Quantitative Assessment of Distributed Generation Benefits to Improve Power System Indices

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Abstract. In this paper, a novel approach is proposed to assess and quantifying some of the technical benefits of Distributed Generation (DG) based on a set of indices. The proposed indices are: Voltage Profile Improvement index, Network Loss Reduction index, Line Capacity Release index and Greenhouse Gases Effect Reduction index. The Zanjan Regional Electric Company (ZREC) power system network has been simulated by DIgSILENT software and proposed indices have been determined in different scenarios. These scenarios have been developed considering the number of busses with DG connection, geographically dispersed substations with installed DGs and the capacity of the installed DG. The study results have been presented and discussed to illustrate quantitatively usefulness of utilizing distributed generation technologies in bulk power system.

Key words

Distributed generation, Quantitative assessment, Voltage profile, Line losses, Line capacity release, Greenhouse effect

1. INTRODUCTION

With present electric sector regulations that allow independent energy producers to access transmission and distribution systems, the presence of customers with energy exportation capabilities and, moreover, governments' incentives for specific energy resources, distributed generation (DG) appears to have many factors supporting its rapid development [1]. DG can be powered by both conventional and renewable energy sources [1,2].

Distributed generations (DG) is related with the use of small generating units installed in strategic points of the electric power system and, mainly, closes to load centers. The technologies applied in DG comprise small gas turbines, micro-turbines, fuel cells, wind and solar energy, etc. DG can be used in an isolated way, supplying the consumer's local demand, or in an integrated way, supplying energy to the remaining of the electric system [3].

Most of the benefits of employing DG in existing distribution networks have both economic and technical implications and they are interrelated. As such, it is proposed to classify the benefits into two groups – technical and economic.

The major technical benefits are:
- Reduced line losses
- Voltage profile improvement
- Reduced emissions of pollutants
- Increased overall energy efficiency
- Enhanced system reliability and security
- Improved power quality
- Relieved T&D congestion

The major economic benefits are:
- Deferred investments for upgrades of facilities
- Reduced O&M costs of some DG technologies
- Enhanced productivity
- Reduced health care costs due to improved environment
- Reduced fuel costs due to increased overall efficiency
- Reduced reserve requirements and the associated costs
- Lower operating costs due to peak shaving
- Increased security for critical loads

Chiradeja in [4] has quantified the benefit of reduced line loss in a radial distribution feeder with concentrated load. A line loss reduction analysis is shown clearly in [5]. The loss can be significant under heavy load conditions. The utility is forced to pass the cost of electrical line losses to all customers in terms of higher energy cost. With the inclusion of DG, line loss in the distribution system can be reduced.

The limit of [5] is only to search the line loss reduction for the simplest case of a radial distribution feeder. In fact, the utility networks are more complex, they usually have a radial structure with many feeders along the transmission line.

The benefits of DG have discussed by evaluating and quantifying in terms of capacity credit, energy value and energy cost saving in[6]. The effects of improvement in voltage profile and loss reduction were not considered in the method. Joss et al. [7] have demonstrated the potential of DG with power electronic interface to provide ancillary services such as reactive power, voltage sag compensation and harmonic filtering. It has proved the ability of DG to compensate voltage sag resulting from faults in the power