Analysis of Relay Protection Problems in Micro-grid

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ABSTRACT: The concepts of distributed generation and micro-grid were proposed. The influence of the micro-grid connected to the distribution network were analyzed from four dimensions, namely the distribution network planning, power quality, operation and control, and the load flow distribution. The protection scheme of the traditional distribution network was preferred. In this paper, the unwanted operation or failure to operation of three phase current protection, protection sensitivity change and lose selectivity were briefly summarized, which was caused by micro-grid interconnection. Several problems should be considered in the protection of micro-grid were pointed out, and its development trend was prospected.

1 INTRODUCTION

With the rapid development of national economy, the growth of electricity demand in a higher level, the size of the grid has continuously expanded. The advantages of great power grid have appeared, such as huge investment and operation costs, difficulty operation maintenance, etc. In this situation, the distributed generation that dispersed around the load caused high attention from country to country. The distributed generation always provide electric power by small generation system (<50MW) like photovoltaic power generation, wind power generation, micro-turbine generation, geothermal generation and tidal power generation.

Compared with the traditional large-scale centralized power generation, distributed generation has the following advantages:
1) Near close to the load, flexible power supply.
2) More use of clean energy generation, environmental protection and low-carbon.
3) Convenient arrangement, small construction costs, can provide a more economical power supply scheme for some remote areas.
4) Combined with the large grid can improve power supply reliability.
5) Low transmission loss, simple transmission and distribution.

However, the merits of distributed generation can’t cover the shortcoming. Most of the power generation situation of DGs will be affected by changes in natural conditions. Such as output of solar photovoltaic power generation system has the close relationship with the changes of weather. In addition, the shortcomings of DG are also exist, high cost of power supply, difficult to control, can’t dispatch, malpractice and poor power quality. In a word, DG with respect to large power grids belonging uncontrollable power, when the distribution network contains a large proportion of DG (high permeability), it’s hard to meet the requirement of the user’s power supply reliability and power quality.

Micro-grid refers to combine the DG, energy storage systems, power load, the control device with the protective device, put these into a small distribution system [4-5]. Development of micro-grid technology provides technical support for DG’s large-scale application [6-8]. The wide application of the control technology can effectively reduce the adverse effects of the intermittent power DG access to the distribution network, especially "plug and play" and "peer to peer" control based on power electronics technology, power management system based on control multi-agent technology, etc. Making full use of the output of DG system can enhanced reliability of power supply, and achieve interconnection and island operation for micro-grid grid.

2 IMPACT OF THE INTEGRATION OF MICRO-GRID TO GRID

The integration of micro-grid to distribution network will be incorporated into the distribution network and the whole power system have a profound impact, especially when high permeability grid, the impact will be more significant. The effect of micro grid access to distribution network can be concluded as the following aspects [9]:
1) The impact on the distribution network planning
It's hard to make the power system load forecasting when lots of DGs in the grid, planners can’t accurately forecast the load changes. Meanwhile, in order to facilitate control and scheduling, point of common connection of micro-grid and distribution network should be installed in power electronic equipment, equipment investments will be produced for distribution network planning certain extent. In addition, an increase in the power network topology nodes, DG proportion of the power structure and other factors, but also all have an impact on the distribution network planning.

2) The impact on power quality

Lots of micro-grid utilize the inverter to connect grid, there are many internal micro-grid power electronic devices, which will result in the distribution network harmonic pollution, a lot of DGs in micro-grid are intermittent power, environmental conditions contribute to the situation by the constraints, fluctuations in power can cause voltage fluctuations and flicker, voltage offset, frequency fluctuations and other issues.

3) The impact on the operation and control

The high permeability of DG access to distribution network always be the single small-scale power generation and dispersed. It’s difficult to develop power generation schemes, a lot of DG belong to intermittent power supply, affected by natural resources and environmental conditions, hard to coordinate control with the load.

