

Assessing Operational Planning Performance among Wind Power System based on N-1 criterion

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Abstract—The current paper presents an operational planning for wind power system, in terms of safe and reliable power system operation. To ensure operational performance in the control area, based on N-1 criterion, in this paper are highlighted the main security criterions, issues related on correcting or remedial actions, as well as the basic requirements for its implementation in the system. In the paper was simulated a contingency case using Power World simulator 5 bus system in order to achieve an operational planning performance for a wind farm placement.

Index Terms— N-1 criterion, power system, stability, security, reliability

I. POWER SYSTEMS STABILITY

The main concerns in power system operation are system safety and reliability. Electric power systems are subjected to various dynamic events like: electromagnetic transients, electromechanical fluctuations or thermodynamics. These dynamic events in power system represents a system perturbation and it must be assessed the behaviour of the system after the perturbation removal. Depending on the disturbance magnitude, the fault evolutes from short transients rapidly cleared, to broad oscillations.

Power system stability is correlated with the fact that if in the system are encountered oscillations, it must continue operate without major effects on consumers.

Besides the fact that power system stability depends on the fault type and magnitude, it is also influenced by the initial operating point.

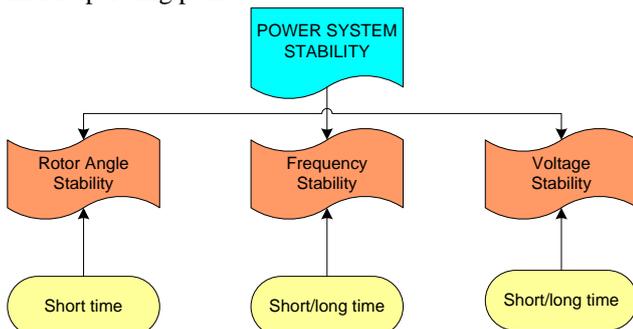


Fig. 1. Power system stability

Power system operation economy and safety depends on its reliability. Power system must comply to safety and reliability requirements, in every moment, so that the failure probability be removed or minimized.

II. N-1 SAFETY CRITERION

The N-1 criterion is a rule that states that the operating elements in the network, after a grid fault, must be able to manage the changes in the grid current flow, caused by that fault.

To provide reliable operation on a power system which also integrates renewable energy from wind, there must be analyzed the system dynamics. As the installed power from wind raised, its impact on the power system must be considered from safety and reliability point of view. When wind turbines are equipped with different types of generators, for example Doubly-Fed Induction Generator (DFIG), there are possible oscillations in the system, leading to power system perturbations. It is important to analyze the N-1 safety criterion when is involved wind power in power system. To comply to this criterion, the power system must be capable to continue operate, even in the situation of loosing a network element (transformer, generator or transmission line).

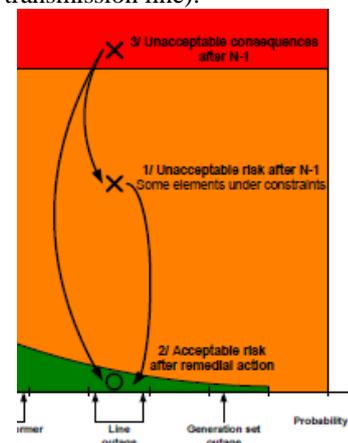


Fig. 2. N-1 criterion and remedial actions [6]

When a failure appears in the system, depending on the type of contingency involved, it must be taken remedial actions, following states and procedures described in [6] and illustrated in Fig.2.

For a power line outage contingency, it is applied the N-1 criterion (point 1). Due to overloaded units, the system is not able to accept the increased loading. For a short time, this situation can be treated as an acceptable risk.

The dispatcher will apply curative remedial actions and the power system will trip to a safe loading area (point 2).

To arrive at curative actions, the power system may also get into unacceptable risk zone (point 3), after applying N-1 criterion.

From this point, it will travel to acceptable consequences zone (point 1) and after that, the dispatcher will apply curative remedial actions to reach the safe zone (point 2).

III. PLANNING PERFORMANCE ON WIND POWER SYSTEM

To assess the power system reliability, most utilities uses probabilistic or deterministic techniques. The most used safety criterion is “N-1”, allowing maintaining the power system in security and reliability limits. It also, delivers significant savings, from economic point of view.

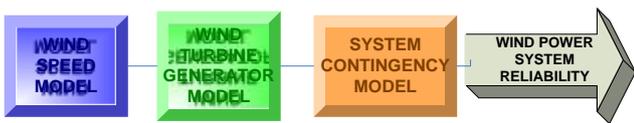


Fig. 3. Wind power system assessment model

As the energy from wind sources has a inconstancy character, is important to evaluate the transmission system from a reliability view point.

