Business from technology

Task 25

Design and Operation of Power Systems with Large Amounts of Wind Power

iea wind

Reserve requirements of wind power

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IEA WIND Task 25

OBJECTIVE:

to analyse and further develop the methodology to assess the impact of wind on power systems

First phase 2006-08, 11 countries + EWEA participate

Second phase 2009-11, 14 countries + EWEA participate.

- Provide an international forum for exchange of knowledge
- State-of-the-art: review and analyse the studies and results so far
  - methodologies and input data, system operation practices
  - **Final report 2006-08 published in July 2009**
- Formulate guidelines:
  - recommended methodologies and input data when estimating impacts and costs of wind power integration
- Quantify the impacts of wind power on power systems
  - range of impacts/costs; rules of thumb

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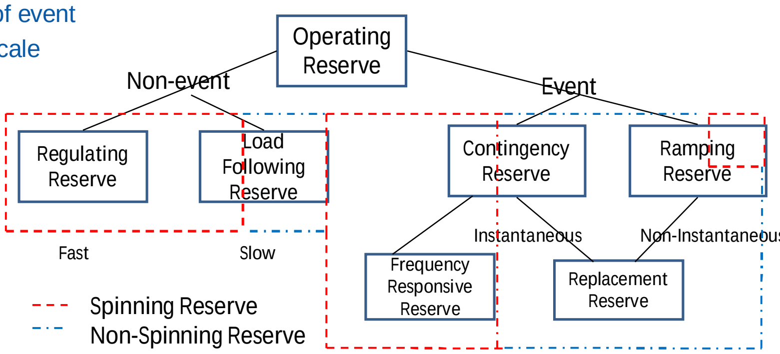
Contents

- General terminology for reserve categories
- Methodologies
- Case study results

Operating Reserves different in all systems – General definition

- "The real power capability that can be given or taken in the operating timeframe to assist in generation and load balance and frequency control"
- Does not include reactive power reserve and planning reserve
- Types of operating reserves differentiated by:
  - Direction of response (up/down)
  - Type of event
  - Timescale

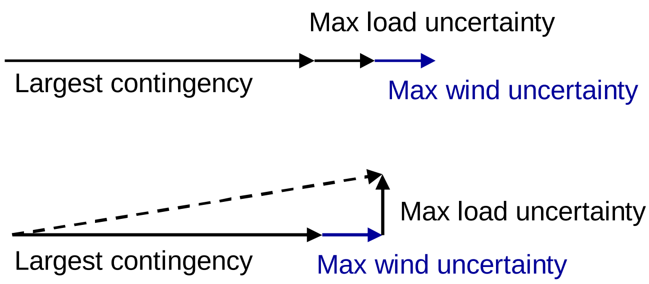


Increase in short term reserve requirements due to wind

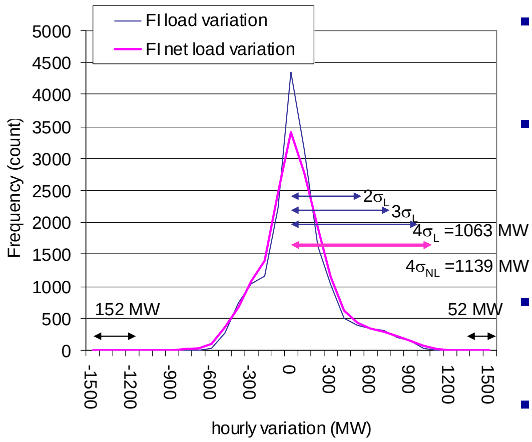
- Reserve categories that are impacted by wind power:
  - Wind power not dimensioning contingency reserve (instantaneous event) but will be seen in non-event and slow event reserve
  - Time scale: Regulating/Frequency responsive (automatic, primary, instantaneous) reserve not much affected but more the Load following/ramping reserves (10 minutes…hours)
- Approaches for estimating the impact of wind power
  - No general rules in how the non-event reserve is dimensioned
  - Compare the uncertainty and variability before and after the addition of wind generation wind and adjust the appropriate reserves while trying to maintain the same system quality of service such as reliability

