Result comparison from simulation and measurement on wind power plant

F. Rajský [1], M. P. Donsión[2], F. T. Oliveira[3]

[1] Department of Electrical Power Engineering and Environmental Engineering
Faculty of electrical engineering, The University of West Bohemia in Pilsen
Univerzitni 8; 306 14 Pilsen; Czech Republic
phone: +420 776 8605232, fax:+420 37 7634301, e-mail: rajsky@kee.zcu.cz,

[2] Electrical Engineering Department, Vigo University, Spain
Department of Electrical Engineering, University of Vigo, Campus of Lagoas Marcosende, 36310 Vigo (Spain),
IEEE, EA4EPQ and AEDIE member, donsion@vigo.es

Department of Electric Engineering, School of Technology and Management of Leiria
Polytechnic Institute of Leiria; Campus 2 - Alto do Vieiro, Morro do Lena, Leiria, Portugal
Phone: (+351) 244 820 331, e-mail: ftadeu@yahoo.com

1. Brief introduction

The aim of this paper is to measure the quality of power coming from the wind power plant to the electrical distribution network. The quality of electrical energy includes many parameters but the main thesis target is to measure a harmonic frequency of current.
I used the program Matlab for the simulation of the connection between the wind power plant and the electrical network. I simulated startup of the wind turbine and changes of wind flowing. Obtained data were plotted on graphs which show harmonic frequencies of current based on these changes.

Key words:

Wind turbine, power quality, modeling of wind power plant, harmonic frequency

2. Simulation process

Traditionally, the formal modeling of systems has been via a mathematical model, which attempts to find analytical solutions to problems which enable the prediction of the behavior of the system from a set of parameters and initial conditions.
While computer simulations can use some algorithms from purely mathematical models, computers can combine simulations with reality of actual events, such as generating input responses, simulating test subjects which are no longer present. Whereas the missing test subjects are modeled, the system they use could be the actual equipment, revealing performance limits or defects in long-term use by the simulating users.
Due to the mentioned reason it is possible only to recommend to create always a special model, which will represent a concrete surveyed physical effect and simulate some definite property namely according to the following progress on figure 1.

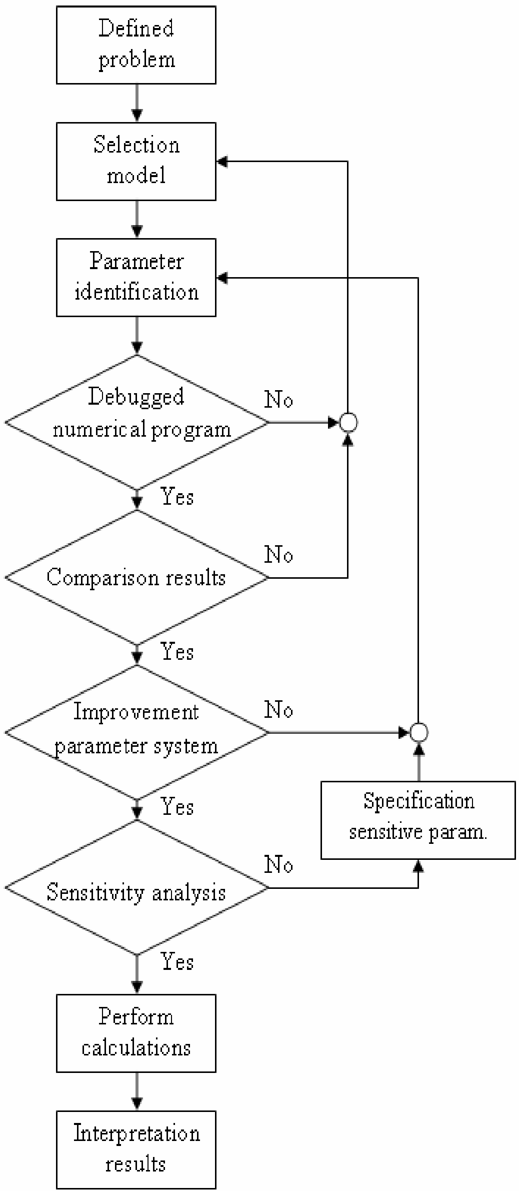

Fig. 1 Simulation process

3. Simulation by Mathlab

In the figure 2 is shown model of wind turbine. The current, voltage measurement and regulation values are situate on right side. Input values like wind speed or wind power and wind trip are simulate in blue box. On the left side from wind generator are transformers, loads, distribution network with fault box in the middle and the last box on the left side is transmission network.

