.611
Fuel	0
Thermical no Renewable	16.814
Hydro pump	2.607
GENERATION	169.619

∑ Renewable Energy ≈ 46%

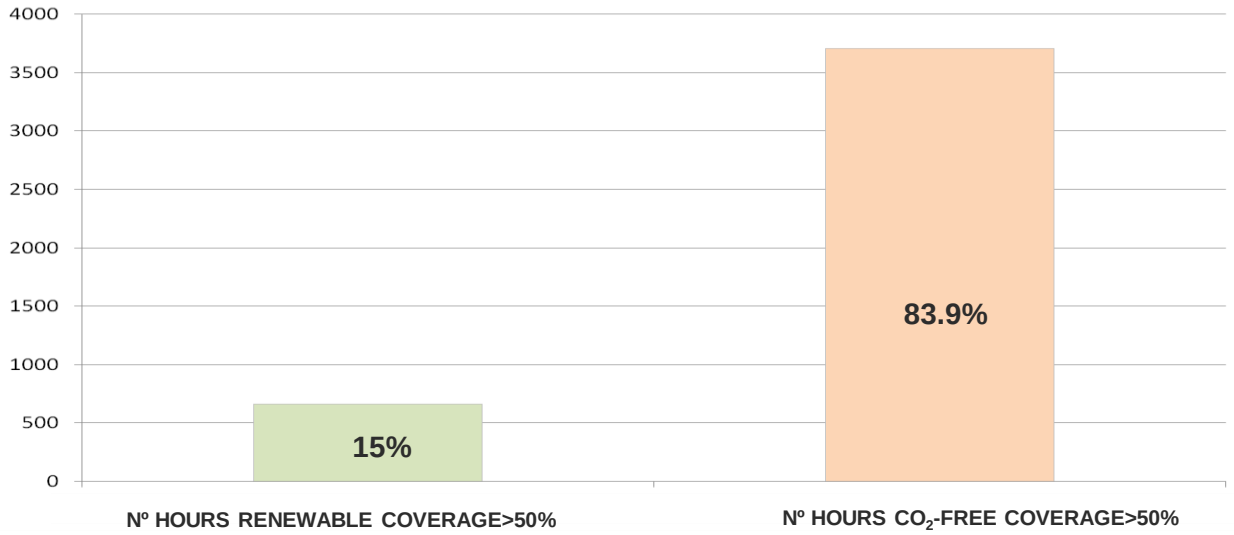


∑ Energy without CO_2 emissions ≈ 67%

(*) Provisional data-January .. August 2014

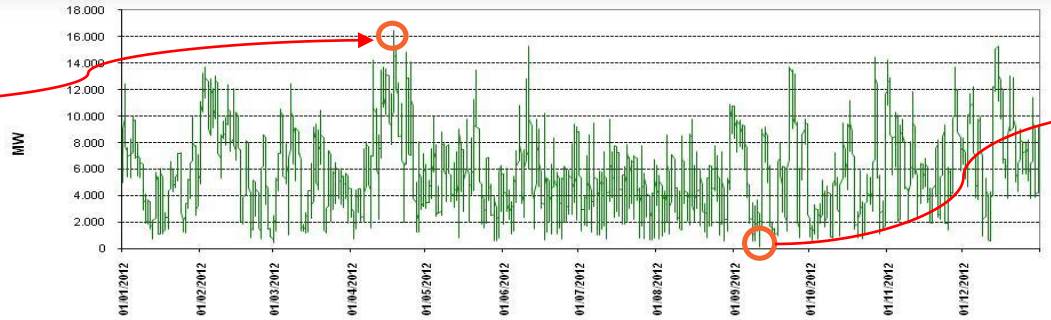
3 CECRE: Renewable demand coverage

Hours with renewable and co2-free demand coverage over 50% (2013)

