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Transmission Network Cost Allocation based on a Possible Maximum Used Capacity for N-1 Secure Operation

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Extended Abstract

I. Introduction

This paper proposes an efficient power flow based approach to transmission fixed cost allocation problem in a pool based electricity market that takes into consideration N-1 secure operation. In power system operation, network users are not able to use full capacity of the transmission facilities of the system. Due to thermal loading and power system security constraints, there is always a reliability margin left between actual usage and maximum capacity of the transmission facilities. In this paper, the possible maximum used capacity of a transmission facility is introduced as the maximum power flow the facility may face under a contingency situation for a certain system snapshot. This capacity is the smallest capacity a facility must have in order to successfully withstand any possible contingency in the network, for a given system state and can be also used as an indicator for identifying corridors that require reinforcement. In this power flow based pricing approach, the differentiated use of system charges for a transmission facility are based on the facility usage at that system snapshot that requires the largest optimal facility capacity considering annual system operation. Network usage is determined by generalized distribution factors [1] and three variations of the MW-Mile method for pricing counter-flows are investigated for the proposed cost allocation method [2]. The three proposed pricing methods are applied on IEEE 24-bus reliability test system and compared with other pricing methods.

II. Proposed method

In power flow based transmission pricing methods, a load flow solution that may be representative of a certain load and generation pattern or an outcome of an optimal power flow is initially needed; then if congestions occur in the network, the marginal based remuneration is calculated and subtracted from total fixed cost. The allocation of transmission line power flows to each network user is performed by using a tracing method, and the remaining fixed transmission cost is allocated to transmission users using an embedded method. This paper proposes a transmission pricing scheme that takes into consideration both security and transmission planning aspects. More specifically, it is proposed that a security constrained optimal power flow (SC-OPF) solution [3] is used first to trace each user’s contribution to the line flows of the network. In this way, a more realistic, “N-1” secure, snapshot of the power system is used for allocating transmission fixed cost to actual network users.

The cost of each facility is not linked any more to its maximum capacity, but to its possible maximum used capacity over a long period simulation. The three proposed MW-Mile approaches are calculated by (1) to (3). In these formulations, counter-flows are charged (1), credited (2) or neglected (3) in the cost allocation process:

$$TCopt_{t,abs} = \sum_{k\in K} C_k \cdot \frac{\left|F_{t,k}^{(M_k)}\right|}{F_{opt,k}^{(M_k)}} \quad (1)$$

$$TCopt_{t,rev} = \sum_{k\in K} C_k \cdot \frac{F_{t,k}^{(M_k)}}{F_{opt,k}^{(M_k)}} \quad (2)$$

$$TCopt_{t,zcf} = \sum_{k\in K} C_k \cdot \frac{F_{t,k}^{(M_k)}}{F_{opt,k}^{(M_k)}} \quad , \quad \forall \ F_{t,k}^{(M_k)} > 0 \quad (3)$$

C_k is the cost of line k, $F_{t,k}^{(M_k)}$ is the power flow on line k caused by user t under load scenario M_k and $F_{opt,k}^{(M_k)}$ is the largest optimal capacity of line k corresponding to load scenario M_k over all LS examined load scenarios. The maximum used (optimal) capacity of each line for each load scenario is provided by (4):

$$F_{opt,k}^{(ls)} = \max(\left|plinec_{k,1}^{(ls)}\right|, \cdots, \left|plinec_{k,K}^{(ls)}\right|) \cdot \frac{F_{k,\max}}{F_{k,\max}^{c}} \quad (4)$$

where $plinec_{k,m}^{(ls)}$ is the power flow on line k after an outage on line m for load scenario ls and $F_{k,\max}^{c}$ is the short term emergency rating of line k.

III. Results

The proposed algorithm is tested on the IEEE 24-bus reliability test system considering generation data as in [4]. Table I shows the load duration and the simulation load for each of the eight load scenarios used in the proposed algorithm. In order to have a realistic view of the committed generators topology, spinning reserve equal to the largest committed generator must be also available by the committed generators. Figs. 1 to 3 show the transmission charges per peak load obtained by the postage stamp, the used MW-Mile and the proposed optimal MW-Mile methods for each demand node. In all proposed pricing methods, the general trend of charges (higher at nodes with lower voltage levels located far from cheap generation) is followed, however, for almost all the lines of the network, a higher share of each line's annual cost is allocated by the proposed method, when compared to the used MW-Mile methods.

