論文の内容の要旨

論文題目　Impact and Contribution of Distributed Generation to System Reliability and System Voltages in Distribution Systems
（配電系統における分散型電源導入の供給信頼性度および系統電圧に対する影響）

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(本文)

In recent years, Distributed Generation (DG) has attracted more and more attention from both distribution utilities and electricity users. The advantages of DG are of both engineering and economic view points. The advantageous applications of DG can be summarized as follows: backup generation, voltage regulation, loss reduction, grid expansion postponement, environmental concerns, peak load service, rural and remote application, combined heat and power generation, and financial and trading purposes. This dissertation concentrates on the issue of backup generation and voltage regulation.

As for the first part, DG can be applied as backup generation when the main supply from the upstream side is interrupted. Without the main electricity source, isolated system is formed and obtains electricity supply from the DG located in the isolated area. As backup generation, DG is supposed to improve the system reliability if the related concerns are deliberately considered and the solutions are strictly implemented. However, protection miscoordination, especially recloser-fuse miscoordination, can have a considerable adverse impact on the reliability of typical radial distribution systems. The installation of DG can interfere with the existing recloser-fuse coordination by changes in fault current, and cause improper sequential operation of the protection system. IEEE standard 1457-2003 requires DG to be disconnected during system abnormality, including the case that DG itself operates abnormally, so that the fault current from DG cannot interfere with the existing protection coordination. Although the risk of DG continuing to operate (i.e. failing to be disconnected) and contribute to the fault current is low, it is not zero. Furthermore, it cannot be guaranteed that all DG sources will be disconnected faster than the operation of system protective devices, which usually operate within only a few cycles. Besides, disconnection is not always preferable, especially when the DG penetration is very high. In such cases, the protection systems may be interfered with and even lose their coordination, e.g. the coordination between recloser and fuse. The details of the mentioned facts are explained, studied, and resolved in this research.

Accordingly, the first part of this dissertation pays attention to the impact and contribution of DG to system reliability. To understand the impact on system reliability and the prevention of reliability degradation, the evaluation and comparison of system reliability are carried out for outage cost and load point indices. The two load point indices are SAIFI (System Average Interruption Frequency Index) and SAIDI (System Average Interruption Duration Index). In regards to the energy index, ENS (Energy Not Supplied) is evaluated. In addition, the prevention of reliability degradation due recloser-fuse miscoordination is proposed. The investigation and the application of the proposed methods have been implemented in a typical distribution and RBTS Bus 2 test systems.

As for the second part, DG can be used to regulate or support the system voltage profile if the installation has been well studied and carried out in an appropriate direction. With the varieties of dispersed locations, operating modes, and installed capacities, DG, in contrast, can be properly designed and controlled to help system voltages be maintained within their standard levels. For example, DG with constant voltage has the advantage of voltage support at remote areas. In addition, DG with capacitive power factor can intentionally help increase the voltage profile at low voltage areas. This kind of DG is over-excited synchronous generators. Likewise, DG with inductive power factor can help decrease the voltage profile at high voltage areas. This latter kind of DG is under-excited synchronous generators and induction generators. However, as is known, the installation of DG, especially ones that derive energy from renewable resources, can bring about the voltage fluctuation and violation to distribution systems. For instance, the installation of DG may raise the voltage profile until the upper voltage limit is exceeded, especially when voltage regulator and/or capacitor bank are operating. These problems are derived mainly from the counter flow and reactive power change. On the other hand, the installation of DG may cause the voltage profile to be lower than the lower limit. This is possible when DG is shut down immediately and the existing voltage regulation cannot respond in time. The types and operating modes of DG also play an important role for the reactive power injection or consumption that is substantially related to the voltage variation. The details of the mentioned facts are explained, studied, and resolved in this research.

The second part of this research utilizes the varieties of locations, modes, and capacities to balance and maintain the system voltage profile in conjunction with the existing voltage regulation. As reinforcement for the prevention of voltage fluctuation, the uncertainty of renewable energy sources, e.g. solar and wind, that is considered the main factor of voltage fluctuation is modeled by Probabilistic Load Flow (PLF). Afterwards, this uncertainty is integrated into the optimization process whose objective function is to regulate the voltage profile to prevent the voltage violation and momentary interruptions. The effectiveness of PLF is not only for the reduction of voltage violation, but also for other applications such as the maximization of DG in a distribution system. The investigation and the application of the proposed methods have been implemented in IEEE-34 Bus test system.