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Optimal capacitor placement on West–East inter-tie in Saudi Arabia using genetic algorithm☆

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ABSTRACT

The growing demand for renewable energy resources, improved power factor, system stability, reliability and security is the target of Saudi Electricity Company (SEC); most of the loads are inductive and need more reactive power (VARs) thus adequate reactive power need to be provided. SEC has introduced the static voltage compensator (SVC) and capacitive banks to improve volt-ampere-reactive (VAR) power flow. Genetic approach (GA) is used to obtain the optimal data for load flow. This paper provides analysis of new-planned 380 kV West–East transmission line inter-tie networks performance under steady and transient states. It considers the reactive power compensation by the addition of capacitor bank at the terminals of the inter-tie. The GA method is outlined and implemented to dynamically solve the capacitor placement problem. The capacitor bank has improved power losses, operating voltage at different buses.

1. Introduction and background

Excessive VAR demands cause reduction of system capacity, higher losses eventually decreased voltage and higher operation costs. Shunt capacitor banks are able to compensate VAR requirements. The power system design engineer considers and need to be optimized the following main factors before connect the capacitor bank in the power system network; the size of the Capacitor bank, optimal location, control methods, and implementation cost of the capacitor bank. In general, “rule of thumb” of fixed capacitor banks method applies, accompanied by several power flow runs that is needed to well tune the size and location. The major drawback of this method does not produce the optimal solution, very time consuming and unrealistic for large network. Therefore, many design engineers consider the capacitor placement problem as an optimization issue; an optimization approach should be employed [1].

Saudi Electricity Company (SEC) is the only utility provider to all customers in the kingdom. Geographically, it is divided to four main regions, the east operating area (EOA, central operating are (COA), west operating area (WOA) and the south operating area (SOA). The eastern, central regions are connected with six 230kv double circuit transmission line and four-380kv double circuit transmission line. The central and west are also non-connected with double circuit 380kv through Hassan, to madina. SEC has taken more plans and actions to meet the rapid increase demand of the all four regions. Many inter-ties are under construction to connect western region to the south region. More efforts and projects are planned to connect the SOA and COA. The paper presents an investigation using an optimal approach of one of the important inter-tie link namely the 380kv double circuit line from Tabuk-Al-Qurayyat to Tabarjal-Jouf illustrated in Fig. 1.

In general, the optimal capacitor sizing and placement problem is consider as a non-linear type. Several well-presented research

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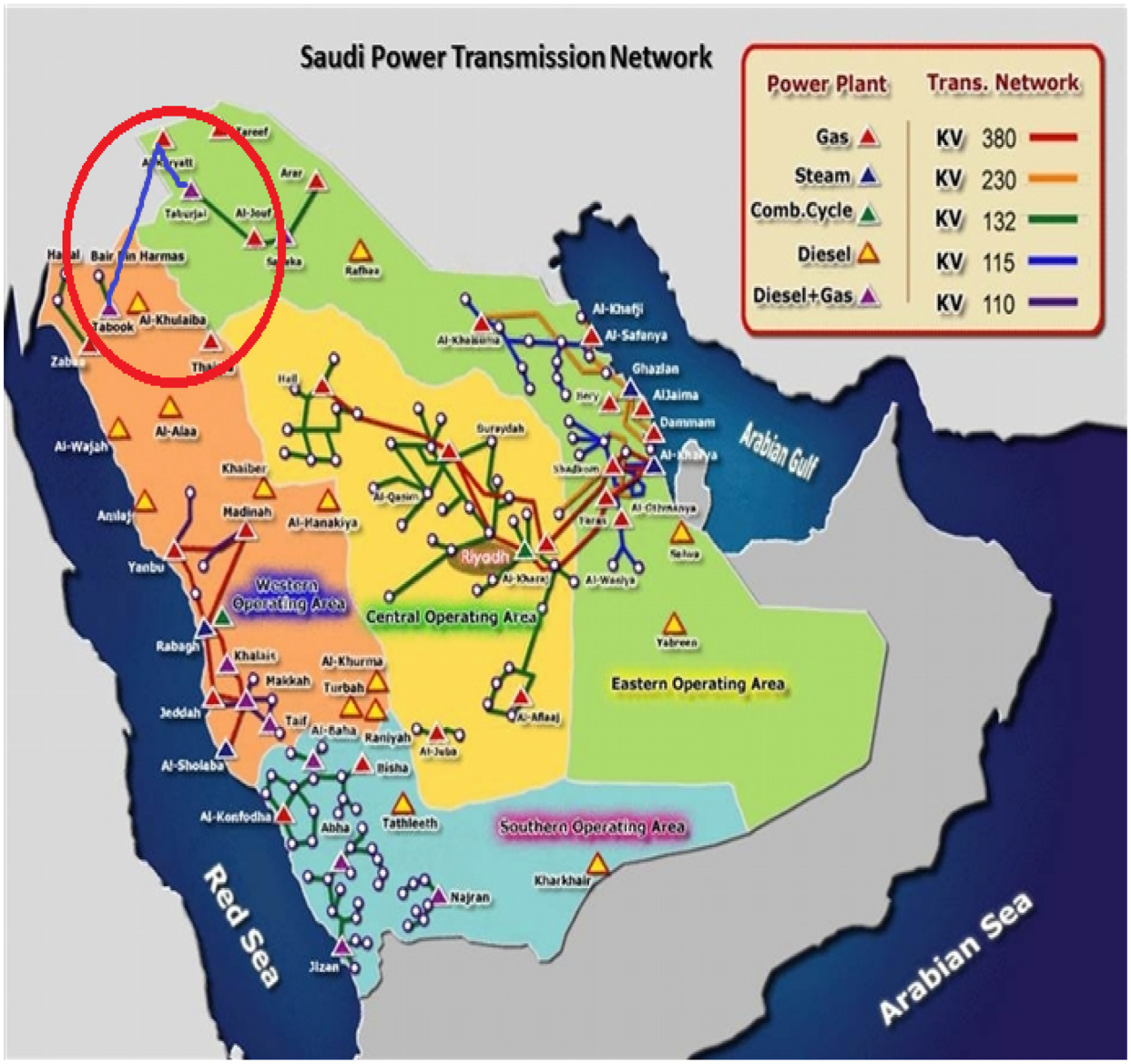

Fig. 1. SEC Proposed inter-tie transmission network [2].

papers have been published with various applications of optimization algorithm to solve such problem efficiently. In Reference [3] it was proposed that the recursive linear programming (RLP) technique to find the optimal location for capacitor placement and reducing the line losses in a distribution system. Antunes et al. [4] proposed the Non-Dominated Sorting Genetic Algorithm (NSGA) to fix the optimal location of the capacitor for reactive power compensation in radial distribution system. Prakash and Sydulu [5] proposed the particle swarm optimization (PSO) with loss sensitivity factors to solve the capacitor placement problem of different bus distribution systems. The objective functions are considered in this study is to increase the voltage in each bus and reduce the active power loss.

The work in [6] proposes a method employing the ant colony system (ACS) to solve multi-period optimization problem. The objective functions taken for this study is reducing the installation cost of the capacitor and net cost of the energy and power losses from base to horizon year, subject to limitations corresponding to lower and higher limits of the voltage at each bus of the distribution network. Muthukumar and Jayalalitha [7] proposed a method employing harmony search (HS) approach to detect optimal size and position of capacitors in unstable distribution systems with harmonics consideration. The objective function considers in this study is