ABSTRACT

This thesis focuses on some key issues related to allocation and management by the independent grid operator (IGO) of unbundled services in multiple transaction open access transmission networks. The three unbundled services addressed in the thesis are transmission real power losses, reactive power support requirements from generation sources, and transmission congestion management. These services are acquired by the IGO from generators or loads in the network and are used to facilitate the transactions.

We develop the general framework that explicitly represents multiple transactions undertaken simultaneously in the transmission grid. The power flows in the transmission system are recast in the multiple-transaction-based framework. This framework serves as the basis for formulating various problems treated in the thesis.

We use this comprehensive framework to develop a physical-flow-based mechanism to allocate the total transmission losses to each transaction using the system. The proposed scheme is based on expressing the transmission losses explicitly in terms of all the transactions in the system. An important property of the allocation scheme is its capability to effectively deal with counter flows that result in the presence of specific transactions. Extensive numerical testing indicates that the allocation schemes produce loss allocations that are appropriate and that behave in a physically reasonable manner.

The loss allocation results are the basis for the construction of the equivalent loss compensation concept and its application to develop flexible and effective procedures for compensating losses in a multiple-transaction network. The proposed procedures provide transactions with the choice of selecting self-acquisition of loss compensation at

designated bus(es) or purchasing the loss compensation service from the IGO. The IGO can provide loss compensation as a value-added service to its transmission customers by acquiring the service in the least-cost manner. The self-acquisition option may coexist side-by-side with the IGO-acquisition, and any physically feasible combination of these acquisition options is possible. The effectiveness and flexibility of the proposed procedures are illustrated with numerical results on a number of test systems.

We present a new physical-flow-based mechanism for allocating the reactive power support requirements provided by generators in multiple-transaction networks. The allocatable reactive support requirements are defined with respect to the support required for the network with no transactions in place. The requirements in the presence of the proposed transactions are formulated as the sum of two specific components - the voltage magnitude variation component and the voltage angle variation component. The formulation utilizes the multiple-transaction framework and makes use of certain simplifying approximations. The formulation leads to a natural allocation as a function of the amount of each transaction. The physical interpretation of each allocation as a sensitivity of the reactive output of a generator is discussed. The extensive testing indicates that the allocation scheme approximates with good fidelity the actual net reactive power outflow from the generator buses. The numerical results also indicate that the proposed scheme behaves in a physically reasonable and intuitive way.

We also focus on the IGO's congestion management in multiple transaction networks. We propose a congestion management allocation scheme that provides the IGO with a useful tool to allocate and relieve transmission congestion. The proposed scheme determines the allocation of congestion among the transactions on a physical-flow basis.

It also proposes a congestion relief scheme that removes the congestion attributed to each transaction on the network in a least-cost manner to the IGO and determines the appropriate transmission charges to each transaction for its transmission usage. The performance and capability of the proposed scheme are extensively tested and validated on various test systems.

The thesis provides a compendium of problems that are natural extensions of the research results reported here and appear to be good candidates for future work.