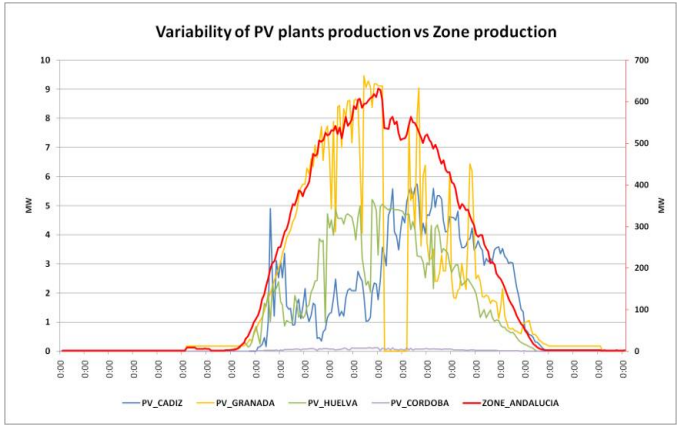


3 CECRE: Variability

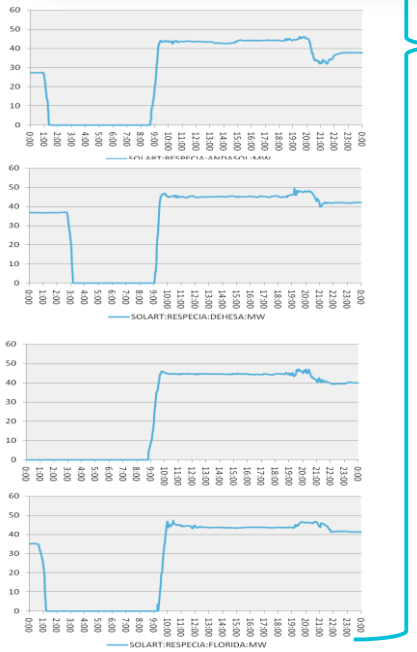
Maximum coverage 64%

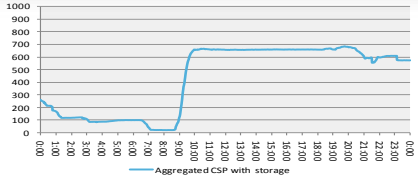


Minimum coverage <1%

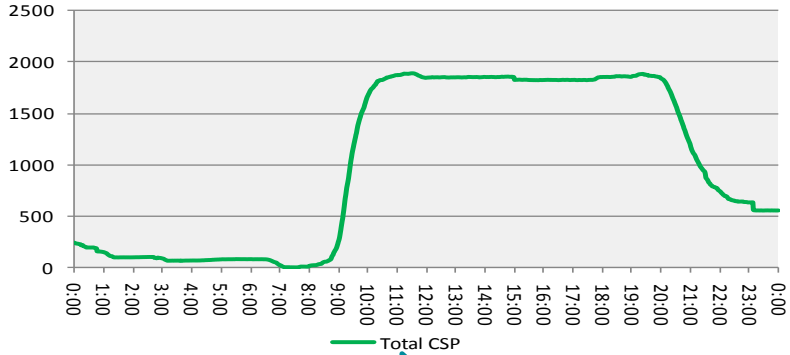