Deterministic approach

- Often the first approach - simple
- Add wind uncertainties to existing reserves
  - no correlation between uncertainties of generation outages/load/wind → reserve can be overestimated (costly)
  - This can be mitigated by taking f.ex. 85 % of max, or by taking a vector sum

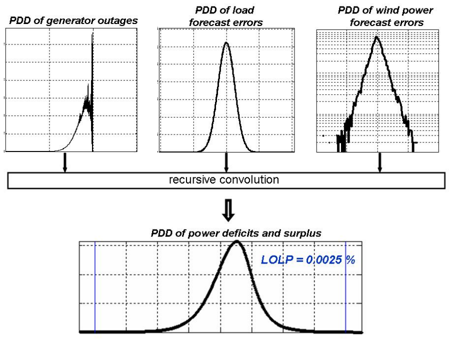


Step changes: from load to net load (load-wind) Simple approach to estimate reserve requirements

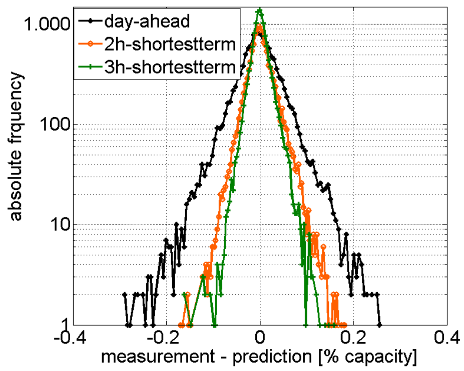


- Example 10 % wind penetration 4000 MW wind, max variation of wind power: 600 MW (15 %)
- Increase in 15-min-reserve :
  - As increase in confidence level of 4σ: 76 MW (2 %)
  - As max increase in variations: 152 MW (4 %)
- Same methodology can be applied to forecast errors, and different time scale reserves
- Not gaussian → Exceedence level instead of 4σ can be applied

Estimating increase in reserve requirements – combining probabilistic density distributions of uncertainties: forecast errors and outages



Challenge: wind not gaussian (tails)
Solution: Using empirical forecast errors



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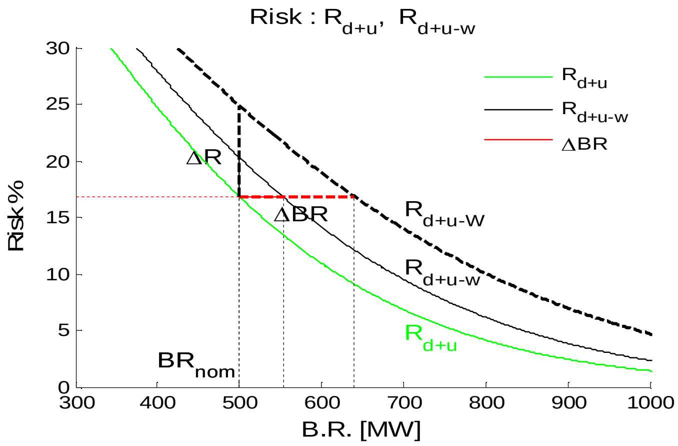
Calculating the risk with different amounts of reserve for different wind penetration levels



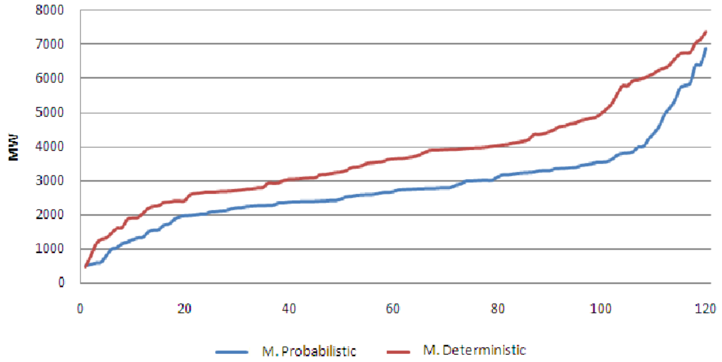
Risk that generation plus reserves (B.R) will not suffice to meet the load at a given time

