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# Active and reactive power transmission loss allocation to bilateral contracts through game theory techniques

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**Abstract:** Transmission loss has a considerable effect in overall power generation. For fairly distributing the charge of losses to generators and consumers in a deregulated power system, the allocation of this loss is very important. Game-theoretic methods seem fairer for share determination of each participant of a coalition with no discrimination. In this paper, the active and reactive power transmission losses are allocated to bilateral transactions simultaneously through load flow calculations and cooperative game theory solutions. The loss allocation problem and each bilateral transaction are treated as a game and a player of the game, correspondingly. Two game theory-based approaches, the Shapley value and the $\tau$-value, are surveyed. The former is the most relevant game theory allocation method, while the latter is a novel approach. The influences of all loss allocation game players and bilateral bargains on transmission loss are considered. These two proposed methods are applied to a simple 6-bus network and the modified IEEE 57-bus test system. In the 6-bus network positive MVA loss allocations and in the IEEE 57-bus system negative MVA loss allocations are studied. Finally, the results of allocation procedures are compared to each other.

**Key words:** Bilateral transaction, cooperative game theory, loss allocation, Shapley value method, $\tau$-value method

## 1. Introduction

With the introduction of energy market concepts and the privatization of electric power systems, which occurred in the early 1980s, most power systems in the world started to move from traditional, monopoly, and vertically integrated structures to competitive markets. For trading electric power in open electrical energy markets, bilateral and pool-based methods are considered. Bilateral transactions are usually long-term agreements determined through individual negotiations between a buyer and a seller [1].

The electric power industry is undergoing a series of challenging changes due to deregulation and competition. One of the most important issues is the allocation of transmission losses among market participants [2]. Different proposals for the allocation of the cost of losses in electricity networks have appeared in the last years for transmission and distribution systems. As a result of the increasing range of agents with open access to transmission networks and the massive quantity of losses concerned, efforts are concentrated on transmission systems [3]. Generally, the transmission loss that is produced by all transactions in the system accounts for 3%–5% of total generation [4]. Thus, the process of loss allocation is important. It determines whether the extra charge can be fairly allocated to each bilateral transaction [5].

Several methods for transmission loss allocation have been recently proposed. One of the earliest methods

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