Wind Power and Market Design

Universidad Carlos III de Madrid

Wind Power in Electricity Markets: Time for revisiting Market Rules?

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Key issues

- **Increasing presence of wind energy in power systems.**
- **Adequacy of market rules for including large amounts of wind power.**
  - **Wind power forecasting.**
  - **Balancing rules.**
- **Suitable support policies.**

Wind power experience.

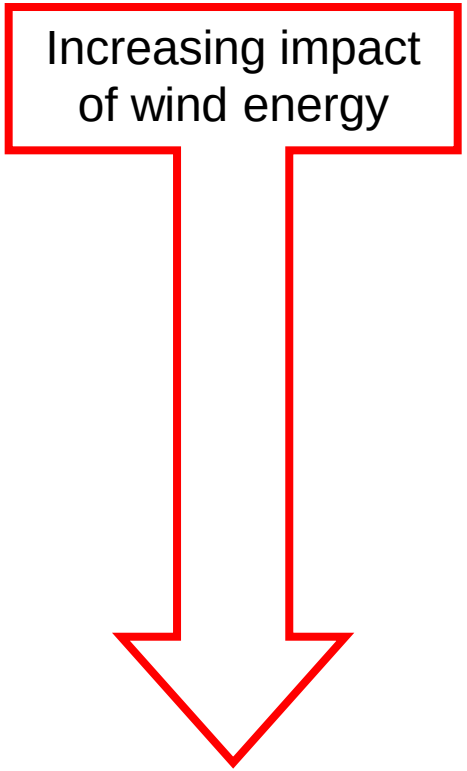
Countries	Wind Power (MW)	Total power (MW)	% demand	Support policies
Denmark	3125	12699	21.22	Environmental Premium + market price
Spain	15145	85959	11.76	Either a feed-in tariff indexed on the regulated price for 20 years or a feed-in premium + market price for 20 years
Germany	22247	114153	7.0	Feed-in tariff for 5 years at fixed price then 15 years with decreasing tariff
France	2454	115900	1.21	Feed-in tariff for 10 years at fixed price then for 5 years the price depends on the load factor
Netherlands	1746	21000	3.4	Premium to add to the market price or reference price (SDE) since 2008 (including the market price)
UK	2389	84000	1.82	Renewable obligation certificate (ROC) to be added to the market price

Support mechanisms and markets.

Support mechanism	Principle	Electricity markets	Balancing	Other
Feed-in tariff	Fixed price	No participation	No	-
Market+premium	Fixed premium	Participation	Yes	-
Green certificates	Fixed quantity	Participation	Yes	Certificate's markets

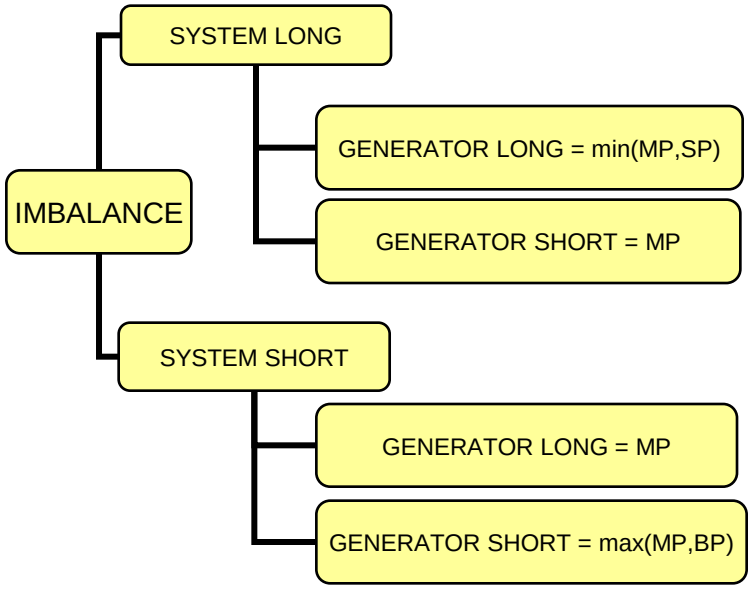
Market architecture.

- **Forward markets**
- **Day-ahead markets**
- **Intraday markets**
- **Reserve markets**
  - **Secondary**
    - **Power**
    - **Energy**
  - **Tertiary**
- **Balancing market/mechanisms**



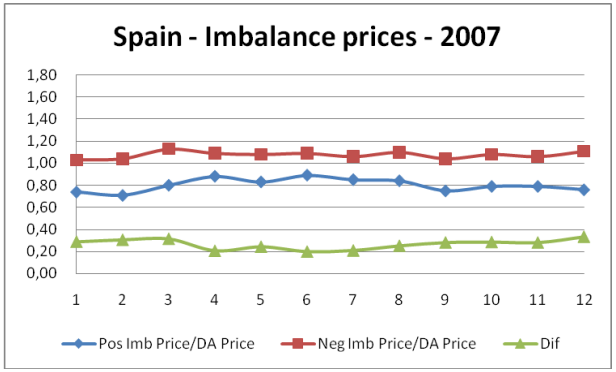
Balancing markets and imbalance cost.

