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

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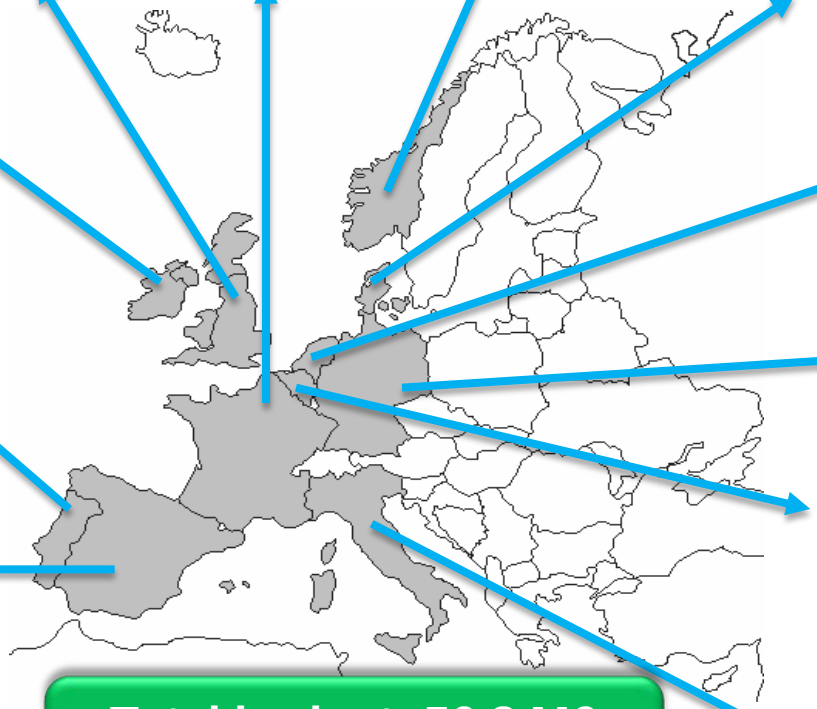
Consortium and budget

10 European Member States
1 Associated Country



United Kingdom (2)
ALSTOM GRID
UNIVERSITY OF STRATHCLYDE

France (2)
RTE
EDF

Norway
SINTEF

Denmark (3)
DONG ENERGY
ENERGINET
DTU ENERGY

Ireland
UCD

Portugal
INESC-PORTO

The Netherlands
TENNET

Germany (3)
FRAUNHOFER IWES
50 HzT
SIEMENS Wind Power

Spain (5)
RED ELECTRICA DE ESPAÑA
IBERDROLA
ITT COMILLAS
GAMESA
ABB S.A.

Belgium (6)
ELIA SYSTEM OPERATOR
EWEA
CORESO
UNIVERSITY LIEGE
UNIVERSITY LEUVEN
UNIVERSITE LIBRE BRUXELLES

Italy
RSE

Total budget: 56.8 M€
EU contribution: 31.8 M€

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?

