Large scale integration of wind power in Portugal

A view from the

Transmission System Operator (REN, SA) and the

National Institute for Engineering and Industrial Technologies (INETI)

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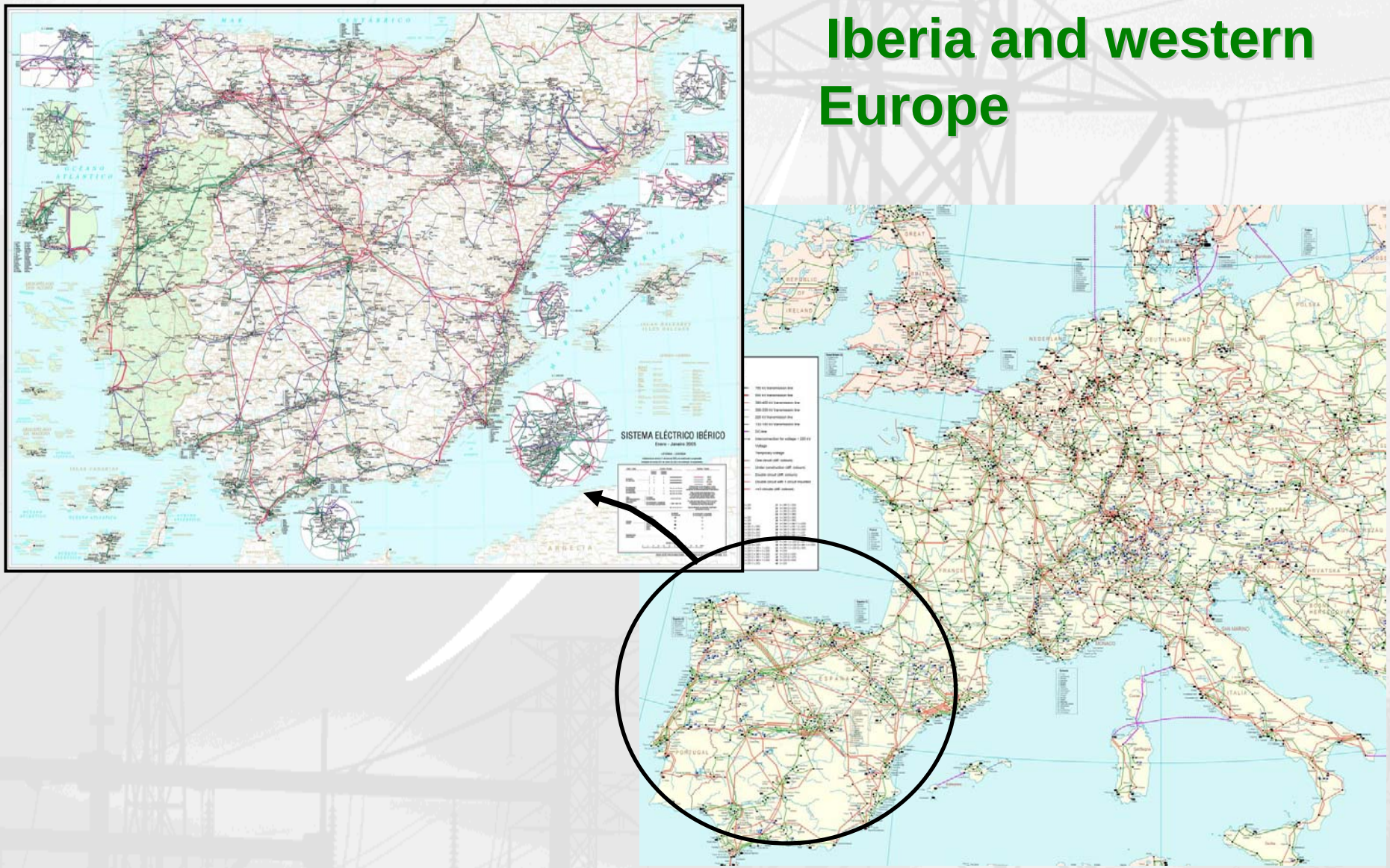
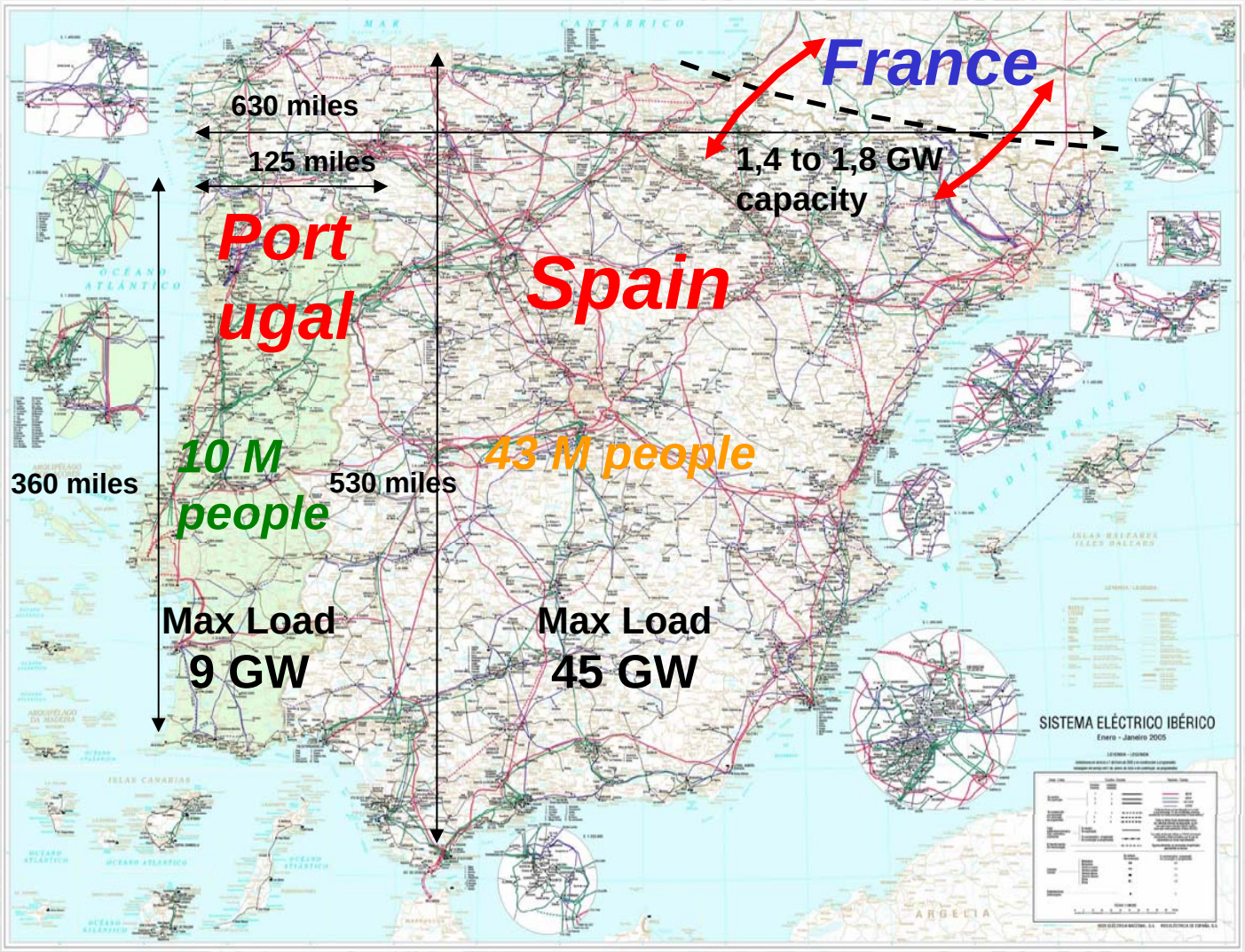
Summary

1. The Portuguese goals for renewables (RES)
2. The challenges for the Transmission System Operator (TSO)
3. The need for transmission grid development
4. The new generation access rules for RES
5. Evolution and forecast of installed capacity. The wind in action
6. Keeping the system stable
7. System management and operation
8. The 2005 request for wind proposals and its innovative specifications
9. Still to be done: Offshore wind
10. Conclusions

