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RESEARCH ARTICLE

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Solving multi-objective optimal power flow problem considering wind-STATCOM using differential evolution

Abstract In this paper, a simple strategy based differential evolution was proposed for solving the problem of multi-objective environmental optimal power flow considering a hybrid model (Wind-Shunt-FACTS). The DE algorithm optimized simultaneously a combined vector control based active power of wind sources and reactive power of multi STATCOM exchanged with the electrical power system to minimize fuel cost and emissions. The proposed strategy was examined and applied to the standard IEEE 30-bus with smooth cost function to solve the problem of security environmental economic dispatch considering multi distributed hybrid model based wind and STATCOM controllers. In addition, the proposed approach was validated on a large practical electrical power system 40 generating units considering valve point effect. Simulation results demonstrate that choosing the installation of multi type of FACTS devices in coordination with many distributed wind sources is a vital research area.

Keywords differential evolution, multi-objective function, optimal power flow, economic dispatch, valve point effect, environment, wind source, STATCOM

1 Introduction

The optimal power flow (OPF) problem is a vital optimization tool for experts of electric utilities. OPF strategy consists of optimizing one or more specified objective functions while assuring secure operating conditions for a power system [1]. Due to the pressing public demand for clean air, many clean air act amendments from USA, European and Japanese governments have forced utilities and expert engineers to integrate environment issue into the standard optimal power flow (OPF) [2–4]. Security optimal power flow can be handled as a multi-objective optimization problem with a large-scale highly constrained nonlinear optimization problem.

In recent years, many types of renewable source (wind, solar, biomass) and a wide variety of flexible AC transmission systems (FACTS) devices, shunt controllers (SVC, STATCOM), series controllers (TCSC, SSSC) and hybrid controllers (UPFC) have been integrated into the modern electrical power system to improve energy efficiency and power quality delivered to consumers [5]. FACTS devices improve the usage of existing installations and provide a better adaptation to various planning and operational conditions [6]. The main role of FACTS technology is not only to bring a system under control and to transmit power as ordered by the control centers, but also to increase the usable transmission capacity to its thermal limits [7]. Wind power industry has been developing rapidly, and high penetration of wind power into grid is taking place [8]. In 2010 the worldwide wind power capacity reached 196 GW with an annual growth rate of 23.6% [9]. With the large integration of these two technologies into the electricity market, the power system becomes more complex, which requires robust techniques to achieve optimal operation and control. Figure 1 shows the basic strategy of security combined environment economic dispatch considering multi shunt FACTS devices and wind sources.

It is important to underline the importance of energy efficiency planning in a deregulated power system. The combined term "energy planning" is usually associated with power quality; how energy is produced (economic issue), how energy is consumed at the point of end use (technical issue), and what is the impact of the total energy produced on the environment (gas emissions). Three important technical issues should be taken in consideration by expert engineers and researchers to exploit efficiently the integration of these new technologies in a practical power system [6]:

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