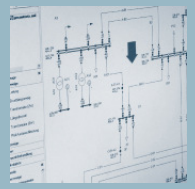


Alternative Approaches for Covering and Reduction of Reserve Energy Demand

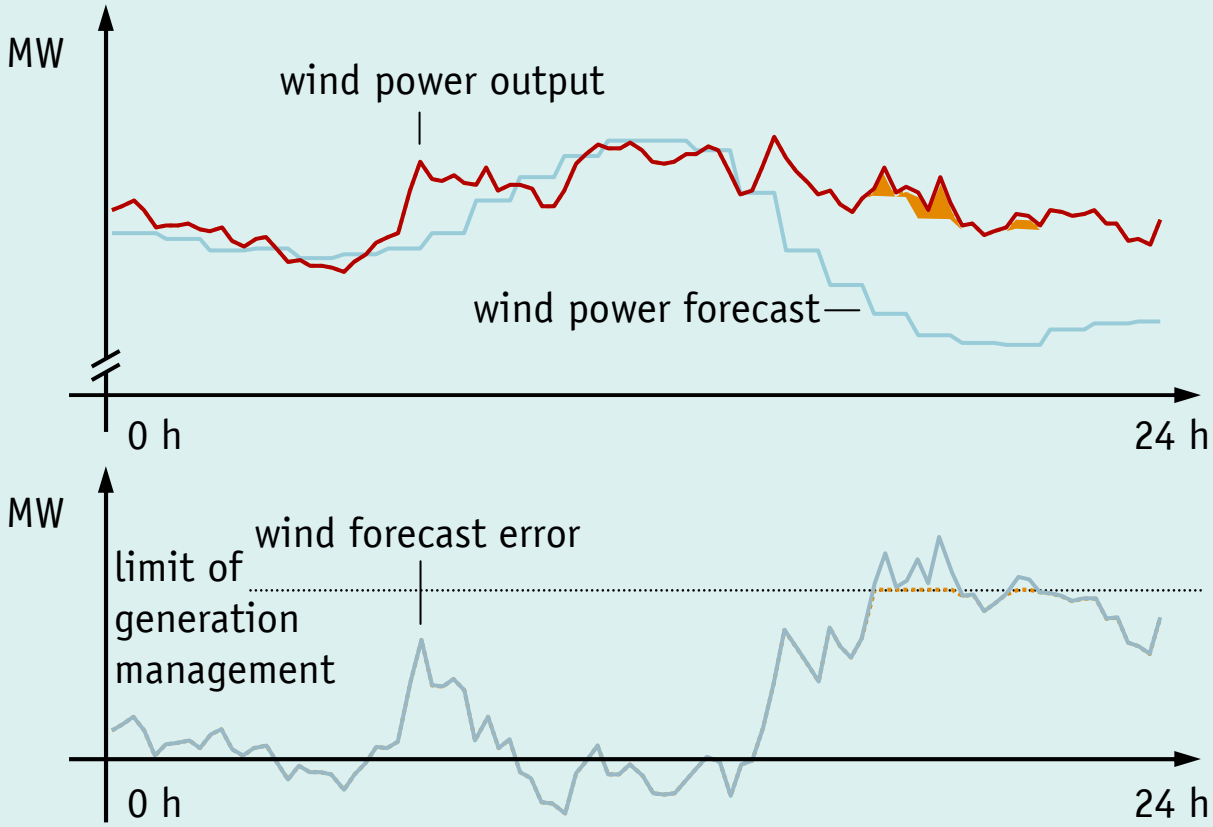
Dr.-Ing. Hendrik Vennegeerts

Beijing, November 19th 2008

Survey of possible measures

- **generation management of wind turbines**
- **potential of demand-side management for provision of control reserve**
- improved prediction of load and wind generation
- **utilization of short-term forecasts for the activation of short-term reserve**
- storage commitment