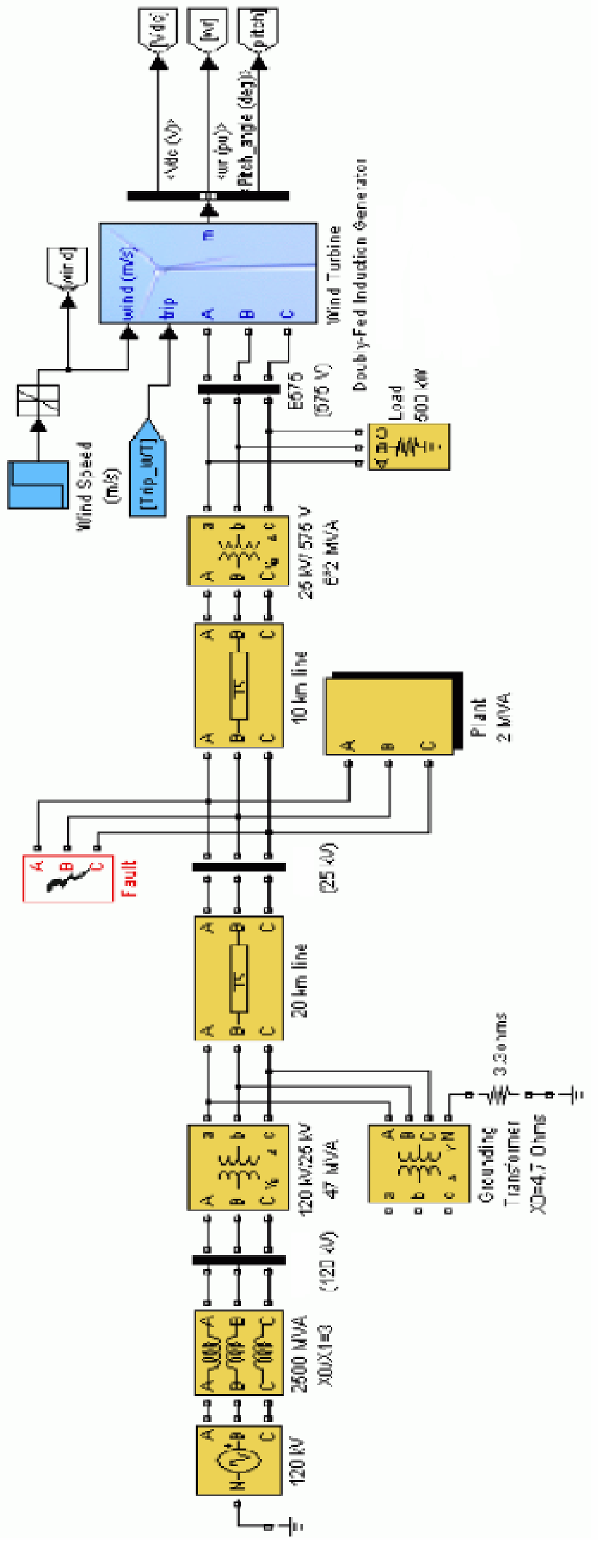

Fig. 2 Distribution network and wind turbine

4. Frequency

The concept of energy quality enables the analyst to account for the previous indirect as well as direct requirements of energy flow. Such total energy flow requirements are analogous to cost in economic analysis. Because the calculation of those energy requirements is based on a set of processes operating at optimum energy efficiency, the energy quality calculations are assumed to identify the total energy cost that is in balance with maximum utility.

Ideally electric power would be supplied as a sin wave with the amplitude and frequency given by national standards UCTE (Union for the Co-ordination of Transmission of Electricity) 50 Hz or system specifications (in the case of a power feed not directly attached to the mains) with an impedance of zero ohms at all frequencies.

Harmonics become apparent when a distorted sinus curve is mathematically analyzed. Through Fourier analysis, an arbitrary periodic function can be divided into a number of sine waves. The example below shows that the distorted curve consists both of the fundamental frequency (50 Hz) and of super-imposed 5th (250 Hz) and 7th (350 Hz) harmonic frequencies.

A harmonic filter usually consists of a capacitor which is connected in series with impedance. The components are dimensioned to create a series resonance circuit for a required frequency. The harmonic filter works like a short circuit at one or more specified frequencies.

Real 24 hours measurement is shown in the first graph. During these 24 hours, wind flowing is low, starting increasing in the end of measuring interval. In this graph, curve of 50 Hz is not shown.

