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A REVIEW ON PHYSICAL PROTECTION OF SMART GRID

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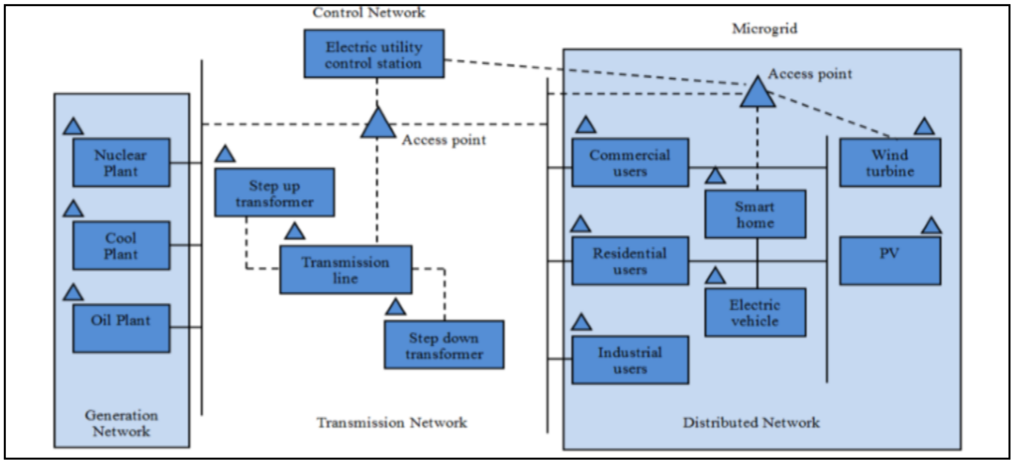
Abstract: A smart grid is an electrical grid that uses analogue or digital information and communications technology to act on information in an automated fashion to improve the efficiency, trustworthiness and sustainability of the production and distribution of electricity .Smart grid is considered as a powerful grid which improves the power grid's reliability, security, and efficiency of electrical system from generation to transmission and to distribution. As smart grid enhances, development of a reliable and stable system is necessary. Paper presents a review on the current technology in physical protection of smart grid.

1. Introduction

Reliability is needed in electrical power. Smart grid is defined as a grid which provides bi-directional flow of electricity and information, with improvement in reliability, security, and efficiency of electric system i.e. the smart grid system engages in conveyance, distribution and generation of electricity. It is motivated by the need to provide a more secure, flexible and effective electric system to overcome the increasing demand of electricity.

1.1 Structure of Smart Grid

It contains four subsections which are generation, transmission, distribution and control network. Each network is interconnected and communicates through communication subsystem such as an access point with wired or wireless communication infrastructure. Information on the network performance is obtained from smart information subsystem such as a smart meter, sensor and phasor measurement unit (PMU). Real time network monitoring, management and control are performed at the control network such as the electric utility control center. A distribution network can be an individual when dispersed generation (DG) is embedded, that allows electricity supply from both DG and utility.



1.2 Physical Protection of Smart Grid

Physical protection is defined as the protection of physical infrastructures in Smart Grid. It addresses the unintentional situations due to the failures of equipment, system and network, human errors, natural disasters and unexpected phenomena in grid infrastructures. For physical protection of a smart grid, two components have been taken into account: (a) System reliability and (b) failure in protection mechanism. A brief overview of both is below.

1.2.1 System Reliability

The system reliability is defined as the reliability of the components as well as the way the components are arranged reliability-wise. System reliability is important in power grid research, design and development. It is expected that the future smart grid will provide enhancement with better system reliability operation and smarter failure protection mechanism. There are four methods to ensure the system reliability:

1) Distributed Generation (DG) reliability in distribution network,
2) Measurement infrastructure reliability.
3) Network reliability before implementation.
4) Substations to perform decision-making.

I. Distributed Generation Reliability

It is expected that the embedded distributed generation (DG) such as small scale generation from renewable energy resources, should be used in smart grid. As the integration of DG into distributed network increases, the risk in distributed network increases. The risk compromises of distribution network reliability and stability, which is a result of the use of intermittent renewable resources. To analyze the reliability of DG, a method has been proposed that uses simulation model which increases local generators in smart grid to handle the failures resulted from DG.

