学位論文内容の要旨

Transmission losses form a significant component of the amount of power that has to be generated in order to meet the power demand. As an example, in a power network with a demand of 10,000 MW and 7% transmission losses, the implication is that the generation must be capable of supplying 10700 MW, an extra 700 MW, fully a large power plant that must be built and operated. Clearly, someone must pay for both the capital investment and the fuel needed to generate the 700 MW of lost power. In the traditional utility, this cost is bundled into the rates together with other ancillary services and charged in some pro-rata fashion. With competition, this practice still persists but, more and more, there will be a need to allocate losses to transactions in a more systematic manner, particularly one that will account for the network location of the buyer and seller as well as the non-linear interaction among simultaneous transactions. For example, transactions where the seller and buyer are electrically close may not generate much in the way of losses. Similarly, some transactions may actually reduce overall system losses while others can have an opposite effect. Methods that can systematically identify such differences in behavior are therefore required.

This research work concerns about the investigations regarding the transmission loss allocation of power systems in the deregulated power industry. Recently the monopolistic electric utility industry has entered an era of freewheeling competition and deregulation, allowing consumers to buy electricity from any company offering it. The increasing prominence of ideas such as conservation, energy efficiency, and free markets helped propel the power system toward open competition. There are certain operating cost associated with power losses cannot be unbundled because of non-linear nature of power flows. The loss allocation procedures developed so far can be categorized into incremental, circuit-based, proportional sharing and miscellaneous approaches for loss allocation including bilateral transactions. Loss allocation is a procedure for subdividing the power transmission losses into fractions, the cost of which then become the responsibility of individual users in the power system. Loss allocation does not affect generation levels or power flows in transmission lines, however, it does modify the distribution of revenues and payments at the network buses among suppliers and consumers. The total loss assigned to a transaction may differ significantly depending on allocation methodology adopted. Therefore, an acceptable procedure is the crying need to conquer the loss allocation problem. The issue of how to consider the power loss to the network users has not been established properly. So, to solve the loss allocation problem; this work demonstrates loss allocation methodologies based on Incremental Transmission Loss (ITL) by using DC Optimal Power Flow (DC-OPF). In this study, four procedures have been developed and discussed in detail.

1. A successive approximation methodology based on ITL of node is called Incremental Loss Allocation (ILA) procedure. In this procedure, starting from the minimum load level, system total load is incremented by a small amount; then total loss, power output and power output change of every generator are estimated by DC-OPF. Incremented loss is calculated and adjusted to the total loss computed by DC-OPF. This adjusted loss is the allocated loss to a generator. After every iteration (except the first iteration), incremented loss is added to the previous allocated loss and then adjusted to the total loss as before. Economic Load Dispatch (ELD) mode of operation of the generators has been applied in this process.

2. A directly ITL based loss allocation procedure called Proportional Allocation (PA) procedure has also been developed. In this procedure, the positive power injection in a generator bus is multiplied by the ITL of that bus and then adjusted to the total loss calculated by DC-OPF.

3. A loss allocation formula has been developed considering that the generators are running under ELD approach. Using this formula the preliminary losses to the generators are calculated at

first and then correction factors are calculated from them. According to the correction factors the preliminary losses are adjusted to the total loss computed by using DC-OPF.

4. A New DC-OPF method (NDC) has been developed which is much faster and accurate than the DC methods developed so far. The main feature of the procedure using NDC method is that the real impact of every transaction on the transmission system has been considered extensively and properly. The numerical analysis using this procedure proves that the system losses are shown to be separable among the buses naturally. No special approximations are required in the derivation of loss coefficient matrices that are useful tools in the loss allocation equations (one for loss allocation to loads and the other for loss allocation to generators). It is extremely simple to formulate and to implement. This procedure also yields allocation levels generally consistent with the power flow computations. Comparing several features of the procedures developed in this work, it is worth noting that this procedure has got the highest priority regarding performance and quality in every sphere of calculation.

Thus, it can be concluded that the proposed loss allocation strategy based on the NDC method is robust and provides a simple and effective way to solve the loss allocation problem, that is, the main barrier in the deregulated power market has apparently been subjugated.

論文審査結果の要旨

電力の規制緩和・自由化にともない、送電線の解放、即ち、ネットワークへの自由なアクセスが実現している。卸電力市場や相対取引市場など電力市場における電力の決済価格を決定する際には、このようなネットワーク使用の経済評価を明確にすることが求められる。即ち、電力輸送に伴い発生する送電損失を誰がどのように分担すべきか明らかしておく必要がある。

本論文は、送電損失分担量決定の前提条件として、系統が経済運用実施下にある場合を想定し、市場参加者間での新しい損失決定法を提案すると同時に従来法との比較から提案法の有用性を述べるとともに、最適潮流計算法への発展が可能であるとして、具体的な手法を展開している。論文では、まず、①増分送電損失（ITL）を使った従来の損失分担法の経済運用環境下での系統への適用法を述べ、次いで、②この手法の欠点を克服するための発電機出力－ITL特性を算定する実験式的評価法を開発し、モデル系統を使った両者の比較検討結果から提案法の有用性を明らかにしている。更に、③線形潮流モデルに基づく損失配分理論を確立し、発電機および需要家において交互に損失分担量を決定するアルゴリズムを導入して、提案手法を新しい最適潮流計算法へと展開し、その有用性を検証している。このように本論文は、新規性、有用性から判断して博士の学位に相応しい内容を有しているといえる。