European Transmission System Operators

European Wind Integration Study (EWIS) Towards a Successful Integration of Wind Power into European Electricity Grids

Contract number: TREN/07/FP6EN/S07.70123/038509

EWIS

Interim Report-Appendix

June-2008

Content

APPENDIX 1

1. Market Model for Scenario Finding

1.1. Market Modelling Tools

The tools used are based on the SUPWIND set of tools, currently applied and arranged under the SUPWIND project, funded by the EU under the 6th R & D framework program.

For EWIS, the key methodological challenge consists of dealing simultaneously with a complex electricity system in a computationally feasible and consistent way. Given the huge geographical scope of a European wind integration study, a fully integrated solution at the required level of detail is hardly feasible. For this reason a set of models based on the same modelling principles and using the same data bases is combined (cf. **Figure 1-1**.) This set is providing a flexible frame for the wide set of scenarios which are calculated. In the following a brief description of the different modules is given.

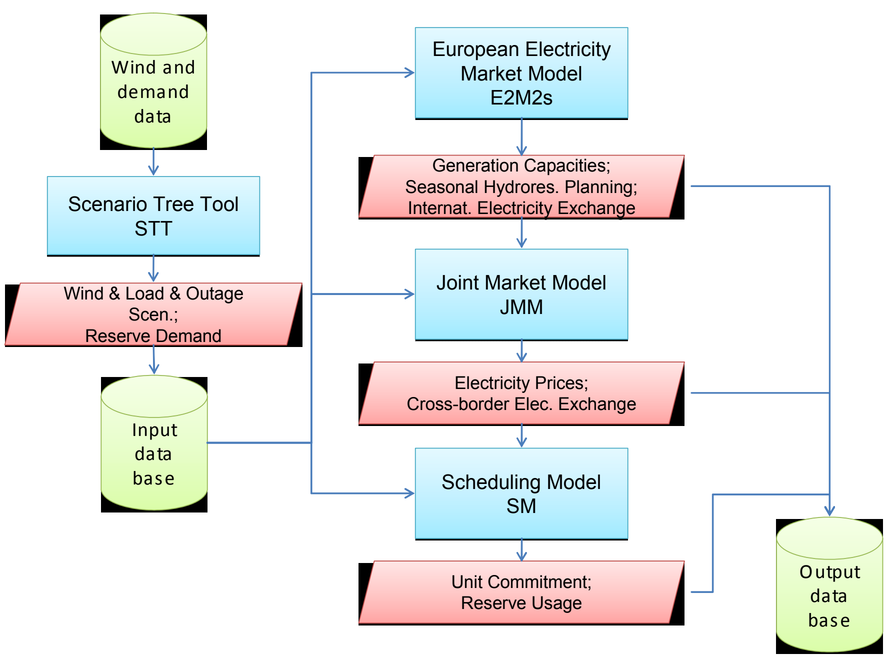


Figure 1-1: Overview of SUPWIND Planning Environment.

The green cylinders are databases, the red parallelograms indicate exchange of information between sub models or databases, the blue squares are models.

1.1.1. Stochastic European Electricity Market Model (E2M2s)

The stochastic European Electricity Market Model (E2M2s) is a strategic planning tool to analyse long-term scenarios of the European electricity market. It explicitly focuses on the impact of fluctuations in renewable energy generation like wind power production on the structure and operation of electricity systems with thermal and hydro power plants. In order to cope with longer time horizons for example up to the year 2015, investments in new conventional power plants are treated endogenously. Results obtained with the model are suitable to assess further the influence of key factors including notably the development of fuel prices, the CO_2 policy and the nuclear policy.

The fundamental approach of the model is based on a cost minimization both considering the operation and extension of the existing European power system. Operational details of unit commitments like start-up costs or lower part-load efficiency of thermal power plants, the use of storage facilities as well as transmission constraints between countries have an important effect on the pricing of wholesale electricity and are consequently treated within the model. Modelling is therefore done with a rather high and flexible time resolution, encompassing currently 12 typical days per year and 12 time segments per day. In addition, the characteristics of the stochastic fluctuations of renewable energy production are taken into account by application of a stochastic approach with recombining trees. This enables both the stochasticity of wind and hydro production to be modelled explicitly.

1.1.2. Joint Market Model (JMM)

The Joint Market model analyses power markets based on an hourly description of generation, transmission and demand. The model is multi-regional consisting of regions connected by transmission lines. It takes into account the balance between supply including net export and demand in each region, capacity restrictions for production units and transmission lines, technical restrictions for power plants including CHP, heat storage, electricity storage (pumped hydro) and hydro reservoirs. It derives hourly electricity market prices from short term marginal system operation costs. This is done on the basis of an optimisation of the unit commitment and dispatch process taking into account the trading activities of the different actors on the considered energy markets. In this model currently two electricity markets, two reserve markets and one market for heat are included:

1. A spot market for physical delivery of electricity corresponding to the spot market at Nord Pool or EEX. This market is typically cleared at 12 o'clock for the following day.
2. A day-ahead market for what in the UCTE terminology is named primary and secondary reserves, i.e. automatically activated reserve power (frequency activated or load-flow activated). The demand for these ancillary services is determined exogenously to the model.
3. An intra-day market for handling deviations between expected production and demand agreed upon the day-ahead market and the realized values of production and demand in the actual operation hour. The demand for regulating power is caused by the forecast errors associated with wind power production and electricity consumption.
4. An intra-day market for positive reserves with activation times longer than 15 minutes and for forecast horizons from 15 minutes to 36 hours ahead (in the following named tertiary reserves). The demand for tertiary reserves may be calculated by the Scenario Tree Tool (see below).
5. Due to the interactions of CHP plants with the day-ahead and the intra-day market, intra-day markets for district heating and process heat are also included in the model. The heat demand is given exogenously.