Iberia and western Europe

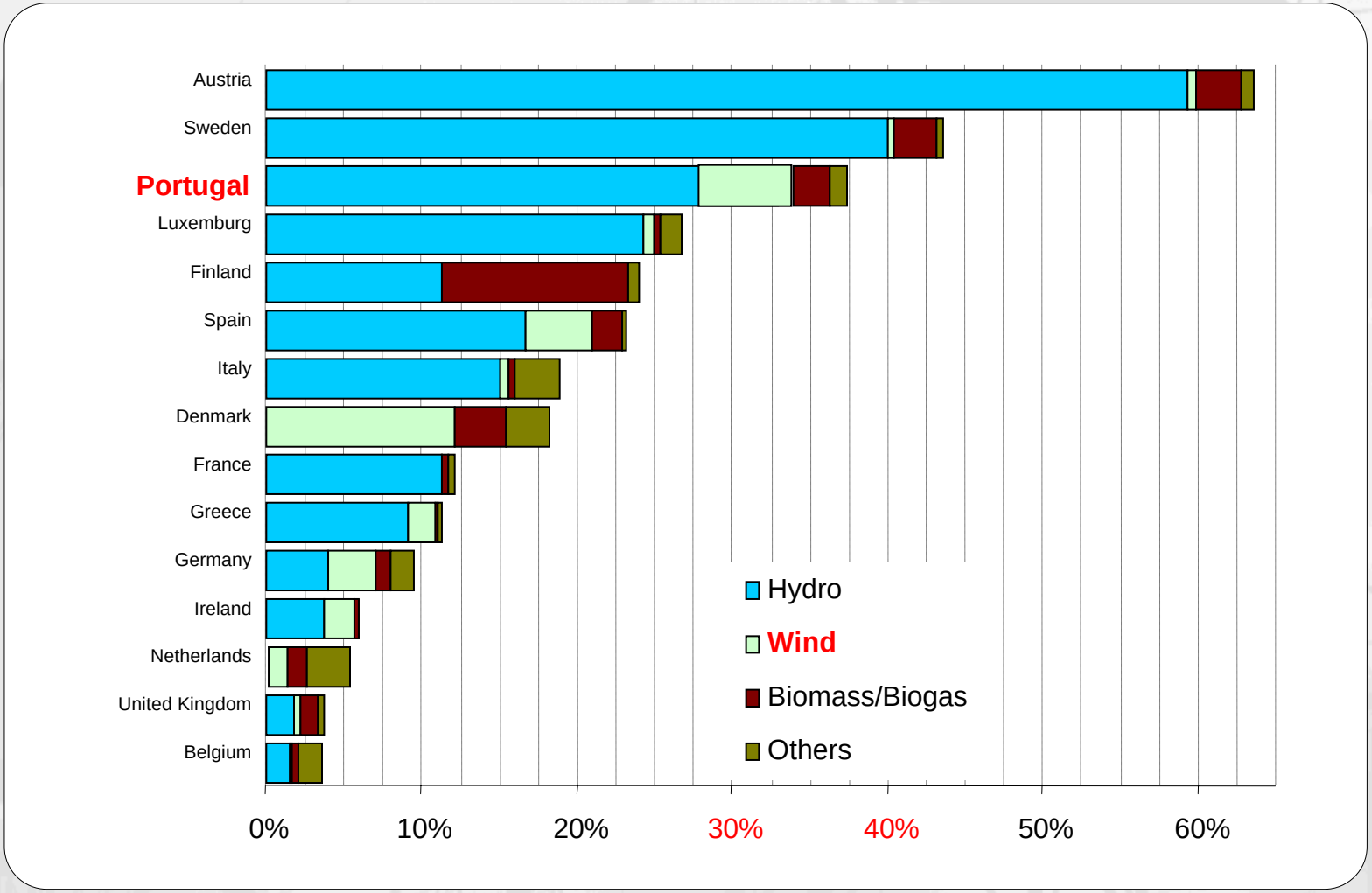


Portugal, Spain and Iberia



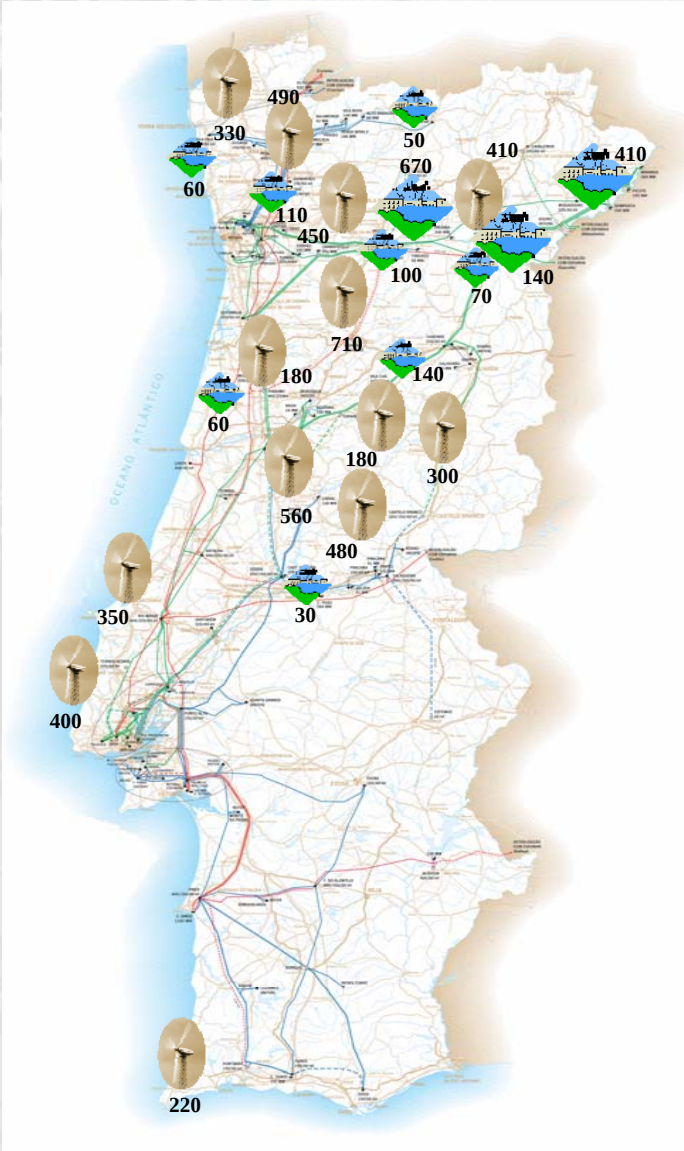
Renewable production in the EU

- Portugal ranks 3rd because of large hydro (>4000 MW) power plants



The Portuguese goals for RES

- The global renewable energy (RES) goal set for Portugal in the European Directive CE/2001/77 is *39% by 2010*. The current value is around 30%
- To meet this objective, a large value of *wind generation ( ) must be installed, approx. 5100 MW* (current target). Also, some small hydro ( ) will be needed
- A few new large hydro ( ) are to be constructed
- The wind and small hydro resources are located in the north and centre-north inner country where loads are small *and the bulk of the 4 GW of large hydro already exists*.

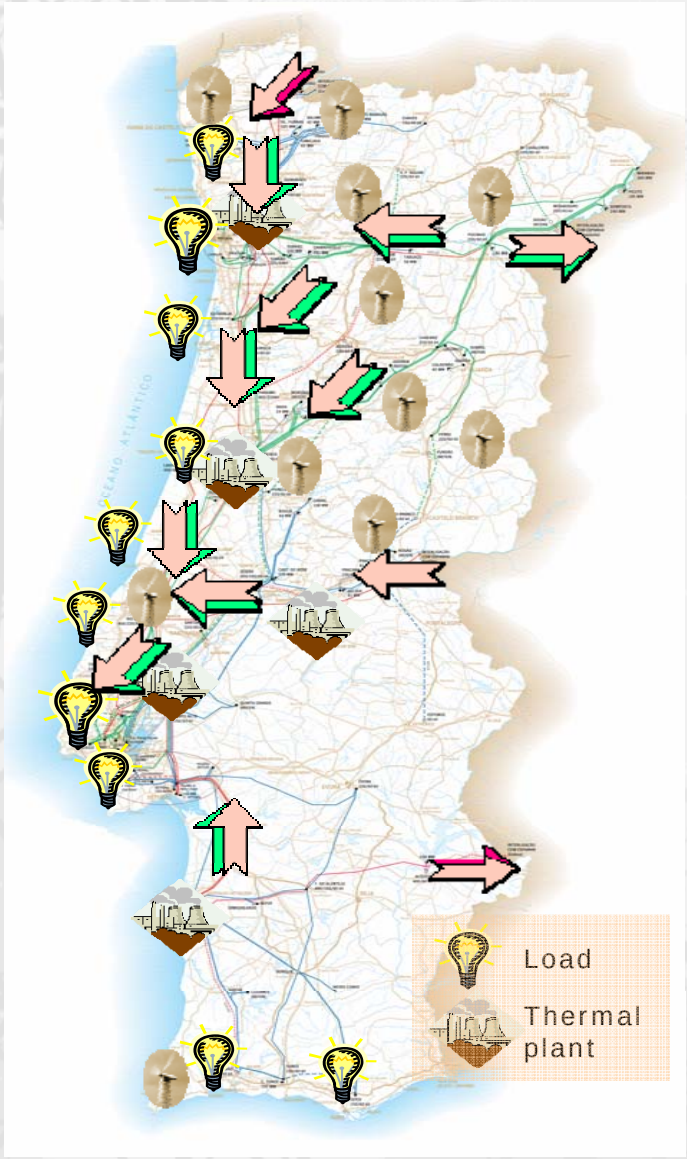


The challenges for the TSO

- Geographic resource identification
- Coordinate review of
  - * Grid planning approach and rules
  - * Generation access rules
- Define a “Grid Development Plan for Renewables”
- Increase, for several years, the level of investment
  - * Get the necessary environmental licences
  - * Mobilise enough outsourcing (studies and construction)
  - * Get finance resources
- Assure future grid stability and security
- Review and update Grid Codes and the dispatch rules & operation
- Help the Ministry and the Regulator to review laws and regulations
- Manage the media interface and contacts with renewable developers

The need for transmission grid development (1/2)

- The new RES generation *will increase even more the excess generation* existing today in centre – north inland areas
- In most of the Transmission Grid (TG) areas the peak flows will *increase* (↓) and only in a few of them (↓) will be *smaller*
- This will imply to increase the transmission capacity from generation to load areas
- Therefore, in 2001/02 a *'Transmission Grid Development Plan for Renewables'* was concluded (REN + University: IST) aiming the reception of RES of the wind resource areas and its transmission to load centres



The need for transmission grid development (2/2)

- The *'Transmission Grid Development Plan for RES'* sets a significant number of grid reinforcements, including some new lines and substations and anticipations of schedule of others previously planned
- The map shows these items, *in orange*, including mainly the following items:

  New lines and substations

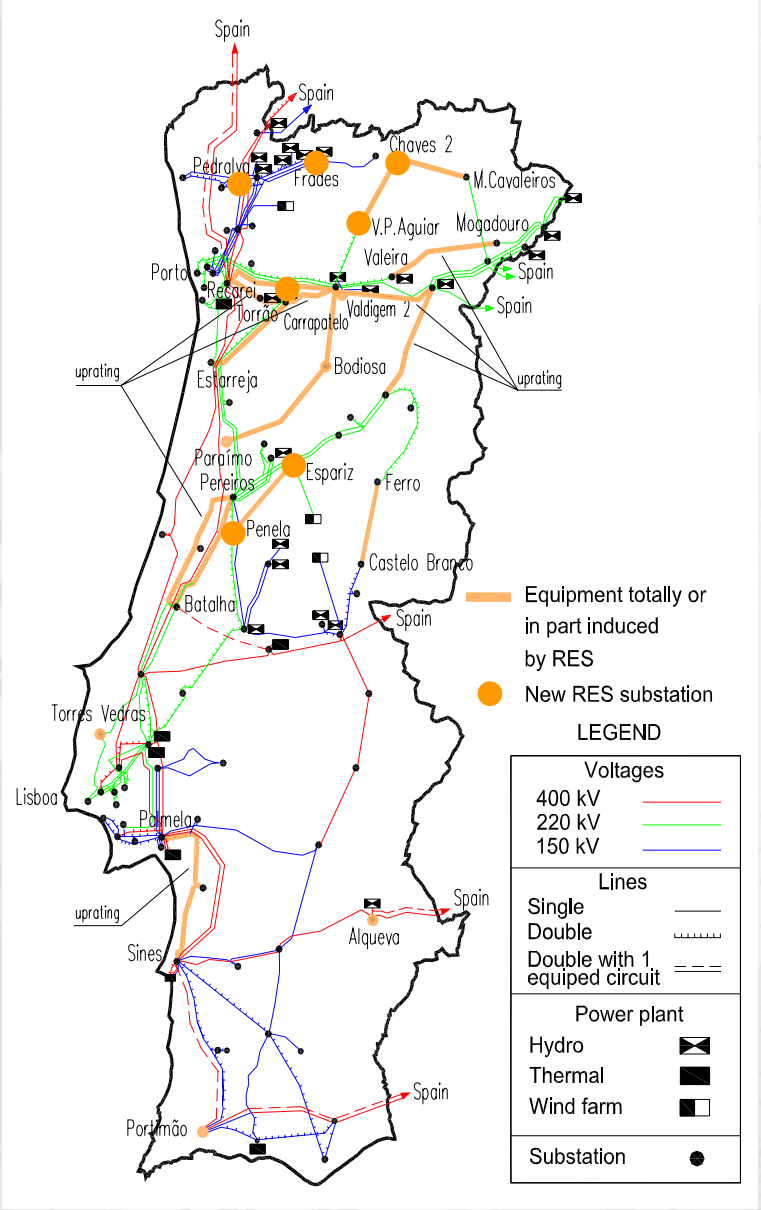
  Uprating or upgrading of existing lines

  Upgrading of a few existing substations

  Construction of new bays in substations

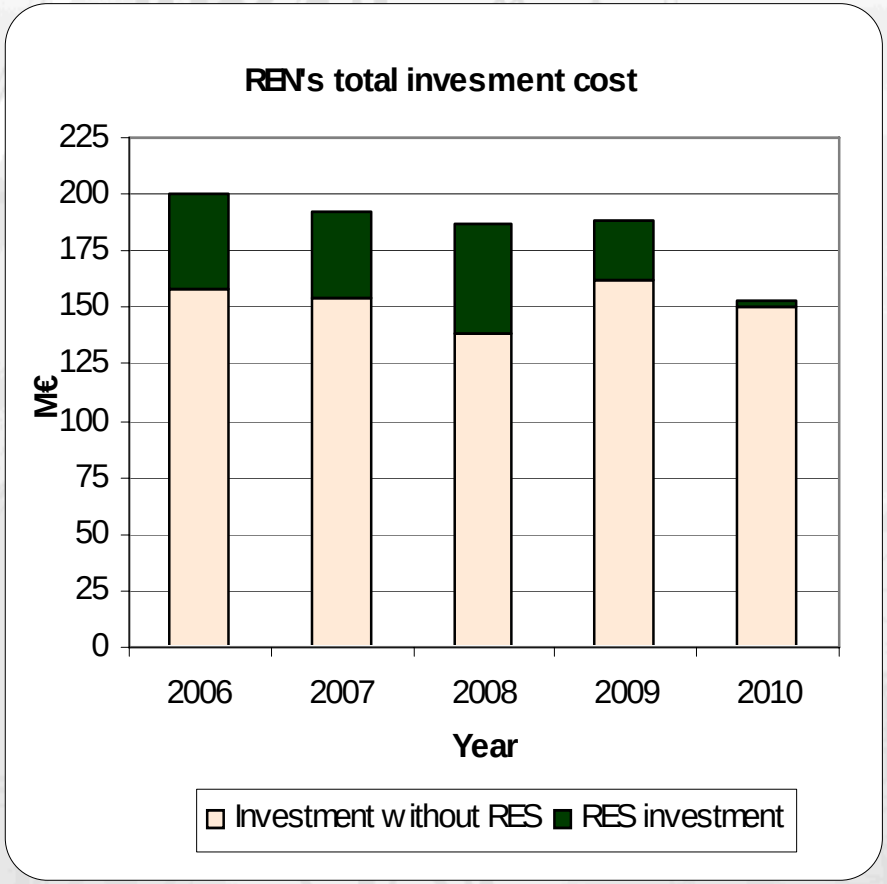
  Boost in reactive compensation capacity

- *The total investment* (sum of cost % of contribution for RES objectives of each item – contracting costs only) totals around *250 M USD for 4000 MW of wind*



The level of investment in the grid

- The need to built all the new transmission grid planned reinforcements to cope with this ambitious wind and other RES program, led to a *sharp increase in the level of investments in the grid*
- In the overall period 2005 – 2010, the investment *directly attributable to RES will amount to 250 million USD*
- All the new projects to be carried out represent a *enormous administrative (environmental) and construction management effort for REN*
- These numbers *do not consider* the investment of the wind park main substation nor the direct line to the grid connection point, which are all built and paid by the developer



The generation access rules (1/2)

1. *The TSO, REN takes into consideration the national goals for RE's*, the wind and hydro resource location and developer's connection applications *when making his grid development plan*
2. REN calculates *grid generation reception capacities* for all substations according to grid plan. These values are public
3. *Developers present to the Ministry of Economy and Innovation (MEI) their applications* for new generation projects, including location
4. *The Directorate of Geology and Energy - DGGE* (backed by REN and the Distribution utility EDIS) *respond to each application* as if the others did not exist, considering only projects already in operation or with capacity already reserved
5. If the *developers* wish to proceed, they *ask the DGGE for MW reserve*
6. For each substation, *should there be excess capacity demand in comparison with grid capacity,* a 'prorata' reduction criteria is applied to define final MW which are attributed and reserved to each promoter

(…)

The generation access rules (2/2)

7. In 2005 the Portuguese Government (MEI) through DGGE launched a *request for proposals for two blocks of wind power* one with 800 (ev.+200) and the other with 400 (ev.+100) involving the construction of a *wind generator factory in Portugal*

- **Therefore**:

Although in a power generation liberal legal environment:

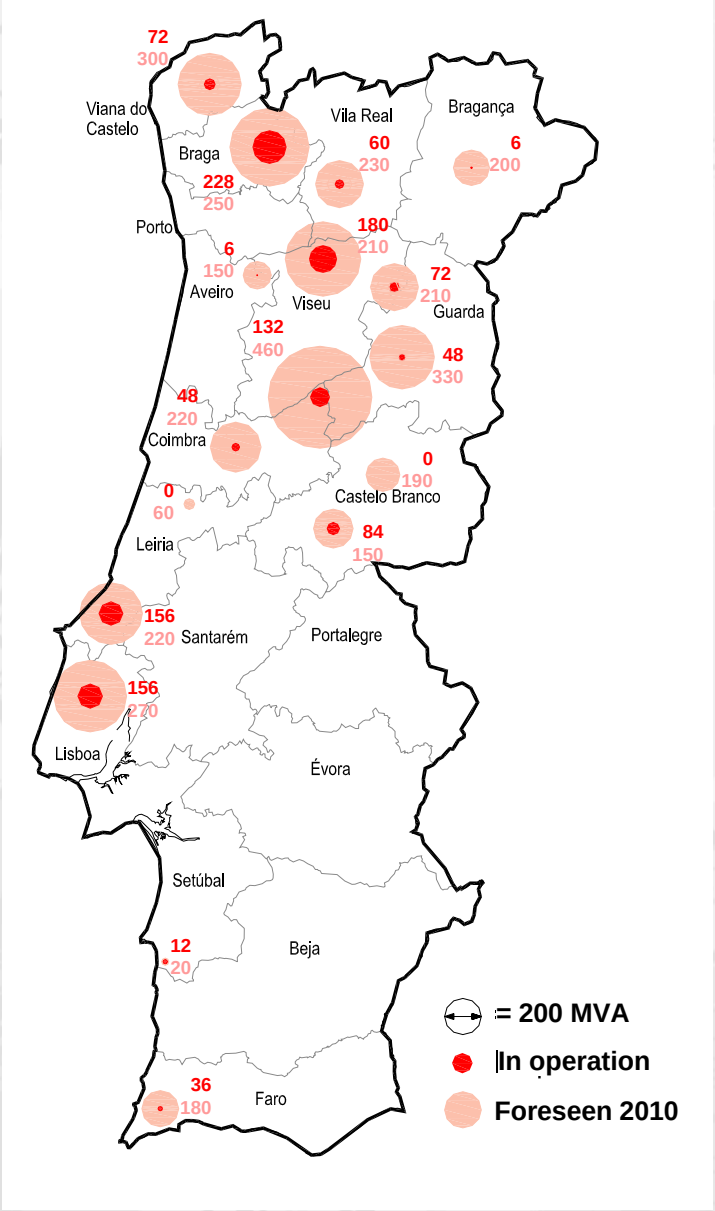
the size of RES, mostly the wind target of 5100 MW, recommended a planned global approach to manage the MW to be connected in each geographic area based in a coherent transmission network development plan to guarantee future correct operation of the system according to grid planning and operation criteria and rules within an adaptative process in time

This means a new transmission grid planning and RES generation connection awarding paradigm

Wind power in service and foreseen (1/2)

