BENEFITS OF USING DMS-SYSTEM FOR DISTRIBUTION NETWORK TO OPTIMIZE DER

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ABSTRACT

This paper describes the study of the possibility to optimize Distributed Energy Resources (DER) in a MV network through switching of network configuration. Two potential scenarios are identified within this study to optimize production of DER. The first scenario is switching residual power production of DER to another zone with higher demand of power rather than restraining production. The second scenario is to include the DER production as a prioritized parameter at isolation and restoration of the network after an identified disturbance. The Distribution Management System (DMS) with restoration logic and load flow calculations plays important roles to the optimization, as well as the possibility to switch the network into different network configurations by the zone concept.

The study is carried out on the island of Gotland in the Smart Grid Gotland project. A pilot installation of zone concept with SCADA/DMS is ongoing at the site.

INTRODUCTION

The increased demand of reliable power supply from consumers and the economic benefits related to the Swedish market regulation of electricity distribution [1] results in increased control and monitoring of the MV network. These are driving forces for the net owner to invest in more advanced DMS system in the MV-network for better monitoring and control

The number of Distributed Energy Resources (DER) are increasing and the importance to make use of the DER in the network is becoming more relevant with the increased energy demand and more and more end customers being both producer and consumer. With this, there will be increased needs of the net owner to integrate the DER in the system operation.

ABB has presented a zone concept, a systematic method of dividing distribution networks into areas based on loads, load criticality and disturbance vulnerability [2]. To fully utilize the benefit of the zone concept, e.g. optimal rerouting alternatives, faster fault clearance and balanced load and voltage supervision, the remote controlled switching devices are recommended to be combined with a Distribution Management System (DMS)[3].

Uneven power production at DER is rather rule than exception. The aim of Vattenfall within this study is to investigate in the possibility of optimizing the production of DER in the network through switching. Thus voltage and frequency balance in the network can be obtained without restraining the production.

The aim is to extend the use of the powerful tools within the DMS-system - dedicated to limit fault impacts – to also optimize production of DER in the network. The study investigates in the possibility of using Load flow calculations to find optimal network configuration to optimize production of DER. This will be combined with utilization of the existing as well as the new-installed zone concept switching devices in the pilot area.

SMART RURAL GRID INSTALLATION WITHIN SMART GRID GOTLAND

In the island of Gotland, Sweden, a smart grid installation in the MV rural grid within the project Smart Grid Gotland (SGG) is currently under development. Vattenfall is partner in the SGG project, where a pilot installation of a new generation towards self-healing network with advanced DMS functionality will be carried out. The pilot area for the installations is a predefined 10kV grid with existing switchgear, feeding industries and private consumers. The pilot area also has approximately 4MW Distributed Energy Resources (DER) connected to it, consisting of five wind farms and several private household with photo voltaic installations.

New reclosers at dedicated locations with breaking capacity combined by Intelligent Electronic Device (IED) will be distributed in the network.

Figure 1 shows the 10kV pilot network for the SGG rural grid installation, where the two 10kV stations A and B have radial feeders with possible interconnections through the northern and southern links. Proposed installations of zone reclosers and colored protection zones are visualized in the zone map.

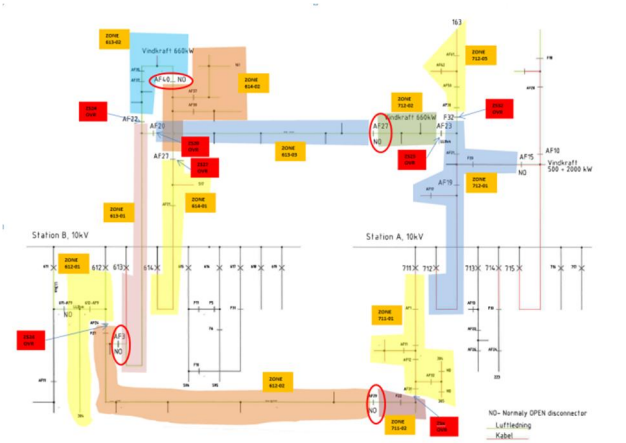


Figure 1: Zone map with arrangement of zones and proposed place for reclosers in the 10kV pilot network.

