Research on the Strategy of Failure Recovery in Smart Grid

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Abstract. With the development of China’s comprehensive construction and the upgrading of industrial system, China began to transform from energy-consuming and high-pollution society to energy-saving and environment-friendly society. Knowledge-intensive and equipment-intensive industries are on the increase, which causes the increasing demand for the stability of electricity supply. At present, the problem of transmission over distribution still exists in the power grid construction of China. In power systems over 110 kV, the strategy of non-homologous dual power supply is adopted to guarantee power supply. When a circuit trip occurs, the spare line can be used to continue the power supply, so the existing domestic main network system has a high reliability. The main function of the distribution network system is to connect the user and the main network, which is an important link of power transmission. In the future of the development of intelligent power network, the original parts such as mobile voltage transformer and current transformer can be used to locate the fault position after the physical fault occurs in the distribution network, and automatic reclosing device can be used for fault isolation and fault recovery. How to use the optimal strategy to make the controllable automatic reclosing device be used for switching operation after the physical failure of the distribution network so as to ensure the reliable power supply of the distribution network, has become the focus of power network hoisting service.

1. Introduction

With the development of smart grid, a large number of new energy access makes the original single-power radial distribution network structure more complex. The distribution network becomes a complex multi-source network with a large number of distributed power supply and microgrid control devices.

Distribution network becomes more and more complex, because of natural disasters, human factors, equipment reliability and other reasons, fault types are diverse and unpredictable. Therefore, according to the type of fault location of distribution network, the strategy of distribution network fault recovery has become the key of distribution network fault recovery.

In the distribution network where micro-grid exists, the micro-network control strategy is used to control the energy in the micro-network so as to ensure that the channel of micro-network energy is accessible. And there is AC bus in the micro-network, which can stabilize the voltage in the network and support the load of some important power loss in the main network under the fault, which is integrated into the micro-network system for unified management [1, 2].

The development of smart grid makes it possible to use fault recovery strategy to maximize the recovery of non-fault power loss. At the same time, the use of a large number of intelligent devices makes the strategy of signal collection, equipment communication, equipment hierarchical management and equipment vertical management of smart grid extremely complex [3]. Smart grid and
traditional grid have the following main differences: the ability to sense and communicate, the ability to self-recover, the compatibility of various energy modes, hierarchical management systems, two-way transaction convenience [4]. In this paper, the key technology of fault recovery strategy for distribution network in the future of intelligent power network is studied systematically.

2. Research on Intelligent Algorithm

2.1 Traditional Optimization Algorithm

Because of the distributed power supply and the addition of micro-power network, the topology of intelligent power network has changed greatly. The traditional optimization algorithm can only be applied to the radial structure of a single power supply. It is generally applicable in the future of intelligent power network, and it is easy to cause a large number of important loads to lose power under fault condition.

2.2 Heuristic Algorithm and Artificial Intelligence Algorithm

In order to solve these problems, a lot of new algorithms are applied to fault recovery of distribution network. Among them, heuristic algorithm mainly includes hierarchical search method, search method based on tree-structure and so on.

In the paper [5], the improved Binary Particle Swarm Optimization is adopted, and the use of binary is more suitable for the characteristics of machine coding. In addition, the improved binary particle algorithm has a better strategy to search the whole world and avoid the program falling into local search. In the paper [6], simulated annealing method is used to introduce dynamic and important information into the system. The system first closes the contact switch to form a ring network, and then the branch exchange method is used to open the segment switch. In the paper [7], the distribution network is simplified into a multi-source tree structure, and the graph theory knowledge is used to solve the problem of fault recovery. In the literature [8, 9], the segmentation tree algorithm is used to transform the isolated island search problem into the cutting block tree problem, and the feasible recovery strategy can be obtained. Paper [10] is based on expert system, the problem of multi-stage load transfer is solved; in the paper [11], genetic algorithm is used to solve the problem of fault recovery in distribution network, the mutation parameters of each iteration are set, and artificial intelligence selection is introduced to eliminate the infeasible solutions. The introduction of mutation parameters avoids the formation of local optimization and ensures that the algorithm traverses the whole world. At the same time, the addition of intelligent selection constraints can ensure that the eventual recovery strategy is feasible.

