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

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Department of Wind Energy

IEA Wind, DTU participation phase 3, 22 May 2013, Helsinki
Consortium and budget

10 European Member States
1 Associated Country

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?

**Overall:** How scalable and replicable are the results within the entire pan-European electricity system?
Demo 4 - The challenge

<table>
<thead>
<tr>
<th>Power System Areas</th>
<th>2020 in MW</th>
<th>2030 in MW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>High</td>
</tr>
<tr>
<td>UCTE</td>
<td>21,421</td>
<td>27,675</td>
</tr>
<tr>
<td>Nordel</td>
<td>4,924</td>
<td>7,019</td>
</tr>
<tr>
<td>UK+IR</td>
<td>15,130</td>
<td>21,500</td>
</tr>
<tr>
<td>Total</td>
<td>41,475</td>
<td>5,6194</td>
</tr>
</tbody>
</table>

www.twenties-project.eu
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

www.twenties-project.eu
Wind turbine modelling

- Conventional High Wind Shut Down (HVSD) wind turbine control
- Simplified model of Siemens High Wind Ride Through™ - (HWRT)

![Graphs showing power vs wind speed for different control systems.](#)
## Storm events

<table>
<thead>
<tr>
<th>Event nr</th>
<th>Date</th>
<th>Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11-Nov-10</td>
<td>HWSD</td>
</tr>
<tr>
<td>2</td>
<td>12-Nov-10</td>
<td>HWSD</td>
</tr>
<tr>
<td>3</td>
<td>07-Feb-11</td>
<td>HWSD</td>
</tr>
<tr>
<td>4</td>
<td>24-Sep-12</td>
<td>HWRT</td>
</tr>
<tr>
<td>5</td>
<td>14-Dec-12</td>
<td>HWRT</td>
</tr>
<tr>
<td>6</td>
<td>30-Jan-13</td>
<td>HWRT</td>
</tr>
</tbody>
</table>

Legend:
HWSD - High Wind Shut Down;
HWRT - High Wind Ride Through
February 7-8 2011

![Wind speed graph showing speed in meters per second (m/s) from 19:00 to 02:00 on 7/8 Feb 2011. The graph includes three lines representing different datasets: Wind farm, Max, and Min. The Wind farm line is in blue, the Max line is in red, and the Min line is also in red.]
February 7-8 2011
January 30, 2013
Wind turbine forecast error

February 7-8, 2011

January 30, 2013
## Wind turbine forecast error

<table>
<thead>
<tr>
<th>Event</th>
<th>Max forecast error [p.u.]</th>
<th>Average forecast error [p.u.]</th>
<th>Difference [p.u.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-Nov-10</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-Nov-10</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07-Feb-11</td>
<td>0.72</td>
<td>0.77</td>
<td>0.51</td>
</tr>
<tr>
<td>24-Sep-12</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-Dec-12</td>
<td>0.18</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>30-Jan-13</td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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

![Graph showing wind speed over time]

- Turbine (A1)
- Wind Farm
- Weather model
Aggregated wind farm model
## Critical weather periods

<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
<th>Year</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>01/01/2001</td>
<td>2008</td>
<td>21/03/2008</td>
</tr>
<tr>
<td>2005</td>
<td>02/01/2005</td>
<td></td>
<td>13/08/2008</td>
</tr>
<tr>
<td>2007</td>
<td>01/01/2007</td>
<td></td>
<td>08/11/2008</td>
</tr>
<tr>
<td></td>
<td>08/01/2007</td>
<td>2009</td>
<td>11/06/2009</td>
</tr>
<tr>
<td></td>
<td>18/03/2007</td>
<td></td>
<td>03/10/2009</td>
</tr>
<tr>
<td></td>
<td>08/11/2007</td>
<td></td>
<td>07/02/2010</td>
</tr>
<tr>
<td>2008</td>
<td>25/01/2008</td>
<td>2011</td>
<td>10/03/2011</td>
</tr>
<tr>
<td></td>
<td>27/02/2008</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Max ramping during storms – 2020

\[ P_{\text{res}}(n) = P_{\text{mean}} \left[ t(n) - T_{\text{ave}} ; t(n) \right] - P_{\text{min}} \left[ t(n) ; t(n) + T_{\text{win}} \right] \]
Simba + WILMAR Intra hour balancing in storm events

Wind power simulations:
- WRF
- Corwind
- WILMAR STT
- HA forecast module

Day ahead scheduling:
- WILMAR JMM
- North Europe

Intra hour balancing:
- Simba
- Denmark

\[ P_{w, pos}[5m] \]
\[ P_{w, HA}[5m] \]
\[ P_{w, DA}[1h] \]
\[ P_{p, DA}[1h] \]
\[ P_{plan}[5m] \]
\[ P_{real}[5m] \]
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