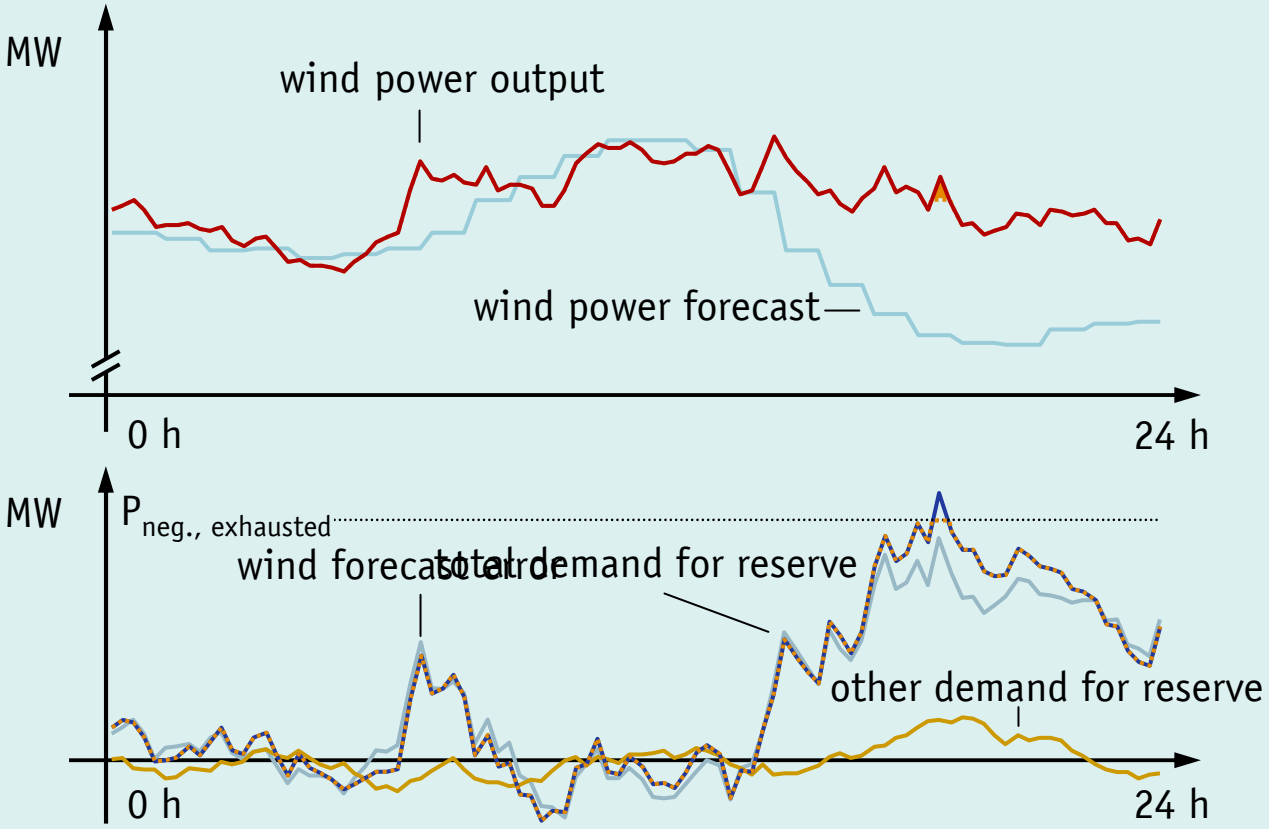
Reduction of wind power output due to limitation of maximum positive wind forecast error



§ low amount of unused wind power expected

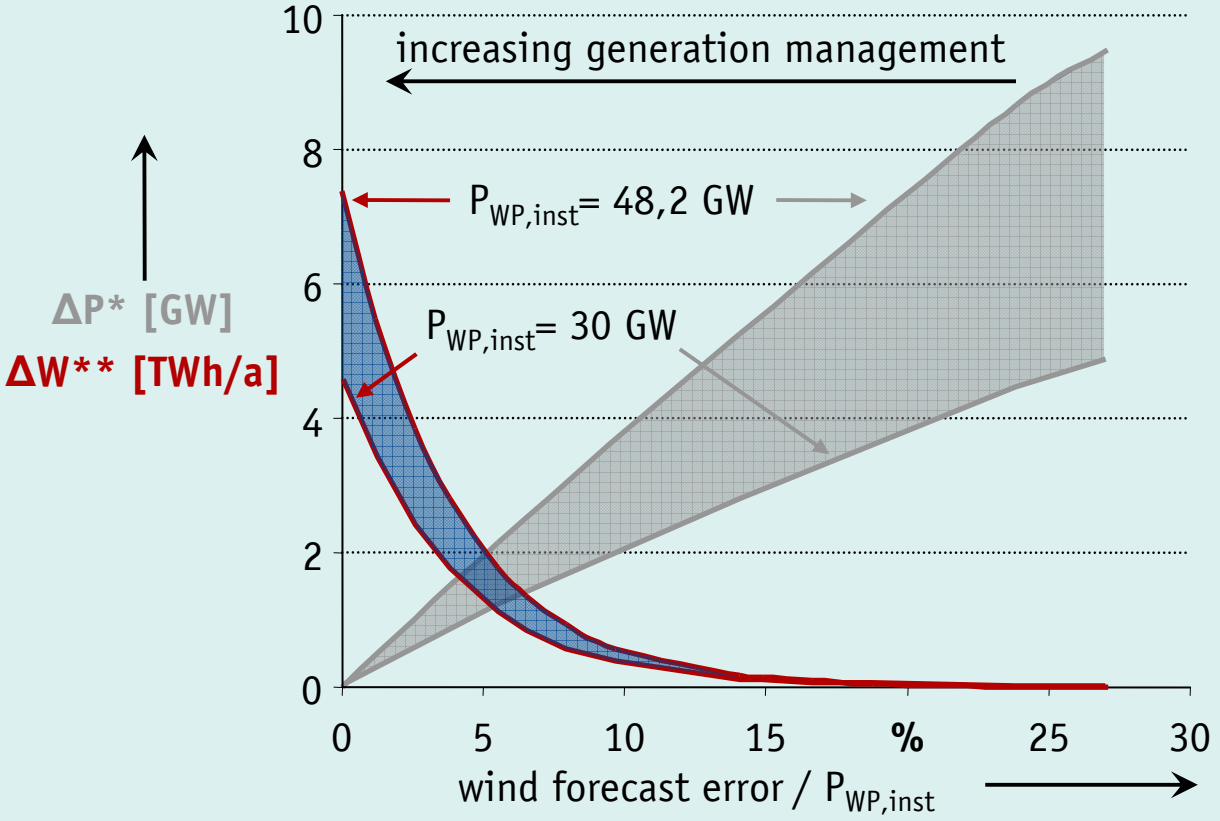
§ incentive for improved performance of wind forecast