Hydro-Québec – Wind Power R&D

Some case study results

Comparison of probabilistic and deterministic reserve allocation (Spain REE)

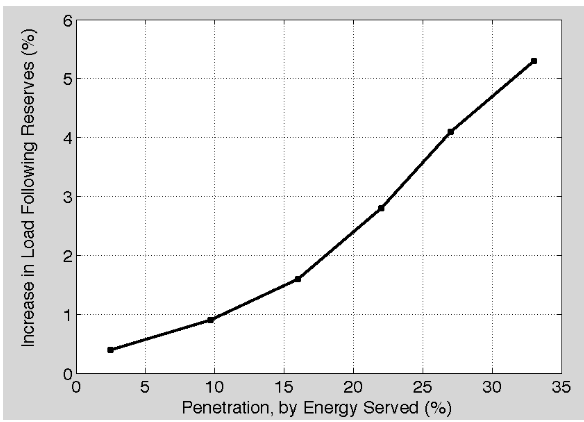
- Data from day-ahead technical congestion management, 120 days
- Difference between the reserves calculated and real reserves that were used at the hourly peak load of that day
- For the probabilistic calculation a confidence interval of 99% is used – lower amount of reserve allocation, but enough in all of the 120 days



VTT TECHNICAL RESEARCH CENTRE OF FINLAND 23/03/2011

We@ Sea Study - the Netherlands

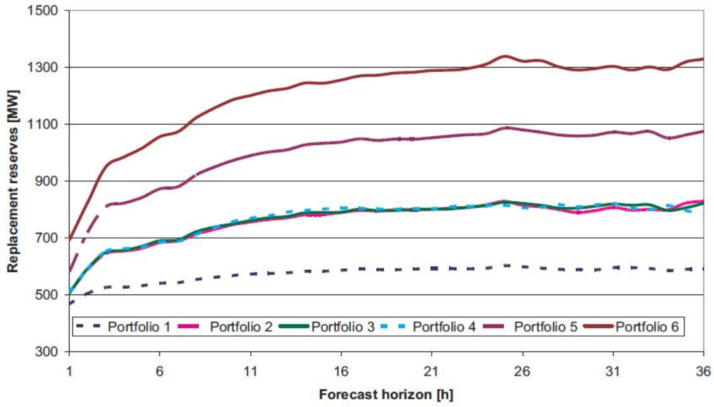
- Studied changes to unit commitment, adequacy of ramping capability
- Wind power estimated from detailed meteorological data
- Combined with load data from Dutch TSO
- Quantified 99% exceedence value of additional load following reserve