In order to show the effect a new transmission investment will have on transmission charges, a new line between nodes 8 and 9 is introduced in the network. In Fig. 4, the percentage cost allocation for the new line between nodes 8 and 9 is presented using the zero counter-flow methods and postage stamp method. By using the proposed method, the transmission use of system charges for the new line is mostly allocated to users that directly benefit from that line (i.e. users at nodes 7 and 8).

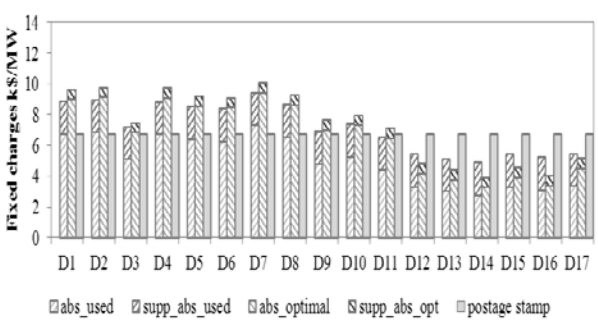

Fig. 1. Consumer annual fixed cost charges per peak load based on the *used absolute* and the *absolute optimal* methods for IEEE 24-bus reliability test system.

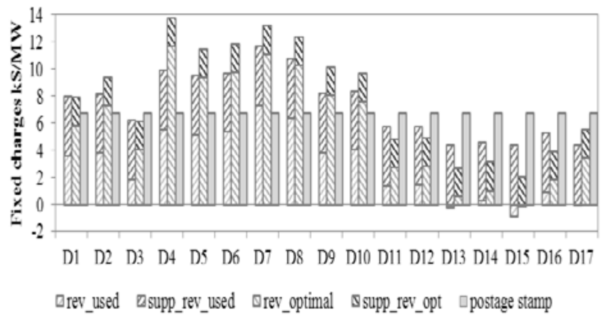

Fig. 2. Consumer annual fixed cost charges per peak load based on the *used reverse* and the *reverse optimal* methods for IEEE 24-bus reliability test system.

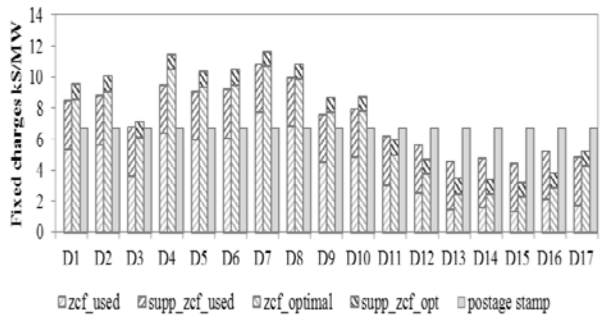

Fig. 3. Consumer annual fixed cost charges per peak load based on the *used zero counter-flow* and the *zero counter-flow optimal* methods for IEEE 24-bus reliability test system.

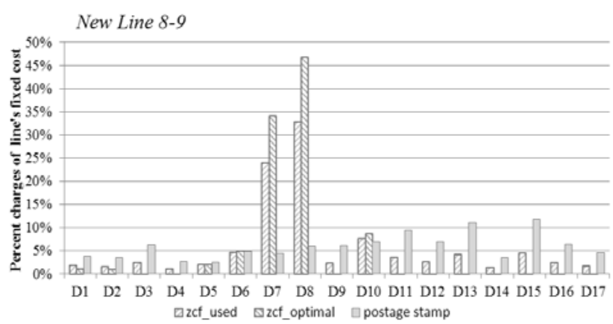

Fig. 4. Percentage share of final fixed cost charges for new line 8-9 when based on *zero counter-flow* methods for IEEE 24-bus reliability test system.

References

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