To assess the wind power system, there must be performed three different analysis on three models [7]: on the wind speed model, on the wind turbine generator model and on the system contingency model. In Fig.3 is presented the diagram of wind power system assessment model.

As wind speed fluctuates over the time and depends also on the geographic position of the wind turbine, this model is simulated based on mathematical expressions (Fig.4).

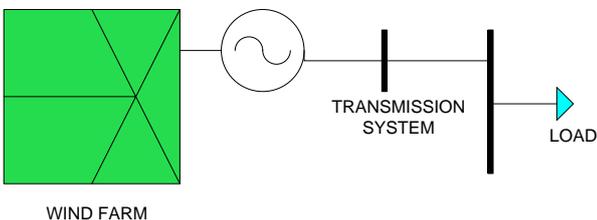


Fig. 4. Transmission system model

The wind turbine generator model combines the wind speed model with the turbine’s generator characteristics (DFIG).

Grid connection of wind generation sources leads to some problems, like voltage fluctuations, flicker or harmonics.

To achieve power system stability, even when it has distributed generation sources connected, the grid must operate without voltage violations or load losses. As the

load increases, due to increased consumption, the generation must increase as well. In this condition, the transmission lines may be overloaded.

A solution to this issue is to inject power from renewable sources in order to reduce overloads. Hence, in a power system where it is involved a wind power source, it is important to determine its location. This is an important factor for wind generation planning, due to the fact that it will influent the flows in transmission branches [9].

IV. CONTINGENCY ANALYSIS AND OPTIMAL LOCATION OF WIND FARM

Contingency cases represents emergency events in power systems, that may cause system outage. In order to ensure a system reliability, in the event of such an outage, these cases must be analyzed. To achieve an operational planning performance in power system, in this paper was performed a study of optimal placing of a wind farm for contingency cases removal.

The wind farm was considered to have a total installed capacity of 30 MW, being composed by 15 small wind turbines.

In Fig. 5 is presented a Power World Simulator diagram for a test system, where each transmission line has a maximum capacity of 150 MVA under steady state condition. The graphical diagram displays the bus voltages in per units, the percentage line loading and the active power generated at the bus. In the studied system were considered different kind of power generation sources (wind, hydro and coal) with different power generation.

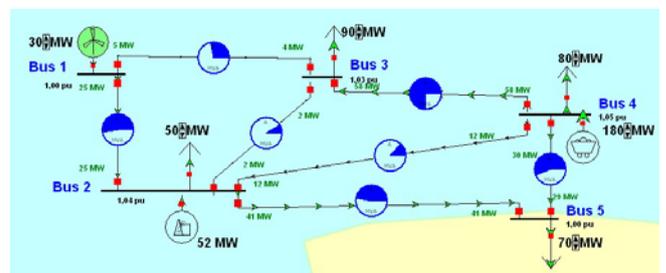


Fig. 5. Power World Simulator system model

Power World Simulator software allows displaying animated contour maps based on different system quantities. In Fig. 6 is illustrated the contour map for the considered test power system in relation to bus voltages.

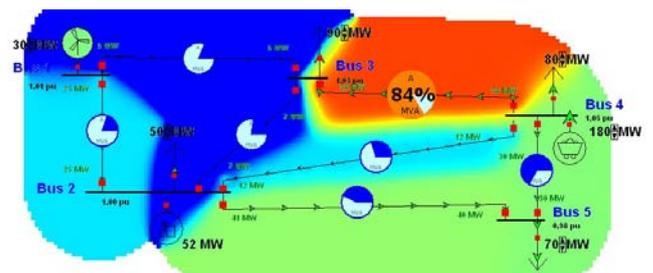


Fig. 6. System model contouring based on bus voltages

In consequence, placing the wind farm at load bus 5 accomplishes all the requirements for optimal location of the renewable energy source in this 5-bus system to solve the considered contingency case which involves the outage of transmission line 2-5.

V. CONCLUSIONS

In order to assess the influence of grid parameters on wind transmission system for optimal planning performance, it is performed a system modeling in contingency assumption.

The basic reliability assessment model is considered of a wind turbine connected to a power network through a transmission system. Operational planning performance is achieved based on contingency analysis using N-1 criterion.

It was simulated a contingency case using Power World simulator in order to achieve an operational planning performance for a wind farm placement. In the considered 5-bus system, were determined the parameters violations for different location of wind farm distributed generation.

Hence, it was concluded that the bus 5 is the optimal location for placing the distributed generation of a wind farm of 30 MW (with DFIG wind turbine) in the considered system.

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