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Review on reliability improvement and power loss reduction in distribution system via network reconfiguration

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ABSTRACT

Usually, consumers experience power failures due to problems in the distribution systems. Distribution systems have evolved to an extent where smart technologies are needed for their smooth operation. Network reconfiguration is one of the functions of distribution automation that improves the performance of the system by altering the structure of the distribution network. In literature, different network reconfiguration problems have been resolved with various methods. However, the active power loss minimisation problem is considered most of all, because if these losses are less than the standard, the distribution companies can benefit monetarily. In addition, during the last few decades, distribution system reliability has been developed to provide interruption free electricity services. With improved system reliability, power distribution companies can save the expenses that are spent on a distribution system's maintenance and operation after a power failure. This paper thus gives a general background, literature review and comparative analysis of methods used for network reconfiguration for reliability enhancement and loss minimisation in the distribution network, so that new researchers can easily read the literature, especially in this area. Moreover, this is the first effort to collect the previous and the most recent research works on the field of reliability of distribution system through network reconfiguration. Therefore, this work will serve as a one stop source for the guidance of the new researchers in this field.

Contents

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1. Introduction

A power system is composed of a generation, transmission and distribution system, where the distribution system is that part of the power system that links electric utilities and power to consumers. The purpose of a power system is to provide electricity to its consumers in a reliable and economical way [1]. However, the power industry has made remarkable modifications towards deregulation to improve economic efficiency [2]. In a deregulated power system, generation, transmission and distribution are disaggregated into separate companies: generation companies (GENCOs), transmission companies and distribution companies (DISCOs). Each company is dedicated to its particular function in the power system. This power system privatisation and deregulation, along with the technological revolution and evolving customer expectations, are the driving forces that have placed electric power utilities into a competitive market. The deregulation of electric utilities may also assist in breaking the monopoly of power system brokers and creating competition between different GENCOs and DISCOs [3]. Consequently, a customer may be able to select the power supplier depending on the supply cost and its acceptable level of reliability [4]. Hence, it is essential for electric utilities to satisfy the customer's need of power demands at a reasonable cost. Moreover, due to the drastically changing nature of power network users, distribution systems may operate under heavily loaded conditions. According to [5], global energy demand is expected to increase 37% by 2040. The annual growth rate for electricity consumption in residential and commercial sectors will be 0.5% and 0.8% from 2013 through 2040, respectively [6]. Therefore, this increasing load demand may overload the distribution feeders and may complicate the system operation [7]. Thus, to meet load demands, distribution networks have to be upgraded, maintained and operated with better planning and incorporate smart technologies.

Distribution systems generally operate in radial topology because of simple protection and coordination schemes and reduced short circuit current [8]. In a radial topology each consumer has a single source of supply. Nevertheless, distribution networks are usually the prime source that causes outages in the power system [9]. It is reported in technical literature that 80% of customer interruption happens because of problems in the distribution system [10]. In Fig. 1 [11], the different reasons for outages that affected around 50,000 customers between 1984 and 2006 are shown. According to the North American Electric Reliability Corporation records in [11], 22% of the initial causes of power outages are due to system's equipment failure. In addition, system overloading is another factor that may cause outages. These power interruptions are more severe nowadays than a few years ago. According to [12], average grid failure events in U.S. has increased from 2.5 to 14.5 per month during 2000–2013. It has been predicted in [13], that power interruptions may appear more and with greater severity in the future. Recently on 21 January 2016, Mangla and Tarbela power stations in Pakistan tripped due to overloading. This resulted in a blackout across most regions of the country [14]. Northern, eastern and north-eastern Indian regional grids collapsed on 30 and 31 July 2012. The reason behind this was overloading on the Bina-Gwalior-Agra link [15]. Thus, there is a need to fill the gap between power supply and power demand to weed out the deleterious consequences of electricity disruptions caused by system overloading.

Power outages can affect both electricity consumers and electric utilities. An unreliable power supply impacts consumers primarily through economic damage, and can also suspend other electric power-dependent activities [16]. On the other hand, electric supply companies incur energy sales loss and they have to pay operational and maintenance expenses for service restoration as well [17]. Research carried out by the Lawrence Berkeley National Laboratory (LBNL) figured out that electricity breakdowns cost the United States economy $80 billion per year [18]. The reliability of the electric supply is now considered an essential planning criterion when maintaining and extending the power system infrastructure [19]. Reliability-based design of a distribution system aims to minimise the duration and frequency of supply discontinuity to the users, and the evaluation is conducted through available assessment indexes [20]. Hence, research on distribution system planning scrutinises reliability improvement as an important objective and noteworthy contributions can be

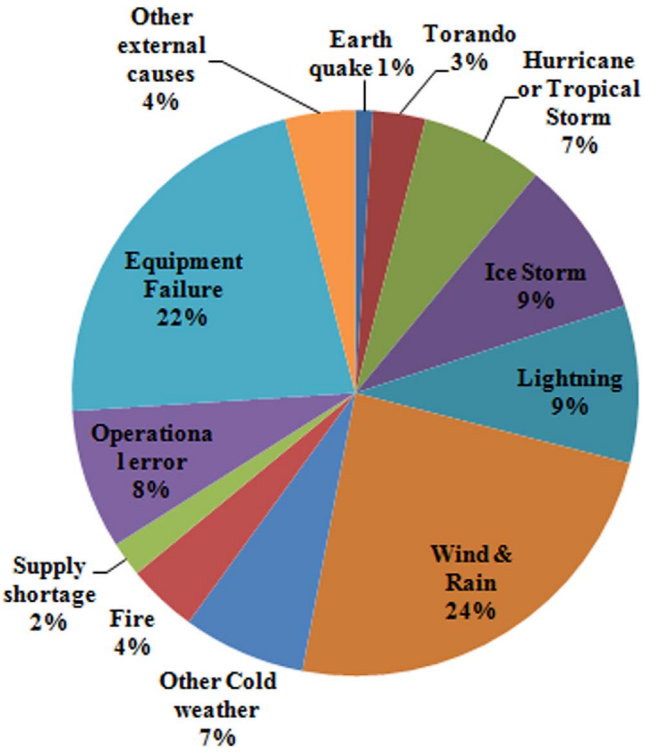

Fig. 1. Initial causes of blackouts [11].