3 CECRE: Outcome of CSP Plants depending on technology

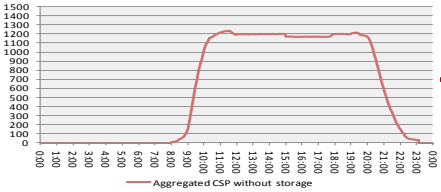


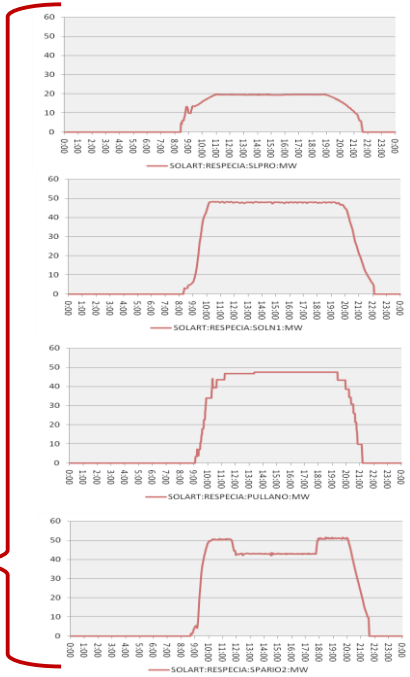


Aggregated outcome power from CSP with storage

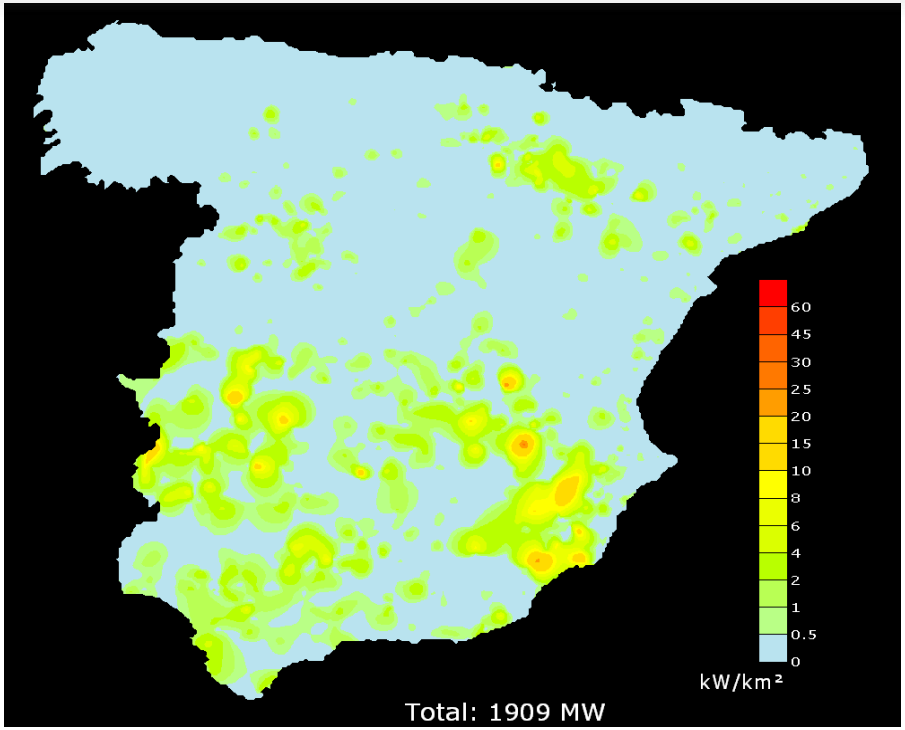