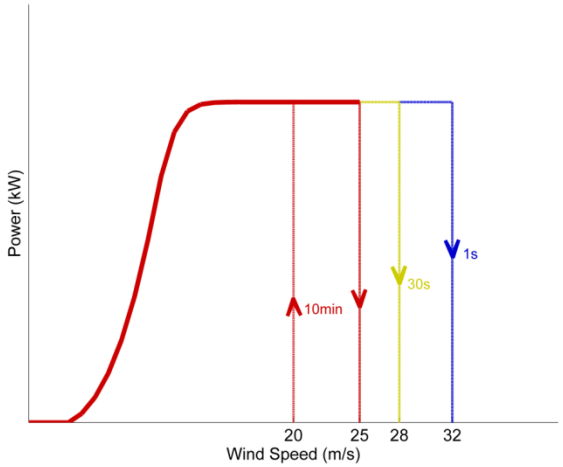
6 high level demonstration objectives

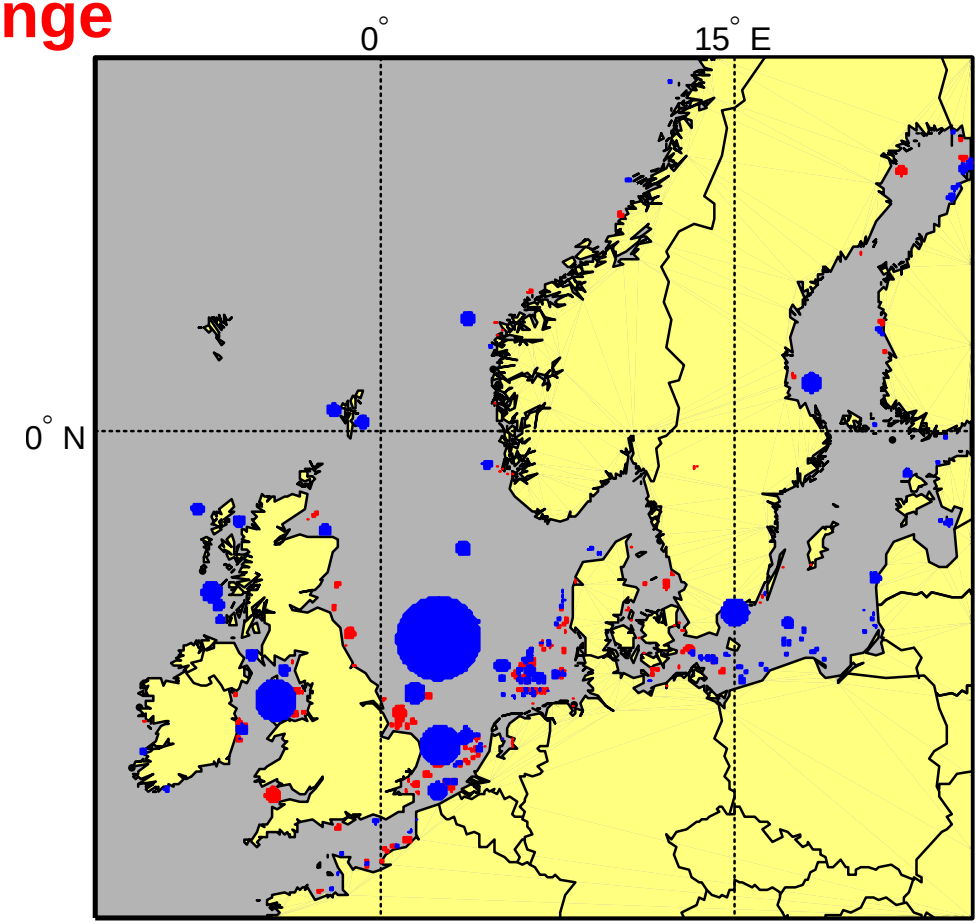
Overall: How scalable and replicable are the results within the entire pan-European electricity system?

2 replication objectives

Demo 4 - The challenge

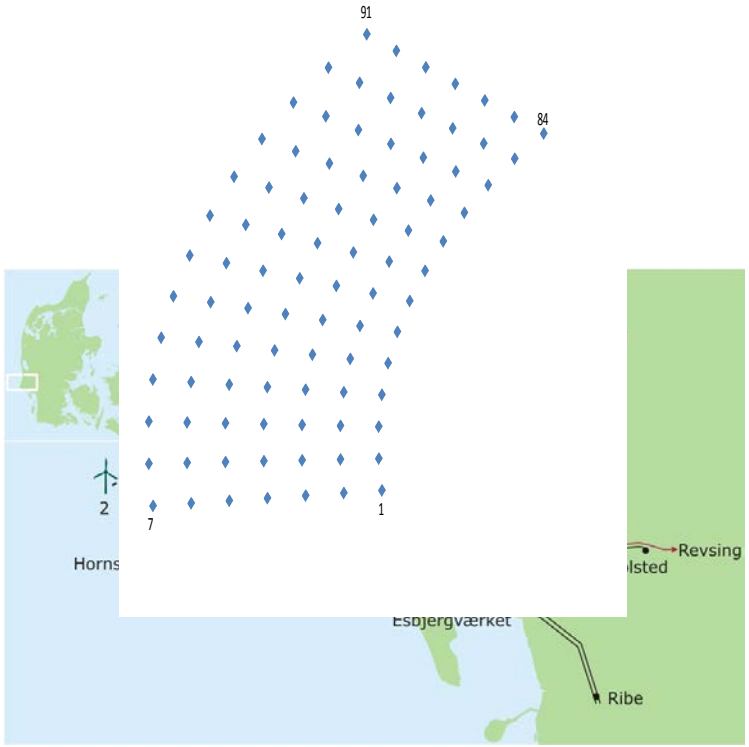
Power System Areas	2020 in MW		2030 in MW	
	Base	High	Base	High
UCTE	21,421	27,675	52,590	69,454
Nordel	4,924	7,019	15,009	20,512
UK+IR	15,130	21,500	37,920	52,090
Total	**41,475**	**5,6194**	**105,519**	**142,056**