Reduction of wind power output in case of exhausted negative control reserve



generation management never in opposite direction to other reserve demand

Potential reduction of negative control reserve
limitation of maximum positive wind forecast error

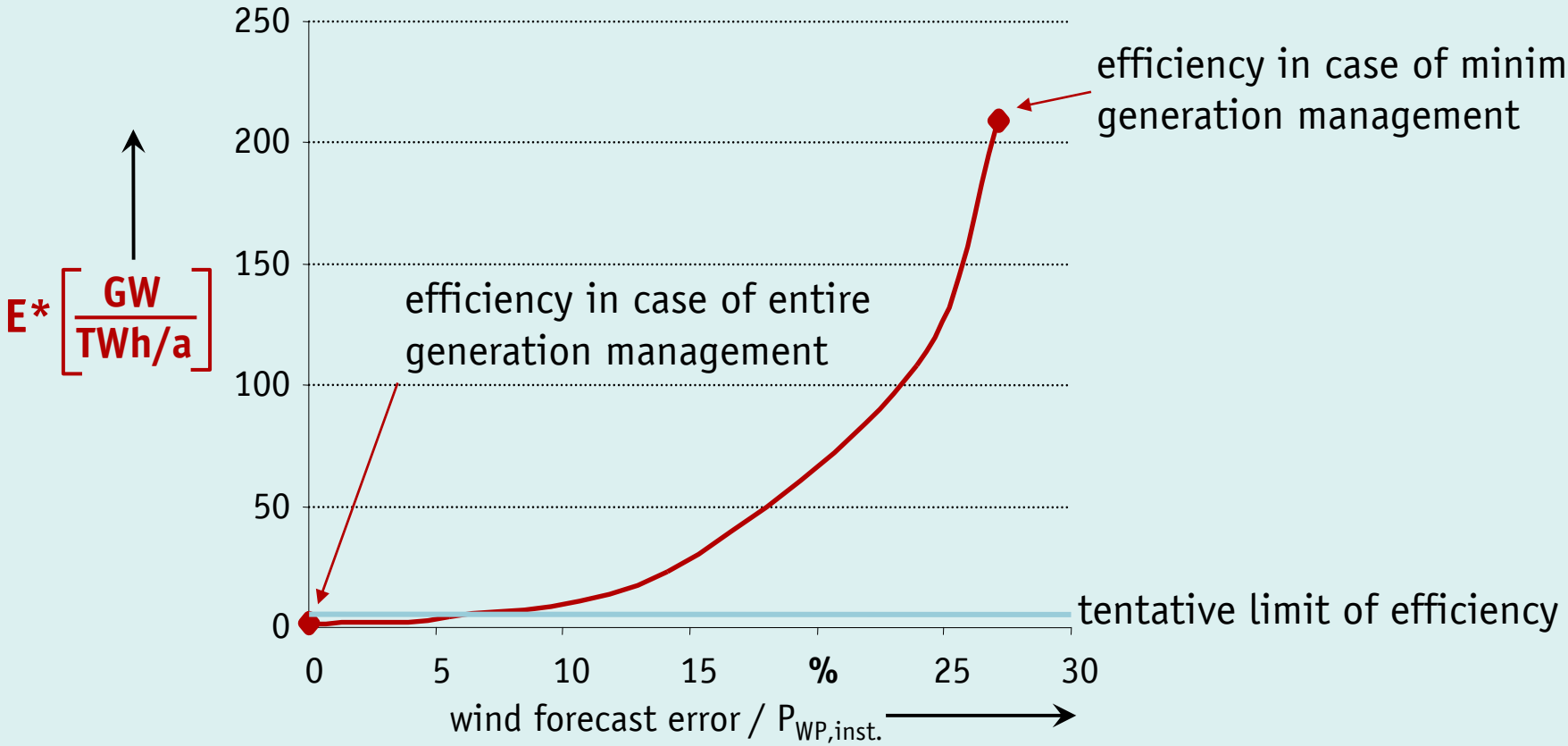


* demand of negative control reserve due to the wind forecast error

** unused wind power due to generation management

Efficiency of generation management ($P_{WP,inst}$ = 48,2GW)