Aggregated outcome power from CSP without storage



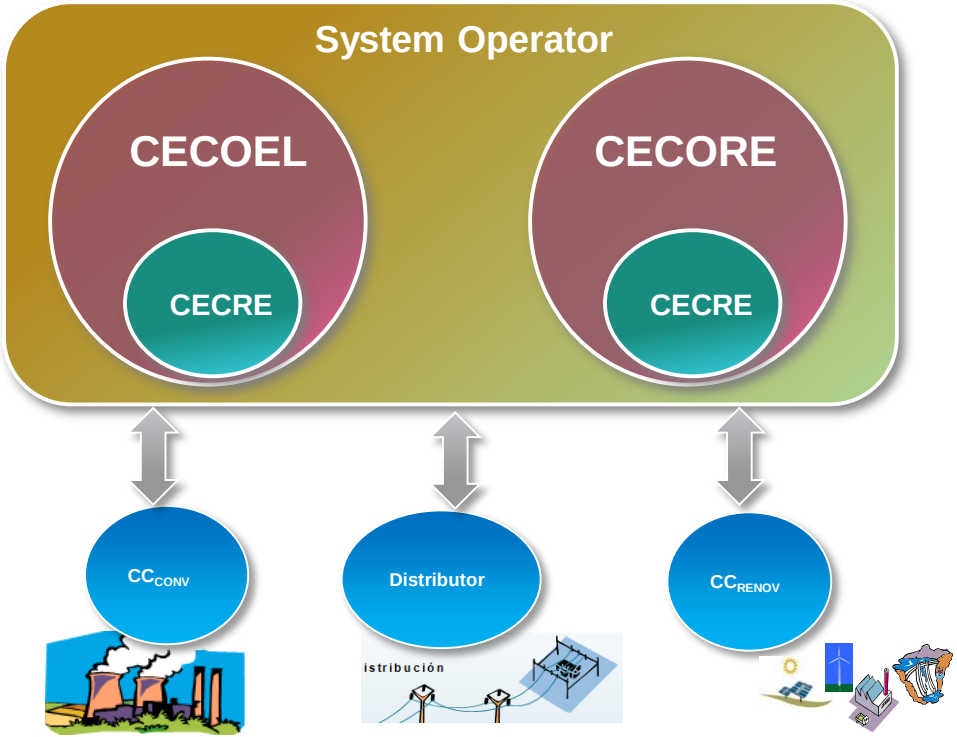


3 CECRE: Observability



Real Time Photovoltaic Generation

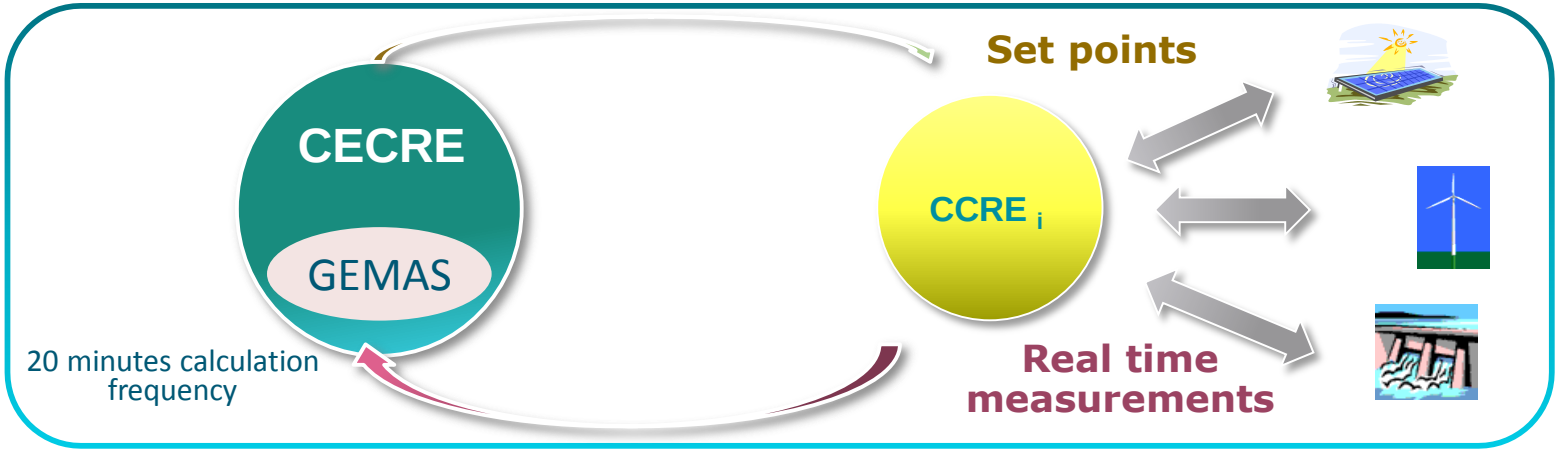
3 CECRE: Control Center for Renewable Energies