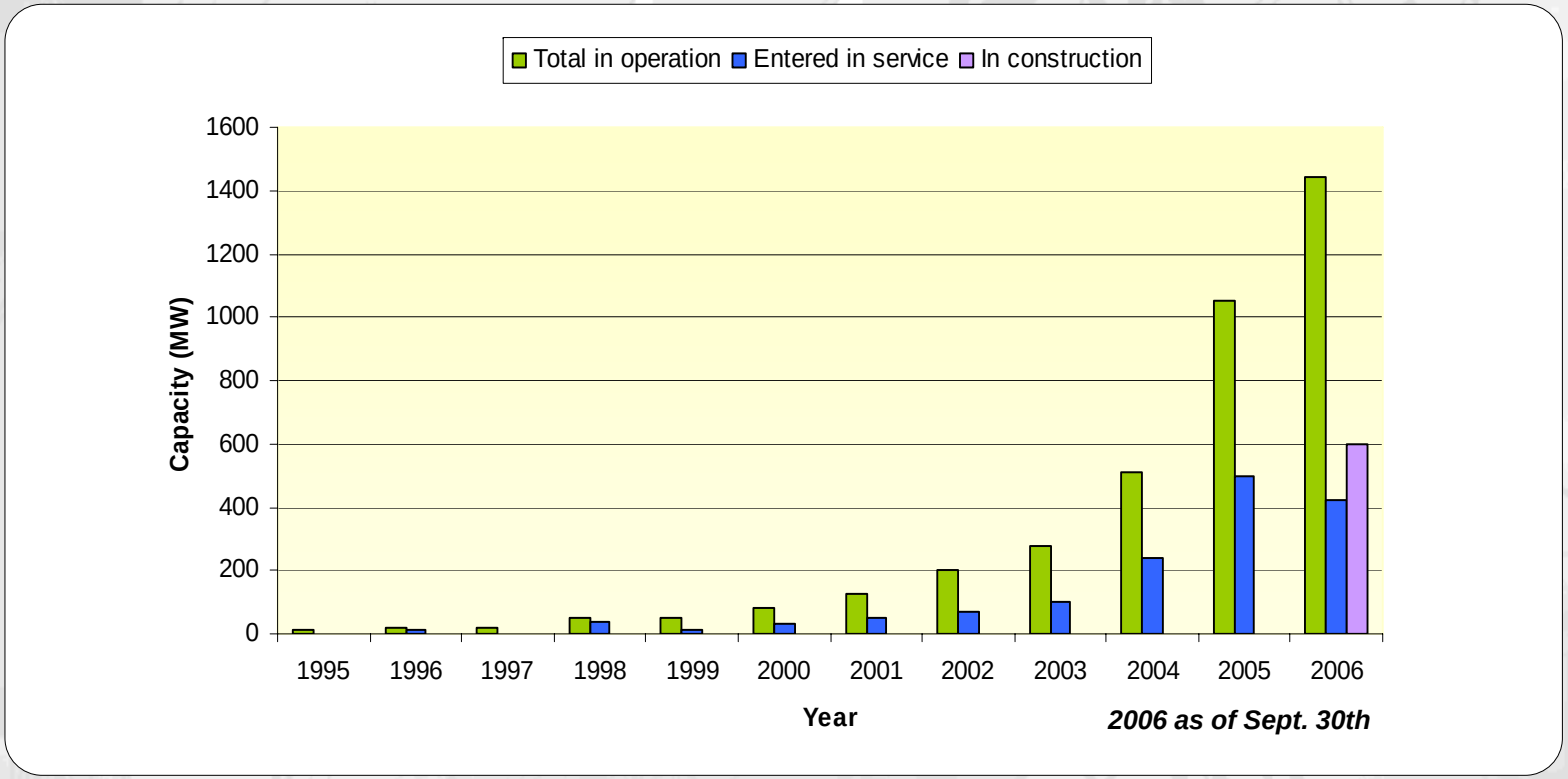
- Wind generation already in service as of Sept. 30th, 2006 totals 1440 MW
- Some more 600 MW are currently in construction
- At least other 1000 MW have, already, reserved capacity
- If we add the 1000+500 MW (eventualy+300), to be attributed by the Ministry (bidding under way) in 2006/7

We are already near the 5100 MW target!



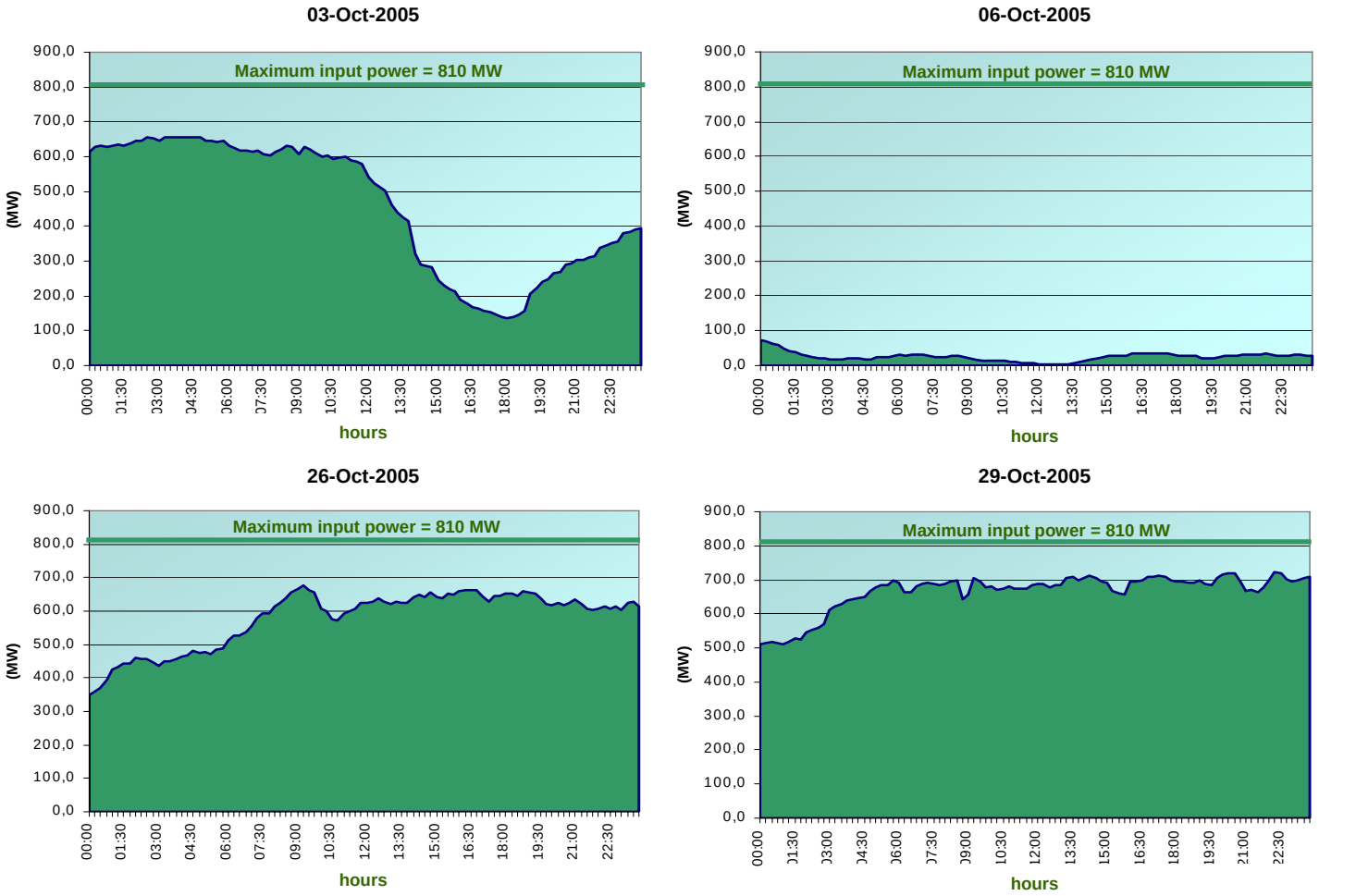
Wind power in service and foreseen (2/2)

As can be seen, from very small values of installed wind power by the end of the 90's, and as a result of all this process, a wind generation boom is under way and will go on for the next years



