Chapter 4
Probabilistic Power System Reliability Assessment:
Distributed Renewable Energy Sources

Oliver Dzobo
https://orcid.org/0000-0001-9602-6835
University of Johannesburg, South Africa

Kehinde O. Awodele
University of Cape Town, South Africa

ABSTRACT

This chapter presents the different dynamics in power system reliability as a result of the intrinsic behavior of distributed renewable energy sources. The output power of distributed renewable energy sources depends on the amount of available respective resource at any given time. This output power generally experiences fluctuations when compared with the output of conventional power generation units. The phenomenon is not usually included in traditional reliability worth evaluation methods for power system networks with distributed generation. In this chapter, a reliability worth evaluation model for power system networks with time-dependent distributed renewable generation resources is presented and analyzed. Time sequential Monte Carlo simulation technique is used, and the operational efficiency of the distributed generation unit is measured using the primary reliability worth index, ECOST. The derived index is fitted to a beta distribution function to show the inherent skewness of the supply reliability worth index.

INTRODUCTION

Power system reliability means the ability of a power system network to generate adequate amount of electricity for an intended period of time under encountered operating conditions to meet the electricity demand. Recently, there has been a growing dependence on safe and reliable electricity supply among electricity consumers. This has been coupled with the growing need to reduce carbon emissions and

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effective asset utilization in power system management. The reduction of carbon emissions is achieved through the use of renewable energy sources (Tazvinga & Dzobo, 2018). Development of new commercial renewable energy technologies has reduced the cost of installing renewable energy sources compared to the conventional power grid. In most cases, renewable energy sources are implemented in remote areas where grid extension is nearly impossible (Tazvinga & Dzobo, 2018; Tazvinga, Xia, & Zhang, 2013). The increasing interest in the deployment of distributed renewable energy sources has therefore provided alternative energy-based solutions which are believed to play a vital role in smart grid and modern utility. However, large scale implementation of distributed renewable energy sources into the conventional power grid will pose great challenges to the design, operation and management of the new-look power grid as it changes from a 'passive' power system network to an automated 'active' power system network. Consequently, there is need for new approaches to the planning and operation of the power system network that enables greater amount of priority to be given to the challenges of an automated power system network.

This chapter presents a supply reliability worth evaluation methodology that realistically represents time-dependent distributed renewable generation (DRG) resources and explicitly examines the influence of supply-to-load correlation on supply reliability. Probability distributions are used to model component failure and repair in time-sequential Monte Carlo simulation, while historical data is used to model the time-dependent DRG source. A probabilistic approach is employed to evaluate the supply reliability worth by simulating hourly generation availability of a solar photovoltaic (PV) source, load profiles, transmission availability, and other factors to estimate a standard supply reliability worth index, ECOST. The impact of large scale deployment of distributed generation sources on the grid reliability, performance, and operation is also considered. The chapter also describes the distributed generation technology landscape, design challenges and a vision of the modern power utility.

BACKGROUND

The power system network is one of the most complex networks built by human beings. The main purpose of the power system network is to provide electricity whenever the connected consumers require it. As the connected customers have become more and more dependent on it, the reliability of the power system has become very important. The power system network can be subdivided into three levels, namely; generation, transmission and distribution. Power system reliability can be performed at any of these levels or a combination of the levels. This section will provide highlights of the recent developments of power systems that have taken place and are ongoing.

Power System Deregulation

Traditionally the power system network has been managed through a vertical organizational hierarchy with a central monopoly. As more energy producing players came into effect, there has been pressure for the power system network to be deregulated so as to allow competition. The decentralized power system network was perceived as being more efficient because of the competitive electricity markets that energy producing players were creating. This has led to many countries shifting from the centralized monopolistic policies to a more liberalized competitive market. As a result, in most countries the power generation and distribution system network have been privatized. Consequently, electricity has