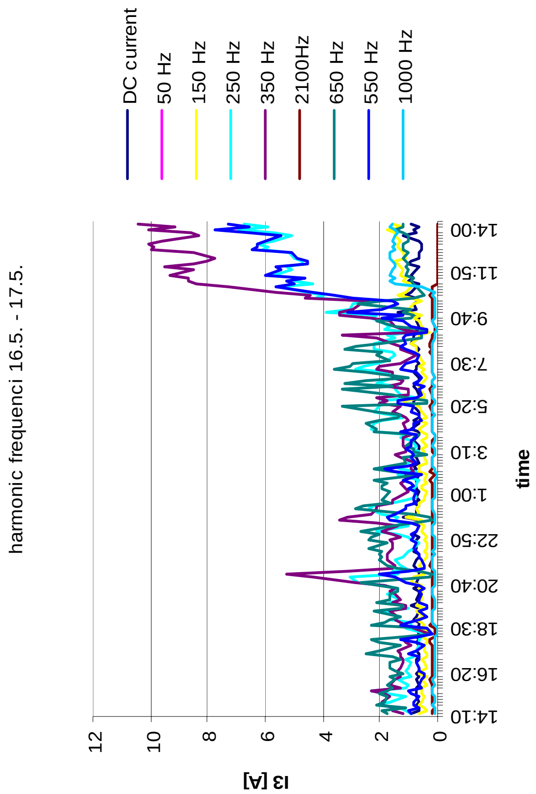

Fig. 3 Harmonic frequency curve during 24 hours

.

For the simulation I chose two different time and different situation. The situation with low and high flow wind is shown in these simulations. Each harmonic frequency is measured separately and for better evaluation it is shown in different scale.

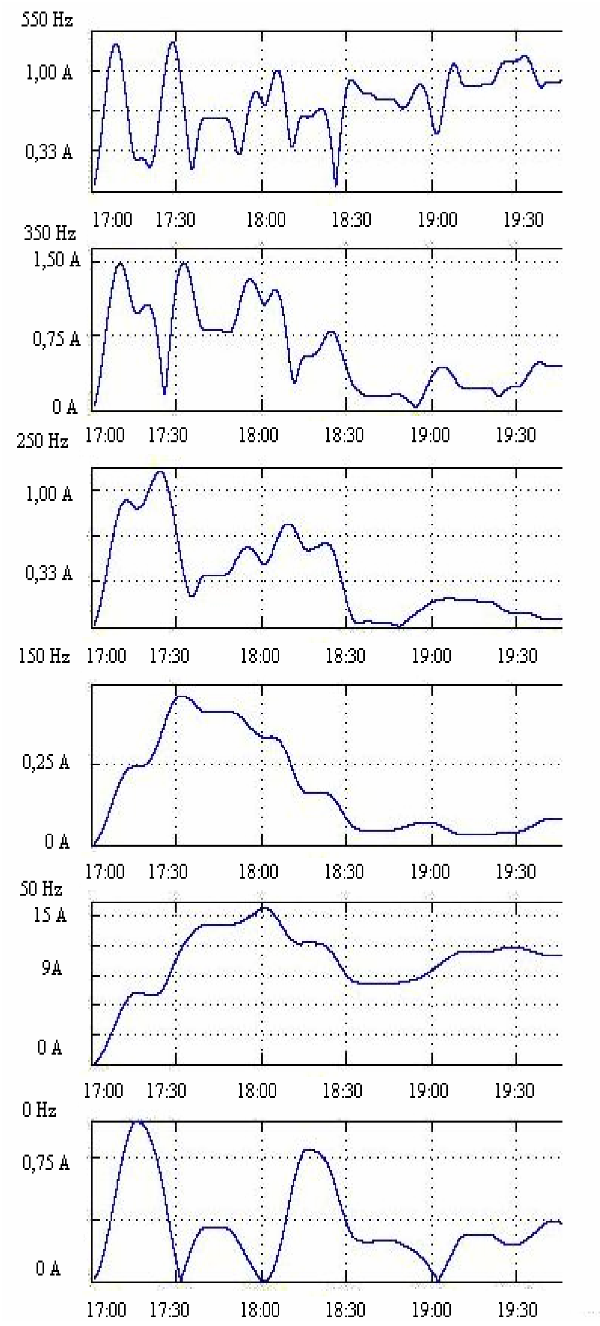

Fig. 4 Simulation of low wind flow

By comparison of these two graphs with the graph of measured values it can be concluded that the wind turbine simulation was correct.

