IMPACTS OF RENEWABLE AND ALTERNATIVE ENERGY SOURCES ON OPERATION AND STABILITY OF ELECTRICAL NETWORK

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ABSTRACT

This paper deals with the evaluation of renewable and alternative energy sources network interconnection and their impacts on the operation and stability of electrical network.

The article shows the dependence of the voltage level magnitude in the point of common connection on the power factor of the renewable energy sources generator.

The following part analyses, how the short-term power variation of the power plants (wind and photovoltaic) regarding the weather changes cause the voltage variations according to the generator operational mode. These variations negatively influence the distribution network operation and the power quality. The dynamic variations were simulated by the NEPLAN software.

In conclusion the feasibility of the plant interconnection is evaluated respecting other important factors (flicker, ripple control signal damping, harmonic voltages content, protective relays function).

Keywords: Alternative, energy, renewable, plants, power, quality, sources, voltage, wind.

1. INTRODUCTION

Utilization of sources, which transfer the energy of sun, water, wind and earth into an electrical energy, mainly depends on the hard correctly weather forecast. That causes problems not only by the long-term planning of electricity production, but especially by the wind power plants and photovoltaic instant power changes. These short-term power variations can negatively influence the operation of distribution grids, where the most renewables are connected.

Another problem considering the grid connection of renewables is a fact, that the distribution grids are operated as one-way power flow from the supergrid to the places of its consumption to the final consumers. For it are adjusted voltage regulation and protection system. Increasing number of generators from renewables can affect the proper function of these systems.

Therefore it is necessary to take care of renewables grid connection and to flexible react on new problems, so that the operation of distribution grids would not be affected and together the maximal power possibilities would be utilized.

2. PROBLEMS OF DISTRIBUTION GRID OPERATION

The primary objective of distribution network operators is to ensure a safe and reliable operation their grid. The operator also have to ensure a required power quality, which is defined by voltage characteristics in a given point of network, compared to the reference levels of power parameters.

„Rules of distribution grid operation“ have been drawn up, with the aim to ensure safe and reliable operation and not to increase redundant costs, both on the operators’ and customers’ side. These rules determine minimal technical, planning, operational and informational requirements for the customers' grid connection and its operation.

To the users of distribution grids also belong the renewable operator, who supplies the power energy to the grid.

It is necessary to connect the plants, which are to be operated parallel with the distribution grid, in the suitable point. This point (point of common connection – PCC) and the way of connection determine the operator regarding the grid configuration, the power and way of plant operation, as well the rightful interest of the investor. Thereby it is about to ensure, that the plant will be operated without any disturbing effects and will not threaten the power supply for other customers.

3. EVALUATION OF WIND FARM GRID CONNECTION

In the following parts of article some simulation of distribution grid operation with help of Neplan software are carried. It is concerned a 22 kV grid connection of 3 wind power plants with different nominal power (see Fig. 1). Computation parameters:

