Electrical Power and Energy Systems 33 (2011) 1470–1478

Contents lists available at ScienceDirect

Electrical Power and Energy Systems

journal homepage: www.elsevier.com/locate/ijepes

Reliability based optimum location of distributed generation

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ARTICLE INFO

Article history:
Received 18 August 2010
Received in revised form 4 March 2011
Accepted 3 June 2011
Available online 19 July 2011

Keywords:
Optimum location
Value based
Distributed generation
Reliability

ABSTRACT

The increasing penetration of distributed generation and changing electricity industry necessitates that maximum benefit is obtained from distributed generators. Due to the importance of reliability of supply, the optimum location to maximise reliability has been investigated. A value based approach is used so that costs associated with levels of reliability may be used as an indicator. These are determined using probabilistic approaches which is a departure from the traditional deterministic criteria currently used.

1. Introduction

Deregulation and restructuring of the electricity industry is one of the major changes that occurred in the last few decades. Most of the literature describes the aim of deregulation as being to open up the market to the private sector [1]. In a deregulated market, the price of energy is determined by economic factors of supply and demand as is the case with most consumer products in a free economy. Additionally, consumers are free to choose their energy supplier. Generally this leads to increased competition and better quality of supply. It also leads to a shift from the traditional vertically integrated utilities to a more distributed structure [1,2].

Environmental factors have become a major factor in most industrial activities and sustainable alternatives are being sought. The same applies to the power industry. There is a push from various utilities around the world to source 20% of the generated energy from renewable energy. An example of this is the European 2020 targets. Hence there is a need to use an increasing mix of renewable energy in the system. The nature of renewable energy sources is such, that large scale centralised generation plants cannot be used as the sole mode of power generation. Distributed generation (DG) is ideal for incorporating renewable energy sources into the generation mix. Apart from this factor, distributed generation can be used to improve system reliability, reduce transmission losses and hence directly reduce greenhouse emissions, global warming and other environmental impacts of electricity generation [3–5]. Puttgen et al. [6] point out that distributed generation is not necessarily renewable generation. However, given the nature of renewable sources such as wind or photovoltaics, it is much more feasible to use these as small scale DG sources rather than large centralised power plants.

Due to these changes in the electricity industry it is inevitable that traditional centralised power systems will be replaced by more decentralised systems with many more entities involved in the power system planning. This is leading to an increased interest in distributed generation [4,7].

In traditional centrally planned systems, reliability planning was carried out using deterministic criteria based on past experience. However, this does not account for the stochastic nature of outages. Thus, it is highly likely that the system may be over or under built if deterministic criteria are used [8,9]. Allan and Billinton [8] further notes that in the present deregulated environment investors entering the industry will want to know the performance of the sector for which they or their shareholders are responsible, which cannot be measured with deterministic criteria. Deterministic criteria are based on meeting certain adequacy requirements and cannot provide an actual indication of system performance. The aforementioned factors provide the need to move from deterministic criteria to using a probabilistic or stochastic approach based on statistical data collected on various system components and it inherently accounts for the uncertainty.

Haghifam and Hadian [3] have already shown that distribution system adequacy can be improved when DG is connected. This occurs even if the DG source is of a variable nature such as wind turbines. Characteristics of a distribution system, such as reliability, vary depending upon the point at which the DG source is connected to the distribution feeder [10]. Therefore it is vital that the maximum benefit in terms of reliability is obtained from the DG by choosing the appropriate location. In the new deregulated

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doi:10.1016/j.ijepes.2011.06.029