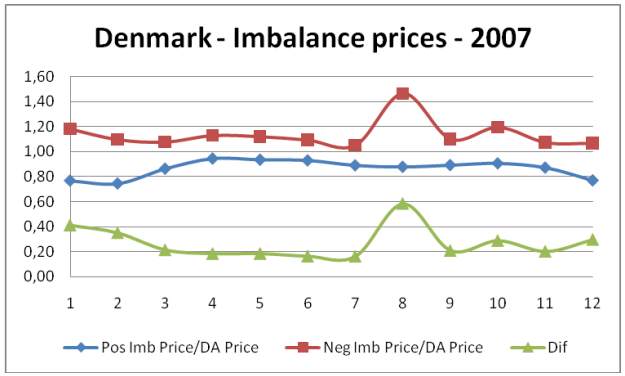
- **Balancing markets**
  - **Managed by System Operator.**
  - **Make use of reserves**
    - **Power**
    - **Energy**
  - **Different time schedules**
    - **Primary**
    - **Secondary**
    - **Tertiary**

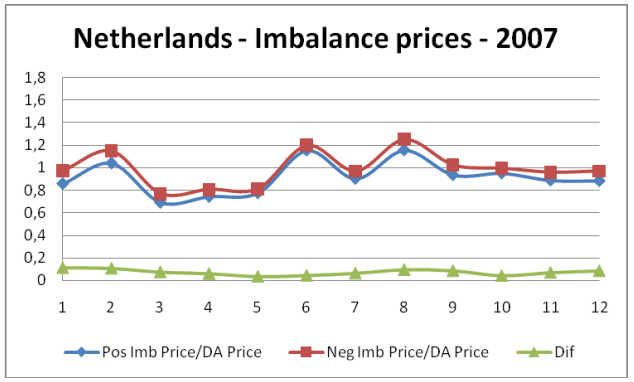


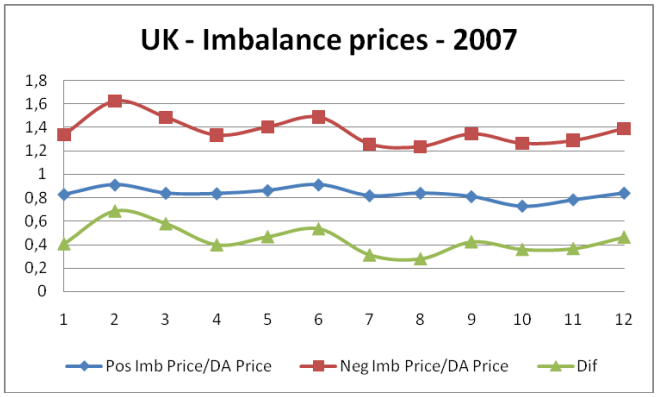
Imbalance cost – two prices

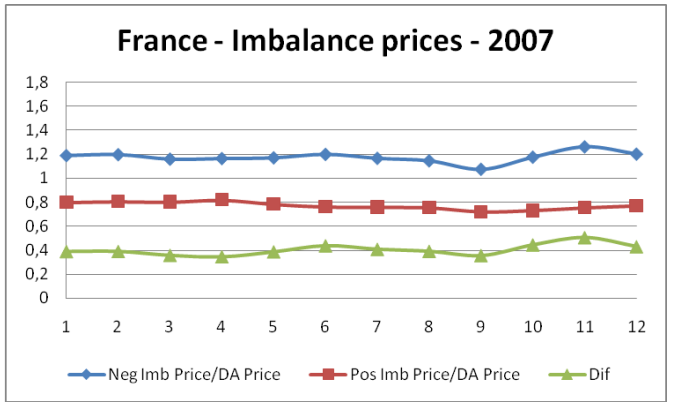
Imbalance prices









