

WP3 Project achievements: Resources and Energy Yield



THE EUROPEAN ENERGY RESEARCH ALLIANCE DESIGN TOOLS FOR OFFSHORE WIND FARM CLUSTER

Support by















Ciemat

Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas









- 1. General scheme
- 2. Gross energy >Fino1 test case
- 3. Availability Losses
- 4. Summary
- 5. Integration with other WPs







- Input data (10 minutes)
 - Wind speed and direction
 - Data period > From 13/01/2005 to 30/06/2012
 - 8 levels of wind speed (cups)
 - 7 levels of wind direction
 - Temperature (4 levels)
 - Pressure (1 level)
 - Generic Power curve (1.225 kg/m³)





- Output checked
 - Mean wind sped and measured period (before filtering)
 - Mean wind speed, turbulence intensity, coverage and measured period (after filtering)
 - Long term mean wind speed and extended period, free decision
 - Vertical extrapolation between 100m and 120m
 - Gross Energy P50
 - Uncertainties considered









• Long term

Participant	Long term Period	Long term method
1	From Jan 2005 to Dec 2011	No reference, 2% mean wind speed increase attending to variability study.
2	From Jan 1983 to Dec 2012	Long-term correction based on monthly NCAR data.
3	From Jan 1996 to Jun 2012	Long-term correction based hourly MERRA data as the reference source. A matrix correlation method was used.
4	From Jan 1979 to Dec 2011	Long-term correction based on monthly reanalysis data. The MCP method was applied for 12 different directional sectors.
5	From Jun 2005 to May 2012	No reference.
6	From Jan 1981 to Dec 2012	Long-term correction based hourly MERRA data as the reference source. A lineal correlation method was used.



• Long term

Long term mast wind speed (100m level). Mean value +/- 1.5%







• Vertical Extrapolation

- Empirical power law used

Hub height long term mast wind speed (120m level). Mean value +/- 1%





• Gross Energy



Gross Energy (120m level). Mean value +/- 6.5%



- Gross Energy
 - Large deviations in available data coverage
 - Different time periods
 - Long term correlation
 - Hub height extrapolation

Large deviations in Gross Energy



• Uncertainties

Uncertainty/Participant	1	2	3	4	5	6
Wind measurements	Х	Х	Х	-	Х	Х
Long term	Х	-	Х	-	-	Х
Variability period used	Х	Х	Х	-	Х	Х
Vertical extrapolation	Х	Х	Х	-	Х	Х
Power curve	Х	Х	Х	Х	Х	Х
Propagation of power uncertainty for each ten-minute interval to the total energy production	-	-	-	Х	-	-
Statistical error for the energy that is calculated from a sample mean	-	-	-	Х	-	-
Air density	Х	-	Х	-	-	-
Future wind variability 10 year	Х	-	Х	-	Х	X



• Uncertainties







- Uncertainties
 - The final uncertainty is the quadratic sum of all the components uncertainties.
 - A Gaussian distribution of the uncertainty is assumed in all cases.
 - General power curve uncertainty is used in most cases (5%),
 - The sources of the uncertainty are clear but they are not enough to estimate it



• Gross Energy yield P90

Gross Energy P90. Mean value +/- 8.5%





- Virtual data
 - Skiron (mesoescale model)
 - Simulation Period: June 2003-January 2013
 - Good Fit!

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- Virtual data
 - Skiron (mesoescale model)
 - Filtering
 - Vertical extrapolation
 - Long term
 - Gross Energy P50
 - Uncertainty
 - Gross Energy P90









- Virtual data
 - Uncertainties

Gross Energy P90. Mean value +/- 8.5%



3. AVAILABILITY LOSSES



- 600 MW Generic Offshore
 Wind Farm
 - o Inputs
 - Turbine Layout and turbine model
 - \circ Site Wave climate
 - Location of O&M Base (from 10 to 150 km)
 - o O&M Strategy
 - o SWARM Software

Wave Climate	Description	Mean Wind Speed at	% of Time Above Hs Limit		
Scenario		100m [m/s]	1.5 meters	2.0 meters	
1	Benign Climate	9.0	16.5%	6.3%	
2	Moderate Climate	9.4	21.0%	7.4%	
3	Severe Climate	9.5	28.3%	12.6%	

Scenario	Number of Workboats	Number of Helicopters	Wave Hs Limit for Boats [m]
1	5	0	1.5
2	5	0	2.0
3	5	2	2.0

3. AVAILABILITY LOSSES



o Results





- CONCLUSIONS:
 - Gross Energy Estimation:
 - Measured data, large deviations in P90, to minimize this:
 - Define clear filtering rules
 - Define how to estimate the uncertainty
 - Virtual mast is a good solution whenever there is a good correlation!
 - Validate in other offshore locations
 - Availability Losses
 - In a generic 600 MW offshore wind farm the Excess Turbine Availability Loss varies between 0.5% and 10.2% depending on the scenario considered.
 - The results are intended to be used in order to compare different wind farm strategies rather than as absolute energy yield loss factors.





Thank you very much for your attention





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