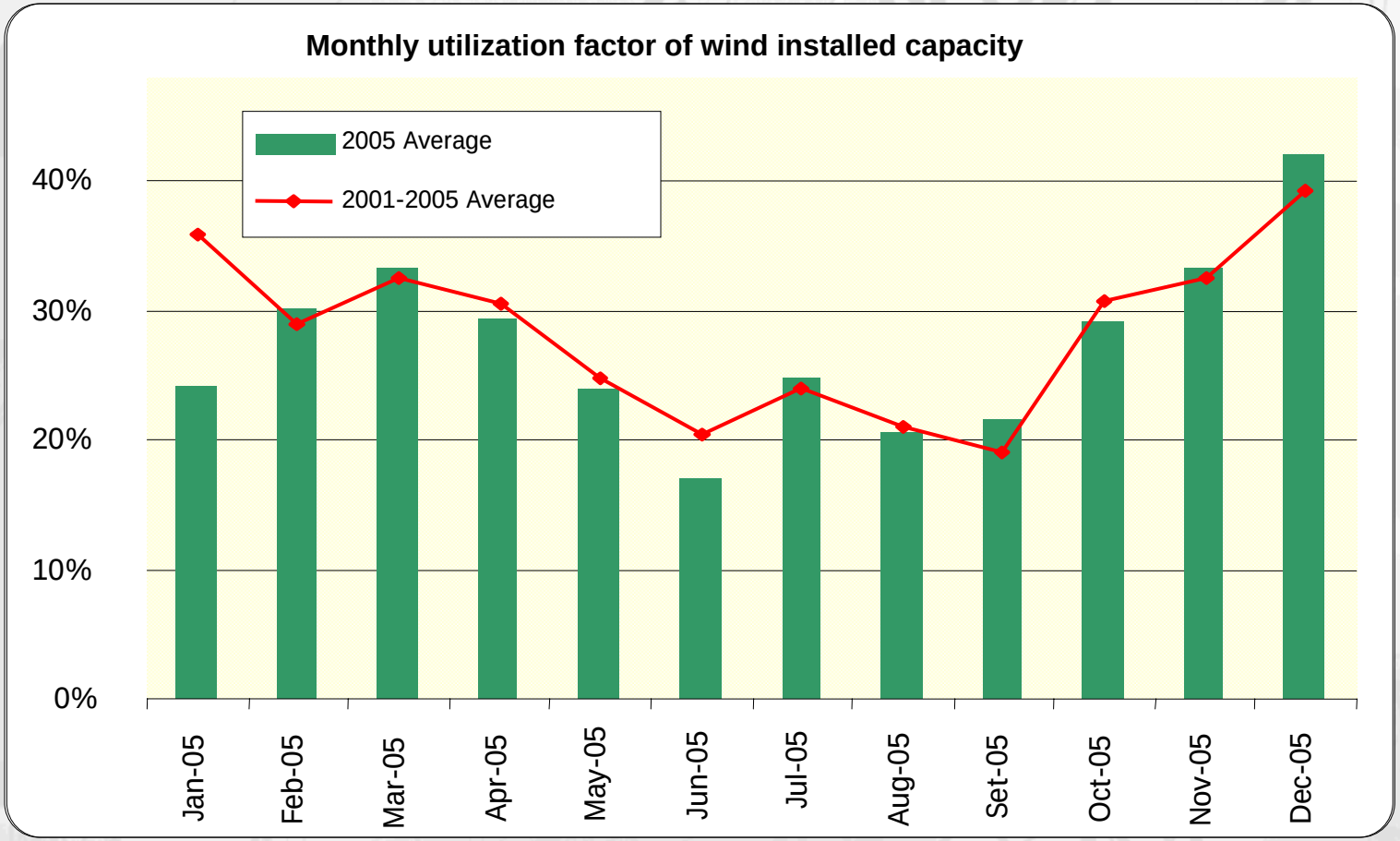
The wind in action (1/4)

- Special days of wind generation: October 2005 with ***810 MW*** of installed capacity



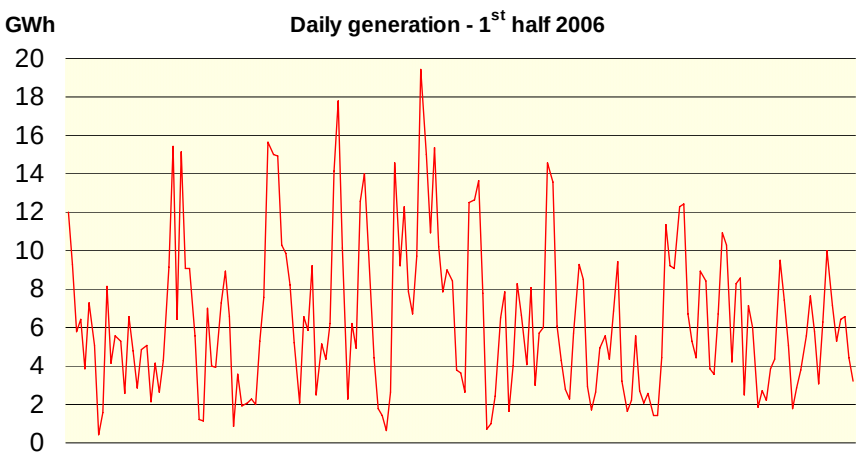
The wind in action (2/4)

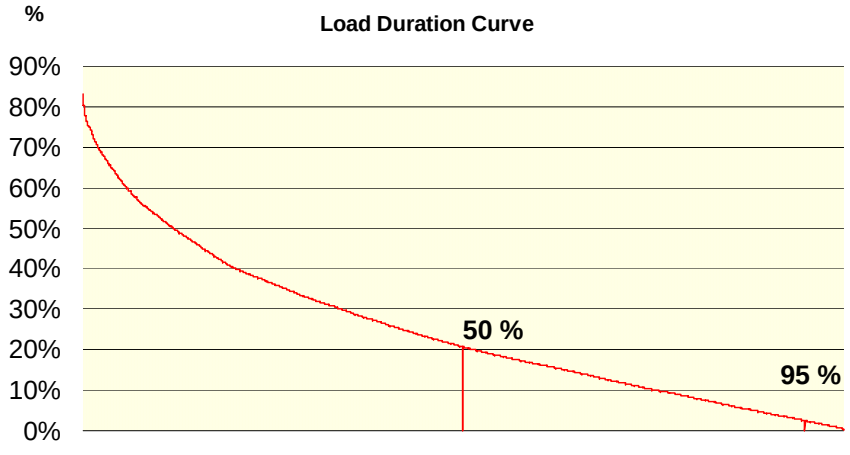
- Monthly utilization factor of wind installed capacity 2001 - 2005

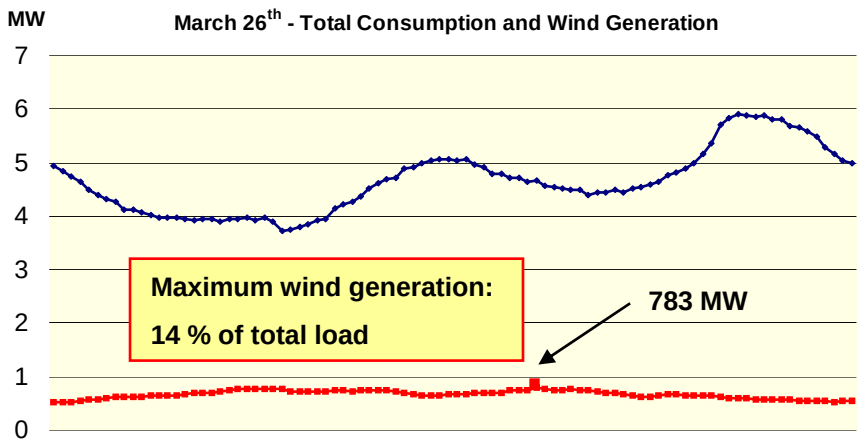


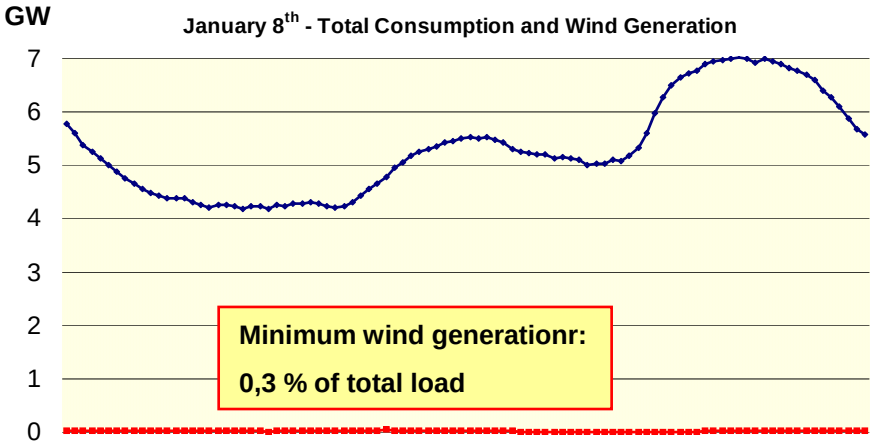
The wind in action (3/4)