However, all of the above heuristic algorithms and artificial intelligence algorithms have some problems such as slow iteration speed and insufficient modeling of micro-grid and distributed power supply.

At the same time, there are ant colony algorithm, Petri net algorithm and fuzzy algorithm which can be used in the fault recovery scene of distribution network. These algorithms are also suitable for the fault recovery scenarios of smart grid. How to further improve the convergence speed and accurately model the nodes of distribution network becomes the focus of further research.

3. Research on restoration strategy of distribution network

3.1 Recovery strategy with distributed generation

When the distribution network contains distributed power supply, the distribution network is transformed from simple single-power radial network to multi-power network. Moreover, because the new energy distributed power supply has no overload capacity, the power supply must be matched with a storage device to ensure a stable power supply. In addition, the capacity of energy storage devices and charging and discharging power are worthy of consideration. In this paper, after detailed study, the output curve and energy storage device of the fan and photovoltaic device are precisely...
modeled in the fault recovery scene of the distribution network, so that it can meet the various application scenarios, the time period and the weather changes.

The charge and discharge power and storage capacity of the energy storage device are affected by many factors, which is a complex mathematical model. In this paper, the dynamic model is constructed for the characteristics of the energy storage device. According to the simulation situation, the storage capacity and recharging power of the energy storage device are updated dynamically. When the storage capacity of the energy storage device is exhausted or the output exceeds the maximum discharge power of the energy storage device, the storage device fails and exits operation.

3.2 Control strategy of microgrid

When the micro-grid in the distribution network is in the power-losing zone, the operation mode of the micro-grid is determined according to different scenarios. If the output of the microgrid is less than the demand of its own load during the fault period, the micro-grid needs to operate independently from the distribution network.

If the micro-power network has excess electric quantity in the fault period, and its energy-storage device has a high level of energy-storage residual, the discharge power of the energy-storage device and the distributed power output power in the micro-network can support the external important load, the power output to the micro-network is carried out through the AC/AC switching device of the micro-network interface with the important load operation outside the micro-network. At the same time, the micro-network energy management system is used to maintain the voltage and frequency stability in the network, update the energy storage device and distributed power information in time, and avoid the secondary failure.

3.3 Stability analysis of microgrid

Because there are many kinds of sensor communication elements in the microgrid, the real-time information of microgrid operation can be transmitted to the system. The system makes corresponding actions according to the real-time information to maintain the power quality in the microgrid.

The micro-network in the power-losing zone is actively separated from the main distribution network, it maintains operation through its own micro-network control system, the control system carries on the micro-network stability analysis according to the data collected in real time, and further guarantees the stable operation of the micro-network. If there is insufficient power in the operation of the micro-network, the system can intelligently remove the load with less dynamic weight to ensure the stable operation of the micro-network.

When making the operation strategy of the important load outside the micro-network, we should determine the stability of the micro-network in the period of fault repair in advance according to the type of fault, minimize the risk of the cutting load and avoid the re-prosperity of the fault.
4. Strategies for recovery of power loss load outside microgrid
When the micro-network exits the power-lossing zone, the load in the power-lossing zone is restored intelligently through the switch combination action. In the process of recovery, the dynamic weight of load is the focus of recovery strategy. The objective function is the dynamic weight of the recovery load, and the net loss and switch operation times are the secondary objective functions.

The automatic search strategy described above is used to traverse the whole network continuously, iterate out the optimal solution of load recovery and complete the fault recovery after operation.

5. Conclusion
The construction of intelligent power network is the inevitable trend of the future development of China's power network. At present, in some developed regions of China, the coexistence of multiple energy sources such as micro-grid distributed power supply has become a reality. It is imperative to study the fault recovery of distribution network in this situation. In the future, we will continue to research and upgrade the micro-network system and algorithms to ensure the maximum reduction of fault loss.

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