The highest harmonic frequency 7th has its maximum on 3 % from 1st harmonic. Moreover, all harmonic together have maximum value 8 % from 1st harmonic frequency. The converter used in this wind power plant produce insignificantly harmonic frequency.

The modeled situations are similar to measured situations.

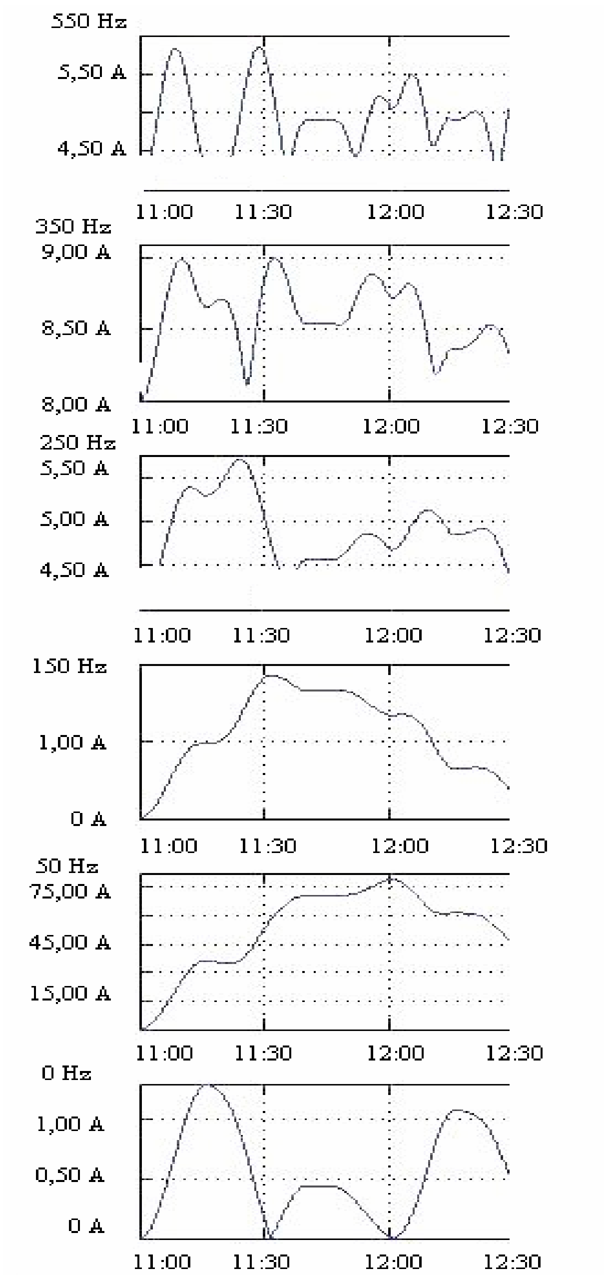

Fig. 5 Simulation of high wind flow

5. The practical measurement of power quality

The graphs of active power during 24 hours are shown on figure 6 and 7. I chose these two days because there was a high probability of mainly constant wind speed. But you can see many differences, e.g. the daily diagrams are complete different. For these reason it is impossible to make calculation exactly with wind energy based on daily diagram.

The summarizations values during 14 days are shown on figures 8. The whole measurements took 30 days.

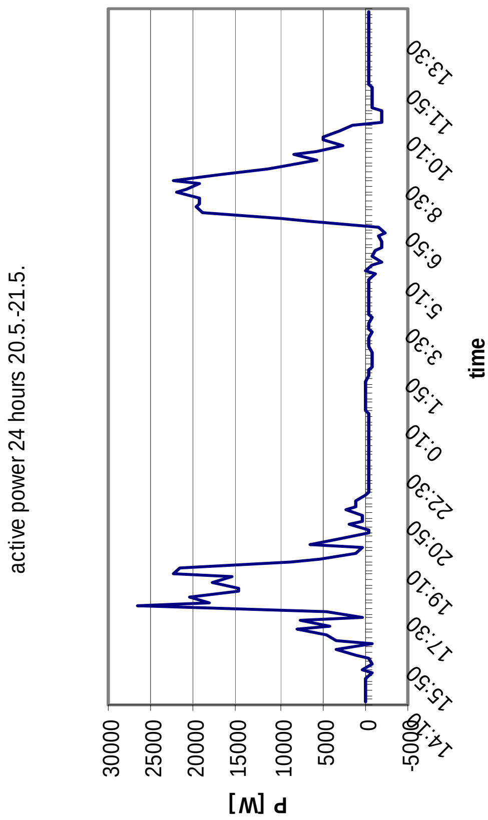

Fig. 7 TheActive power curve during 24 hours 20.5.