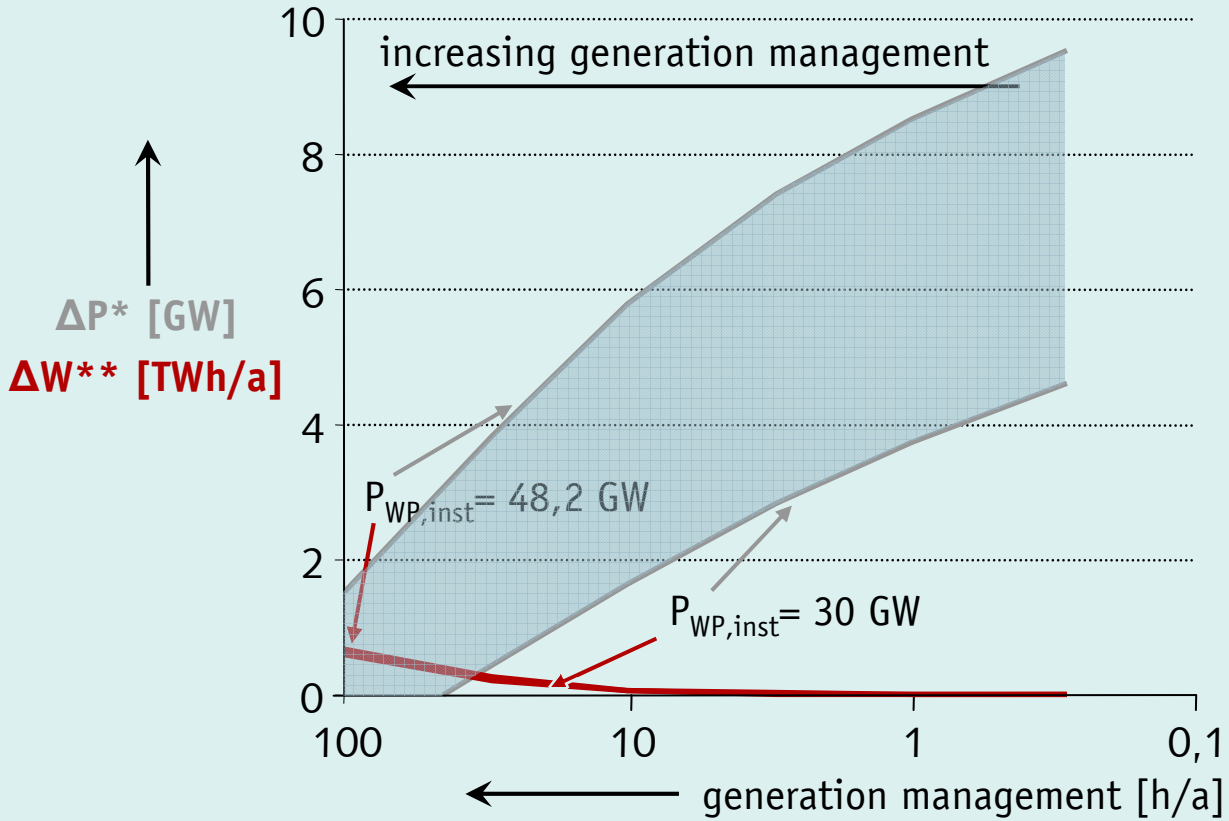
limitation of maximum positive wind forecast error



* ratio of possible reduction of control reserve to unused energy

⇨ high national savings depending on costs of control reserve and value of unused energy of wind turbines

Potential reduction of negative control reserve
limitation in case of exhausted reserve