The zone concept with the advanced DMS in combination with the existing switchgear forms the smart rural grid of Smart Grid Gotland.

Introducing Zone concept for increased reliability

The principle of the zone concept is to integrate reclosing and protection functions deeper into the MV network on overhead lines to minimize fault impact for unfaulty parts of the network as well as giving possibilities of alternative paths at the rural grid. This gives the possibility of faster restoration and fewer customers affected by the fault.

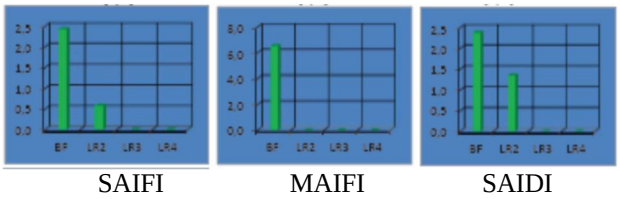
The novelty of the zone concept within SGG rural grid project is that the existence of each zone breaker can be motivated with economic benefits in terms of payback time of each installed switching device and how much each switching point contributes to fewer customers affected by fault in terms of changes in reliability indices. The calculations are executed in a specific zone calculation tool developed by ABB Center of Excellence in Vasa, Finland.

By installing a recloser in feeder 612, two zones are created: Zone 612-01 and zone 612-02, see Figure 1. Zone 612-01 reaches from the Basic Feeder (BF) to the recloser ZS24, which in the calculations is called LR2. Zone 612-02 reaches from ZS24 further out in the radial until a normally open disconnector. The original feeder where no reclosers are installed is called the Basic Feeder (BF). It is protected by the substation breaker/recloser against short-circuit and earth faults.

Theoretical change of reliability indices through installing the recloser LR2 in 612-01 zone is shown in Figure 2 by the calculation tool.

The reliability indices System Average Interruption Frequency Index (SAIFI), Momentary Average Interruption Frequency Index (MAIFI) and System Average Interruption Duration Index (SAIDI) all describe performance of electricity distribution system. It can be seen in the graph in Figure 2 that introducing LR2 changes the reliability indices to the better in the created Zone 612-01.

612-01



SAIFI MAIFI SAIDI

Figure 2: Theoretical change of reliability indices SAIFI, MAIFI, SAIDI when installing a Line Recloser (LR2)

More results and further description of the calculation tool and how the graphs are interpreted is described in a separate paper no. 0398 “Combining existing and modern equipment towards a new generation Self-healing Network” in this conference. Paper no. 0398 also describes payback time and optimal location of recloser further.

Redistribution of load

The DMS functionality provided is used to supervise and operate the network with input from necessary network data. With measurement devices distributed further out in the network, data measured contributes to more accurate knowledge about the network. DMS utilize functions such as fault location, load flow analysis and short circuit calculations. These functions in combination with the zone concept contribute to enable faster restoration and possibility to utilize alternative routes independent of power direction.

It is within the scope of SGG Rural Grid project to investigate in the possibility to show how reliability indices changes further when combining DMS with the zone concept, and to find an aggregated reliability indices change for the whole pilot area.

With load flow control, included in the DMS-system, it is possible to obtain a balance between the energy generated and consumed in a network. With the algorithms in the load flow control, it is possible to determine the most optimal network configuration to keep a stable voltage level. By remote switching operations, load can be redistributing and balance maintained.

