

#### Demo 4: Storm management

Detlefsen, Nina; Gøttig, Allan; Cutululis, Nicolaos Antonio; Sørensen, Poul Ejnar

Publication date: 2011

Document Version Publisher's PDF, also known as Version of record

Link back to DTU Orbit

*Citation (APA):* Detlefsen, N. (Author), Gøttig, A. (Author), Cutululis, N. A. (Author), & Sørensen, P. E. (Author). (2011). Demo 4: Storm management. Sound/Visual production (digital)

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# **DEMO4: STORM MANAGEMENT**

Nina Detlefsen, Energinet.dk (demo leader) Allan Gøttig, Energinet.dk Nicolaos Cutululis, Risø DTU Poul Sørensen, Risø DTU (presenter)







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### **Demo 4 STORM MANAGEMENT (Leader: Energinet)**

#### Main objective

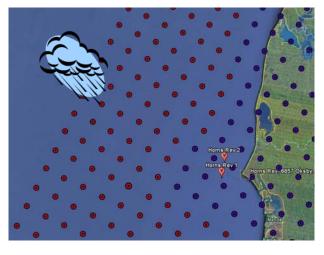
 Demonstrate shut down of wind farms under stormy conditions without jeopardizing safety of the system

#### Approach

- Horns Rev 2 (200MW)
- Flexible turbine control
- Storm front forecasts
- Investigate cost of changed production associated with the planned down regulation
- Coordinate wind farm control with HVDC interconnector control and with hydro power plant operation

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Risø DTU National Laboratory for Sustainable Energy

www.twenties-project.eu





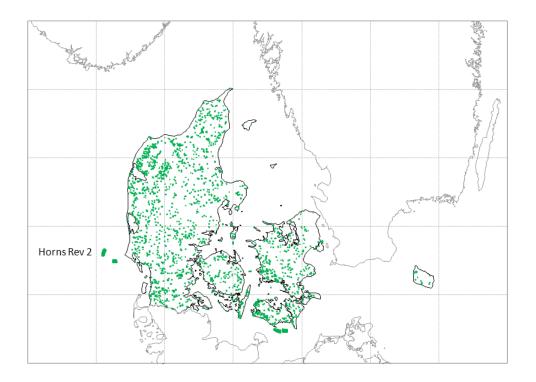
48







**Present wind turbines in Denmark** 

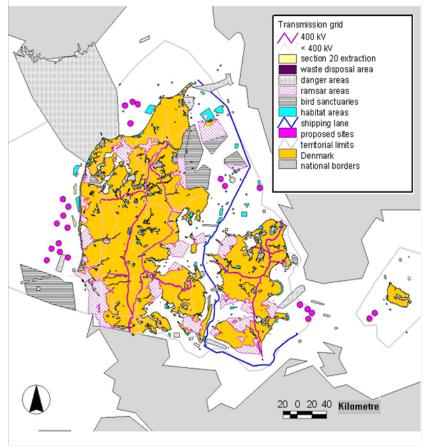








### Possible offshore wind plants in Denmark (23 x 200 MW)









# **Strategies**

#### • Two possible strategies:

Manual control
 Automatic control

#### Manual control involves:

Wind speed forecasting
Wind power forecasting
System imbalance forecasting
Regulating power