The model is defined as a stochastic linear programming model. Thereby, the stochastic part is represented by a scenario tree for possible wind power generation forecasts, electricity demand forecasts and demand for tertiary reserves for the individual hours. The advantage of the stochastic modelling approach is that the best operation schedule (and corresponding electricity prices) may be derived, when the uncertainty of wind forecasts is taken into account. Yet the JMM may also be run in a deterministic version – speeding up computation and reflecting a situation, where the market participants do not anticipate wind stochasticity in their bids. In rolling planning mode, both the stochastic and deterministic version may be run with wind forecast errors included or turned off. When including wind forecast errors, the repeated planning completed in the rolling planning mode reflects then the effect of wind forecasts being gradually updated.

The JMM uses an exogenously specified portfolio of power plants, transmission lines and storages. It interacts with E2M2s by receiving a power system portfolio calculated by E2M2s.

1.1.3. Scheduling Model (SM)

Depending on the size of the scenario, trees used in the JMM, the stochastic optimisation induces quite long calculation times to solve the problem. Therefore when dealing with larger model areas e.g. a model area covering Denmark, Finland, Germany, Norway and Sweden as used in previous studies, it was considered necessary to introduce a linear approximation of the unit commitment in the JMM to avoid the usage of integer variables thereby saving calculation time.

Although the linear approximation is suitable in model runs, where individual power plants are aggregated into unit groups, such as for the large model area mentioned above, detailed analysis of costs connected to wind power integration requires unit commitment with integer variables. For this purpose the Scheduling Model (SM) has been developed.

The SM is equal to the JMM except that unit commitment is completed with integer variables making the model a mixed integer, stochastic (or deterministic) programming model. The SM is suitable when analysing a smaller model area (e.g. one market area or one synchronous area) with a detailed representation of power plants. The JMM will be used to provide boundary conditions for the smaller model areas treated with the SM. The boundary conditions can be transmission exchange schedules and/or price interfaces calculated with the JMM.

1.1.4. Scenario Tree Tool (STT)

The Scenario Tree Tool (STT) generates scenario trees containing three stochastic inputs to the Joint Market Model and Scheduling Model: the demand for positive reserves with activation times longer than 15 minutes and for forecast horizons from 15 minutes to 36 hours ahead (in the following named tertiary reserves) as well as forecasts of wind power production and of load. The determination of the tertiary reserve demand by the Scenario Tree Tool allows quantifying the effect forecast errors have on the tertiary reserve requirements for different forecast horizons. Furthermore the Scenario Tree Tool generates time-series describing forced outages of conventional power plants.

The implications of increased wind power production are manifold. The focus of this study is on the implications at the interface between markets and grid operation. Obviously the market modelling provides results on unit commitment and dispatch, which are used as input to load flow simulations and the other planned forms of power system analysis (cf. EWIS WG 3). Those will help answering the question, whether it is still possible to operate the grid safely under these conditions.

On the pure economic side, the quantification of integration costs of wind certainly stands out as a primary objective. Thereby the results of the market models can be used. However, it should be considered that integration costs partly also result from changes in the power plant portfolio. But those are also quantifiable within the integrated modelling environment to be used here.

Besides the immediate economic consequences, the model results can also be devoted to the analysis of possible responses to the new challenges arising from an increasing amount of electricity produced from intermittent renewable sources. The results from the market model are helpful for looking at the impact of market and reserve allocation rules on wind integration feasibility and costs. Thereby, conclusions can be derived based on the modelling results obtained in the previous working packages.

1.2. Data used for market modelling

EWIS is collecting the relevant data for the modelling of the year 2015 from the members of the UCTE. A TSO questionnaire was sent out to obtain necessary data from TSOs to perform costing.

1.2.5. Data for wind scenarios

EWIS uses optionally the TradeWind data set for the wind power installed capacities all over Europe and for the wind time series[1].

1.2.6. Data for international power exchange

To find out the future wind power in-feed impacts EWIS uses the Net Transfer Capacities (NTC) of the European Countries identified by the TSO questionnaire.

The power-flow based market modelling requires power transmission distribution factors (PTDFs) to compute the interregional power flows. Those are taken from existing studies as far as the existing grid is concerned. They have however to be adapted to account for the foreseen grid extensions.

[1] TradeWind cooperation for synergies: TradeWind and EWIS concluded a Memorandum of Understanding for information exchange and distribution of work. EWIS has access to the TradeWind data set.

1.2.7. Data for power plant dispatch and market modelling

For a detailed modelling of market mechanisms and resulting power plant dispatch, the data used are summarised in the table below. Those are taken from various sources, including existing studies, TSOs own data and expert estimates.

Table 1: Data for power plant dispatch and market modelling

Data Object
Fuel data - Carbon and Sulphur content, heating values - Fuel prices (Euro/GJ)
Electricity consumption - Hourly electricity demand - Yearly electricity demand
Heat consumption in district heating grids - Hourly heat demand (MWh/h) - Yearly heat demand
Need for reserve power - The demand for primary and secondary reserve power - The demand for tertiary reserves
Thermal units (all data exclude the power consumption of the plant itself): - Fuel type - Generation type (dispatch or must-run) - Maintenance schedule - Maximum capacity (MW) - Minimum stable running level (MW) - Minimum down time (h) - Minimum up time (h) - Ramp rates when starting up - Start-up time (h) - Start-up energy - Data describing the fuel consumption (heat rate characteristics) - Reserve characteristics (ability to provide reserves for primary, secondary and tertiary reserves)

Data Object
- CHP plants: C_V and C_B factors
Heat pumps - Coefficient of performance (COP) factors
Hydro power with reservoir - Time series describing the hydro power inflow during the year - Maximum and minimum energy content of reservoir - Optimal hydro reservoir filling degree during the year
Run-of-river - Time series describing the hydropower production during the year
Pumped hydro storage - Maximum and minimum content of reservoir - Efficiencies when pumping and generating - Restrictions on the operation of the pumps
Heat storages - Maximum content of heat storage - Efficiency of heat storage
Taxes and tariffs: - CO2 emission permit price

APPENDIX 2

2. Validation of Wind Turbine Models

2.1. Introduction

The European electricity network is the route for the efficient transport of wind power from turbines to consumers. It also provides the means for managing the variability of wind generation by harnessing diversity and backup energy sources. To meet Europe's renewable energy targets, changes are needed in order to most efficiently integrate wind power. In order to better analyse the future development of RES generation in Europe, thorough examinations will be performed at a European level to find cost effective solutions to maintain system stability and security, providing impact on the electric infrastructure as a whole and the future tasks for infrastructure development.