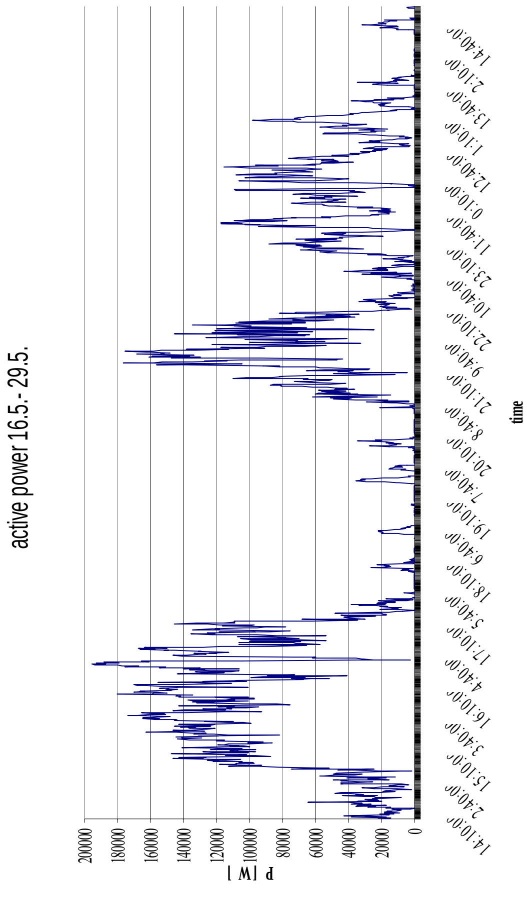

Fig. 8 The active power curve during 14 days

These graphs show:

- Non constant electric energy supply
- Non regulated electric energy
- Unpredictable electric energy supply
- The source of electric energy which need electric energy for own start
- The source of electric energy which need another source for regulation

6. Conclusions

The wind power is good source of renewable electrical energy. But problem related with this kind of energy is its instability, non constant producing power energy. During a few years device or appliance for constant producing this kind of power energy must be invented.

Wind turbines and solar panels are considered to be alternative sources of energy because they generate electric energy without producing CO_2. Naturally, these sources depend on wind flow or solar activity therefore massive installation and utilization is complicated by connection these in-time and power unstable devices into the distribution network.

Solution can be found in intermediate stage which will be able to accumulate created energy into particular medium allowing constant output power supply and fast reaction on fluctuating power supply during daily energy peak. The system based on fuel cell technology can be regard as the intermediate step capable of chemical energy storage in reverse mode and energy delivery into electric network in power mode.

Acknowledgement

The authors wish to thank the support from the Spanish “Ministerio de Ciencia e Innovación”. Research Project: ENE2007-6803-C04-01.

References

[01] T.Petrů – Modeling of wind turbines for power system studies- Göteborg, Sweden 2003

[02] M.P. Donsión – Análisis de la estabilidad de sistemas de potencia – Universidade de Santiago de Compostela 1993, ISBN: 84-7191-985-0

[03] W. M. Nicholas , J. Sanchez-Gasca, "DYNAMIC MODELING OF GE 1.5 AND 3.6 MW WIND TURBINE" GE Power Systéme Energy Consulting, IEEE WTG Modeling Panel, Session July 2003

[04] NOHÁČ, K.; NOHÁČOVÁ, L. Přehled současných možností počítačové simulace v elektroenergetice. In *Česká energetika a elektrot.* 2004, č.3+4, s.20-24, ISSN 1213-4171.

[05] S. Casoria, P. Brunelle, and G. Sybille, "Hysteresis Modeling in the MATLAB/Power System Blockset," Electrimacs 2002, École de technologie supérieure, Montreal, 2002.

[06] F. Rajský – Modeling of wind power plant. *In* Environmental impacst of power industry 2008. Plzeň : ZCU v Plzni, 2008. ISBN 978-80-7043-

[07] F. Rajský – Preventing faults in a distribution network. *In* Environmental impacst of power industry 2007. Plzeň : Západočeská univerzita v Plzni, 2007. s. 72-75. ISBN 978-80-7043-541-0

[08] F. Rajský and M.P. Donsión - Comparison of transmission and distribution systems in the Czech Republic and Spain. ICREPQ´08 - Santander 2008