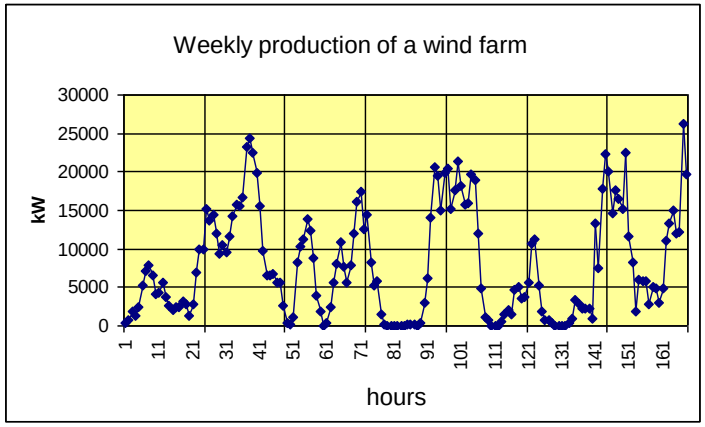


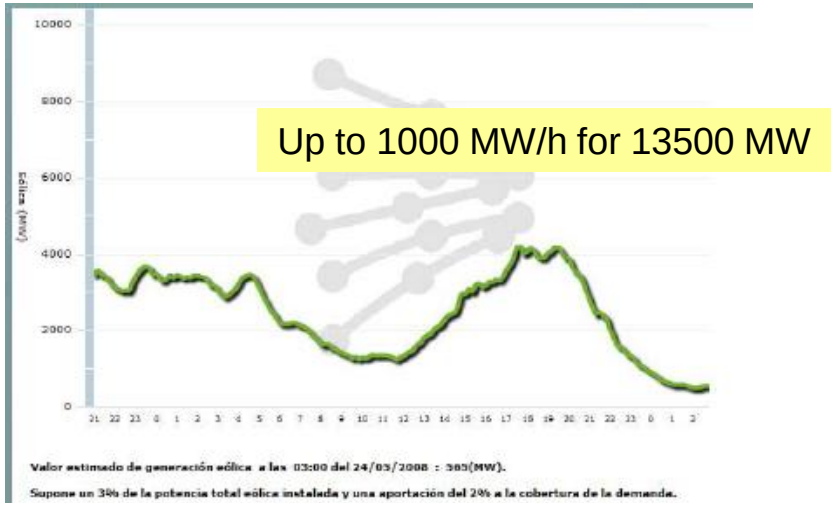
Electricity markets and wind energy.

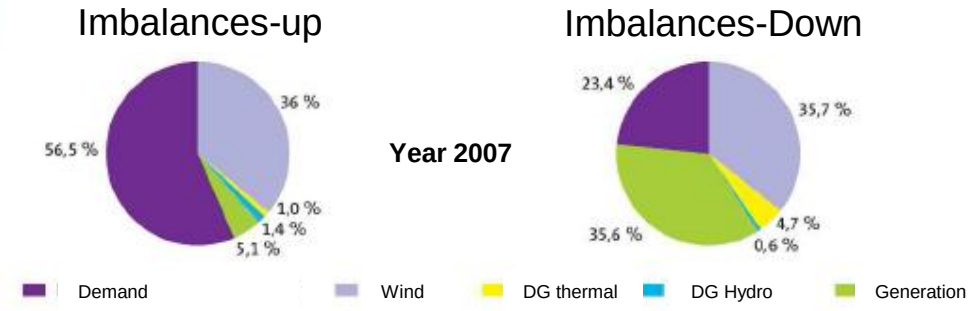
- **Wind energy**
  - **Non-dispatchable - variability.**
  - **Partially controllable.**
  - **Difficult to forecast.**

  - **Null marginal cost → unlike thermal units.**
  - **Non storable → unlike hydro units.**
  - **No modulation → unlike demand.**

Variability and impact on balancing. Spain.