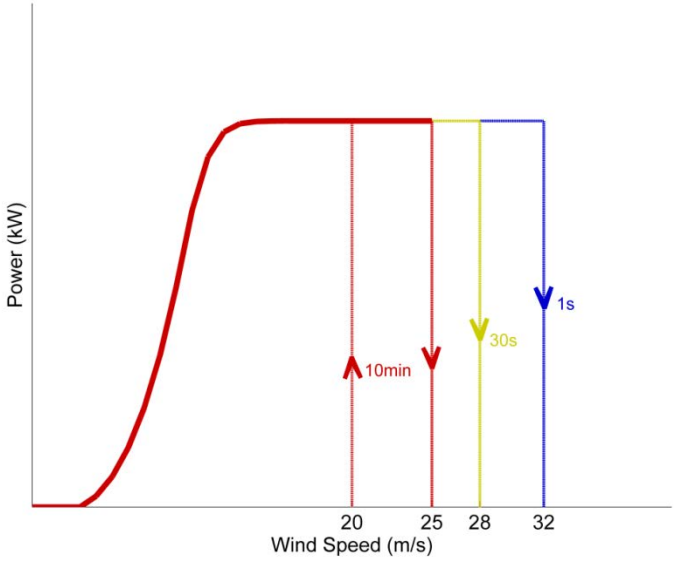
The demonstration

- 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™ - (HWRT)
- 3 years of storms monitored – including both controllers