#### • Automatic control involves:

• New controller in the turbines • Automatic imbalance control

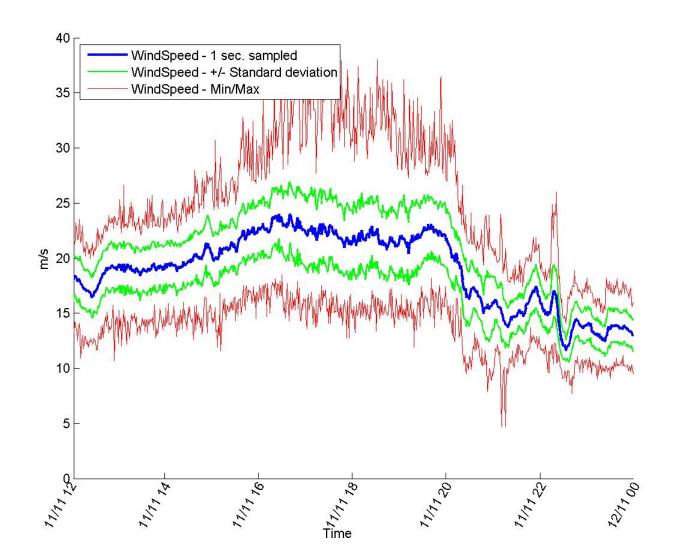


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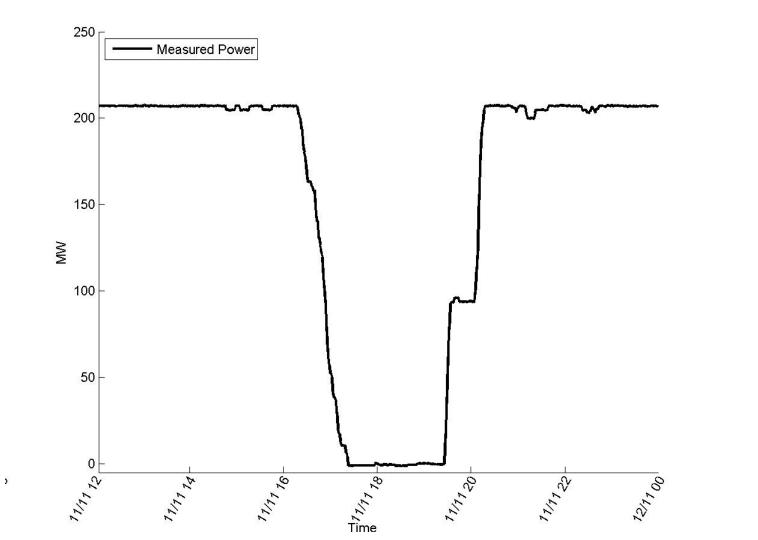


### Wind speed – statistics of 91 wind turbines





# Wind power







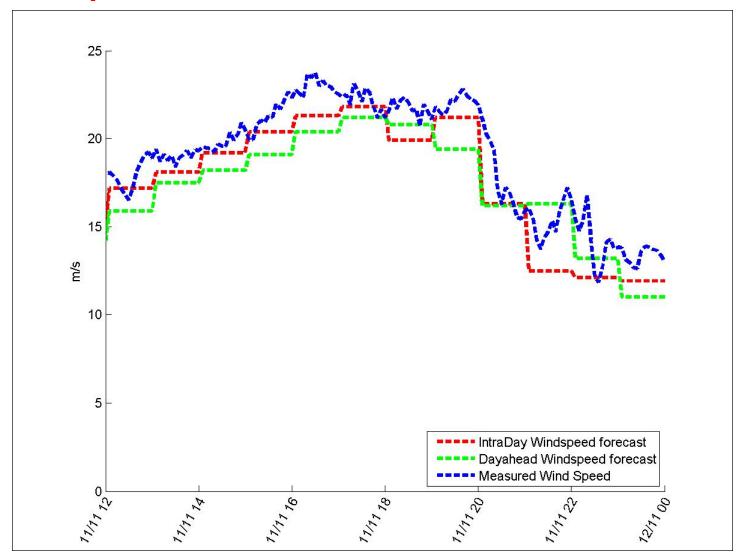
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Wind speed forecast



