#### Technical University of Denmark



### Wind power variability and power system reserve requirements at 2020 at 2030 scenarios for offshore wind power in Northern Europe

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#### Wind power variability and power system reserve requirements at 2020 at 2030 scenarios for offshore wind power in Northern Europe

Poul Sørensen

Technical University of Denmark Department of Wind Energy





EUROPEAN COMMISION

IEA Wind, DTU participation phase 3, 22 May 2013, Helsinki







#### **10 European Member States Consortium and budget 1 Associated Country United Kingdom (2)** Denmark (3) France (2) **ALSTOM GRID Norway DONG ENERGY** RTE UNIVERSITY OF SINTEF **ENERGINET** EDF **STRATHCLYDE DTU ENERGY** Ireland UCD **The Netherlands** Portugal TENNET **INESC-PORTO** Germany (3) **FRAUNHOFER IWES** 50 HzT **SIEMENS Wind Power** Spain (5) **Belgium (6) RED ELECTRICA DE ESPAÑA** ELIA SYSTEM OPERATOR **IBERDROLA** EWEA **ITT COMILLAS CORESO** • GAMESA UNIVERSITY LIEGE ABB S.A. UNIVERSITY LEUVEN UNIVERSITE LIBRE BRUXELLES Total budget: 56.8 M€ Italy EU contribution: 31.8 M€ RSE 2







## **Project objectives**

Task force 1: What are the valuable contributions that intermittent generation and flexible load can bring to system services?

**Task force 2:** What should the network operators implement to allow for off-shore wind development?

Task force 3: How to give more flexibility to the transmission grid?

6 high level demonstration objectives

**Overall:** How scalable and replicable are the results within the entire pan-European electricity system?

2 replication objectives

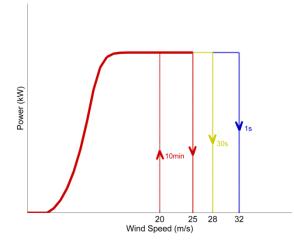


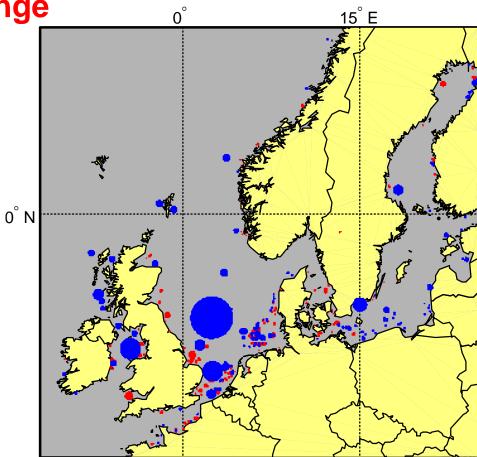




#### **Demo 4 - The challenge**

Power System Areas	2020 in MW		2030 in MW	
	Base	High	Base	High
UCTE	21,421	27,675	52,590	69,454
Nordel	4,924	7,019	15,009	20,512
UK+IR	15,130	21,500	37,920	52,090
Total	41,475	5,6194	105,519	142,056





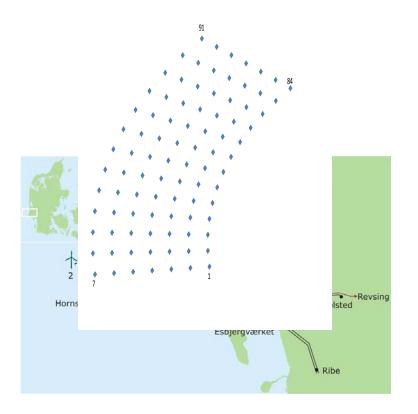






### The demonstration

- Lead by Energinet.dk
- Horns Rev 2 wind farm owned by DONG Energy
- 91 x 2.3 MW Siemens wind turbines
- Siemens turbines built with conventional storm control
- Siemens developed and installed High Wind Ride Through<sup>™</sup> - (HWRT)
- 3 years of storms monitored including both controllers





