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Transmission cost allocation based on the users' benefits

M. Roustaei [a], M.K. Sheikh-El-Eslami [b,*], Hossein Seifi [a]

[a] Department of Electrical & Computer Engineering, Tarbiat Modares University, Tehran, Iran
[b] Department of Electrical & Computer Engineering, Tarbiat Modares University, P.O. Box: 14115-111, Tehran, Iran

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ABSTRACT

In a competitive electricity market, transmission can be viewed as being in competition with generation. The transmission network indeed allows remote generators to compete with local ones. Thus, transmission benefits are not the same for all and this fact is important in transmission cost allocation method. There are various methods to allocate the transmission costs among the network users; but the most of the proposed methods are only based on the transmission flow (or physical usage).

This paper, focusing on transmission cost allocation in an economic way that is based on "users' benefits". This method is according to transmission value and direct beneficiaries of transmission which are indirectly related to transmission physical usage. The beneficiaries of each transmission facility are determined for each market participant (consumer and/or producer) by calculating its revenues with and without the facility. The proposed algorithm is applied to a 3-bus and 24-bus IEEE test system and their results are compared to popular Bialek's tracing method.

Introduction

Cost allocation of electricity transmission is a challenging subject, due to the presence of economies of scale and density investment. Therefore, transmission prices should send the correct signals to investors [1]. In an electric power market, proper transmission pricing could meet revenue expectations, promote an efficient operation, encourage investment, and adequately reimburse owners of transmission assets. Importantly, the pricing scheme should implement fairness and be practical. The ongoing research on transmission cost allocation (and pricing) indicates that there is no generalized agreement on pricing methodology [18]. An important aspect in the electric power market design is the transmission cost allocation method. With the growing complexity of networks and the large number of transactions in electricity market, the development of a fair transmission pricing model has become a contentious issue [5]. Transmission cost allocation policy should move in the direction of reducing or eliminating cost socialization and ensuring that costs allocated to beneficiaries are commensurate with the benefits [10]. Based on the Federal Energy Regulatory Commission (FERC) order "The cost of transmission facilities must be allocated to those within the transmission planning region that benefit from those facilities in a manner that is at least roughly commensurate with estimated benefits" [8]. Transmission network is subject to "economies of scale" in expansion and it appears that transmission incentives will not be enough to induce the desirable investment. Transmission can be thought of as the vehicle that connects the producers to the consumers of electricity and the opportunity to profit from price differences to be a significant driver in investment [6].

There are various methods to allocate the transmission costs among the network users. Major transmission cost allocation methods are: Postage-Stamp, MW-Mile and MVA-Mile, Contract Path, Unused Transmission Capacity, Counter-flow, Distribution Factors, Bialek's Tracing, Kirschen's Tracing, and etc. [18,12].

Abou El Elaa and El-Sehiemy [3] present a transmission cost allocation survey and then, transmission cost allocation using different proposed methods has been efficiently solved in the deregulated environment. Some authors use game theory for transmission cost allocation [5,20]. Bhakar et al. [5] represent a new method for transmission cost allocation using the concept of cooperative game theory; Game theory concept provides stable solutions to all the participants.

Radzi et al. [17] represented a transmission cost allocation algorithm which is called Distribution Factors Enhanced Transmission Pricing (DFETP) method to promote the green technology and increasing the utilization efficiency of the network in a market environment.

In [14] a new method is proposed to allocate the transmission cost based on power flow equations and a modification to the

* Corresponding author. Tel.: +98 21 88220121.
E-mail addresses: m.roustaei@modares.ac.ir (M. Roustaei), aleslam@modares.ac.ir (M.K. Sheikh-El-Eslami), seifi_ho@modares.ac.ir (H. Seifi).

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network impedance matrix. In the other research, a simple transmission pricing scheme using a power flow tracing method is presented [15]. The methods that have been used in two recent papers are classified in tracing methods. In [9] a new method to allocate electricity transmission costs from nodal pricing viewpoint is presented that the price elasticity values for nodes are defined instead Locational Marginal Price (LMP).

Beckman [4] described the evolution of cost allocation for India's transmission system and analyzed the impacts of the shift from a postage stamp method to a flow-based method for transmission cost allocation. In decentralized markets, two pricing methods are point-to-point tariff and the point-of-connection tariff. Point-to-point tariff is a transaction based method and has been calculated by power flow (i.e. MW-Mile method). Point-of-connection (POC) scheme is a non-transaction based method (i.e. postage stamp) in which the geographic distance between buyers and sellers does not affect transmission changes [2].

Telles et al. [19] proposed a new method based on Long Run Marginal Costs (LRMC) and the min–max optimization technique to seek transmission tariffs. The proposed method can be used to optimize costs for generators and loads.

Most of these concepts and associated methods employ a contribution factor for each market participant based on use of transmission facilities that is one defect of traditional approaches.