* demand of negative control reserve due to the wind forecast error

** unused wind power due to generation management

⇨ for investigated system this strategy slightly favourable

Conclusions for the application of generation management at wind turbines

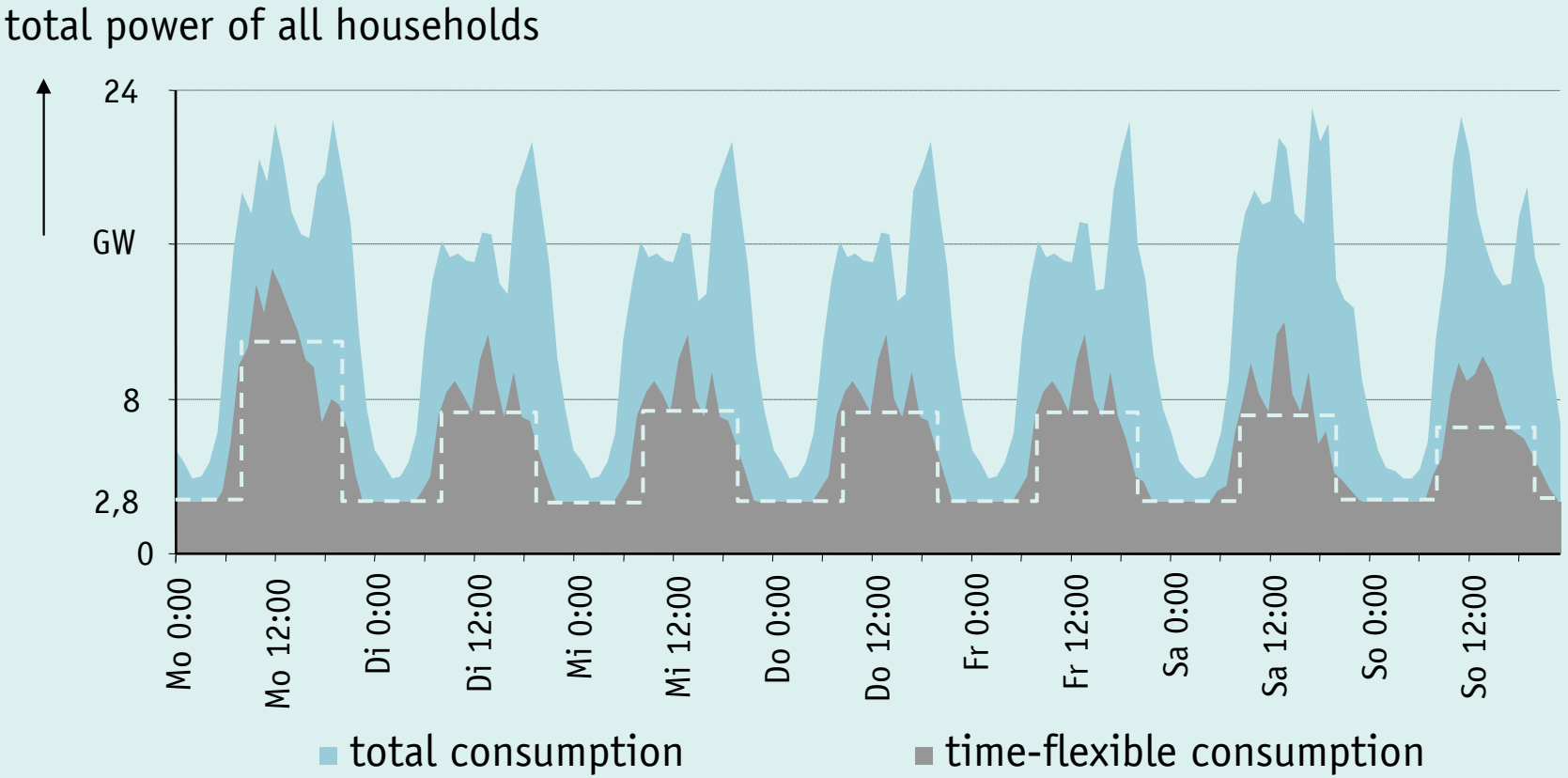
- high national savings depending on costs of control reserve and value of unused energy of wind turbines possible
- due to short-notice application requires
  - corresponding organization
  - technical steering systems including communication between control centers and distributed wind turbines
- additional remarks on investigated strategies
  - limitation of maximum wind forecast error
    + incentive for improving wind power forecast
    + application only, when wind power is responsible for high reserve demand
    - generation manag. can be in opposite direction to other reserve demand
  - limitation at exhausted control reserve
    + optimal strategy from system point of view
    - not strictly following ‚causer pays principle'

Approach for the evaluation of potential of demand-side management for control reserve purposes

- in industrial area strongly depending on the processes supplied
  - application already existing in Germany via reserve market

- for households probabilistic model necessary
  - average equipment per household
  - maximum power demand and profile for each equipment type
  - time-dependent utilization for each equipment type
- determination of total load curve for all equipment in German households, which application is time-flexible
  - washing machine
  - laundry dryer
  - dishwasher
  - refrigerators

Potential of load shutdown in German households



- time-flexible load at least 2,8 GW according to refrigerators
- time-flexible load between 9am und 9pm approximately 7 GW

Conclusions for the application of demand-side management at households

- high potential exists
- quantification of potential acts on the assumption of shutdown of operating equipment
  - in practise permission to switch washer, dryer of dishwasher on has to be given to control centres
    - guidelines have to be defined
    - communication between control centres and equipment necessary
- self-sustaining load steering of refrigerators possible without remarkable restriction for equipment user
  - efficiency dependent on cost for control and communication

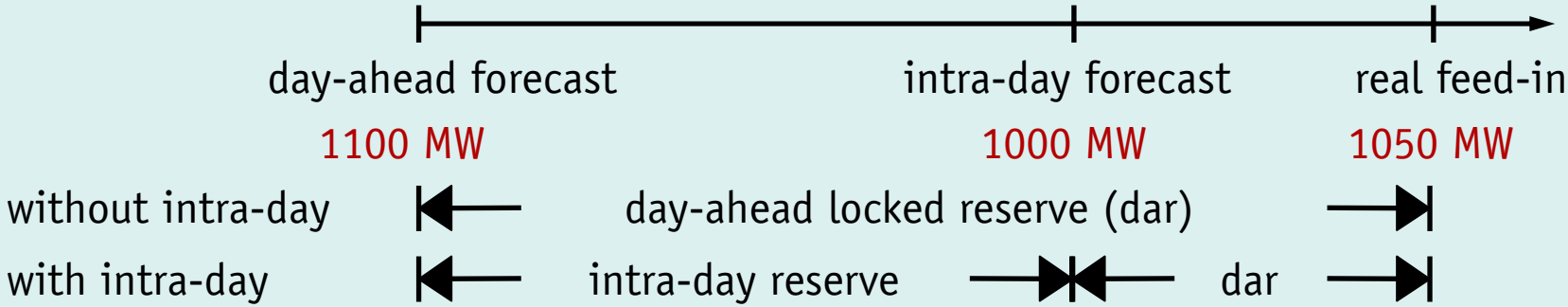
Possible application of power plants for reserve control

power plant type / provision of reserve at	pumped-storage gas turbine	combined cycle gas turbine hard coal	brown coal run-of-river nuclear
day-ahead notice	unlimited	possible	inappropiate/ unusual
intra-day notice	unlimited	limited	inappropiate/ unusual