For the purpose of this study wind turbine equivalent models are used, based on publicly available data, endorsed by wind turbine manufacturers, validation and information within simulation tool packages. Some of these sources are listed in the List of References. The report shows an overview over the model representation in all relevant software packages for power system simulation as MODES, Netomac, PowerFactory, PSD, PSS-E, etc.

The complexity of the models used for the actual study has on the one hand to be exact enough with respect to the dynamic behaviour of the turbine, fulfilling all grid code requirements in Europe but on the other hand be suitable for large-scale grid studies. Therefore, simplified wind turbine models are used in EWIS that perform the typical response of each technology (see 2.3).

Measurements for wind turbine models in the form of certificates and bilateral analysis together with manufacturers are available, but related to specific wind turbine architecture virtually confidential. The described standard models are derived from specific WT-models given by manufacturers with respect for power system analysis. For the completion of the report the cooperation to TradeWind is an opportunity to implement real measurements for the general types of wind turbine models.

2.2. Current wind power supply and harmonised models for wind turbines

For the regional and pan-European investigations it is necessary to find out the most convenient and realistic distributions for wind power supply. Steady state analysis and the grid expansion/re-enforcement measures will depend on this subject.
As wind power has the highest growth of all RES, transient analysis is focused on the impacts of introducing wind power into the power system. Therefore special wind turbine models are used, e.g. the following aspects are taken into consideration:

- Wind turbines (WT) equivalents for grid connections in distribution and high voltage systems.
- Regional distribution of different WT-technology related to the installed capacity
- Different operation modes of WT-models in accordance to grid requirements
- Representation and distribution of old installations which can not or through retrofitting fulfil new grid code requirements (e.g. fault-ride-through behaviour)

As the use of wind power plants increases worldwide, it is important to understand the effect these power sources have on the operation of the grid. Transmission System Operators (TSOs) focus their attention on the system interaction of the various wind turbine types and the differences compared to conventional power plants as power plants have to provide system services to enable the steady operation of a grid. There are different wind power technologies. The three most commonly used technologies will be taken into consideration for this study:

- The squirrel cage induction generator (with or without fast voltage support)
- The doubly fed induction generator and
- The full size inverter model.

The required behaviour of different WT-technologies is considered and implemented in the dynamic equivalents:

- Reactive power generation and voltage control capability
- Behaviour in case of system faults
- Frequency control and others
- Damping of inter-area oscillations (control capability of global swings).

The WT equivalents cover steady state, short circuit and stability calculations for the different operation modes of WT-models dependent on the national grid code requirements (e.g. FRT-capability, disconnection).

2.3. Test System

The wind turbine models used within the study have been verified using a simple test system with an infinite bus, a voltage source transformer and the respective wind turbine, see (**Figure. 2-1**), the tap changer is fixed:

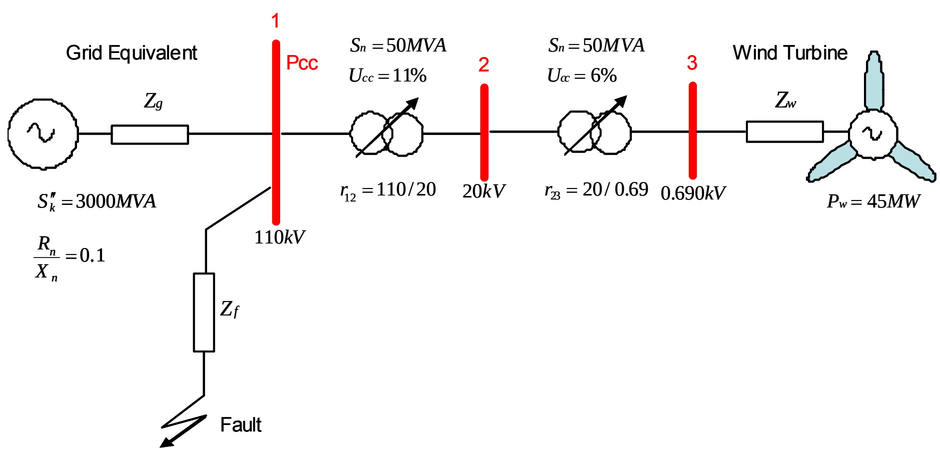


Figure. 2-1: **Test system**

Generator Types

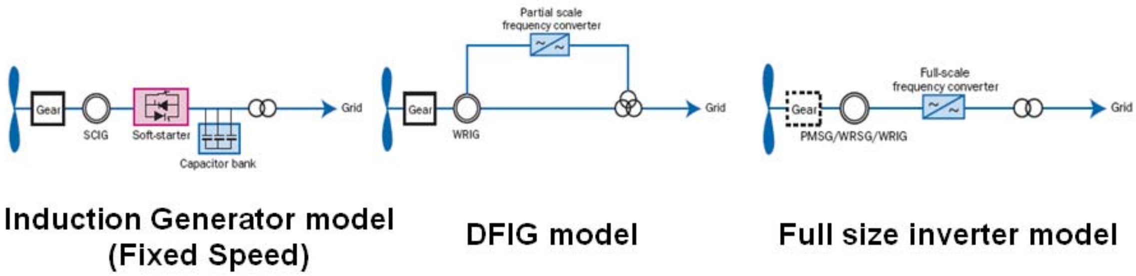


Figure 2-2: **Different Wind Turbine Types**

It has been decided, that three types of wind turbine should be taken into account, These are

a) The squirrel cage induction generator (with or without fast voltage support)

b) The doubly fed induction generator and

c) The full size inverter model.

For the two latter ones, the reactive power exchange at the point of common coupling is set to zero.

2.4. Grid Connection Requirements

Currently there are several grid connection requirements for wind turbines valid in several TSO regions, some examples are shown in Figure-2.3.

Special characteristics, such as fault ride through capability; voltage support or voltage control depend on the national grid codes.