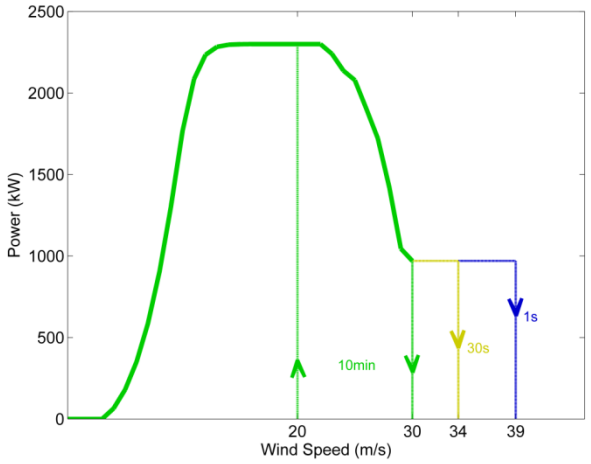


Wind turbine modelling

- **Conventional High Wind Shut Down (HVSD) wind turbine control**



- **Simplified model of Siemens High Wind Ride Through™ - (HWRT)**

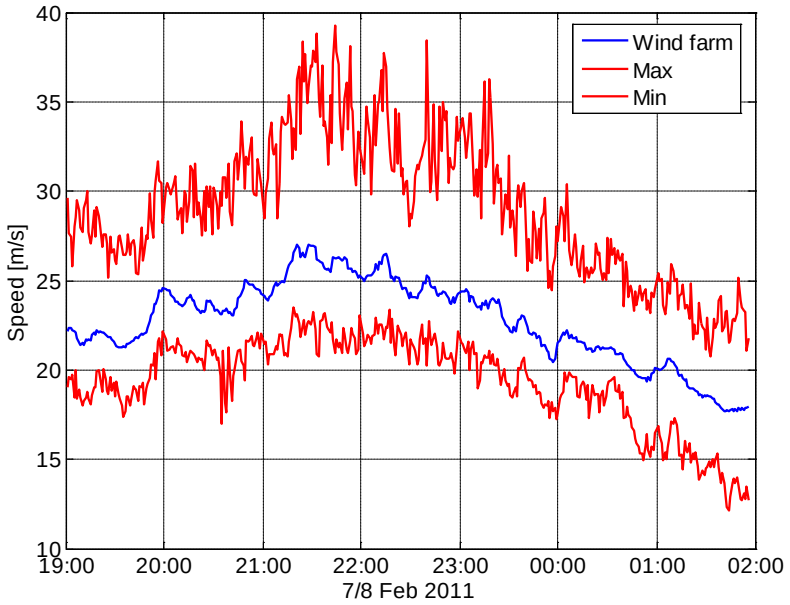


Storm events

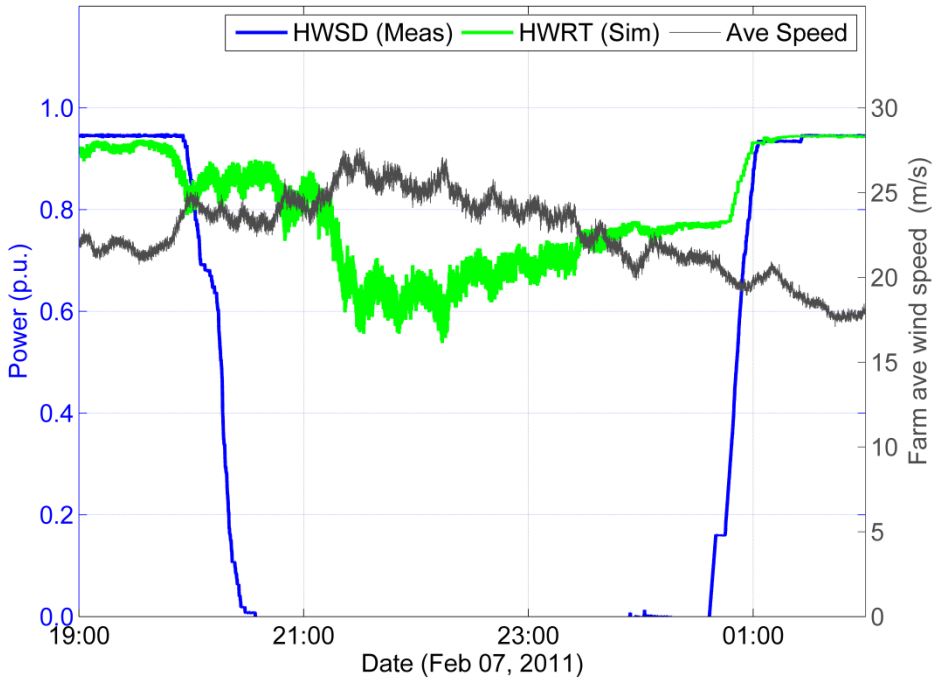
Event nr	Date	Controller
1	11-Nov-10	HWSD
2	12-Nov-10	HWSD
3	07-Feb-11	HWSD
4	24-Sep-12	HWRT
5	14-Dec-12	HWRT
6	30-Jan-13	HWRT