- Wind in 2006 - Highlights



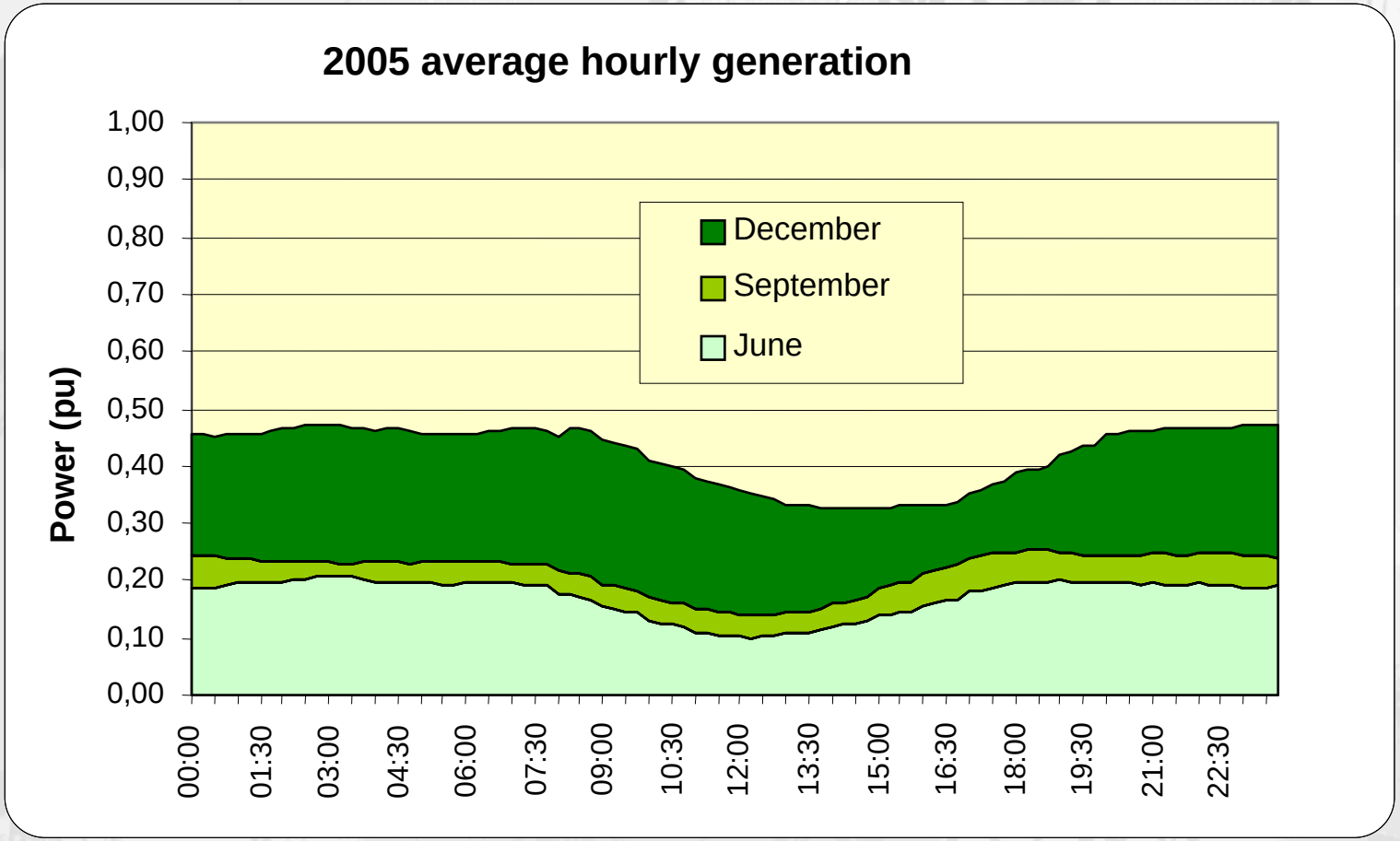






The wind in action (4/4)

- 2005 average hourly generation



Keeping the system stable (1/2)

- When the amount of wind generation was negligible, connected only to the distribution networks, *the idea was to disconnect them, the faster the better, after a nearby short circuit (SC).* The existing rules and practices are according with this concept

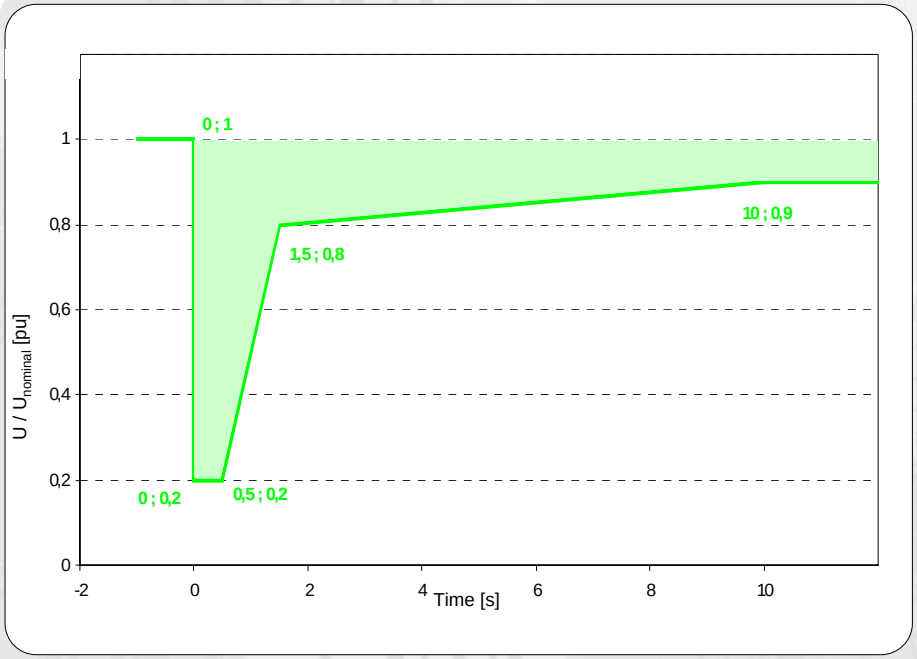
- With so high target values for wind generation, *it is no more possible for the security of the electric system to loose a few thousand of MW* after a SC.

- A study carried out in 2004 by the University (Instituto Superior Técnico) and REN showed that *the danger of instability in Portugal+Spain* following a SC in certain locations of the TN

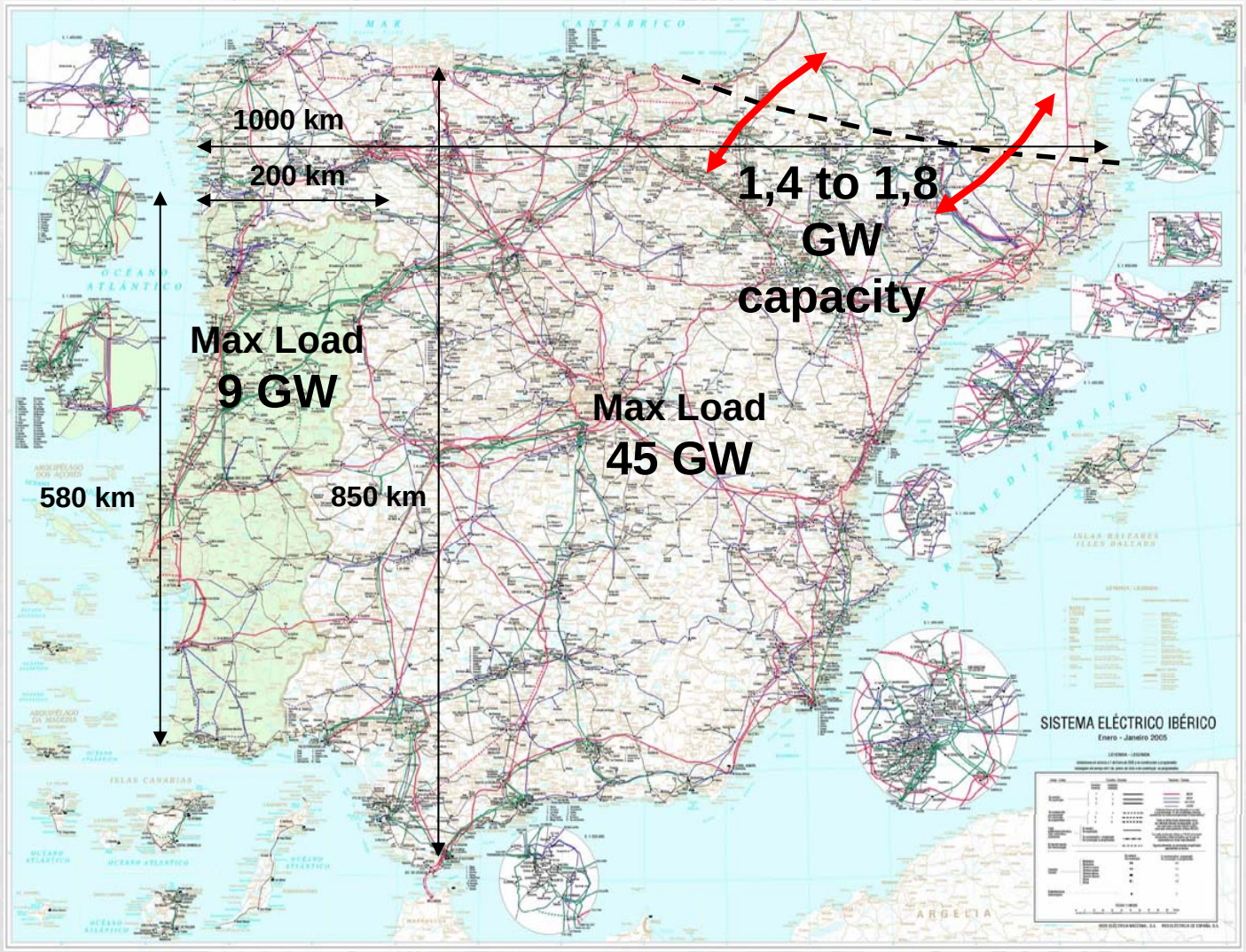
- REN and its Spanish counterpart REE completed in July 2006 a more detailed *joint study* with higher wind targets (5,1 GW Port+20 GW Spain) to *set limits for wind due to stability reasons*

Keeping the system stable (2/2)

- *The imperative need for TSO's and DSO's to safeguard system security* lead to the need to change the existing status
- *Wind generator (WG) manufacturers* had already understood that lack of SC resistance was becoming a barrier to wind generation expansion and *have been developing new WG more and more 'Ride Through Fault Capable' (RTFC)*
  - At present, almost all of the major manufacturers have reached a reasonable RTFC performance
  - *REN has proposed to the Ministry of Economy and Innovation the adoption of a mandatory minimum RTFC* for future wind generators



Some notes on the Iberian system (1/2)



Some notes on the Iberian system (2/2)

- As can be seen from the following map, *the Iberian peninsula is an area of Europe with a peak load of 54 GW but which is very weakly connected to the rest of the UCTE grid*
- The fact that the France-Spain interconnection capacity level is so small (*less than 1800 MW now - max 4000 MW future*) is a considerable handicap when both Iberian countries decide to set ambitious goals of wind power (5 + 20 GW)
- Should we have in Portugal or Spain an instantaneous loss (due to a SC at specific substations) of a part of total wind generation in a moment of high production, the interconnection would be unable to give the necessary support and a more or less extended Iberian blackout could happen
- **This is the reason why in both Iberian countries the implementation of RTFC is a key issue at present!**

System management and operation

Other issues of great importance which REN is dealing with:

- Acceptance of *overcapacity* in installed wind parks (up to 20%)
- The definition of *new criteria to manage the power factor compensation* of wind generation in real time (new rules already proposed to the MEI)
- *Wind forecasts* to be used in the National Dispatch: A basic model is already implemented; perspectives for the use of more advanced models)
- Creation of *information and control links*, in real time, with the wind parks connected to REN substations
- Introduction of *wind power in TN probabilistic grid & generating system simulation model* ZANZIBAR (already completed)

The 2005 call for proposals (1/2)

The new technical rules for wind energy development (2008-2013):

Current status (May 06)