One of the study´s objectives is to investigate the effect of grid codes changes or their adaptations on overall system behaviour.

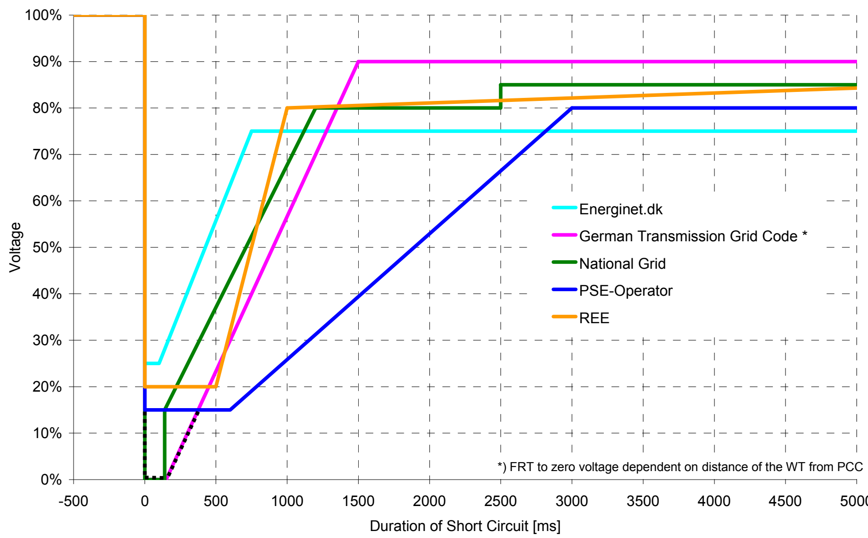


Figure 2-3: **Voltage dip ride through requirements in Europe**

Thus, to achieve this goal with the models used in this study, a calibration possibility is required which enables the turbine models to fulfil grid code requirements e.g. with respect to

- Fault Ride Through Capability,
- Contribution to voltage support characteristics,
- Contribution to frequency maintenance.

2.5. Type of Investigations

To compare the behaviour of the wind turbine models, several investigations have been made connecting the different wind turbine types to the test system.

A 150 ms symmetrical three-phase short circuit at the point of common coupling (PCC) bus has been simulated with a voltage dip at the 110 kV node to:

- 80%,
- 50% and
- Below 20% of nominal voltage

To calculate the fault impedance to reach the desired voltage dip, the methodology of IEC [17] has been used.

- To obtain the voltage of 0.2 p.u. at the PCC, the fault reactance is set to 0.965 Ω.
- To obtain the voltage of 0.8 p.u. at the PCC, the fault reactance is set to 15.45 Ω.

Asymmetrical faults have not been investigated because no influence on the overall system security is expected.

2.6. Conclusion

The results of the different wind turbine models connected to the test system have been compared and evaluated. It was concluded that the respective wind turbine models, which are used in the study, behave in a way they are expected to, after initiated faults in the test system. Some exemplary graphics calculated with several software tools are shown in the exemplary results. The results show slight differences based on different grid codes or turbine technologies e.g. the protection scheme or different control strategies. These differences could further be adapted to each other, but for the purpose of this system study it was decided that their influence on the overall system behaviour is negligible.

This report gives an exemplary result for the Doubly Fed Induction Generator WT Model (Appendix). Similar investigations have been carried out for the remaining two types of the WT models namely squirrel Cage Induction Generator and Full Converter Model. The detailed results of all types of WT Models based on various grid code requirements are documented in the report 'Wind Turbine Model Validation Report' which is available with the EWIS First Year deliverables' at the EWIS homepage.

For the vision 2015, based on the technical investigation, EWIS will find out the best option to set minimum Pan European harmonized requirements for WT models behaviour which will ensure safe and reliable operation of the European Power System. By this minimum guidance, those TSOs who have not yet developed their own customized Grid Code requirements for wind power plants can benefit.

EWEA Feedback on the 'EWIS-Wind Turbine Model Validation Report

⇒ EWIS received EWEA Feed Back to Wind Turbine Model Validation Report

⇒ Provision of Real Measurements

⇒ WT-Model Validation discussed with EWEA adds more value to EWIS investigations.

EWEA
WIND IS POWER

DATE: TUESDAY, OCTOBER 28, 2008

Send to: Wilhelm Winter	From: Frans Van Hulle
Office Location:	Phone Number: 00 32 2 546 1987
Fax Number: +49 921 915-4149	Number of Pages, Including Cover: 11

✓ URGENT ☐ REPLY ASAP ☐ PLEASE COMMENT ☐ PLEASE REVIEW ☐ FOR YOUR INFORMATION

COMMENTS:

Presentation of ABB with comments on EWIS Wind turbine validation report

- **EWEA -** Time duration for the grid disturbance (150 ms) is not sufficient to demonstrate the reactive current support and active power production during the voltage dip-

  EWIS have used even longer time duration like 500 ms and the WT models fulfill the requirements like reactive current support and active power production during voltage dip. (SeeFigure 2-4)

- **EWEA -** EWIS WT model's excessive crowbar operation time:100ms-

  With the available experience of the TSOs the average timing for crowbar firing is 100 ms, still EWIS WT models are capable of using 40ms time for the crowbar firing and shows satisfactory performance of the reactive power infeed during fault duration. (SeeFigure 2-4).