Legend:
HWSD - High Wind Shut Down;
HWRT - High Wind Ride Through

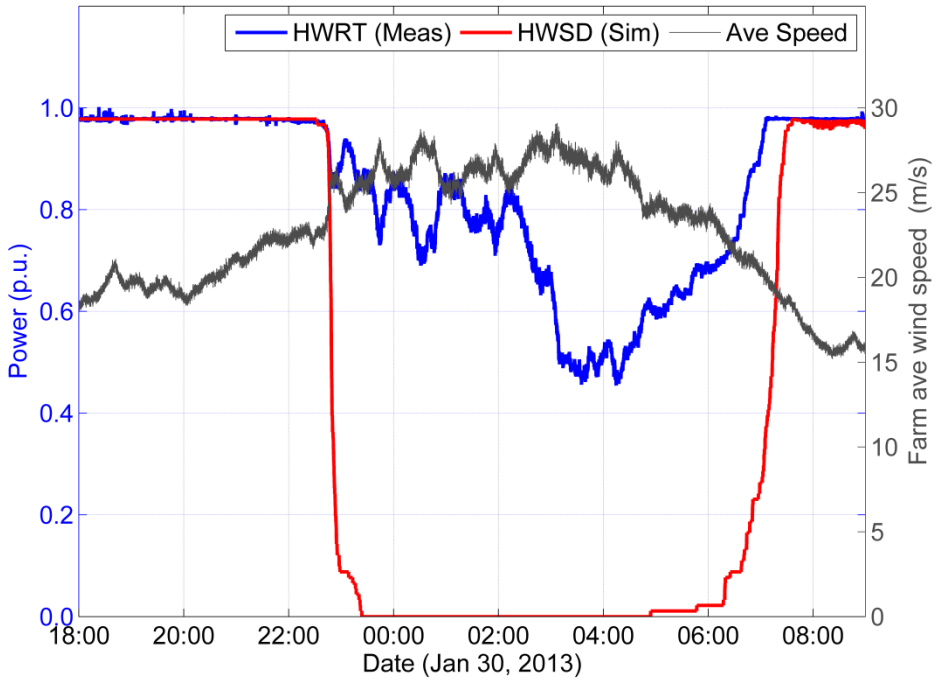
February 7-8 2011



February 7-8 2011

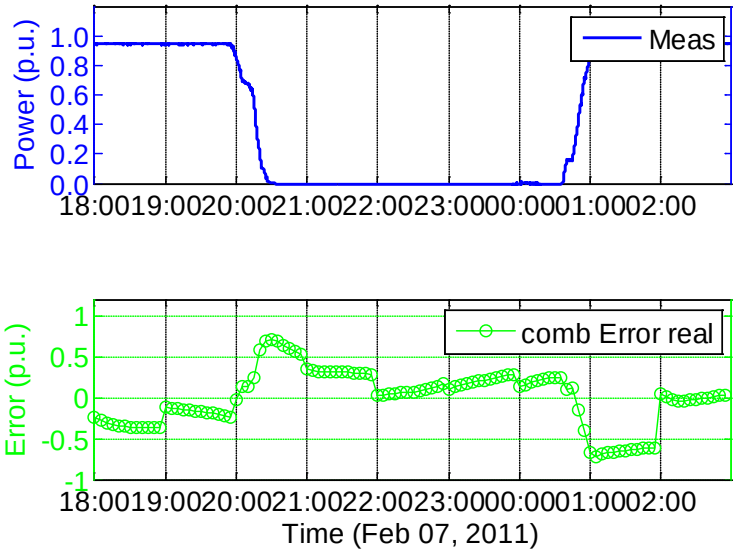


January 30, 2013

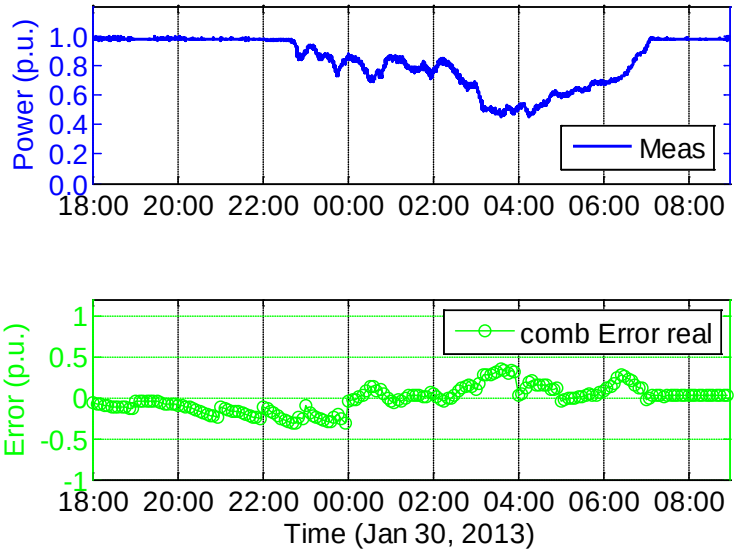


Wind turbine forecast error

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	0.77	0.51
12-Nov-10	0.80		
07-Feb-11	0.72		
24-Sep-12	0.26	0.26	
14-Dec-12	0.18		
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.

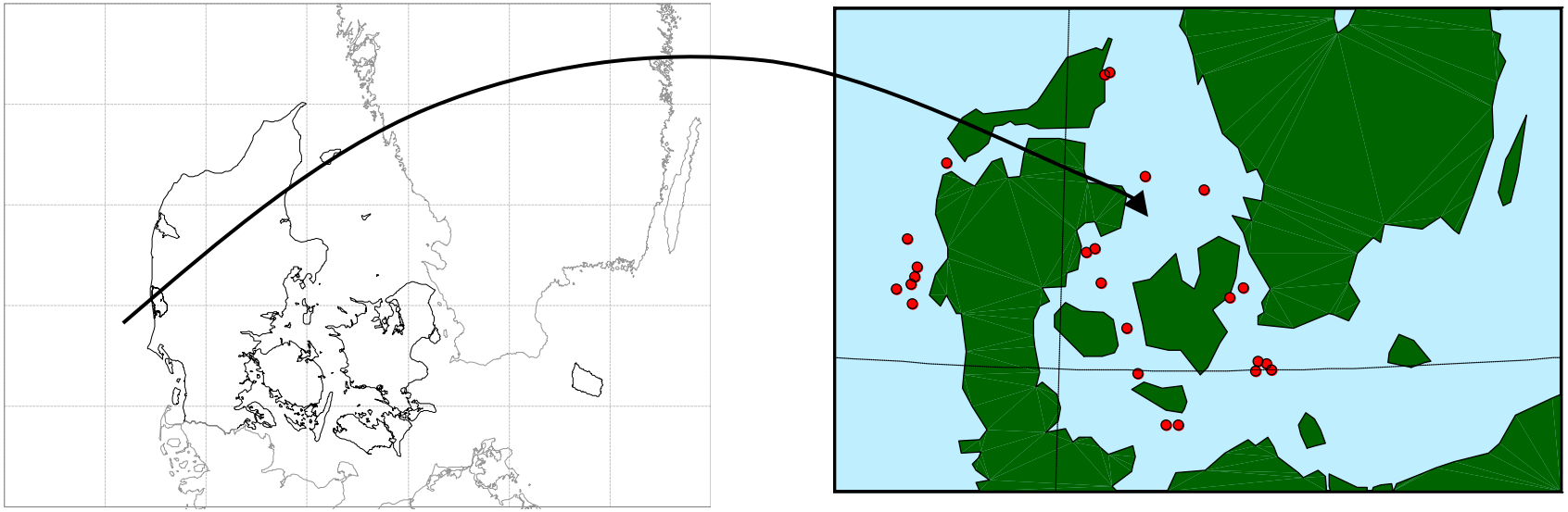
WP 17: EU Offshore barriers (Leader: TENNET)