4) Change the power flow distribution of distribution network

Traditional distribution network is single power supply radial network, micro-grid access to distribution network causes the network structure is changed, the situation is even multiport double power supply in some branches, the system also trends no longer a simple single flow. In addition, the changes of individual DG output will affect the system power flow, the uncertainties of system power flow will affect the voltage control of system, will also cause a change to protection configuration method and mechanism.

3 THE ANALYSIS OF DISTRIBUTION NETWORK PROTECTION WITH MICRO-GRID

3.1 The protection scheme of traditional distribution network

The traditional distribution network is a radial network structure with a single power supply, distribution network close to the user side with a lower voltage level, usually belongs to a neutral non-effectively grounded small current grounding system. At the time of single-phase short circuit fault, the short-circuit current is very small, always utilize interphase protection. Three-stage protection with the advantages of simple and reliable protection in traditional distribution networks widely used configuration.

3.2 The impact on three stages protection caused by micro-grid access

Three stage protection current fast-tripping protection, limited-time current fast-tripping protection and timing over-current protective. Numerous studies show that the influence of three stage current protection caused by micro-grid access gets close relationship with the access location, access capacity and the permeability of DGs. These factors will influence current protection from different levels of selectivity, reliability, speed and sensitivity [11-13].

Effect of micro-grid on distribution network protection mainly includes the following aspects:

1) Led maloperation of the line protection

When the micro-grid supply electric energy to electricity distribution network by PCC, then short circuit fault occurred, micro-grid may be transferred short circuit current through line to the point of failure, lead the current increase, this circuit malfunction possible protection, power outage probability of extending increased.

Figure 1. Sketch of micro-grid led to maloperation of the line protection.

As shown in Figure 1, when the micro-grid to electricity distribution network feedback through the PCC, short-circuit fault occurs at point k, because the micro-grid transfers short circuit current to failure point through protection 3, if the short circuit current output by MG is big enough, the protection 3 may take false action.

2) Led the protection sensitivity changed, even refusing action

Micro-grid connected distribution network by PCC and distribution network, and produce the auxiliary current or shunt current, these will impress the value of short circuit current, and further more change the protection sensitivity and cause refusing action.
When the micro-grid absorbs the electricity in distribution network through PCC, after the grounding fault occurs at point k. Due to the shunting action of micro-grid the short circuit current which through protection 2 will decrease, these cause the sensitivity of protection 2 decrease, even refusing action. Conversely, when the micro-grid feedback the electricity to the distribution network, after the grounding fault occurs at point k. Due to the auxiliary current of micro-grid, the sensitivity of protection 2 will increase.

3) Led maloperation of the adjacent line protection, protection loss selectivity, expanding the scope of power cut

When the micro-grid feedback the electricity by PCC, due to the auxiliary current of micro-grid, in case of this line occurs grounding short circuit fault, the short circuit current in adjacent line will increase, the protection may maloperate, thus expanding the scope of power out and protection loss selectivity.

As shown in Figure 3, when point k on this line occurs grounding fault, the short circuit current will be provided by both micro-grid and distribution network. Due to the impact on MG auxiliary current, the short circuit current through protection 1 will increase after the micro-grid accessed. As the fault current provided by MG is big enough, protection 1 will take action, cut down this line and adjacent line, thus expanding the scope of power put and protection loss selectivity.

3.3 The influence on automatic reclosing due to micro grid interconnection

The experience of power system operation has shown that in the fault of distribution network, more than 80% of failure is transient. Automatic reclosing can effectively avoid power cut due to transient fault, improve the reliability of the power grid. For traditional single radial distribution network, AR’s advantage is more obvious. The influence of reclosing as shown in figure 4:

In the system shown in Figure 4, When k point instantaneous fault occurs, protect 1 action, breaker trip, distribution network is no longer provides fault current to the fault point, when the micro grid is not connected, line quickly restore power supply under the action of the AR. When micro-grid is incorporated into the distribution network, MG will continue to provide short-circuit current to the fault point, interference arc extinguishing. With the increase of MG output capacity, arc may be re-stroke, even continuous arc, which leads to the failure of automatic reclosing.