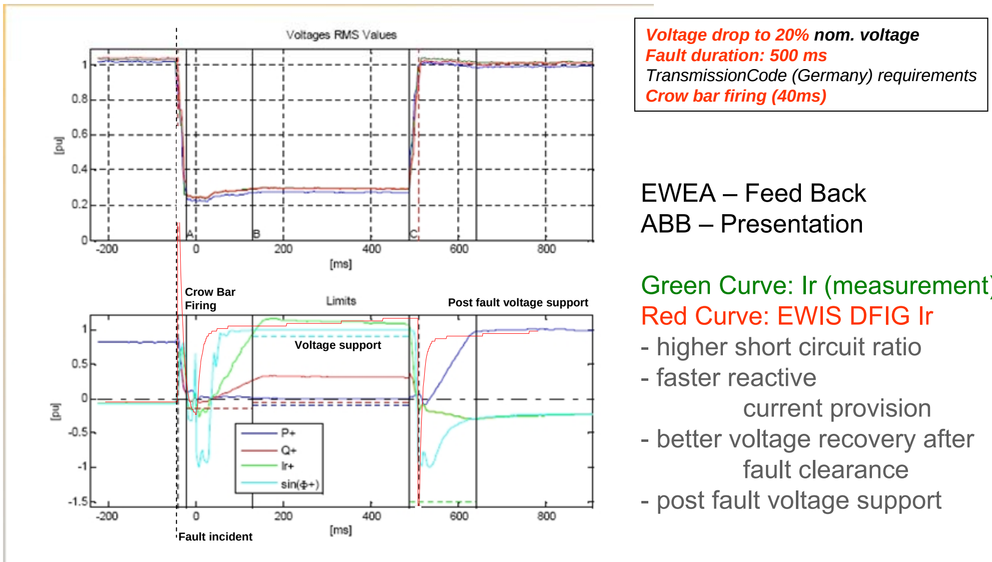


Figure 2-4**: EWIS Results compared with the Real measurement provided by EWEA**

- **EWEA –** Capability of EWIS WT models for using 3rd order or 5th order transient model for DFIG

  The 5th order transient model is useful for local behaviour (regional level). It will have no influence on global system behavior (EWIS - Global level project).
  EWIS WT models are capable of using both 3rd order and 5th order transient models. . It was agreed for stability studies the 3rd order model is appropriate.

EWIS models shows satisfactory response for each technology of WT – evidence by EWEA feed back after the EWIS – EWEA wind turbine model validation meeting on 12th of December 2008, Renewable Energy House in Brussels.

Summary of Feedback

- EWIS is thankful to EWEA for their feedback on the EWIS-Wind Turbine Model Validation Report.

- EWIS WT models are updated to fulfill additional requirements asked by EWEA such as crowbar firing time, fault duration and the 3rd and 5th order transient models.

- EWIS WT models are simplified for the Extra High Voltage level but detailed enough to show the desired WT behaviour on the Extra High Voltage level for the EWIS study.

- The simulation results shown in the presentation confirms that EWIS WT models fully satisfy the criteria '**simplification and accuracy**' required for the Global level investigation such as EWIS.

- All meeting participants agreed that wind turbines are well represented by the presented EWIS standard wind turbine model behaviour, all the open questions were discussed and solved.

- The meeting participants agreed that EWIS can start the investigation based on the represented wind turbine behaviour presented during the EWIS-EWEA wind turbine model feed back meeting on 12th of December 2008, Renewable Energy House, Brussels.

2.7. System Parameters

Table 1 Additional System Parameters

System Component	Parameter	Value
Equivalent Grid	c – Factor	1.
	Voltage Magnitude Setpoint	1 pu
	Voltage Angle Setpoint	0°
Transformer 110/20 kV	Copper Losses – P_{Cu}	0 kW
	No Load Current – I_0	0 %
	No Load Losses – P_{Fe}	0 kW
	Vector Group HV-Side	YN
	Vector Group LV-Side	YN
	Phase Shift	0°
Transformer 20/0.69 kV	Copper Losses – P_{Cu}	0 kW
	No Load Current – I_0	0 %
	No Load Losses – P_{Fe}	0 kW
	Vector Group HV-Side	YN
	Vector Group LV-Side	YN
	Phase Shift	0°

The fault reactance in case of U_{RES}=0.2pu is equal to 1Ω and in case of U_{RES}=0.8pu is equal to 15.5Ω.

Table 2: Parameter of DFIG

Parameter	Value	Unit
P_n	1500	[kW]
U_n	690	[V]
x_n	U_n^2/P_n	[Ω]
l_n	x_n/ω_1	[H]
p	2	
ω_1	$2\pi f_n$	[rad/s]
f_n	50	[Hz]
r_1	0.008 x_n	[Ω]
r_2’	0.008 x_n	[Ω]
l_{1s}	0.080 l_n	[H]
l_{2s}’	0.080 l_n	[H]
l_h	3.0 l_n	[H]
l_1	$l_h + l_{1s}$	[H]
l_2	$l_h + l_{2s}$’	[H]
kP and kQ	3.56 e-5	[V/W]
TiP and TiQ	0.0128	[s]
W21	2.7	

Table 3: Parameter of DFIG transformed into p.u.-system

Parameter	Value
R_s	0.008 p.u.
X_s	0.080 p.u.
X_m	3.0 p.u.
R_r’	0.008 p.u.
X_r’	0.080 p.u.

The following settings are recommended:

Table 4: Summary of electrical parameter settings

Parameter	Value
S_n	51.379 MVA
U_n	0.69 kV
n_0	1500 rpm
R_s	0.008 p.u.
X_s	0.080 p.u.
X_m	3.0 p.u.
R_r'	0.008 p.u.
X_r'	0.080 p.u.
Slip Range	± 20%
U_{ROTrat}	1939V
I_{ROTmax}	32.45kA *)
R_{CROW}	0.16pu
$P_{SET\text{-}POINT\_PCC}$	45 MW
$Q_{SET\text{-}POINT\_PCC}$	0 Mvar
$P_{SET\text{-}POINT\_GEN\_STATOR}$	38 MW
$Q_{SET\text{-}POINT\_GEN\_STATOR}$	7 Mvar
C_{DC}	144412.8 µF
$S_{GridFilter}$	20MVA
$U_{N\_GridFilter}$	0.69 kV
$u_{K\_GridFilter}$	31.8%
Copper Losses Grid Filter	21 kW

*) Such a high value results from the assumption of the basis current for the rotor one of the software tools

Table 5: Summary of mechanical parameter settings

Parameter	Value
Base Power – P_{BASE}	5 MW
Turbine Damping - D_{TUR}	0 Nms/rad
Inertia of the Turbine – J_{WTR}	$6.1 \cdot 10^{6}$ kg m^2
Inertia of the Generator – J_{GEN}	101.72 kg m^2
Shaft Damping - D_{SHAF}	$1.4 \cdot 10^{6}$ Nms/rad
Stiffness Constant – k_{ms}	$8.3 \cdot 10^{7}$ Nm/rad
Nominal Angular Speed of Turbine	18 rpm
Inertia of Equivalent Generator - J_{EQV}=30xJ_{GEN}	3051.6 kg m^2

Assumptions:

- Transformers: $P_{cu} = P_{Fe} = 0$ MW
- Grid equivalent: voltage factor c = 1.0 .