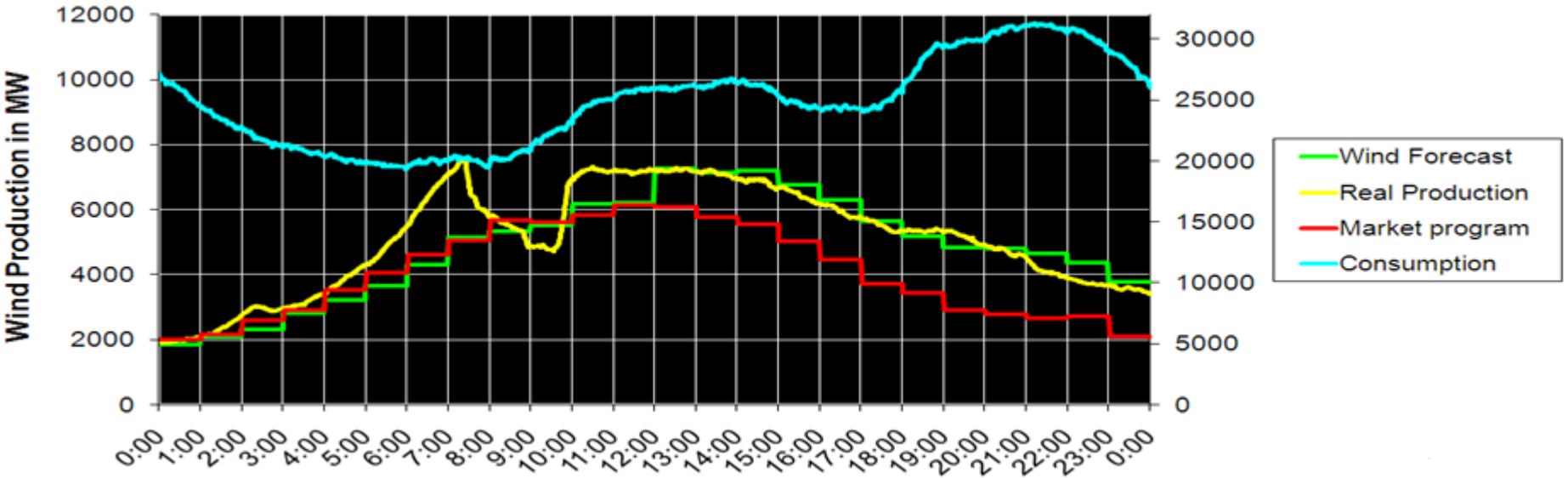
- 3 000 generation installations
- 37 generation control centers
- 350 distribution operators
- Communication is needed in case of emergency, outages or maintenance

3 CECRE: Controllability

SECURITY ANALYSIS USING A REAL TIME WIND SCENARIO



3 CECRE: Controllability



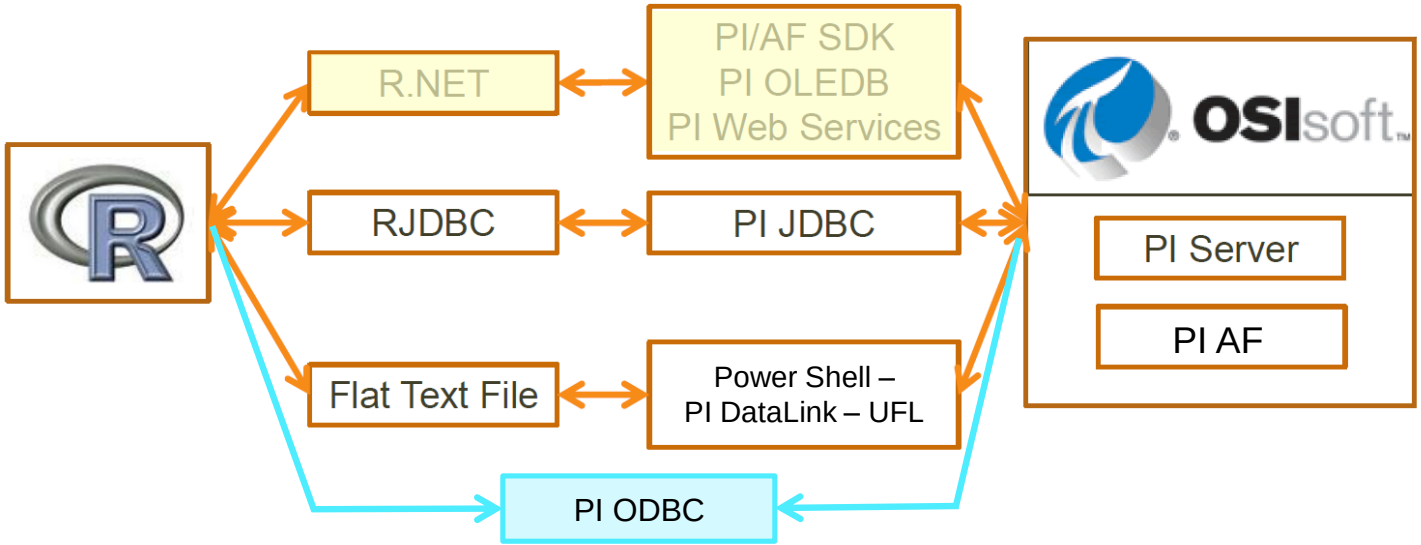
4 Operational Data analysis combining PI System and R

