MultiCraft

International Journal of Engineering, Science and Technology
Vol. 3, No. 3, 2011, pp. 133-153

INTERNATIONAL JOURNAL OF ENGINEERING, SCIENCE AND TECHNOLOGY
www.ijest-ng.com

Review of distributed generation planning: objectives, constraints, and algorithms

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Abstract

The Distributed Generation (DG) technologies, which include both conventional and non-conventional type of energy sources for generating power, are gaining momentum and play major role in distribution system as an alternative distribution system planning option. The penetration of DGs is potentially beneficial if distributed generation planning (DGP) is optimal i.e. their site and size are selected optimally by optimization of single or multi-objective function under certain operating constraints. Many researchers have presented some rigorous optimization-based methods for DGP. This paper will review the various objectives, different constraints as well as optimization based models using conventional algorithms, intelligent searches and fuzzy set applications in DGP.

Keywords: Distributed Generation, distribution system, distributed generation planning.

1. Introduction

Distributed generation, unlike traditional generation, aims to generate part of required electrical energy on small scale closer to the places of consumption and interchanges the electrical power with the network. It represents a change in the paradigm of electrical energy generation. The distributed generation, also termed as embedded generation or dispersed generation or decentralized generation, has been defined as electric power source connected directly to the distribution network or on the customer site of the meter (Ackermann *et al*, 2001). The emergence of new technological alternatives allows the DG technologies in distribution network to achieve immense technical, economical and environmental benefits (Chiradejaand *et al*, 2004; El-Khattam *et al*, 2004; Pepermans *et al*, 2005). These benefits could be maximized by proper planning i.e. placement of DGs at optimum locations with optimum size and suitable type.

The environmental concerns and the limitations of conventional power stations have imposed the restrictions on new large scale conventional power station or expansion of existing conventional power stations. Moreover, concerns over security of fuel supply have led governments to set targets to diversify their energy mixes in forthcoming decades. The incentives are already in place to encourage renewable and combined heat and power developments pertaining to the distribution network. Voltage control, fault levels, reliability, and power losses are among the issues, faced in integrating DG into distribution network (Pepermans *et al*, 2005; Barker *et al*, 2000; Jenkins *et al* 2000; Willis *et al*, 2000; Jóos *et al* 2000; Edwards *et al*, 2000; Girgis et al 2001; Masters *et al*, 2002; Walling *et al*; 2008). In fact, the DG fundamentally changes the characteristics of network (Ault *et al*, 2000; Dugan *et al*, 2001).

In literature, various objective functions have been considered and optimized, subject to different operating constraints, using conventional methods, intelligent searches and fuzzy set application for DGP. After a detailed study of the large amount of literature, a review on DGP will summarize the objective function model, the constraint model, and the mathematical algorithms. These three components are succinctly discussed as follows.

The objective function may be single or multi-objective to achieve maximum benefit of DGs without violating the equality and inequality constraints of the system. The base objective is to minimize total real power loss in the system (Rau *et al*, 1994; Kim *et al*, 1998; Hedayati *et al*, 2008; Acharya *et al*, 2006; Singh *et al*, 2009; Gözel *et al*,2009; Singh *et al*, 2008; Nara *et al* 2001; Krueasuk *et al*, 2005; Lalitha *et al,* 2010; Hung *et al*, 2010). Other possible objectives may be to minimize real and reactive power loss (Popović *et al*, 2005) or to maximize DG capacity (Keane *et al*, 2005; Harrison *et al*, 2007; Dent *et al*, 2010; Dent *et al*, 2010;