TUDelft

System size: 22 GW

All Island Grid Study - Ireland

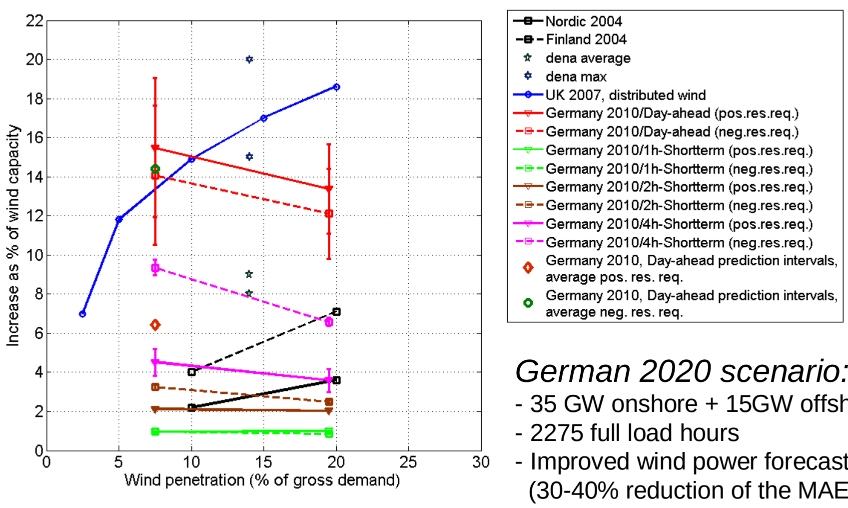


Wind capacity:
Portfolio 1 – 2000 MW
Portfolio 2-4 – 4000 MW
Portfolio 5 – 6000 MW
Portfolio 6 – 8000 MW

(1) hourly power balance assuming perfect forecasts and no forced outages, against
(2) hourly power balance considering scenarios of wind and load forecast errors as well as forced outages.

Replacement reserve target = 90th percentile of deviation between power balances

Impact of forecast error time scale - Germany



German 2020 scenario:
- 35 GW onshore + 15GW offshore
- 2275 full load hours
- Improved wind power forecasts (30-40% reduction of the MAE)

Reduction of the increase of reserve (in % of wind penetration)

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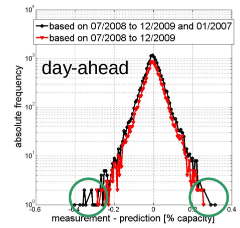
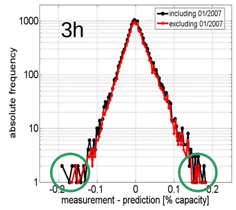
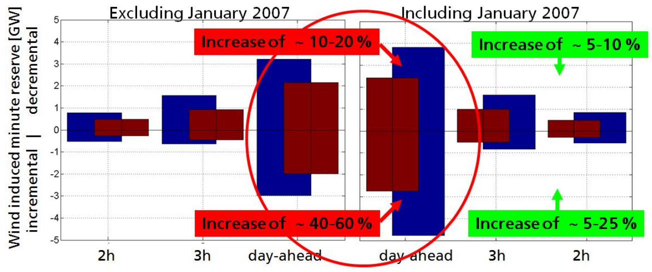
Including only one additional month of (large) historical forecast errors





January 2007: Storm event „Kyrill" leads to very large forecast errors due to sturm cut-offs of many wind turbines



Clear > impact on the estimated reserve using < day-ahead forecasts
Minor > impact on the estimated reserve using < 2-3h shortest-term forecasts

