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Investigation of Wind Energy Utilization On Egyptian Electrical Network

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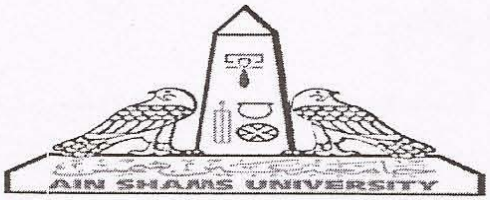

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ABSTRACT

Wind energy is increasing its contribution to energy generation worldwide. In some countries, wind energy penetration has an important fraction of the generation capacity, and it is expected to be increased even more in the future. At present, it is very common to find renewable energy resources, especially wind power, connected to transmission systems. The Egyptian authorities have ambitious plans to increase the capacity of installed wind farms in the national grid. These wind farms are to be installed in the Canal Zone due to the high average wind speeds in the area. The wind power penetration into the Egyptian grid is expected to reach 7200 MW especially in the areas of the Gulf of Suez, West and East Nile Valley by the year 2020.

This large penetration level of wind farms might have deleterious effects on the voltage stability of the electric network. This is because wind farms absorb reactive power from the transmission network and an observable drop in bus voltages occur. To mitigate this effect, system must be studied under steady-state and transient conditions. The results of these analyses determine the weak buses in the network (where the largest drops in voltage levels occur), and the size of external reactive power device such as capacitors, SVC, or STATCOM.

The aim of this thesis is to investigate the voltage stability of the Canal Zone in the presence of high penetration levels of wind farms. The analyses are performed under normal operating conditions, contingency conditions, and transient conditions to identify the weak buses in the given grid. The PSS®E software program is used to conduct the above mentioned analyses. For the steady state analysis, both PV and QV methods are used. The PV analysis determines the voltage profile and the voltage sensitivity factor of each bus. The QV analysis computes the size of the reactive power compensation device to maintain the weak bus voltage at 1 p.u and hence prevents the voltage collapse. Contingency analyses are performed under (N-1) condition to check the voltage stability of the system under study in case of any outage of generation station or transmission line. The analyses are conducted with and without reactive power compensation. The transient analyses are conducted to determine the dynamic performance of the system following the occurrence of 3-ph faults, and to demonstrate the strength of the system with and without reactive power compensation.

Based on the results of the thesis, Ghard and Italgen buses are found to be the weakest buses in the Canal Zone. The required reactive power was compensated using capacitor banks or STATCOM devices. However, the use of STATCOM is found to be more effective as its reactive power is proportional to the voltage and not to the square of the voltage as for the capacitors. The use of STATCOM is adequate and can enhance the voltage stability of the system whether under normal or contingency operating conditions. The dynamic analysis shows that STATCOM rating can be determined at 0.95 p.u voltage instead of 1 p.u as in the steady state analysis. This reduces the size and cost of the installed STATCOM which will be more economic.

Keywords— Wind generators, Voltage stability, PV analysis, QV analysis, voltage sensitivity, reactive compensation, STATCOM.

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