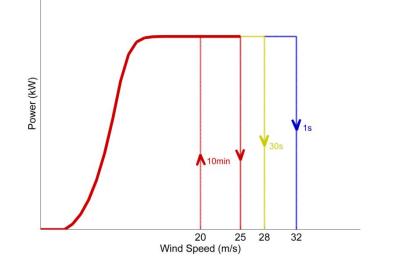


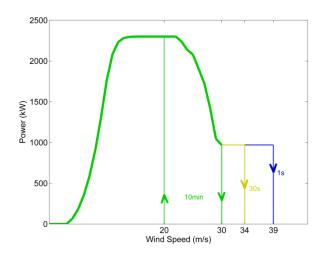


## Wind turbine modelling

 Conventional High Wind Shut Down (HVSD) wind turbine control













**Storm events** 

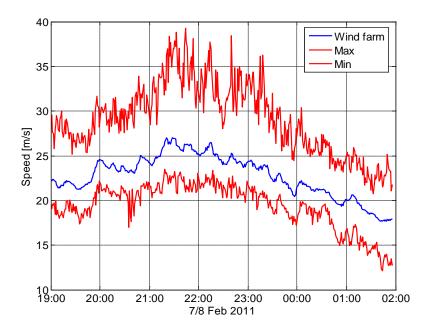
Event nr	Date	Controller			
1	11-Nov-10	HWSD			
2	12-Nov-10	HWSD			
3	07-Feb-11	HWSD			
4	24-Sep-12	HWRT			
5	14-Dec-12	HWRT			
6	30-Jan-13	HWRT			
Legend:					
HWSD - High Wind Shut Down;					
HWRT - High Wind Ride Through					







February 7-8 2011

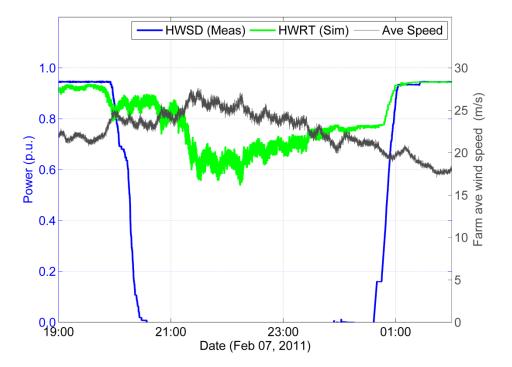








February 7-8 2011



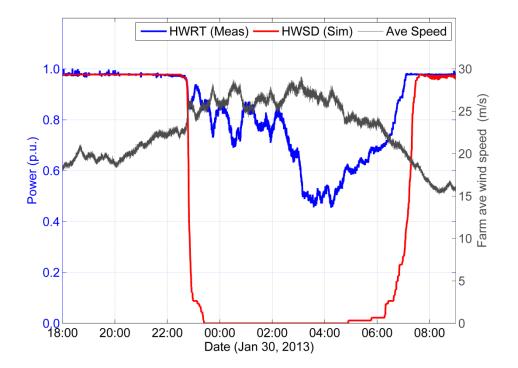






EUROPEAN COMMISION

## January 30, 2013



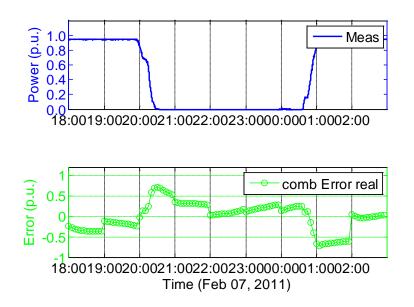




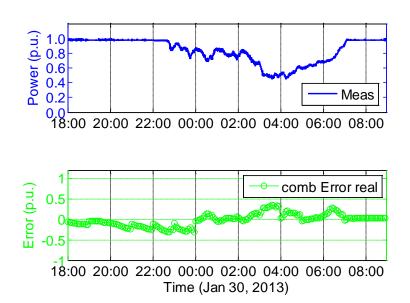


#### Wind turbine forecast error

#### February 7-8, 2011



January 30, 2013









#### Wind turbine forecast error

Event	Max forecast error [p.u.]	Average forecast error [p.u.]	Difference [p.u.]
11-Nov-10	0.80		
12-Nov-10	0.80	0.77	
07-Feb-11	0.72		0.51
24-Sep-12	0.26		0.51
14-Dec-12	0.18	0.26	
30-Jan-13	0.35		





# Replication work packages: barriers and up scaling

WP 15: Economic impacts of the demonstrations, barriers towards scaling up and solutions (Leader: IIT)

- Assess the local economic and/or technological impact of each demo.
- Identify the barriers to scale-up the outcomes at a member-state or regional level, and propose solutions to overcome these barriers.

WP 16: EU wide integrating assessment of demonstration replication potential (Leader: DTU Wind Energy)

- Assess portability of voltage control, frequency control and VPP model to other countries and regions.
- Evaluate North European 2020 offshore wind power variability, hydro potential and barriers and grid restriction studies.
- Pan European economic impact study.

#### WP 17: EU Offshore barriers (Leader: TENNET)

- Address the issues of **smart licensing of submarine interconnectors** with and without wind parks in the North Sea and Baltic Sea.
- Identify common licensing barriers and propose regulatory measures.