- 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.

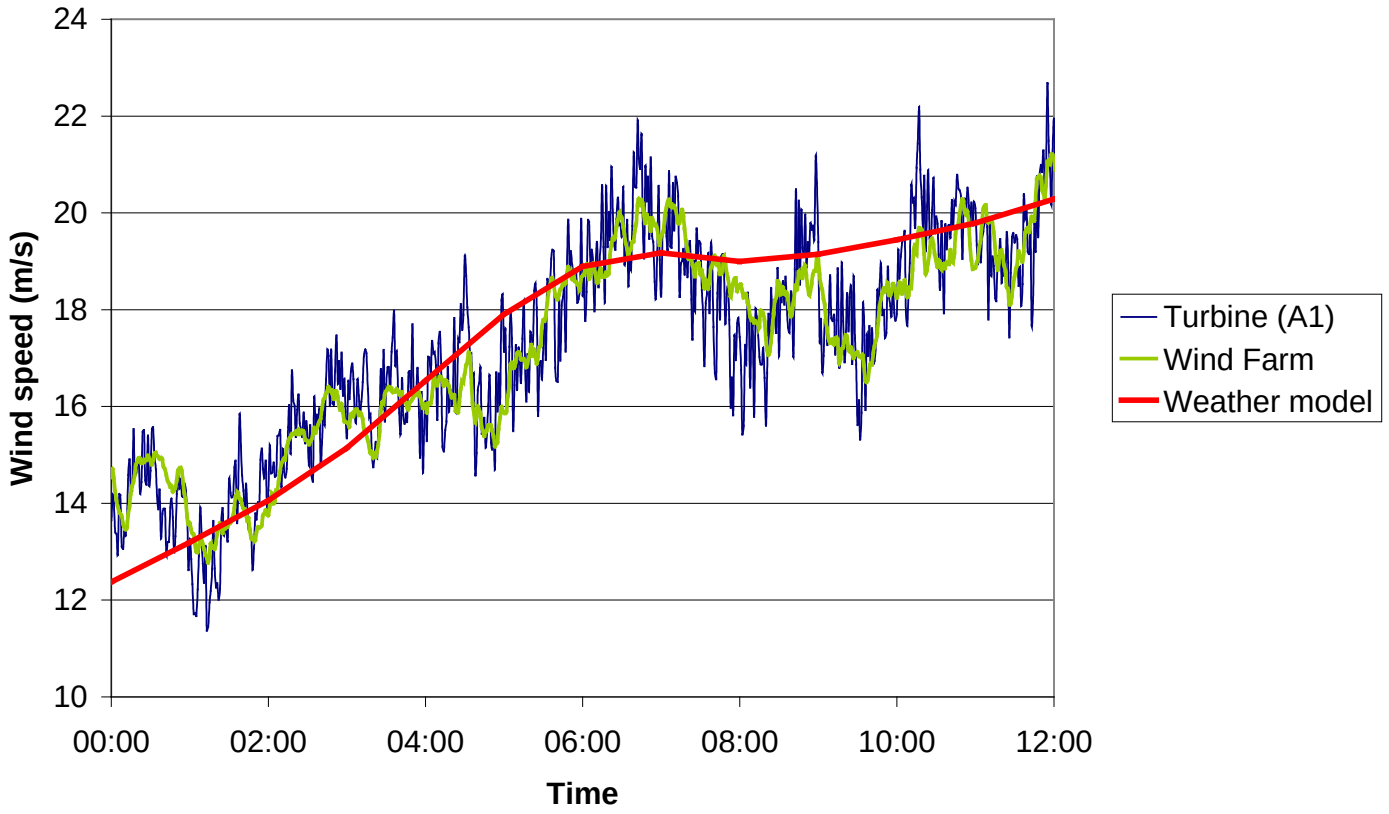
Upscaling of Horns Rev 2 to > 3 GW offshore wind