~1200 MW installed and in operation

2006 – 2010

Capacity by 2010	**3750 MW**
Capacity penetration:	**25%**
Energy penetration:	**~14 %**

Gov. legal basis: RCM 63/2003

2008 – 2013 (post-Kyoto)

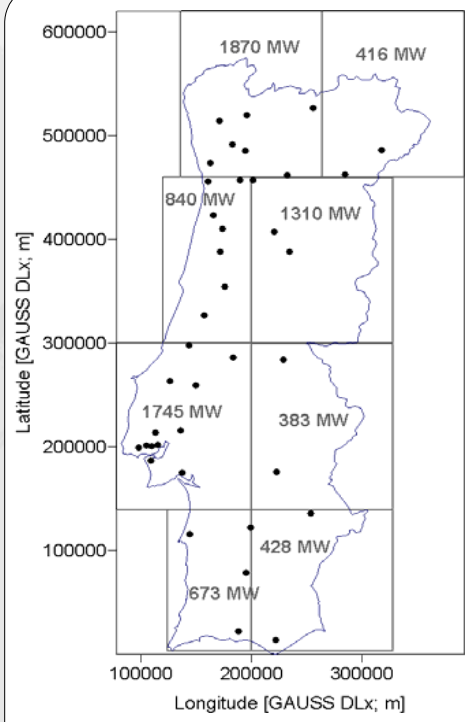
Capacity by 2013	**5100 MW**
Capacity penetration:	**~33%**
Energy penetration:	**~17 %**

Gov. legal basis: RCM 169/2005

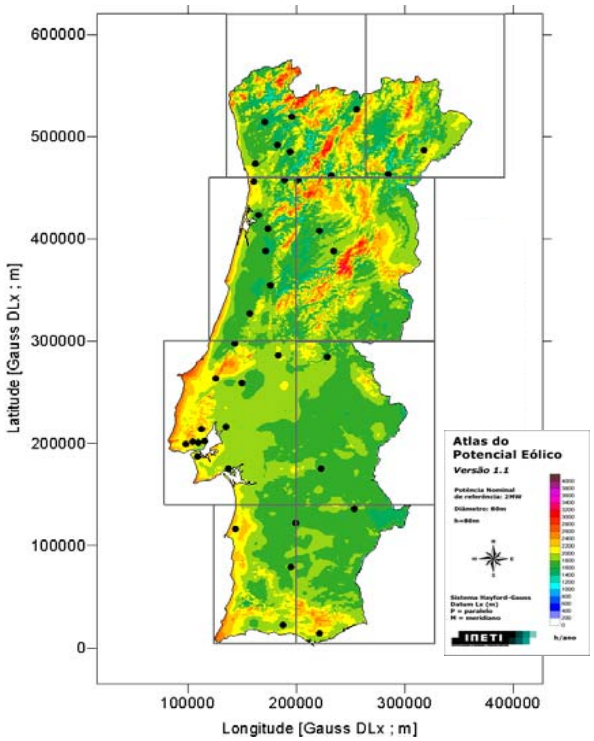
A call for proposals (1500 MW) was opened for the period (2008-2013) with new technical rules to cope with power system limitations and very high wind penetration

The 2005 call for proposals (2/2)

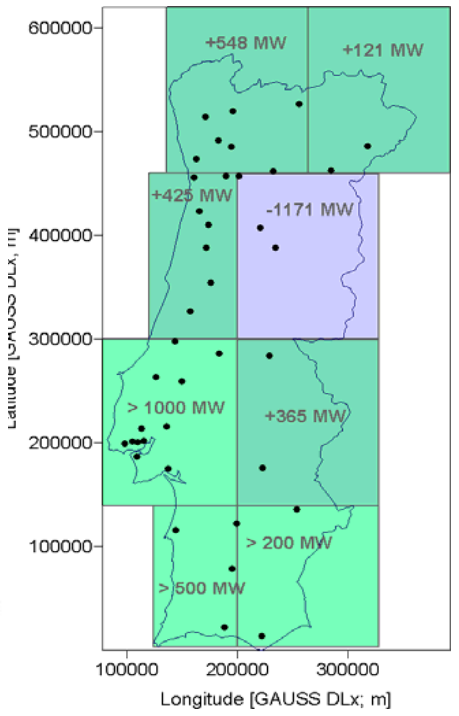
Phase 1 – The wind potential was accessed and correlated with exiting TN capacity



a) Grid capacity in 2013 (~7000 MW)



(b) Onshore sustainable wind resource 5900 MW (aprox.) + >1000 MW offshore



(c) Deficit/superavit by region

Local **distribution** of wind resource vs. TN capacity

Innovative specifications of the new wind farms (1/5)

A. Innovative characteristics of the wind farms (valued within the 1500 MW call)

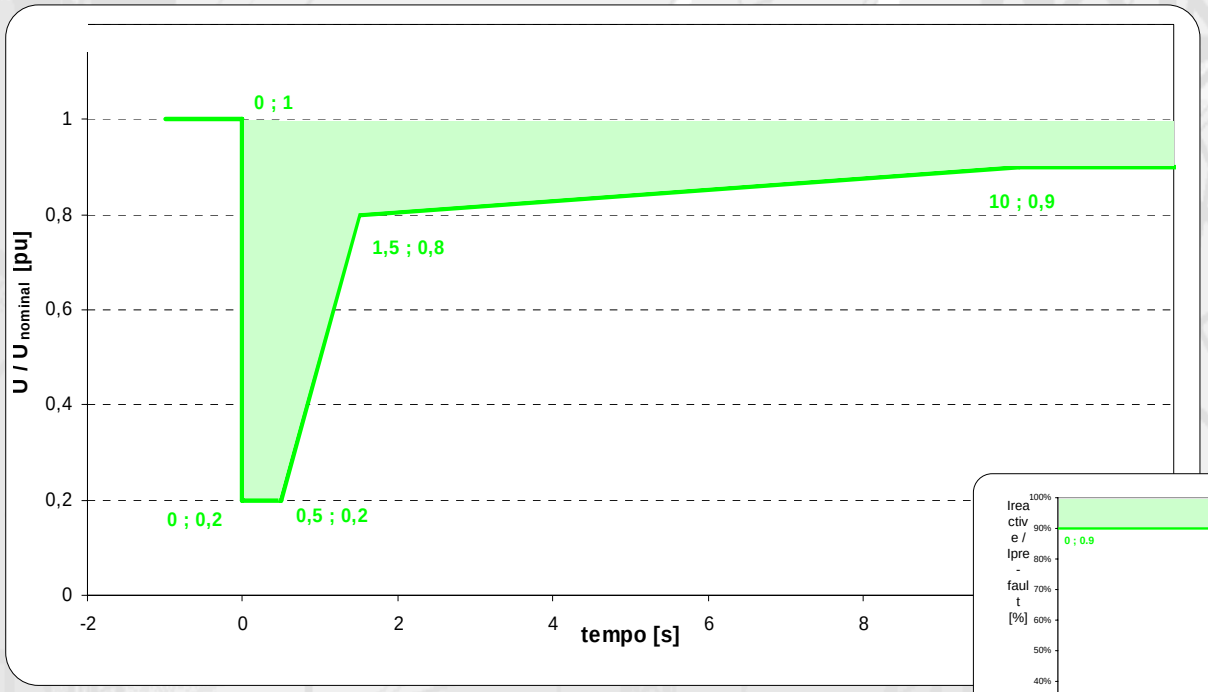
1. Management of wind parks by clusters (“local wind power dispatch centers”)
2. Additional reactive power control: tg fi within [-0.2, +0.2]
3. Curtailment of wind production anticipated (no-load periods)
4. Solutions for “wind/RES energy storage”: specially in hydro stations
5. Participation in the primary frequency control

   wind turbine operation at 95% of P_{opt} in previously requested periods (by TSO)

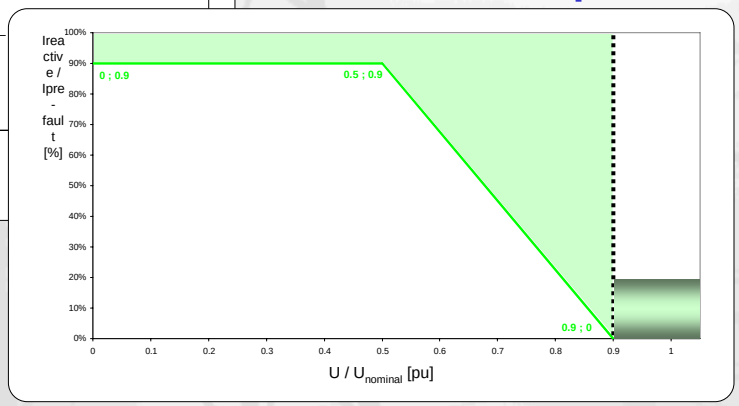
6. *RTFC - Ride through fault capability is a “minimum requirement”*

Innovative specifications of the new wind farms (2/5)

A. RTF capability + added reactive (required for the 1500 MW call)



Reactive power contribution required



Ride Through Fault Capability soon to be included in the Portuguese Grid Code

Innovative specifications of the new wind farms (3/5)

B. New strategies and equipments (TSO and DSO):

Installation of Wind Generation Dispatch Centres (acting as Generation Aggregation Agents)

this dispatch centres will enable to adapt the wind production to the network operating conditions without compromising security operational levels

valued within the 1500 MW call

Introduction of a new grid element in Portugal: the phase-shift autotransformer.

to "force" wind power injected in the 150 or 220 kV levels (or 60 kV DN) to flow to the 400 kV grid, using available capacity to avoid the construction of new HV lines.

a 450 MVA phase shift machine designed by REN/CESI (Italy) and constructed in Portugal by EFACEC is already in operation at a REN substation.