Transformer 110/22 kV, Short-circuit power = 268 MVA , number 1

VE1 – 220 kW, number 51

VE2 – 315 kW, number 61

VE3 – 630 kW, number 71

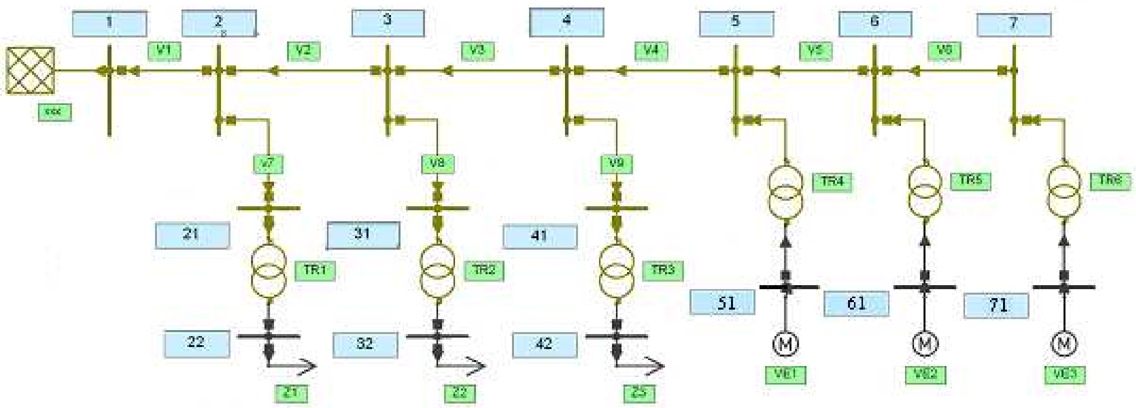

Fig. 1. 22 kV line with wind farm connection

4. VOLTAGE INCREASE BY STEADY STATE OF WIND FARM

In individual very simple cases can be a manual calculation useful as a guess. Above all by the variable reactive power supplies or by the evaluation of voltage level in more grid nodes, it is recommended to use a computer analyses of power flows, especially when the compensating capacitors shall be respected [6].

For voltage change by the power supply to the single PCC pay:

$$\Delta u_{An} = \frac{\Delta U_{An}}{U_V} = \frac{S_{nE\max}}{S_{kV}} \cdot \cos(\psi - \varphi_E),$$

where ΔuAn is a relative voltage change, ΔUAn – a voltage change, UV – a voltage in PCC (see Fig. 2), SnEmax – a maximal supply power, SkV – a short-circuit power in PCC, ψ – an angle of grid impedance in PCC, φE – an angle between active and reactive power of source

It is necessary to determine the relative voltage change ΔuAn with power flow analysis by the power supplies from more sources into more nodes and especially by more complicated network configurations, as are ring und meshed networks.

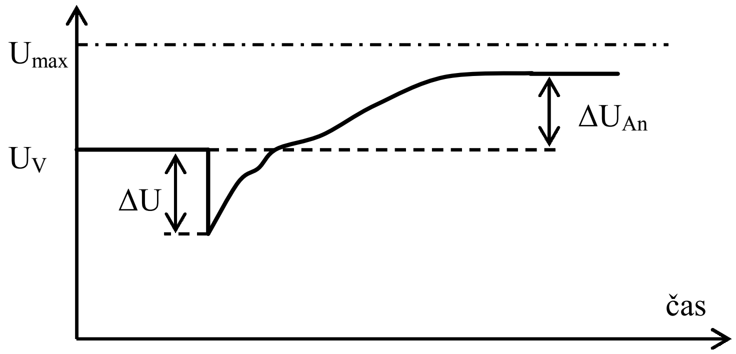

Fig. 2. Relationship between short-term voltage change ΔU and steady state voltage change ΔU_{An}

The calculated values of steady state voltage in the main nodes before and after connection of wind farm can be seen in Fig. 3. The voltage changes in each node are of interest.

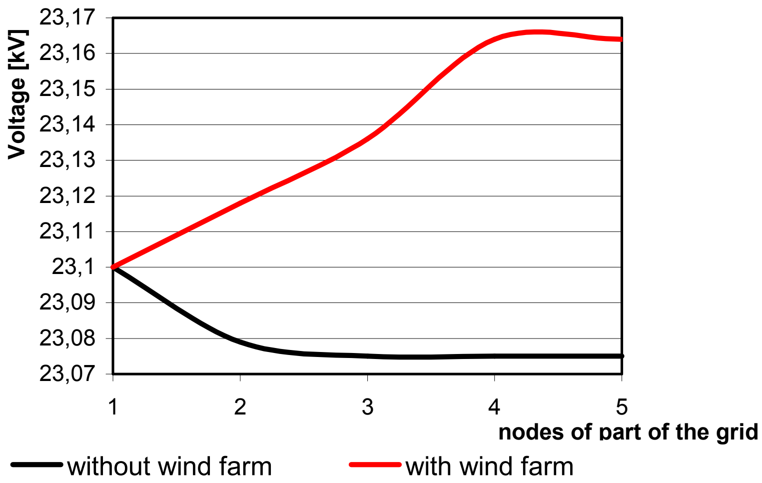

Fig. 3. Voltages in the main nodes with and without power supply from wind farm.