R Programming

- *R is a free software programming language and software environment for statistical computing* and graphics.
- *The R language is widely used among statisticians and data miners for developing statistical software and data analysis.*
  - Effective data handling
  - A suite of operators for arrays and matrices
  - Graphical facilities for data analysis and display
  - A well-developed, simple and effective programming language

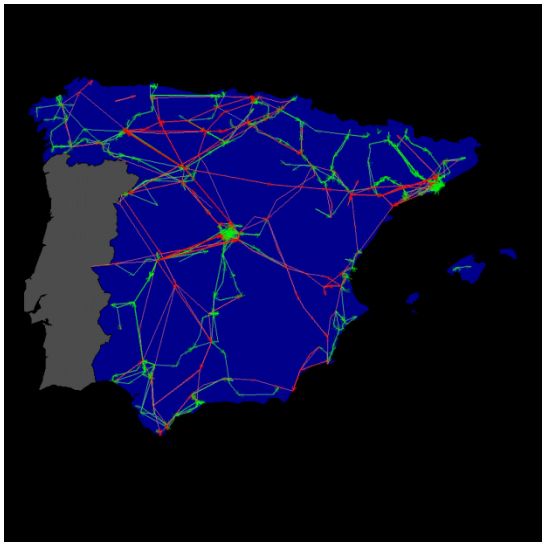
Combining PI System with R

Possible Architectures

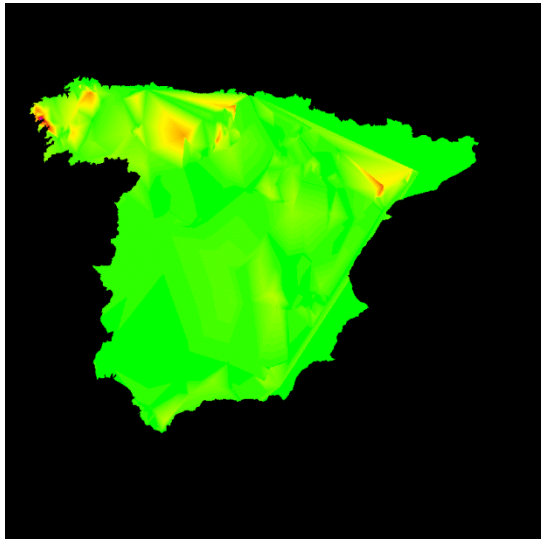


4 Operational Data analysis combining PI System and R

- *Monitoring Electrical variables and Power Generation in real time*



- **Real Time Power flows in the Transmission Grid**



- **Real Time Wind Power Generation**

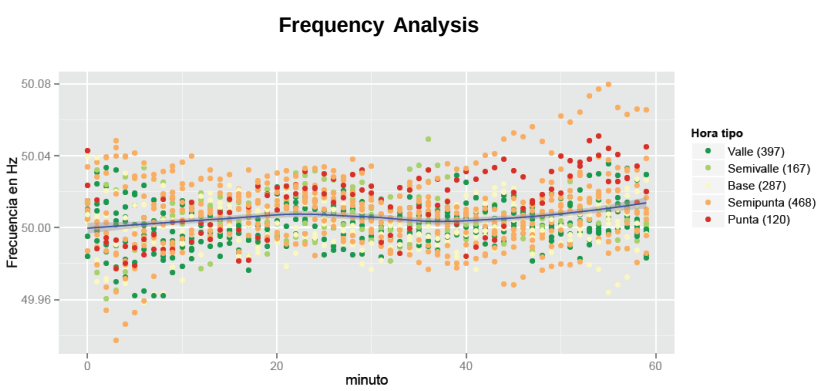
contornos_eolica_2014-06-23.gif

R Packages required:

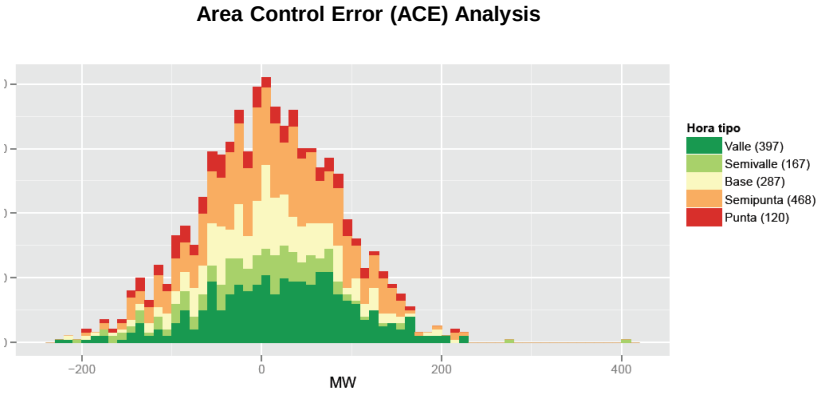
- Rmaps.r
- Ggmaps.r
- Akima.r

4 Operational Data analysis combining PI System and R

- *Historical Analysis of Electrical Variables*



- Distribution of frequency values with 1-minute sampled



- Daily Distribution of the Area Control Error (ACE)

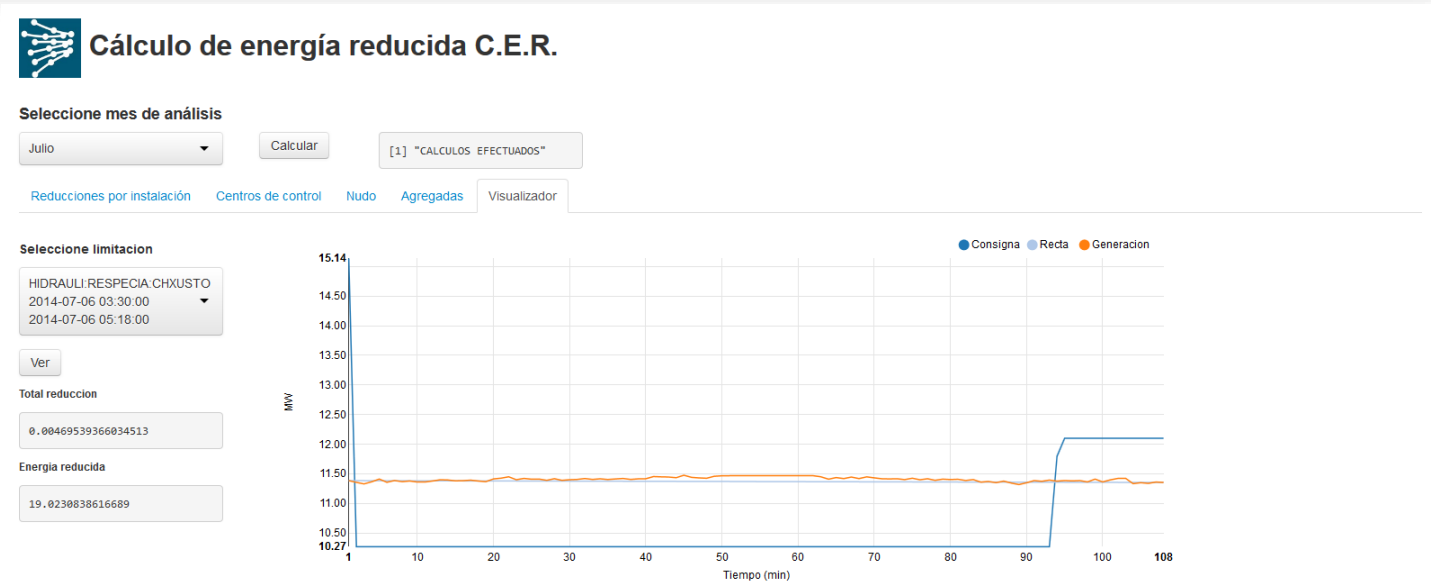
R Packages required:

- GGplot

4 Operational Data analysis combining PI and R

- *Automatic report generation*

4 Operational Data analysis combining PI System and R



- **Renewable Energy Curtailment analysis application using PI System, R and Shiny**

5 Conclusions and Next Steps

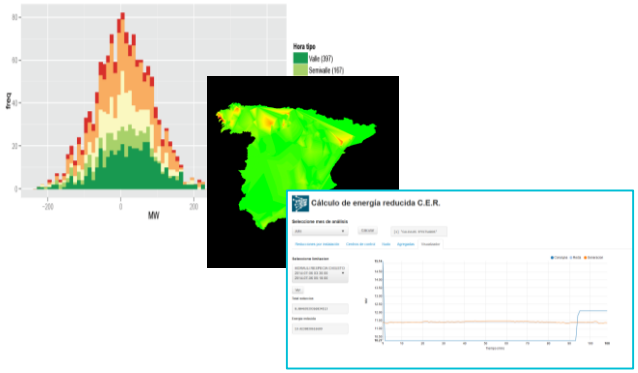
5 Conclusions and Next Steps

- Real time data awareness: 2.5 billion telemetries every day.
- PI System is a powerful tool for:
  - Retrieving both real time and historical data values.
  - Monitoring at the electrical control center.
  - Advanced data processing: PI System supports standard programming languages.
- Combining PI System and R programming allows more powerful way to analyze data

5 Conclusions and Next Steps

- Future steps using PI DataLink & R approach:
  - Implementing more efficient architectures to link PI DataLink and R (R.net /PI Web Services) in order to speed up even more retrieving and data analysis.
  - Implementing this approach to other existing analysis tools used in the control centre.
  - Development new tools for System Operation using this approach (voltage control, calculation of running reserves, processing structural information of both conventional and renewable generation).

Big Data Analytics and Real Time Data Awareness at CECRE



Business Challenge

- Management and analysis of big data for Electrical System Operation.

Solution

- Implementing PI DataLink, for easy data handling.
- Combining PI DataLink with R programming for complex statistical analysis of large amount of data.

Results and Benefits

- Better operational tools for system operation analysis.
- Alternative real time and historical graphical representation.

RED ELÉCTRICA DE ESPAÑA

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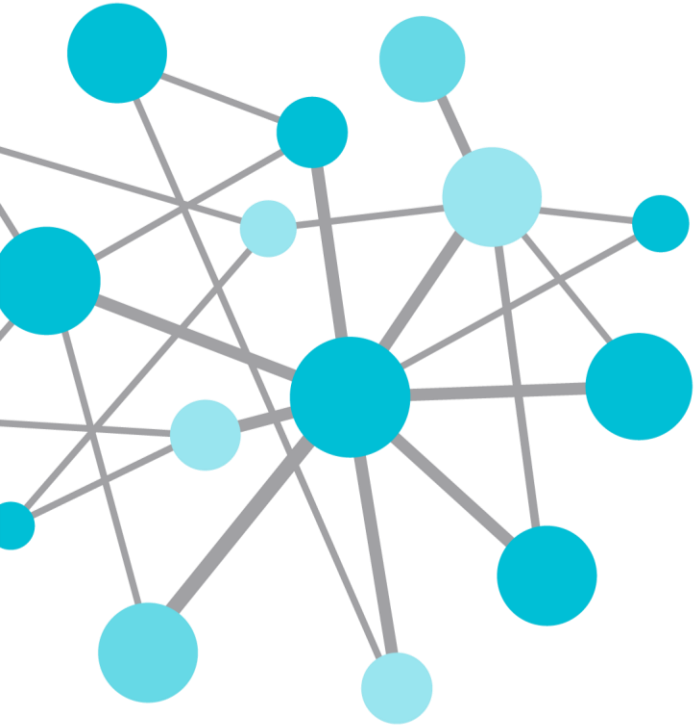
- Electrical Control Center Department
- REE

Questions

Please wait for the **microphone** before asking your questions

State your **name & company**



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