Innovative specifications of the new wind farms (4/5)

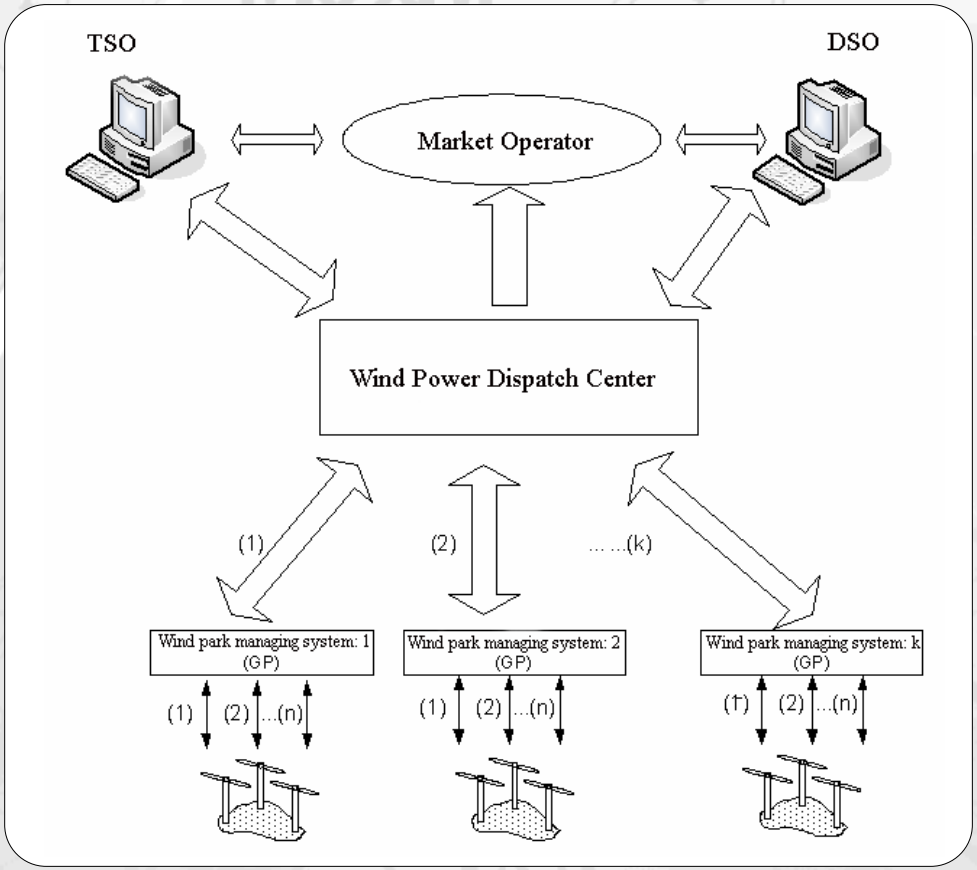
B. New strategies and equipments:

Installation of ***Wind Generation Dispatch Centres***, acting as

"Generation Aggregation Agents"

the forecasted wind power dispatch centres will enable to monitor and adapt the wind production injection to the network operating conditions without compromising security operational levels.

valued within the 1500 MW call



Innovative specifications of the new wind farms (5/5)

C. New strategies and equipments (not yet decided):

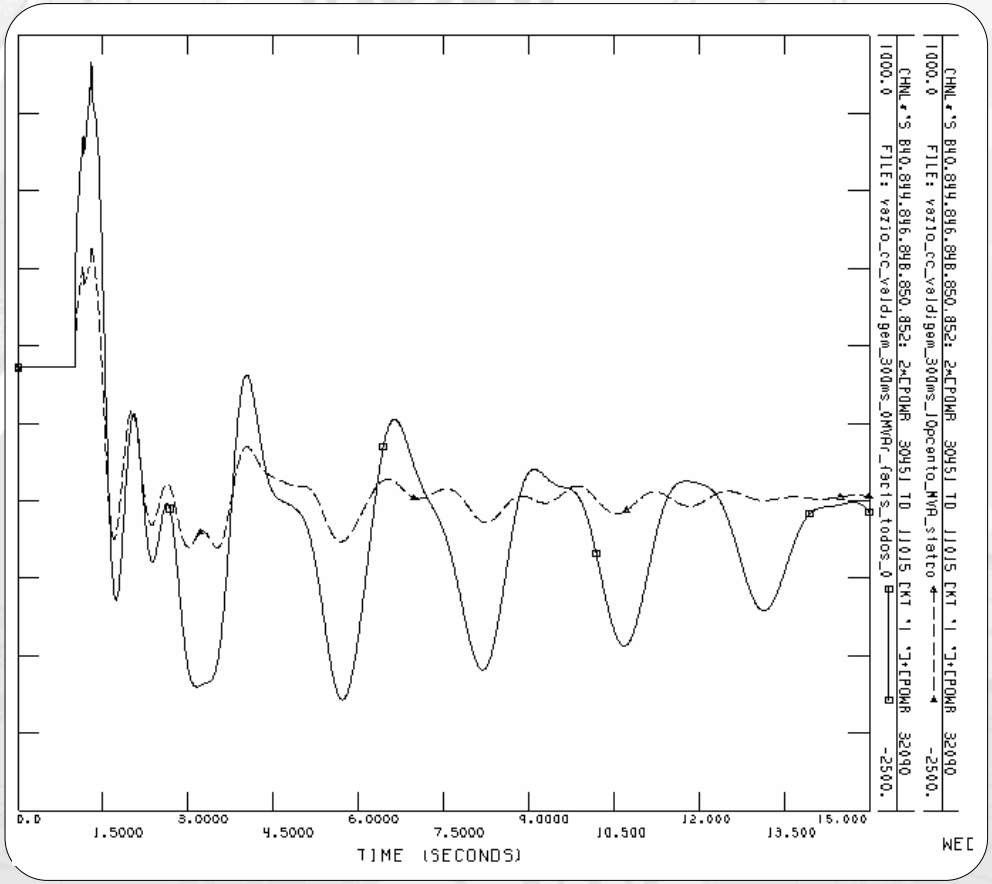
FACTS

Still and also possible to install FACTS in strategic buses of the Portuguese transmission network to:

1. Mitigate the impact of short circuits

2. Help to prevent the disconnection of large amounts of wind power for under voltage protection relays actuation

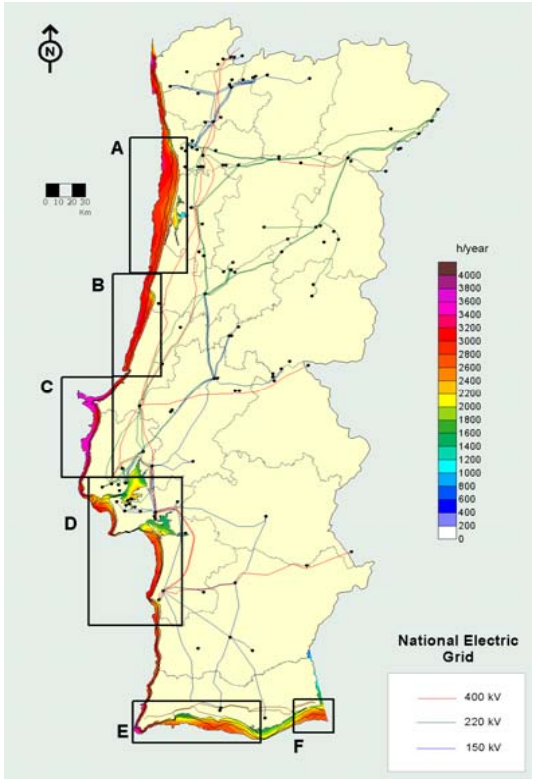
3. Contribute to the damping of oscillations.



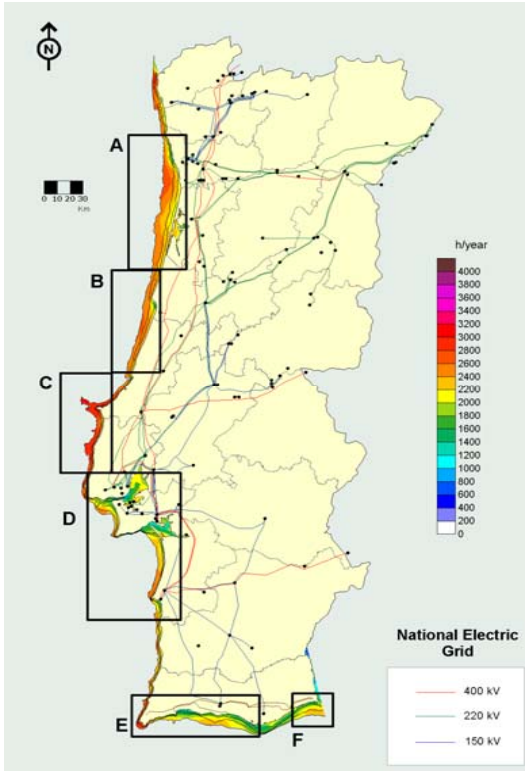
Still to be done: offshore wind

The offshore development plan!

Site identification for resource assessment completed (INETI)



GEWE 1.50 SL 1500 kW
H=60m



VESTAS V80 2000 kW
H=80m

Experimental campaigns to start during the summer'06 (waiting for environmental permits)

Conclusions (1/2)

- To introduce high penetration of wind generation presents TSO's and DSO's an enormous challenge
- We have faced it in its different areas, creating some new approaches and the results, so far, are promising
- A wise level of central management and decision is important
- Cooperation and coordination between TSO and DSO's and between neighbour TSO's are also necessary
- The specification of new technical requirements for safe and correct future system operation is necessary
- The compliance with FRTC is key to ensure system stability

Conclusions (2/2)

- FACTS such as phase-shift transformers and STATCOM's can help
- Manufacturers and wind developers must understand that it is vital that, in some aspects such as resistance to voltage dips, TSO's ask for similar performances to conventional generators
- A decentralised structure to operate the larger wind farms is necessary with regional control centres.
- Offshore wind is a possibility yet to be implemented

Is everything now OK? Not yet. But most of the work is done

Let the wind blow our modern sails!

THANK YOU

for your attention

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