At the same time, after micro-grid is incorporated into the distribution network, when failures happen, the power island generated from the micro grid and distribution network is generally difficult to maintain synchronization. Under this circumstance, AR will lead to the emergence of nonsynchronous closing, generate large impact current and impulse voltage, and endanger the safe operation of the system.

3.4 Several issues to be took into account for the relay protection of micro grid

Micro grid has two states of grid connected operation and isolated island operation, micro grid relay protection configuration should ensure that the micro grid in the two operating conditions are able to accurately action, under this situation, the traditional relay protection scheme based on the local electric quantity shows obvious deficiency.

Due to the DG’s output is intermittent, operation mode changes frequently, different types of DG fault characteristics are quite different, at the same time, the network topology of distribution network with micro grid is greatly changed. This requires the protection configuration can effectively adapt to these characteristics, and reliable action.

With the development of micro grid technology, high penetration of DG will become a reality in the near future micro grid relay protection configuration should ensure DG reliable action in this case.

The internal and PCC of micro grid contains a large amount of expensive power electronic
equipment, different DG on fault current injection capacity is also different. The protection of these devices also need full consideration.

In addition, with the continuous development of electric vehicle industry and its related technology is becoming increasingly mature, electric vehicles for the power grid is both a load and energy storage, the development and matures of V2G(Vehicle to Grid) technology make it a reality. Aimed at the moving characteristic of electric cars, the research on protection configuration scheme of micro grid with mobile energy storage system should get enough attention [14].

4 EXPECTATION

At present, there are two kinds of protection scheme for distribution network containing micro grid: the first is to improve the protection of traditional distribution network; the second is the existing transmission line has been widely used in the mature of relay protection scheme applied to distribution network containing micro power grid. At present, the research on the protection configuration scheme mainly include current differential protection, adaptive protection, negative sequence current protection, edge direction variation protection, multi agent (Agent) protection, longitudinal joint protection, distance protection and so on [15-18].

It should be noted that the above all kinds of protection configuration scheme has a certain limitation, the current differential protection, longitudinal joint protection, distance protection and adaptive protection can effectively improve the many problems caused by micro power grid interconnection, improve the reliability of distribution network protection action. But it is necessary to reform the system's hardware and software, installation and maintenance work is more complex, the cost of protection is higher, the application in distribution network is not enough economic. The negative sequence current protection can be accurately action when asymmetric fault occurred in distribution network, and the effect is not good when the system occurs symmetrical short circuit fault. Branch Directional Variation Protection has better theoretical feasibility, but the dependence on the network topology of distribution network is strong, need to real-time acquisition of the node voltage. When the network topology changes suddenly, the protection cannot be accurately action. Multi Agent technology used in the field of relay protection can effectively improve the fault tolerance of power distribution network relay protection, but for intelligent algorithm and communication technology dependence is larger; at the same time the study also not enough, but the development potential is huge.

With the advancement of intelligent distribution network, the development of micro grid protection in the near future has the following trends: (1) Intelligent, adverse effects caused by the changes in the network topology can be reduced or even avoided effectively. (2) Information sharing, it should realize the micro grid control, scheduling and protection of the communication system of the depth of integration and information sharing. (3) Good ability of fault tolerance, it can avoid the judgment error caused by partial data or equipment error. (4) Better scalability and compatibility, it is easy to facilitate the expansion of micro grid and better compatibility with other kinds of measurement, monitoring, communication equipment. (5) Economical and feasible, it can adapt to the micro grid large-scale connected grid and DG high permeability access to distribution network.

5 CONCLUSION

The development of micro grid technology provides technical support for the integration of DG, the change of network topology and uncertainty of power flow in distribution network caused by grid connected micro grid, it has a great influence on the protection configuration of the original distribution network, the selectivity, sensitivity, reliability and speed of the protection. There are various characteristics of the current micro grid relay protection research, but there is no effective configuration scheme for large-scale applications, and related issues need further study.

REFERENCES