Chapter 13
Transmission Expansion Planning by using DC and AC Models and Particle Swarm Optimization

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ABSTRACT

The Transmission Expansion Planning (TEP) entails to determine all the changes needed in the electric transmission system infrastructure in order to allow the balance between the projected demand and the power supply, at minimum investment and operational costs. In some type of TEP studies, the DC model is used for the medium and long term time frame, while the AC model is used for the short term. This chapter proposes a load shedding based TEP formulation using the DC and AC model, and four Particle Swarm Optimization (PSO) based algorithms applied to the TEP problem: Global PSO, Local PSO, Evolutionary PSO, and Adaptive PSO. Comparisons among these PSO variants in terms of robustness, quality of the solution, and number of function evaluations are carried out. Tests, detailed analysis, guidelines, and particularities are shown in order to apply the PSO techniques for realistic systems.

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INTRODUCTION

The Transmission Expansion Planning (TEP) problem consists of determining all the changes needed in the transmission system infrastructure, i.e. additions, modifications and/or replacements of obsolete transmission facilities, in order to allow the balance between the projected demand and the power supply, at minimum investment and operational costs. The TEP problem is a large scale, mixed–integer, non-linear, non-convex and combinatorial problem. It has been largely discussed in the specialized literature and this is still considered a very complex problem where better algorithms are needed. The publications, according to the optimization technique, are classified into mathematical, heuristic, and meta-heuristic approaches. Techniques such as dynamic programming (Dusonchet, 1973), linear programming (Oliveira, 2007), non-linear programming (Youssef, 1989), mixed-integer programming (Alguacil, 2009), Benders decomposition (Akbari, 2011), Hierarchical decomposition (Romero, 1994), and Branch and Bound (Choi, 2007) method have been used and are categorized as mathematical based approaches. These techniques demand large computing time, due to the dimensionality curse of this kind of problem. Heuristic methods emerged as an alternative to classical optimization methods; their use has been very attractive since they were able to find good feasible solutions, demanding a small computational effort. Some heuristic approaches have been proposed using constructive heuristic algorithms (Romero, 2005), and the forward – backward approach (Seifi, 2007). Meta-heuristic methods emerged as an alternative to the two previous approaches, producing high quality solutions with moderate computing time. Genetic algorithms (Gallego, 2007; Rodriguez, 2009), Differential evolution (Georgilakis, 2011), Greedy Randomized Adaptive Search Procedure (Binato, 2001), Harmony search algorithm (Verma, 2010), Tabu search (Da Silva, 2001) have been used to solve the TEP problem among other metaheuristic optimization techniques. It is important to point out that they cannot guarantee the global optimal solution to the TEP problem.

In the last years, several novel meta-heuristic techniques have been proposed. In particular, Particle Swarm Optimization (PSO) has been successful in tackling power systems related problems, and constitute a serious option when one has to solve complex optimization problems (Del Valle, 2008; Torres, 2011).

The TEP problem involves several hierarchical levels of power system analysis studies and requires a large amount of expertise of the system planners. In each stage of the planning horizon, some alternatives for the TEP are selected and used as a starting point for the next planning stage. This kind of study can be performed for three time frames, namely long term, medium term, and short term. Each stage presents some particularities, which requires the utilization of an adequate power system model. The DC model is used for medium and long term studies, while the AC Model has been recently proposed to be used for short term ones (Rider, 2007).

There are several works reported in the literature regarding the use of the DC Model in TEP (for instance Romero, 2002; LaTorre, 2003; Romero, 2005). On the other hand, only very few works have been developed using the AC network model (Rider, 2007; Rider, 2007; Rodriguez, 2008; Gallego, 2009; Rodriguez, 2009; Rahmani, 2010).

One of the most common approaches to deal with the TEP problem is by modeling the load shedding, which has been proposed only using the DC model. The load shedding approach is not only useful in quantifying this variable in the obtained expansion plans, but also it is important to penalize the objective function, in case of a constraint violation, in an easy way. In this research