This paper, focusing on a new transmission cost allocation concept based on calculation of transmission capacity benefits for users; so, the proposed method in this paper is based on "users' benefits". This method is according to transmission value and direct beneficiaries of transmission which are indirectly related to transmission physical usage.

This paper is organized as follows; in 'Responsibility for transmission costs payment', the responsibility for the transmission costs payment is addressed. 'Transmission cost allocation approach' describes the proposed algorithm. In 'Case studies', results of the application of the method to a simple 3 bus network and the IEEE 24 bus test system are presented. Finally, 'Conclusion' presents brief conclusions and some policy implications of the results in the paper.

Responsibility for transmission costs payment

Who are responsible to pay the costs of transmission services? In some proposed cost allocation methods, producers (or generation side) are responsible and in the others, consumers (demand side) or both are. According to FERC order, the determination of beneficiaries of a transmission facility whether should include generators or loads depend on how the use of the transmission system is interpreted, how beneficiaries are defined [7]. As a general rule, all Regional Transmission Organizations (RTOs) in the United States allocate the costs of transmission infrastructure to consumers (demand side). But, generators interconnecting to the transmission system are responsible for the cost of direct interconnection facilities. In the European Union, there is a wide variance in how much transmission infrastructure costs were allocated to generations. In 13 countries, power producers are not pay any portion of the transmission costs and in 12 other EU countries, producers pay some portion of transmission costs, ranging from 0.5% (in Poland) to 35% (in Norway). In other countries, transmission costs were allocated to producers as well as consumers. For example, in Australia and Singapore consumers are 100% responsible, in Brazil and South Korea responsibility of producers and consumers is equal (50%) and in Chile, producers bears a large share of transmission costs (80%) compared with consumers (20%) [16]. In this paper, the contributions of generation and demand sides are not important as they are determined automatically after calculation of each user contribution.

Transmission cost allocation approach

In a competitive electricity market, transmission benefits are not the same for all users and this fact is important in transmission cost allocation method. There are various methods to allocate the transmission costs among the network users which are directly based on the transmission flow and are known as usage-based methods. Usage-based methods are according to physical usage of transmission capacity and do not consider the economic viewpoints. It is technically reasonable, however, is not so successful in transmission investment or transmission expansion planning. Therefore, based on the FERC order, it is purposed that the cost of transmission facilities must be allocated to those that benefit from those facilities [8] which is indirectly related to the transmission uses.

"Transmission value" and "users' benefits" are described in the following and then, the proposed algorithm is presented.

Transmission value and users' benefits

For illustration of the transmission value and users' benefits, a simple example is presented in Fig. 1. In this example, two remote generators with a transmission line compete to supply local and remote loads.

There are two areas ("A" and "B") with one connection. We assume that the demands in A and B are constant and equal to 1000 MW and 2000 MW, respectively and these demands do not vary with time (are perfectly inelastic). Electricity production prices in A and B are: $\pi_A = 10 + 0.01^* P_A$ and $\pi_B = 13 + 0.02^* P_B$.

Generators from both sides compete to supply the total demand, which is equal to the sum of the two demands: PA + PB = DA + DB = 1000 + 2000 = 3000 MW. Electricity price in A is significantly lower than in B. One might therefore envision that generator A might supply not only their domestic demand but also the entire demand of B demand. We would then have $P_A = 3000$ MW and $P_B = 0$ MW. There are two extreme cases for generators productions:

- *Case 1:* In the absence of an interconnection, the two sides operate independently and the prices in A and B are 20 $/MW h and 53 $/MW h, respectively. The value of transporting the first megawatt-hour from A to B is thus equal to the difference in price between the two countries, that is 33 $/MW h. In this case: $P_A = D_A = 1000$ MW, $P_B = D_B = 2000$ MW, $P_{A\sim B} = 0$ MW and payments of A and B demands are equal to revenues of A and B generators, respectively.
- *Case 2:* In the presence of unlimited capacity interconnection, the two sides operate in equal prices and the price in A (and/or B) is 31 $/MW h ($\pi = \pi_A = \pi_B = 31$ $/MW h).

In the presence of limited capacity interconnection (0 < $_{PA\sim B}$ < 1100 MW), the prices of two sides are different and payments of demand and revenues of each generator are dependent to the capacity of interconnection line.

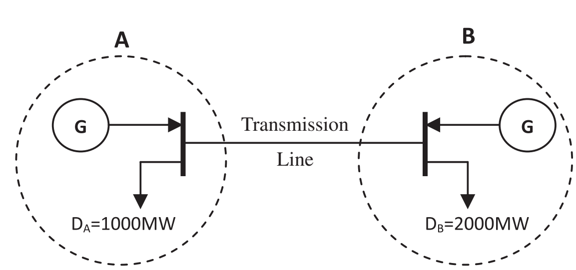

Fig. 1. Model of 2-node interconnection.