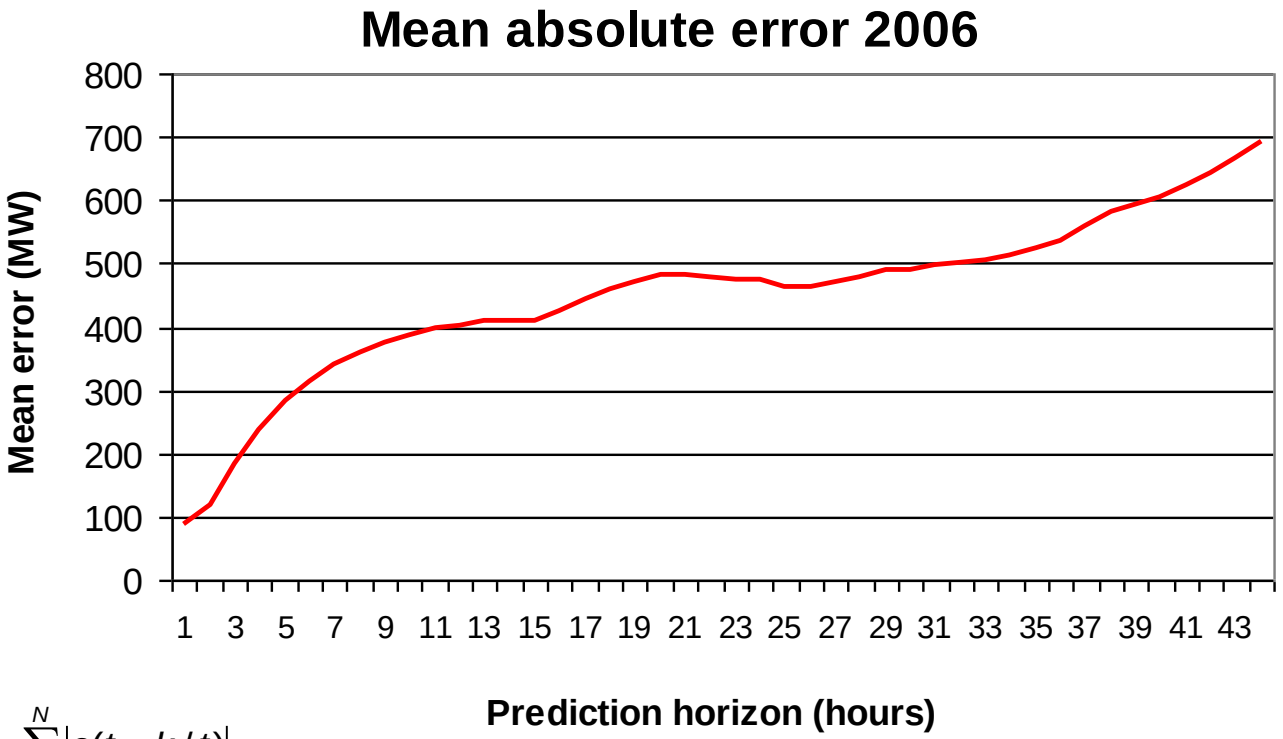






Source: REE

Prediction error. Spain.



$$MAE(k) = \frac{\sum_{t=1}^{N} |e(t+k/t)|}{N}$$

Source: REE

Wind producer's losses due to imbalances.

- **Assumptions:**
  - **Participation of wind power in the electricity market.**
  - **Same rules as any other producer.**
  - **Bids at price zero → all energy is accepted.**

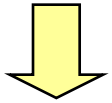
- **Losses quantification**
  - **Daily markets ~ 10% MR**
  - **Updating in ID ~ 2% MR**
  - ***Strategic* bids ~ 3-5% MR**
  - **Porfolio effect ~ up to 50% error reduction**

Simulations in technical literature

MR = maximum revenue (no imbalance)

Some questions.

Do we need specific market rules for wind farms?



- **Incentives given by a well-designed market.**
  - **Do balancing costs give right incentives to improve forecasting?**
  - **Does market send the right signals for controllability and innovation?**
- **Are current balancing rules giving right incentives?**

Do balancing costs give right incentives to improve forecasting?

Local vs centralized prediction

- **A local prediction may be more accurate than a centralized one for a wind farm.**
  - **Local modelling of terrain and knowledge of availability.**
  - **But local improvement may be expensive (2000-30000 €/farm year), and their effectiveness is not sure.**
- **Local predictions are less important than global prediction for the system imbalance.**
- **Portfolio effect is a better source of error reduction.**

Do balancing costs give right incentives to improve forecasting?

Incentives to give the « *best* » prediction.

- **Economic incentives do not push producers to give their « best » prediction.**
- **Asymmetries of the uncertainty and of imbalance cost tend to promote underestimation in the bids.**
- **A joint bid of many wind farms will be biased for minimizing losses.**

Does the market send the right signal for controllability and innovation?

- **Responsibility of imbalances avoids cross-subsidies → symmetric rules for all market participants.**
- **Market participation may promote joint ventures between different technologies (wind-hydro-pumping-storage).**
- **And they may encourage controllability and innovation.**

Consequences.

- **Market incentives are not enough for promoting accurate predictions from wind farm owners.**
- **System operators must made a centralized prediction for their territory.**
- **The cost of imbalances must be considered in the support mechanism.**

Are current balancing rules giving right incentives?

Cost-reflectiveness.

- **Necessary properties for cost-reflectiveness:**
  - **Imbalance price equal to imbalance cost**
  - **Imbalance cost recovery equal to real incurred cost.**
- **Many balancing mechanisms are not cost-reflective.**
- **Imbalance costs promote further wind bids grouping → reducing over-recovering.**

Are current balancing rules giving right incentives?

Gate closure time.

- **The possibility of updating the bids is convenient for the wind power producers.**
- **Technical constraints and cost minimization draw in the opposite sense.**
- **Too much back and forth renegotiation is pointless.**
- **The effect of much wind power on balancing markets is still to be quantified.**

Policy recommendations. Conclusion.

- **Need of central accurate forecasting of wind energy.**
- **Including balancing cost in support mechanisms.**
- **Cost-reflective imbalance management rules.**

- **Wind power participation in an electricity market may give right incentives for a technology mix that could help system operation.**