- limitations at some power plants at intray-day notice due to
  - dependency on actual operating state and
  - activation time
- evaluation of potential for different intra-day wind power forecasts

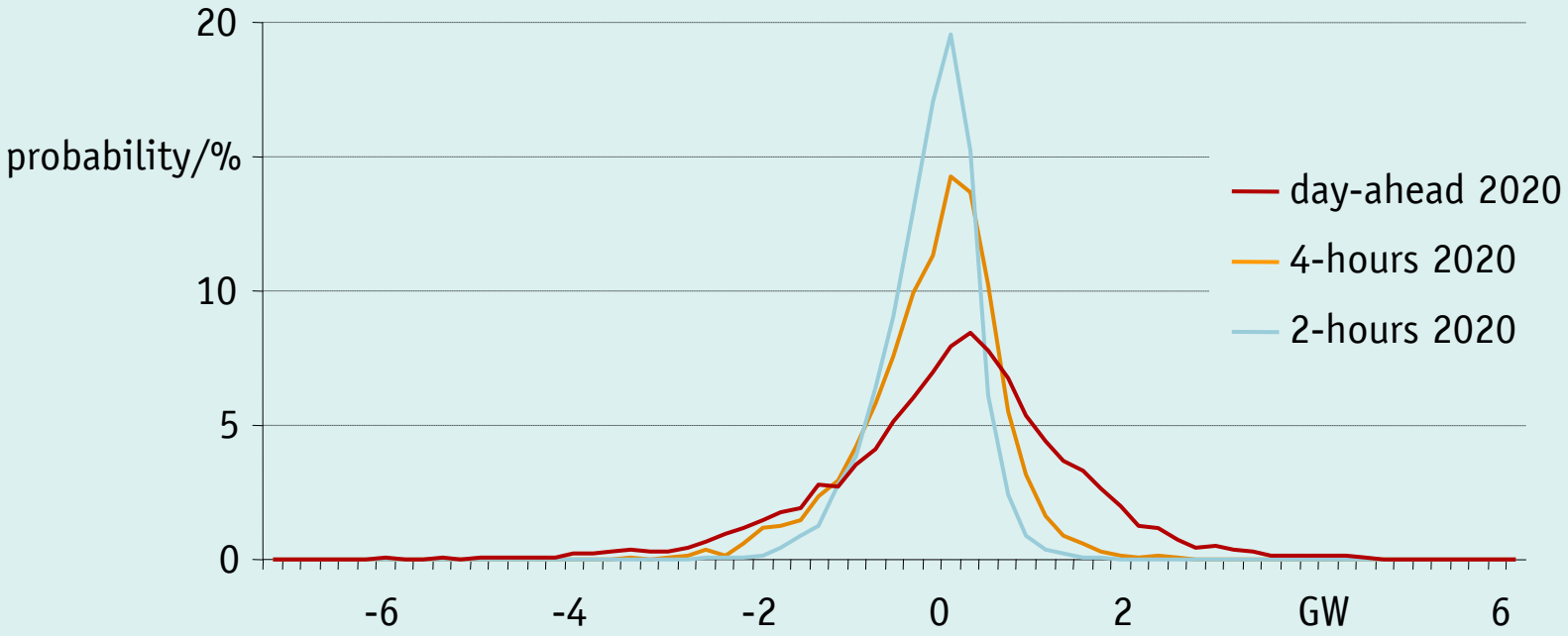
Utilization of intra-day reserve

- intra-day wind power forecasts (some hours) possible with significant higher accuracy than day-ahead prognosis
- utilization of intra-day reserve for balancing the difference between day-ahead and intra-day wind power forecast