It can be seen in Fig. 3, that the biggest voltage change occurs in the PCC of wind farm – in node number 5. The voltage increases from initial value of 23,075 kV to 23,166 kV. Also the relative voltage change ΔuAn equals to 0,4%, which fits the standard [8] in the terms of grid integration. The standard‘s limit for the relative voltage change ΔuAn equals to 2%.

5. VOLTAGE VARIATIONS IN POWER SYSTEM CAUSED BY WIND FARM OPERATION DURING WIND VELOCITY VARIATIONS

From the point of view of the wind farm operation, the keeping of the fixed power output into the grid is not feasible because of wind velocity variations.

Following results were obtained by the wind farm mesuring, see Fig. 4 and Fig. 5.

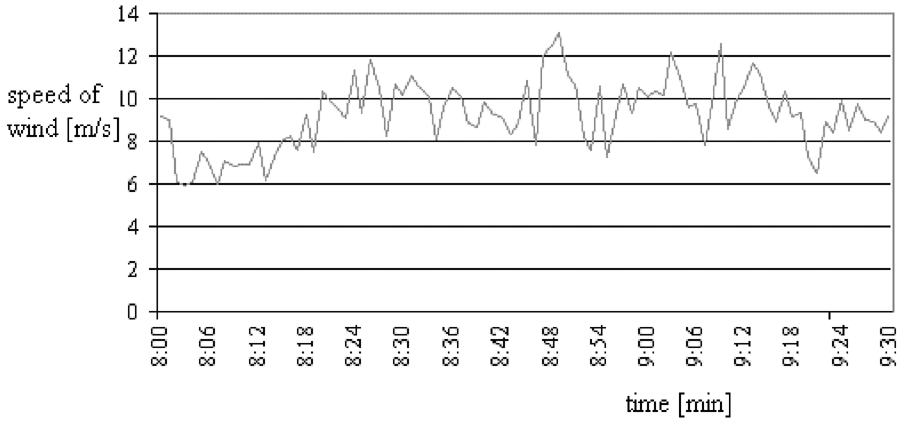

Fig. 4. Minute record of the wind velocity.

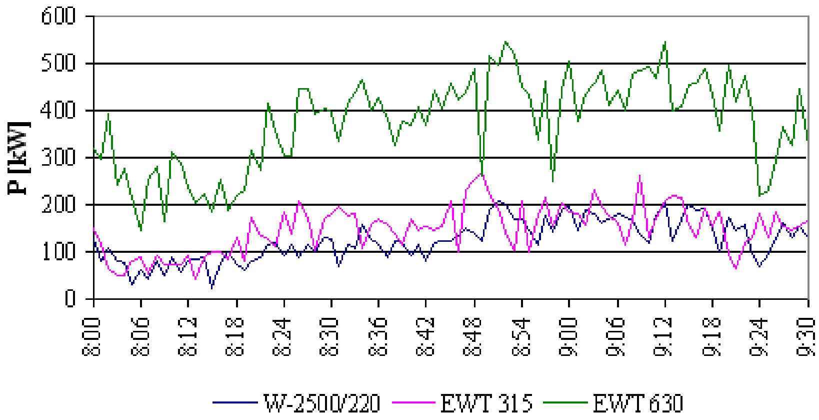

Fig. 5. Minute record of the measured power.

Significant wind velocity swings that occure in order of minutes, are demonstrated in the Fig. 4 and relevant short-term power swings measured on individual generators are demonstrated in the Fig. 5.

Complex voltage variations in the power network are caused by the power fluctuations, consisting of the active and reactive component ΔP and ΔQ, according to the generator system properties. These variations cause voltage variations ΔU at the network impedances that consist of the active component R and reactive component X, in the process the voltage in the point of common coupling fluctuate too(Fig. 6). The power factor cosφ is constant in this case, thus the reactive power is dependent on the active power generation.