OPTIMIZE PRODUCTION OF DER

An investigation is ongoing to evaluate the possibility of using load flow control to optimize production of DER in the pilot area. The network for the zone concept pilot is suitable for this study since the network features possibilities of alternative rerouting paths with the zone concept. Measurement possibilities further out in the network and closer to the end-user and closer to the DER contributes to more secure information about the network. The idea if this study is to investigate in the possibility of balancing uneven production of DER through rerouting, even though DER is normally used to supply the network locally rather than to feed the grid.
Supervision of the rerouting is possible through the IEDs installed at the zone dividers in general and through power quality measurements functionality in the IEDs.
Two scenarios are identified to optimize the production of DER:

- Optimize uneven power production of DER at normal operation
- Optimize DER production during disturbances in the distribution network

Optimize uneven power production of DER at normal operation

Uneven power production of DER is rather rule than exception. Rather to restrain the power production at DER to obtain a voltage and frequency balance in the network, the aim is to use load flow analysis to find optimal network configuration of the existing and new-installed switching devices. Residual power production of DER will then be able to contribute to an area with shortage of power. The aim is to redistribute power rather than load.

Optimize DER production during disturbances in the distribution network

When fault occurs in the network, the DMS localize isolate and restore the healthy parts of the network. It will be investigated in the possibility of also taking the DER production into account when optimizing the network configuration of the restoration, in addition to the parameters already existing today such as critical customers, number of customers, voltage violations etc. An important parameter to look further into is also how this will affect the fault restoration. The gain of including the DER is the additional power production to balance the voltage level in the restored network.

POWER QUALITY SUPERVISION

Power quality measurement functions will be installed in the distributed IEDs in the network to provide information to the DMS. The power quality measurement functions can be used to analyze secure switching in both scenarios of normal operation switching and restoration switching, described above. With communication between the IED that measures power quality and DMS, the rerouting of power can be supervised from the control center. The operator can follow power quality parameters changes during the switching. The distributed Power Quality measurement parameters are to be evaluated to supervise if and how the DER affects the restored network after fault clearance.

Measurement vs source location

It is well known that DER contributes to power quality distortions such as flicker, harmonics, voltage peaks etc. Generally, power quality measurements should be carried out close to the DER source. This is to ensure which source contributes to power quality distortion.
The zone dividers with IEDs in the SGG project are placed to limit fault impacts in the network. The location of the zone dividers do not consider optimization of DER or power quality measurement. The calculation of zone divider placement is based on pay-back time of the installation as well as change of reliability index such as SAIDI, SAIFI, MAIFI, which includes parameters such as physical environment of the overhead line, transition between cable and overhead lines, frequent fault appearance, amount of customers affected etc.
Hence, the location of the zone dividers and IED gives the possibility to investigate in the correlation of power quality distortion in relation to distance to the physical to source and if it is possible to derive power quality distortion to certain sources or network configurations.

The island of Gotland is especially suitable for this kind of project since it represents a miniature of a larger MV network. The DER components such as wind farms and photo voltaic are situated in rural areas, which is the common case of many renewable energy resources. The contribution of DER in the pilot area of 4MW is not very much to stabilize voltages in general, but the study gives valuable information of how the network is affected; if power can be redistributed rather than load and if optimization of DER is possible during isolation and restoration after disturbances.

CONCLUSIONS

The island of Gotland is especially suitable for studying optimization of DER in a defined content. The pilot area has wind farms and photo voltaic, even though in a smaller extent. The zone concept pilot installation in SGG features possibilities of alternative rerouting paths, which is required when balancing uneven production of DER through switching. The DMS system contains load flow functionality. This is essential when switching to the most optimal network configuration of the zone dividers to optimize DER production.

With the power quality measurement functions distributed in the network, the power quality parameters can be supervised during switching into a new network configuration. This will be studied at normal operation and at restoration after disturbances. The aim is to redistribute power rather than load. Then residual DER production can be transferred to another zone where power is needed.

The zone dividers and power quality measurements are not placed to neither optimize the contribution of DER in the network or to optimally measure power quality at the DER. This gives the study possibility to investigate in correlation between power quality distortion and distance to source.

The study contributes to achieve knowledge about integration of DER in to the system operation.

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