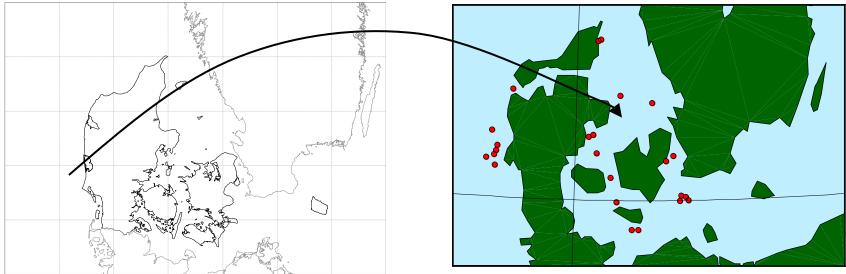






2020: 2.8 GW

2030: 4.6 GW

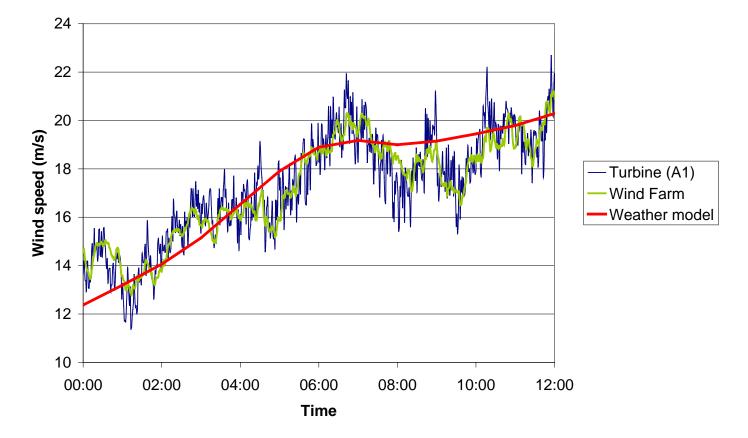








#### Simulation of correlated wind power – CorWind

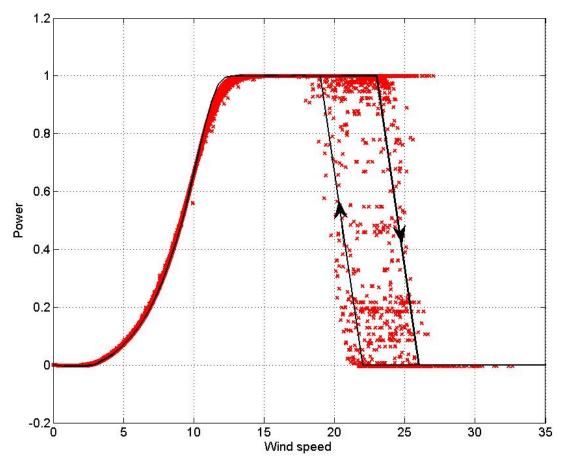








### **Aggregated wind farm model**



www.twenties-prc







### **Critical weather periods**

2001	01/01/2001	2008	21/03/2008
2005	02/01/2005		13/08/2008
2007	01/01/2007		08/11/2008
	08/01/2007	2009	11/06/2009
	18/03/2007		03/10/2009
	27/06/2007	2010	11/11/2010
	08/11/2007		07/02/2010
2008	25/01/2008	2011	10/03/2011
	27/02/2008		

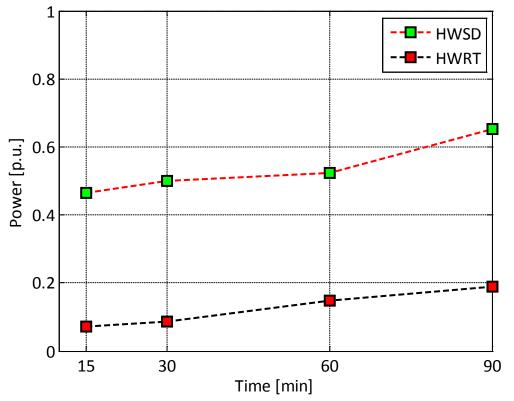






# Max ramping during storms – 2020

$$P_{\text{res}}(n) = P_{\text{mean}}[t(n) - T_{ave}; t(n)] - P_{\text{min}}[t(n); t(n) + T_{win}]$$

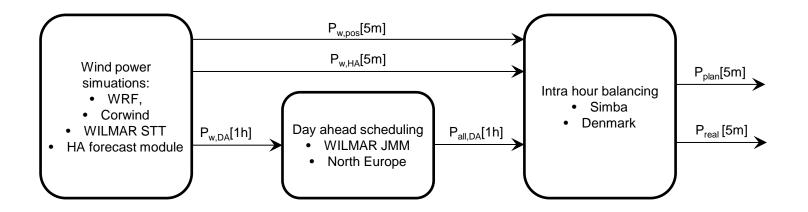








## Simba + WILMAR Intra hour balancing in storm events









# Summary

#### • Observations:

• Wind power forecast error reduced by 50% of installed capacity

#### • Modelling:

• Maximum ramping in Denmark 2020 reduced more than three times







Thank you

www.twenties-project.eu