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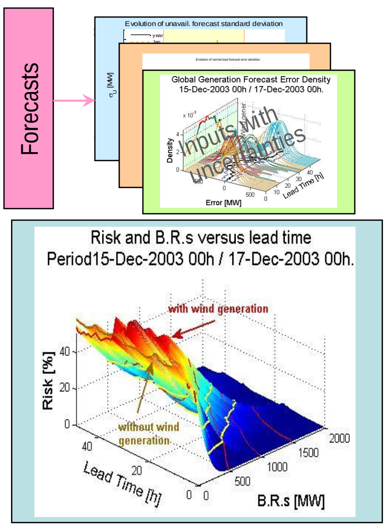
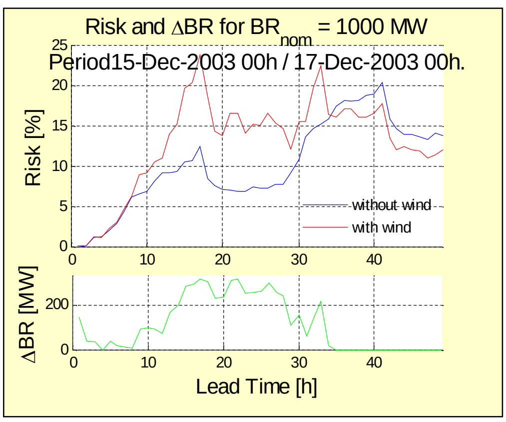
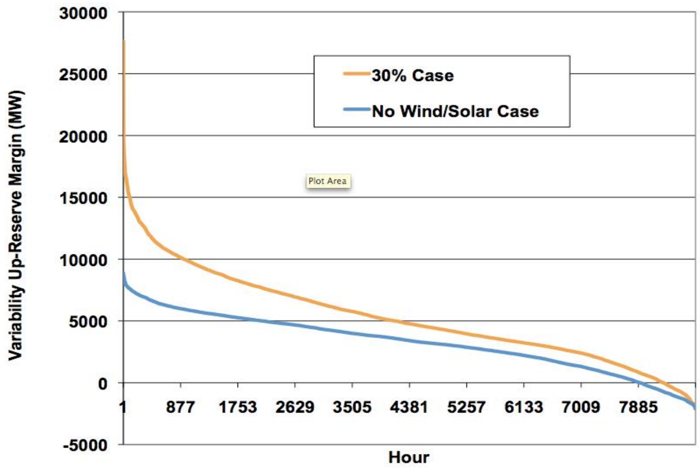
HydroQuebec computation of balancing reserves (BR) for forecast uncertainties (1-48 hours ahead)



Additional reserve to maintain original risk

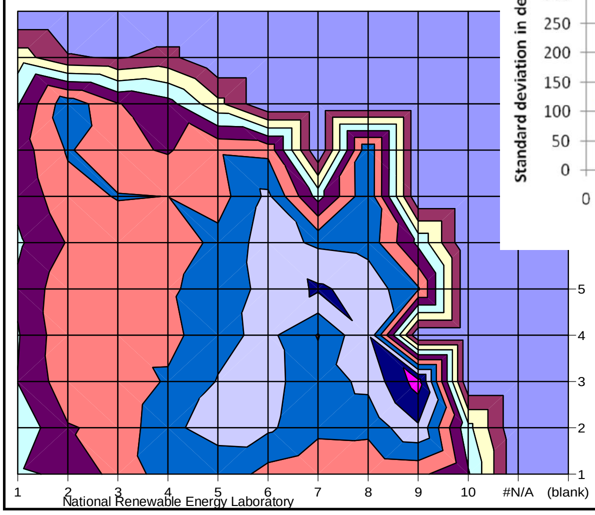


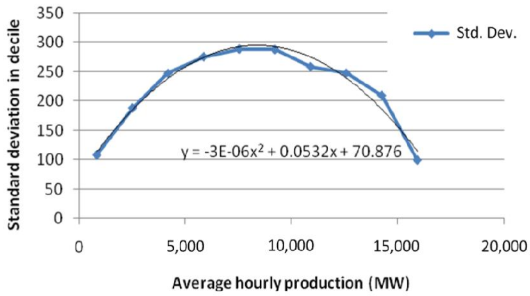
Western Wind and Solar Integration Study, US



There are more up-reserves available in the high renewables case than in the no wind/solar case because the additional renewable energy generation causes many conventional units to be backed down

Wind variability - Net Load Variability, US EWITS





- Net load variability increases with wind
- Requirement is a function of both load level and wind level

Some general results on short term reserves

- Wind starts to dominate the variability/uncertainty in higher penetrations → more reserve requirements
  - Large variations or forecast errors of wind power are rare events → dynamic allocation (low wind situations → low impact)
- The reserve requirement needs are often estimated available from existing conventional power plants
- Larger balancing areas and using transmission to neighbouring regions to share balancing will reduce the requirements
- Intra-day markets / correcting largest errors after day-ahead forecasts for wind power will reduce need for reserves
- Work in progress for comparing the methodologies and results

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Final report 2006-08 published in July 2009

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