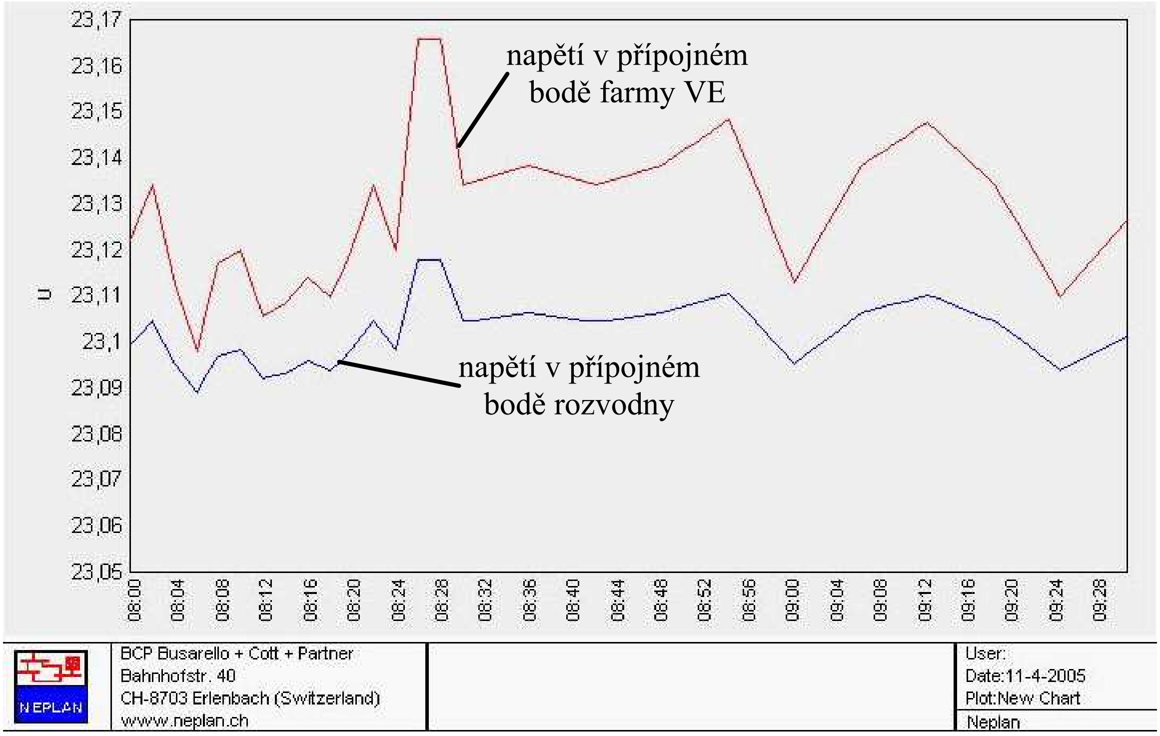

Fig. 6. Influence of the wind farm on voltage fluctuation in the power system.

The integration of wind power plants into the automatic secondary voltage regulation(ASRU) system would be a solution for the mitigation of voltage fluctuations. Then the power factor magnitude would be modified according to the instantaneous active power production and reactive power demand. Contemporary wind power plant generators are equipped with the power electronics that enables, in some bounds, the regulation of the reactive power supply or consumption, (doubly fed induction generator with an inverter in the rotor circuit). These ganerators enable the power factor(cosφ) regulation in the range 0,98/0,96 (capacitive/inductive) [3].

The integration of wind power plants into the ASRU system could limit, possibly eliminate, voltage variations caused by their, in the comparison with classic power plants, anomalous operation(power fluctuations in dependence of wind velocity variations).

This possibility of the voltage regulation is ,however, significantly limited by the quantity of the reactive power regulative reserve.

6. CONCLUSIONS

Required data about the future power system behaviour can be obtained by the dynamic simulation of various operating states, this way negative impacts on power system stability and power quality can be prevented.

Studies of the new power sources interconnection feasibility into the power network can be realized by these simulations. The interconnection feasibility of distributed power sources must be assesed very sensitively, particularly the investigation of the suitable power factor range for the generator operation in the given area. The study, that asseses the influence of other factors on the network operation, must be elaborated for the responsible appraisal of the power source interconnection feasibility to the power system, as is prescribed by "The rules for the distribution system operation" (flicker, ripple control signal damping, harmonic voltages content, protective relays function).

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ACKNOWLEDGMENT

This paper was written under solving science projects MŠMT 1M06059, “Progressive technologies and systems for energetics (PTSE)” and GAČR 102/06/0132.