2020: 2.8 GW

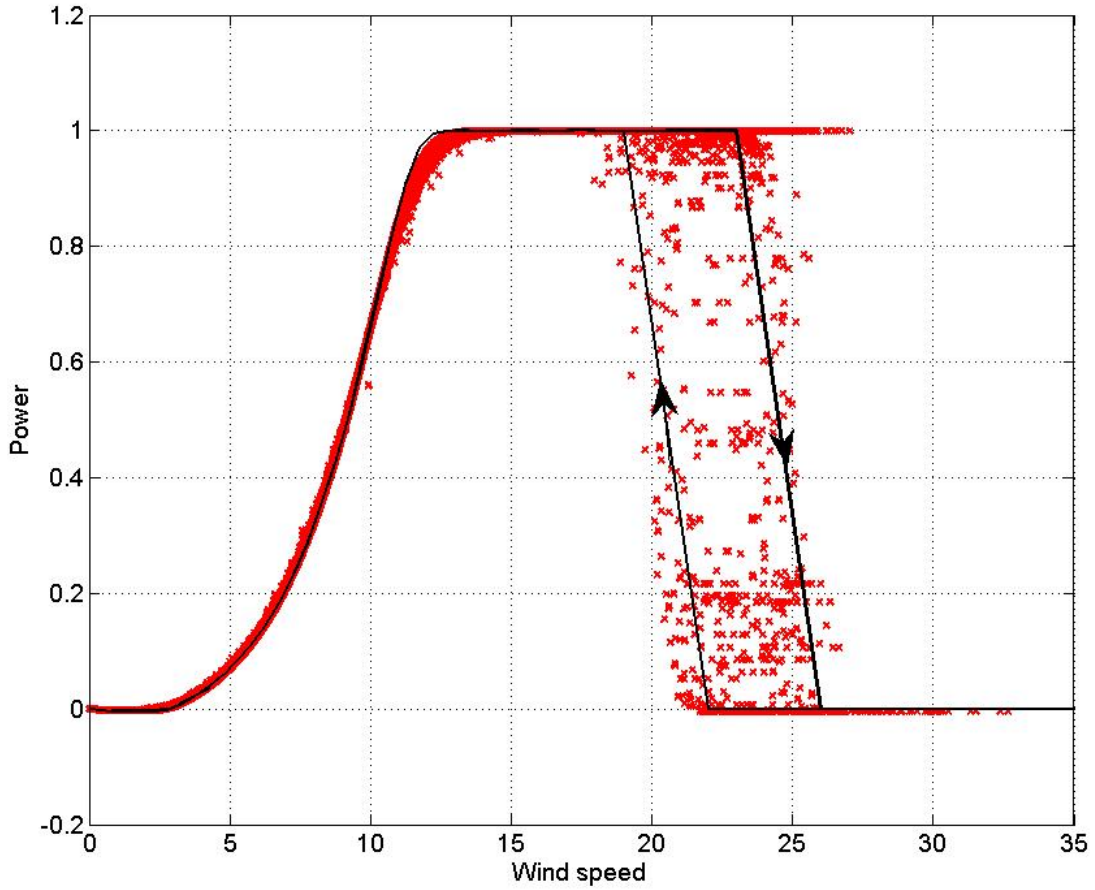
2030: 4.6 GW



Simulation of correlated wind power – CorWind



Aggregated wind farm model

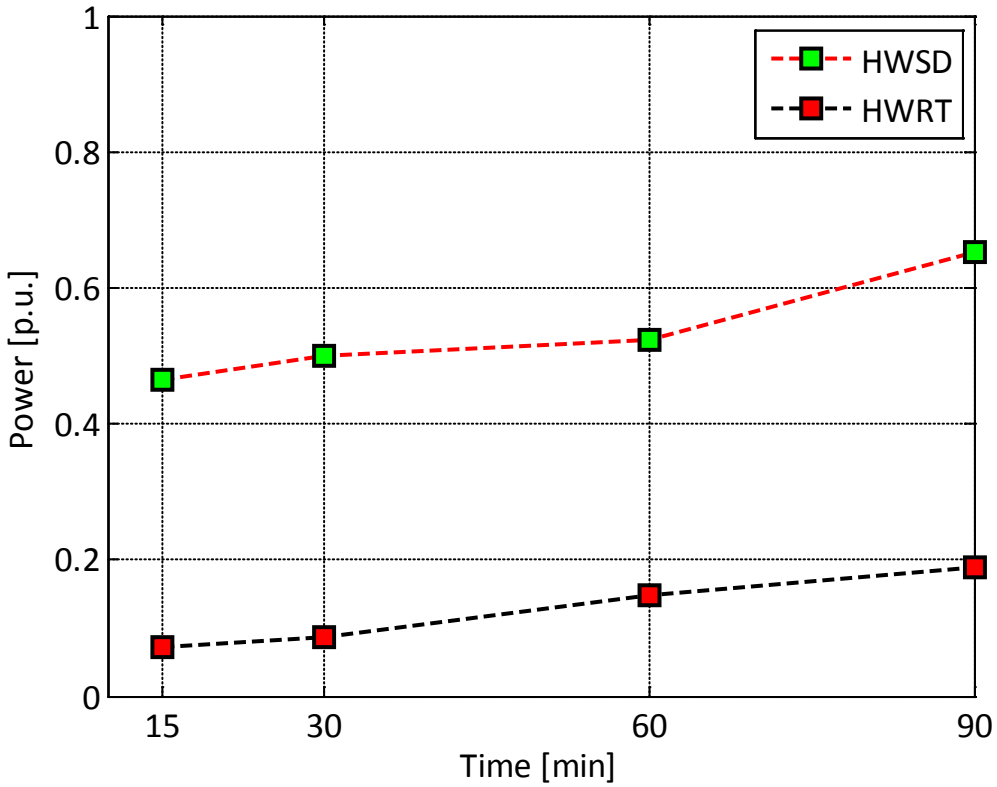


Critical weather periods

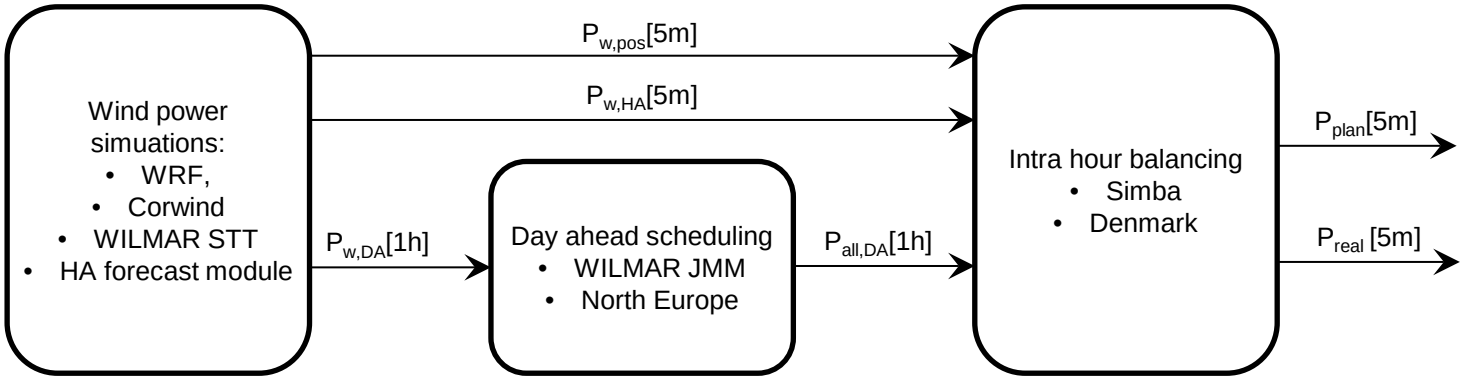
2001	01/01/2001
2005	02/01/2005
2007	01/01/2007
	08/01/2007
	18/03/2007
	27/06/2007
	08/11/2007
2008	25/01/2008
	27/02/2008
2008	21/03/2008
	13/08/2008
	08/11/2008
2009	11/06/2009
	03/10/2009
2010	11/11/2010
	07/02/2010
2011	10/03/2011

Max ramping during storms – 2020

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



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