II. Measurement Infrastructure Reliability

A smart measurement infrastructure is required for operating a smart grid. Measurement infrastructure helps in observing network healthiness, reliability and stability. The measurement unit is phasor measurement unit (PMU). PMUs have been widely used in wide-area measurement system (WAMS) for monitoring, controlling and protecting function in smart grid. A quantify reliability evaluation method to analyze the reliability of WAMS has been presented by researchers which uses combined Markov modeling and state enumeration techniques to evaluate WAMS reliability.

III. **Network Reliability before Implementation**

Simulation of system reliability provides a view of the system's advantages, weaknesses and short comings before implementation. Through the evaluation and decision making based on the simulation results, system can be made reliable and stable. Godfrey proposed a modeling method of using smart grid applications with co-simulation, which focuses on communication and power network in smart grid toto examine the effect on communication failures. Their simulation method enables the investigation of wide range of smart grid issues with high capability and accuracy. Ghosnals designed one more architecture for simulation that provides scalable and adaptable design that grows hierarchically into a more complete model. Such architecture also enables smart grid developer and designer to understand the weaknesses, potential short coming issues and identify the way to improve the electrical grid. There are various such methods have been researched.

IV. **Substation with Decision Making**

By empowering substation with the ability to perform decision making, the system cangive a response own its own without waiting for instruction from control network. This enables the substation to resolve the issue in a short time span and ensure the reliability of the network. Overman defined a multilevel framework trust model to ensure network reliability with reasonable compromises in both the failure and reliability. Suggestion was to pre load the substation with necessary information so that the system doesn't have to wait to perform the action. In their research, they have proven that by pre-loading the substation with a set of "next action to be taken" instructions, the proposed model could significantly increase the grid reliability and at the same time reduce real time impact from loss of reliable control.

1.2.2 Failure in protection mechanism

Mechanism has been divided into two parts:

(i) Prediction and Prevention of failure

(ii) Identification, Diagnosis and Recovery of failure.

Prediction and prevention of failure is about predicting failure location and preventing failures from occurring. If prevention of failure could not be done, identification, diagnosis and recovery are required to restore network from failure to normal position.

I. **Prediction and Prevention of failure**:

For a smart grid to operate effectively, accuracy should be there in predicting the failure and preventing failure from occurring is necessary. One approach to predict the failure is to locate the weak points in smart grid. Chertkov developed an approach to efficiently predict the weak points in a power grid and identify possible failure modes in static load distribution. The findings concluded that this approach can provide an accurate predictive capability in locating the problematic links based on different failure modes of load operation. Approach seemed to have an improved reliability in the power system. Forecasting of short circuit fault and predicting its magnitude in smart grid are also important in preventing network failure. Chen introduced an algorithm which came out to be effective in predicting the magnitude of short circuit in the shortest possible time.

II. Identification, Diagnose and Recover of failure

Failure Identification: If failure occurred, it must be identified quickly in the shortest possible time so as to avoid damage. Once the failure has been located, it must be diagnosed in order to search for the root cause. When the fault is cleared, the network must be resynchronized and restored back to normal operation. Calderaro presented a method to identify and locate failure in smart grid. The method detects the failure in data transmission and fault in distribution network through matrix operation. Verification of methods has also been done. Through the verification, it is found that the method is able to remove a lot of complexity associated in data analysis and permit quick assessment and evaluation of information, while avoiding occurrence of failures in power system protection.

Failure diagnosis: One of the crucial step is to carry out a diagnosis of failure. Various methods exists for this evaluation, for example, Hypothesis test, stepwise regression, stepwise selection by Akaike's Information Criterion etc.It has been observed that there is no single method that is best for all cases. Each method has its own potential in a particular case.

Failure Recovery: Failure recovery is an important feature in smart grid. When failure occurs, a self-healing reconfiguration in smart grid splits the power network into self-sufficient networks to stop the propagation of failure. For failure recovery within a network, Li et al presented a self-healing system reconfiguration technology with an area partitioning algorithm, to minimize the power imbalance between generation (DG) and load in network. With this efficient algorithm and by appropriately controlling the system, its restoration can be improved. Smart meter can be used to recover the missing data as data can have vital information about system analysis, decision making and smart grid operation.

Conclusion

In this paper, a review of current state of physical protection of smart grid has been presented. It focuses on ensuring the system reliability which is important in realizing effective and efficient means of smart grid operation. The development of protection mechanism to resist the attacks and failure is also necessary in order to maintain the continuity of supply as well as to ensure the stability and safety of smart grid.A brief analysis about system reliability and failure in protection mechanism has been done

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