54

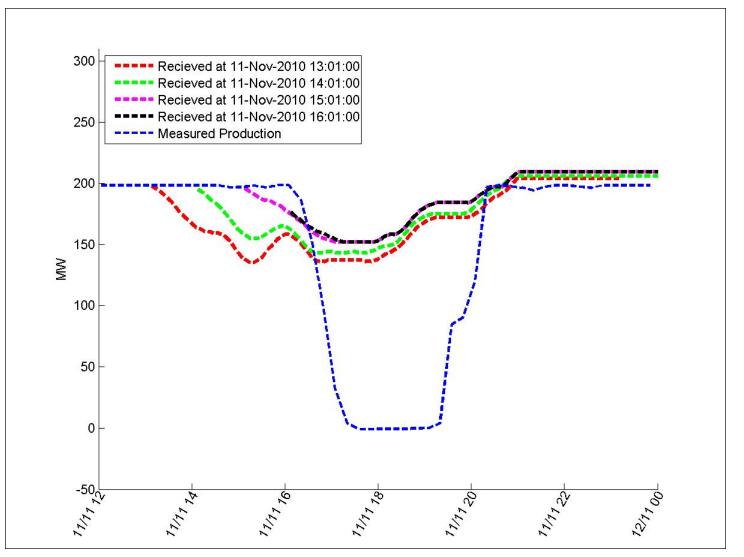






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## Wind power forecast









# **Definition of Extreme Wind Period (EWP)**

### • Wind speeds:

- v₁: cut-in wind speed
- v<sub>2</sub>: rated wind speed
- v₄: cut-out wind speed
- $\circ v_3$ : high wind reconnection wind speed
- EWP for single turbine

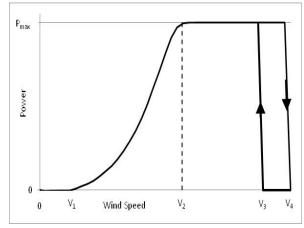
• Starts when v > v<sub>4</sub> (typically 25 m/s)

• Ends when  $v < v_3$  (typically 20 m/s)

• EWP for wind power plant (wind farm)

 Starts when half of wind turbines are cut-out (typically at wind farm average 22.5 m/s)
 Stops when half of wind turbines are re-

**connected** (typically at wind farm average 18 m/s)



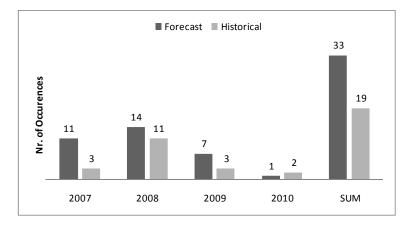


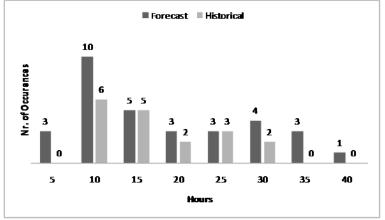




## **Statistics of Extreme Wind Periods (EWPs)**

- Ideally, purpose is to compare actual and forecasted wind speeds
- Difficult to provide sufficiently long period of data
- Forecasts are from Energinet.dk
- Historical data would ideally be measurements, but are re-analysis performed with Weather Research and Forecasting (WRF)-model
- Grahps show 100m height (10m data much better agreement, but less relevant)





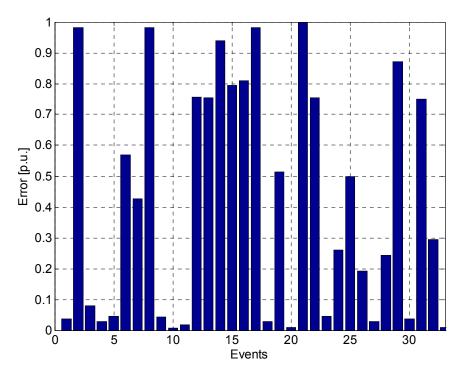






**KPI: worst case forecast error** 

 Maximum absolute power prediction error for each Extreme Wind Period (EWP)









# Conclusions

- New turbine controller will be developed
- Improved actions based on wind power forecasts will be developed
- Potential of Norwegian Hydro
- Impact from storm in Danish (UCTE) and Nordic system
- Correlation of storms in the regions will be assessed

### THANK YOU FOR YOUR ATTENTION