



IEEE-PES meeting

Modelling of Wind Power Plants

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Company in brief





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Company's portfolio





Common DFIG-based platform





DFIG Operation Principle





1) Rotor fed by converter (adapts U_{stat} and f_{stat} to U_{grid} and f_{grid})

2) Stator is connected and provides power: $P_{net} = P_{stat} - P_{rot}$

3) To keep 50 Hz on stator, rotor field inverts, rotor provides power: $P_{net} = P_{stat} + P_{rot}$

Protection principle during grid fault (nominal op')





1) Fault on the grid <u>w/o protection</u>:

- Rotor currents charge DC-Link
 DC-Link power cannot flow outside
 Too high DC voltage
 => destruction
 2) Fault on the grid <u>w/ crowbar</u>:
 Rotor currents charge DC-Link
 - CR short-circuits rotor, (RSC in diode mode) => DC-Link energy dissipated
 - Crowbar => Induction generator
- 3) Fault on the grid <u>w/ chopper</u>:
 - Rotor currents charge DC-Link
 - CH dissipates DC-Link additional energy
 - Generator control possible => <u>grid</u> <u>support possible</u>







Benefits and future of wind-turbine modelling







Need of wind turbine models



Approach of model validation in Germany



Model insight

Comparison between simulation results and measurements



Benefits and future of windturbine modelling



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Agenda





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WEC model validation in the entire process







Overview of the German technical guideline: TR4









WHO is concerned ?

 All renewable system manufacturers
 (Wind, PV, biomass,...) => same modelling and certification requirements

WHAT is concerned ?

- RMS model of the renewable system

WHERE is the focus on ?

- Model accuracy compared to standardized measurements acc. to *TR3* (equ. to *IEC* 61400-21 2nd Ed) during FRT-Tests
- Definition of baseline requirements

























* average values calculated over the considered interval duration







5°) Quality assessment of the simulation model for P, Q, I,





Calculated deviations:

- Mean values during transient intervals (**E**_{*Trans* K})
- Mean values during stationary

intervals (**E**_{Stat K})

- Positive sequence values during



Total error of simulation model





5°) Quality assessment of the simulation model for P, Q, I,

Calculation of a global deviation for the entire FRT-Test

SM total error =
$$C_A \times E_A + C_B \times E_B + C_C \times E_C$$

Deviation	Weight		
Before fault (<i>E_A</i>)	10 % (C _A)		
During fault (<i>E_B</i>)	60 % (С _в)		
After fault (<i>E_c</i>) clearance	30 % (C _c)		

$$\boldsymbol{E}_{\boldsymbol{K}} = \sum_{K=A}^{K=C} (\boldsymbol{E}_{Trans\ \boldsymbol{K}} + \boldsymbol{E}_{Stat\ \boldsymbol{K}})$$

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Generator detail level	Туре	Applications	Remarks
Full Order Model	ЕМТ	- Fast transients - Electro magnetic interferences	Crowbar firing capabilitie
Enhanced Reduced Order Model (E/ROM)	Usually RMS	- System integration - Stability studies	Crowbar firing capabilities
Reduced Order Model (ROM)	Usually RMS	- System integration - Stability studies	Quick simulatior time

C o m p l e x it y





Reduced order DFIG model triphase











* not compulsary

Agenda





Benefits and future of windturbine modelling



results



Compared items between simulation and measurement







results

Balanced voltage dip down to 45%

2°) Measurement & Result formatting





results





results



Balanced voltage dip down to 45%

5°) Assessing model



Agenda





Benefits of wind-turbine modelling





Goals of keeping modelling

- Avoid expensive equipments

- Better integration into the grid
 - Simulation of complete wind-farms

- Simulation of scenarios not testable in reality (stability risks)

Future of wind-turbine modelling





Future of wind-turbine modelling





Thanks for your attention !





Thanks for your attention !





Backup slides







Equations can be found in:

"Validation of an RMS DFIG Simulation Model according to New German Model Validation Standard FGW TR4 at Balanced and Unbalanced Grid Faults"

Jens Fortmann, Stephan Engelhart, Jörg Kretschmann, Christian Feltes, Prof I Erlich.