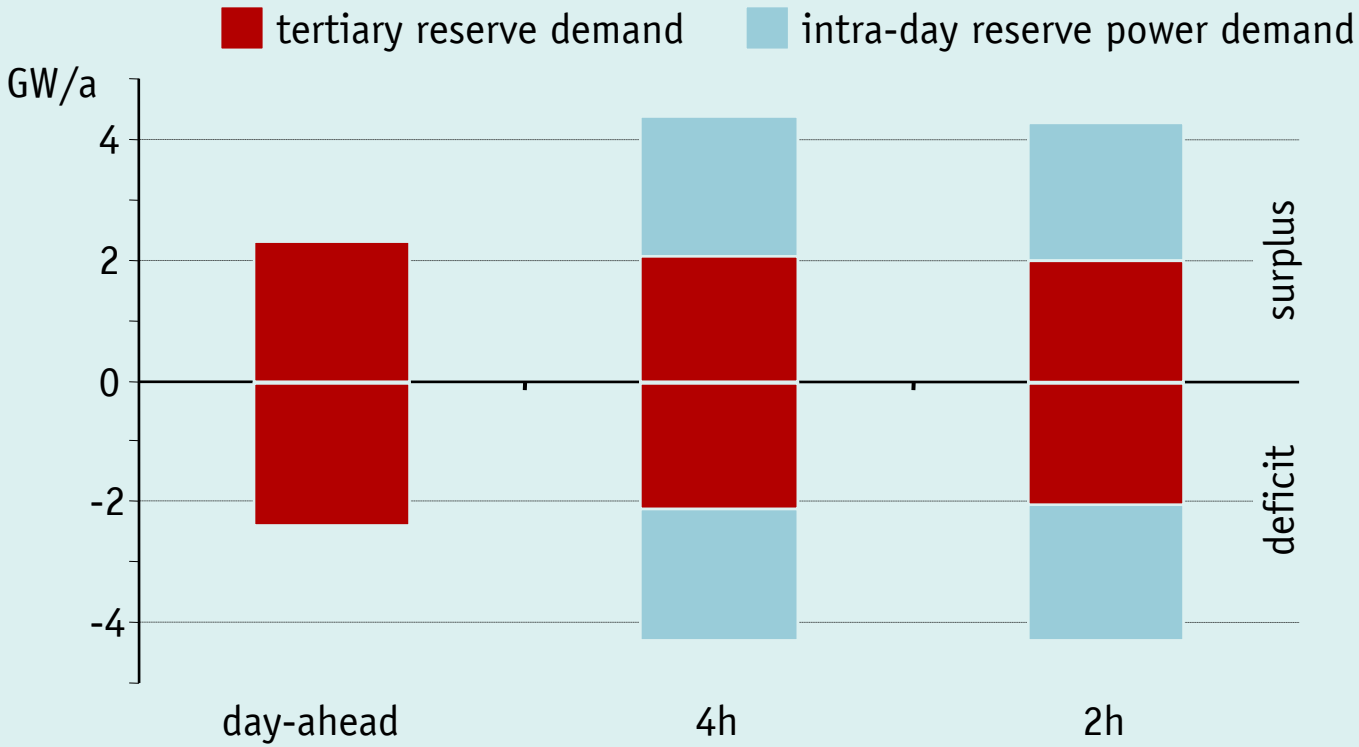
- use of power plants with an activation time of a few hours possible
  - more economic commitment of power plants expected
- partly contradictory control possible
  - increasing total reserve demand

Distribution of wind power forecast error



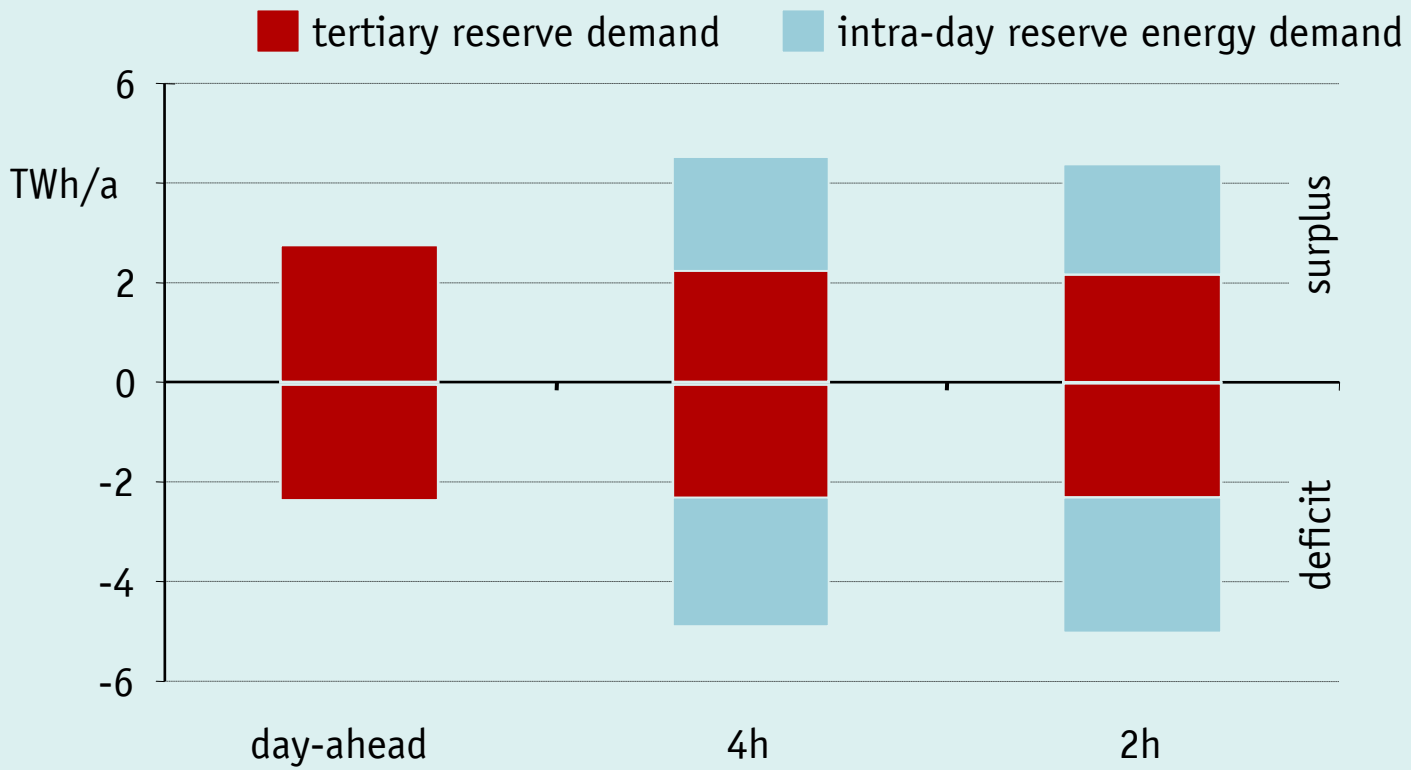
- significant higher quality of 4/2-hour-forecast in comparison with day-ahead-forecast
- note: decisive factor for dimensioning of control reserve are small quantiles of forecast error distribution