In order to transform the equivalent grid parameters into the p.u. system, some calculations are necessary:

$$\left|Z_g\right| = \frac{c \, x \, U_1^{\,2}}{S_k^{\,''}} = \frac{1.0 \, x \, (110 kV)^2}{3000 \, MVA} = 4.033 \, \Omega$$

$$\left|Z_g\right|^2 = \left|R_g\right|^2 + \left|X_g\right|^2 \quad and \quad \frac{R_g}{X_g} = 0.1 \;\Rightarrow \left|X_g\right| = 4.013 \, \Omega \quad and \quad \left|R_g\right| = 0{,}4013 \, \Omega$$

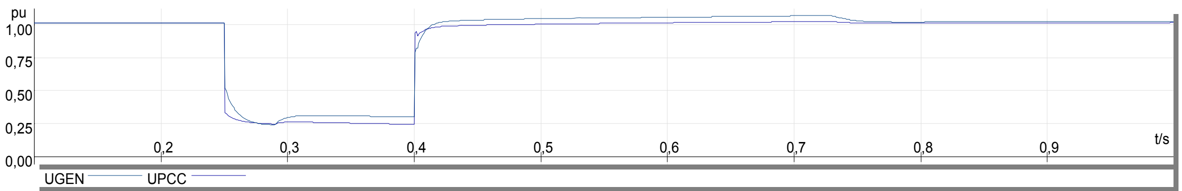
Visualisation of the results:

The example of the DFIG during a symmetrical three phase fault at the 110 kV PCC with UFault = 0.2 p.u. for a wind farm with P = 30 *1,5 MW with voltage support is shown, visualizing a simulation period of 1 second. The other respective investigations on different turbine types and grid faults have been executed accordingly, but are not documented in this report.
In terms of comparison, the following variables have been visualized and compared:

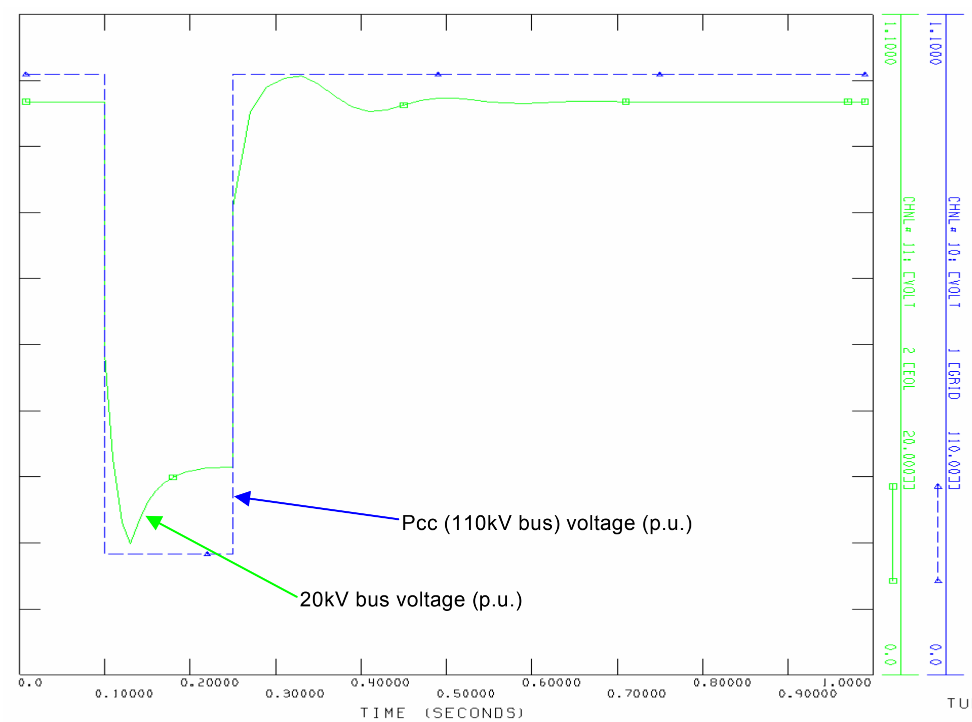
- The generator voltage at the 20 kV generator bus bar and the 110 kV point of common coupling (PCC) in [p,u].
- Active and reactive power in [MW] resp. [MVar] at the 110 kV PCC,
- Active and reactive current in [kA] or [p.u.] at the 110 kV PCC,

Exemplary results for the DFIG, exposed to a 150 ms three phase Test Fault with U_{Fault} = 0.2 p.u.

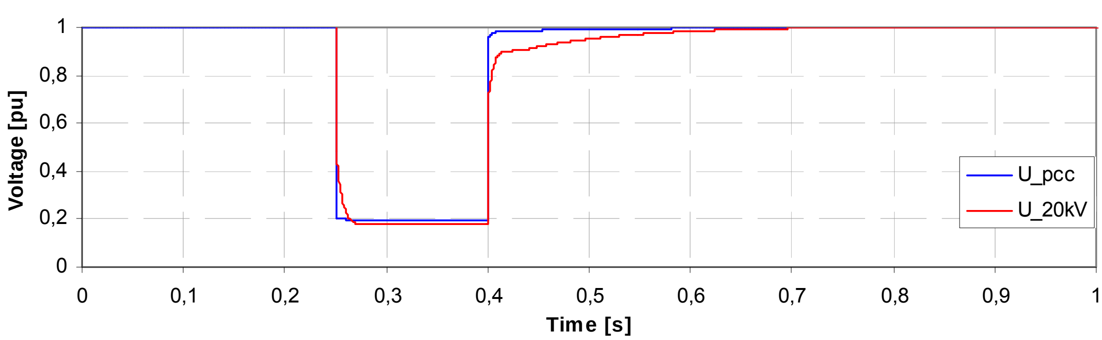
Voltage profile:



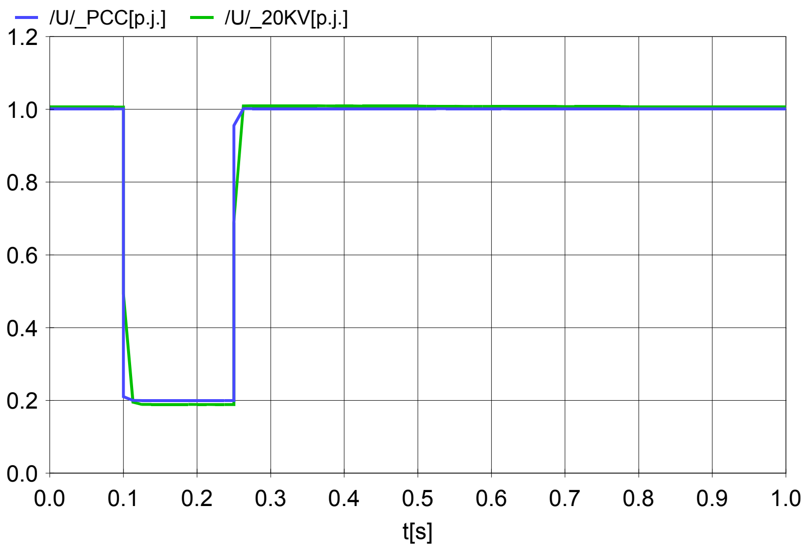
Software 1, Grid Code 1, Protection Scheme 1



Software 2, Grid Code 2, Protection Scheme 2

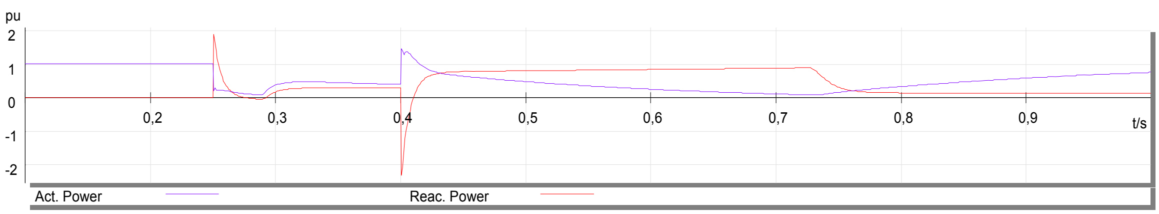


Software 3, Grid Code 3, Protection Scheme 3

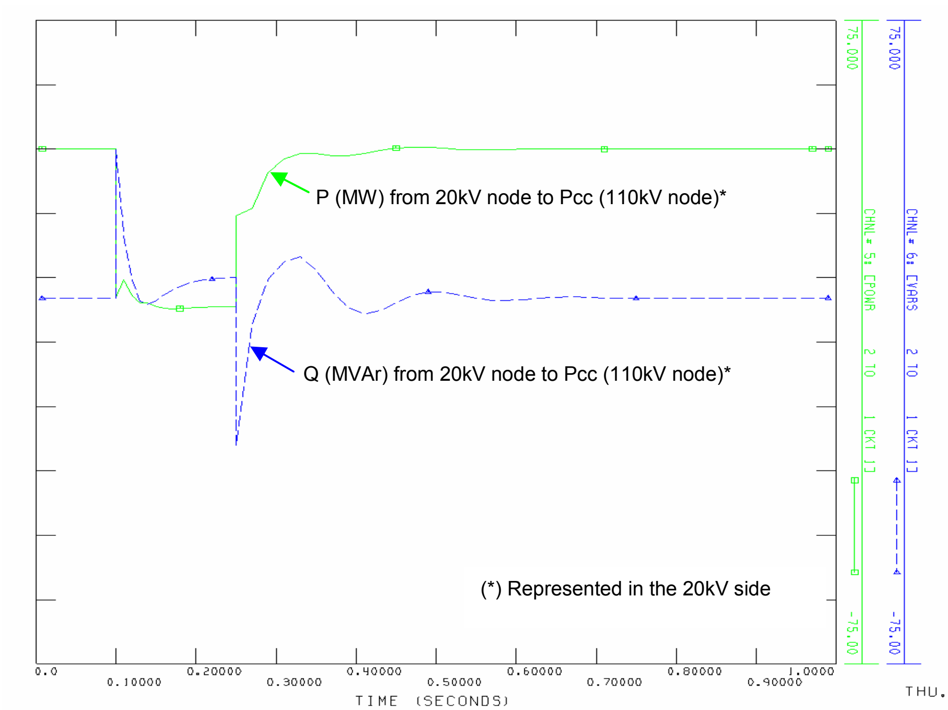


Software 4, Grid Code 4, Protection Scheme 4

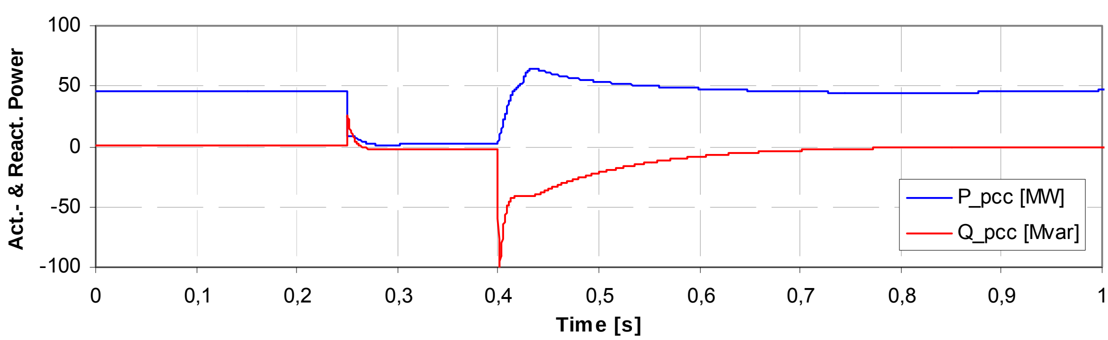
Active Power and Reactive Power:



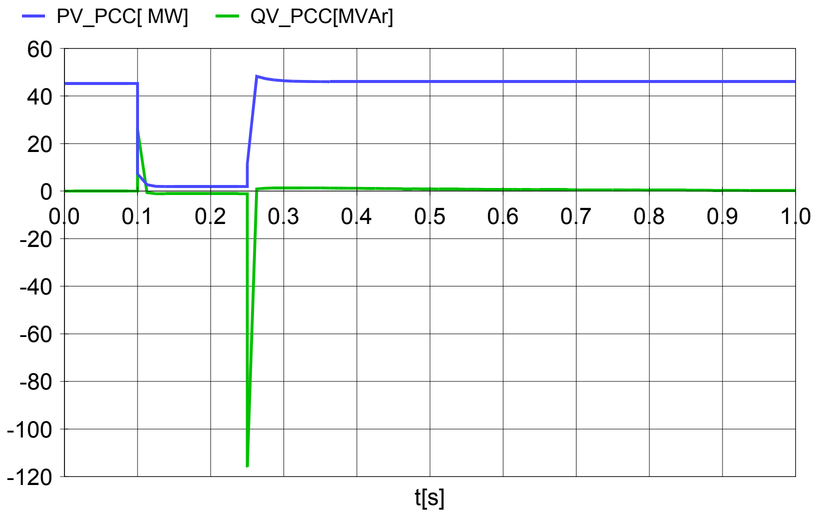
Software 1, Grid Code 1, Protection Scheme 1



Software 2, Grid Code 2, Protection Scheme 2

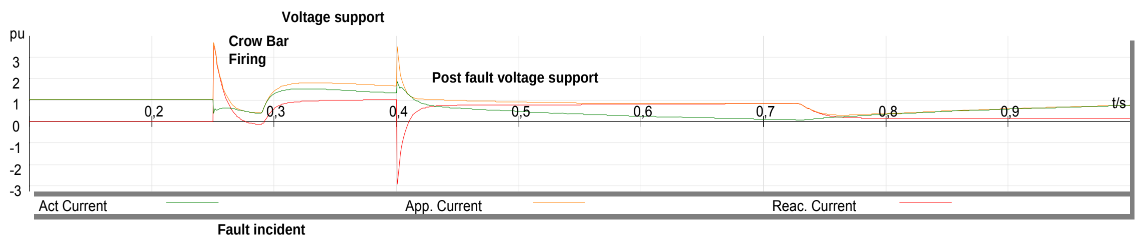


Software 3, Grid Code 3, Protection Scheme 3

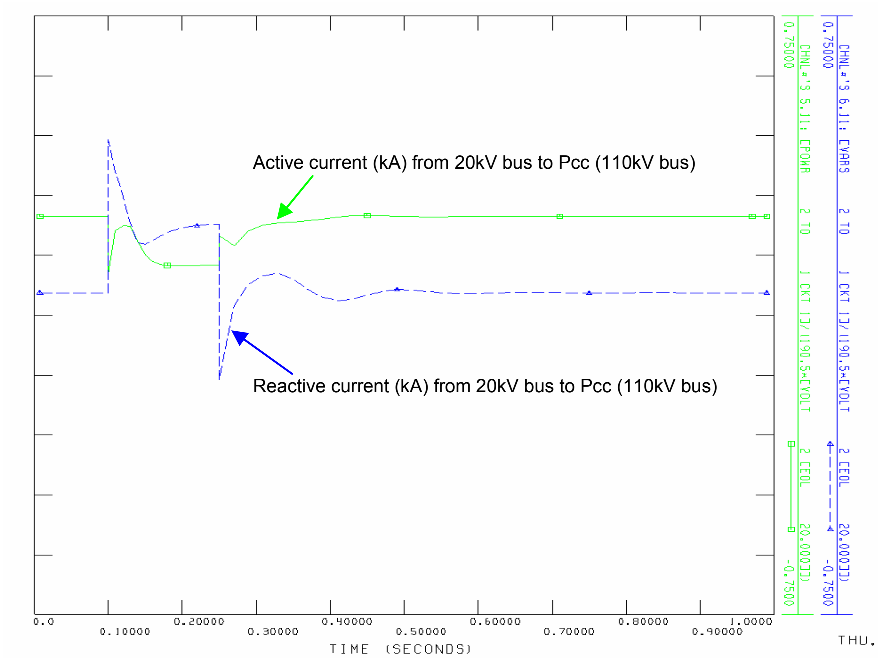


Software 4, Grid Code 4, Protection Scheme 4

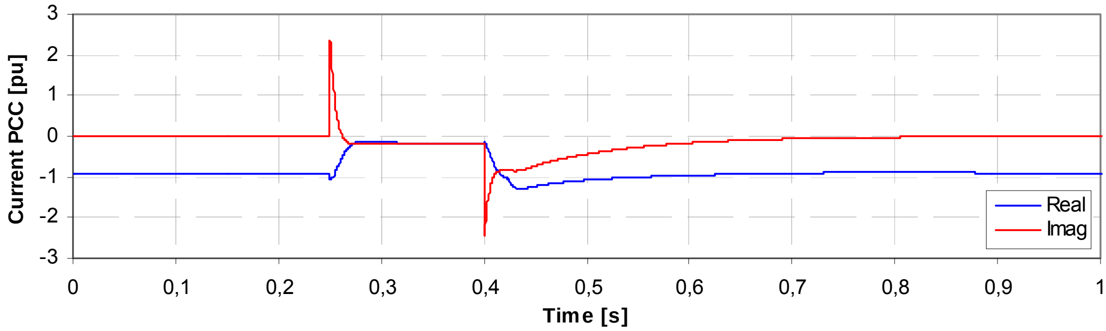
Active Current and Reactive Current:



Software 1, Grid Code 1, Protection Scheme 1



Software 2, Grid Code 2, Protection Scheme 2



Software 3, Grid Code 3, Protection Scheme 3

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