Annual demand for tertiary and intra-day reserve power



- smaller forecast horizon leads to decreased demand for tertiary control
- increased total reserve power demand due to possible opposite utilization
- remarkable amount of intra-day reserve needed

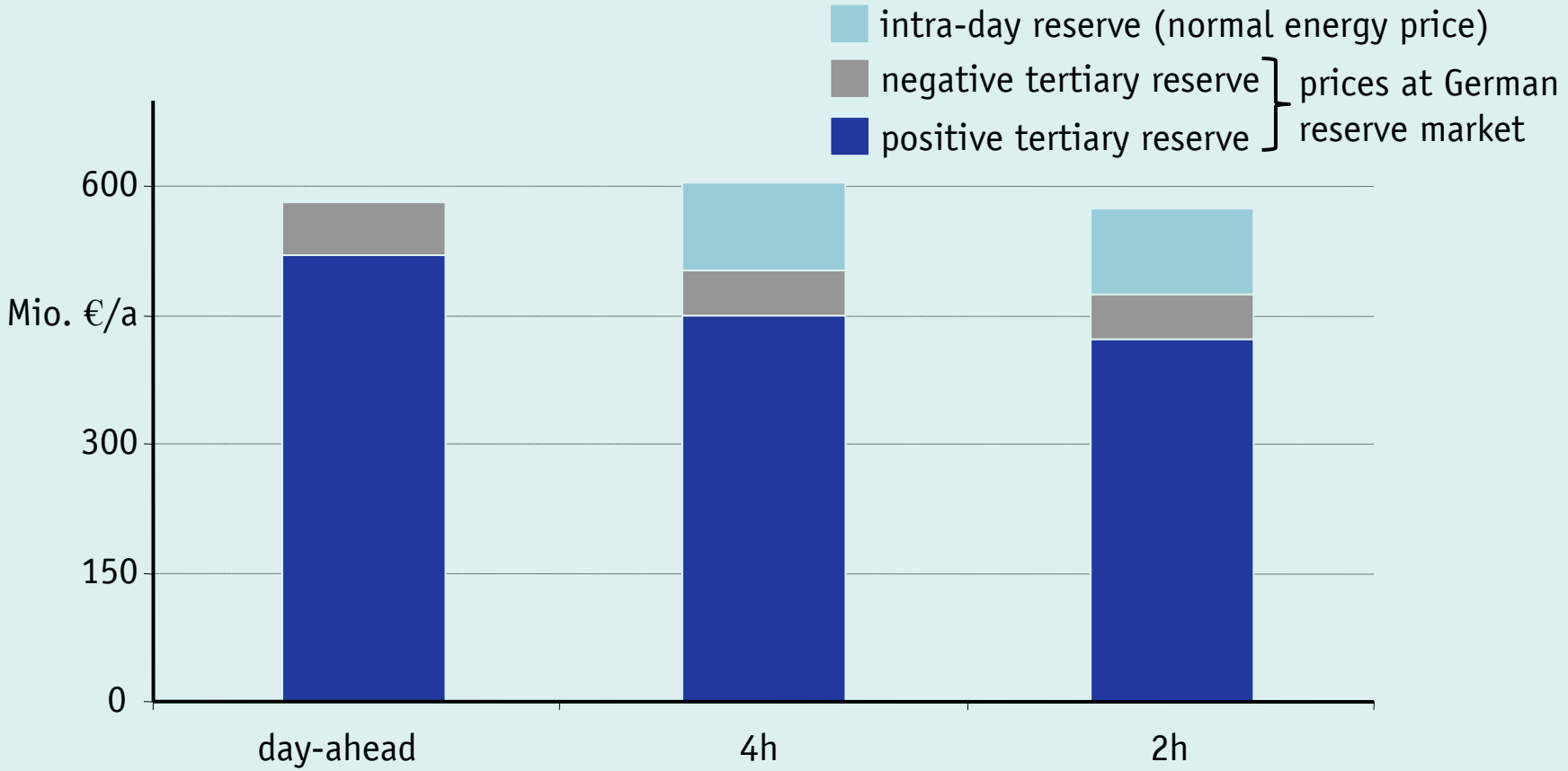
Annual demand for tertiary and intra-day reserve energy



- increased total reserve energy demand due to possible opposite utilization
- rough estimation with expected costs for reserve possible

Results of a rough monetary evaluation

(for model control area representing 30% of Germany)



- economic benefits possible depending on cost structure of generation system