Chapter 10
Transmission Risk Optimization in Interconnected Systems:
Risk-Adjusted Available Transfer Capability

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ABSTRACT

Available transfer capability is a key indicator of transmission reliability and varies with the variation in power flow pattern through the network. ATC determination considering the uncertainties in renewable generation and demand is of key significance for the safe and economic operation of power system, especially in a competitive market environment. A two-stage, risk-adjusted, generation dispatch minimizing the variation in ATC, caused by the changes in renewable energy power output and the change in load, is discussed. The solution strategy is designed for a network operator, considering the ease of use and practicality. A combined transmission-distribution system with solar, wind, and conventional dispatchable energy sources is developed, and ATC for the systems is estimated combining continuation power flow and power transfer sensitivity factor methods. The joint probability distribution function of ATC is derived using individual discrete probabilities renewable power generation and loads. Risk, quantified as the variance of ATC, is minimized using stochastic weight trade-off non-dominated sorting particle swarm optimization, considering various goals of the network operator, for example, maximizing overall system performance and minimizing the renewable energy risk.

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INTRODUCTION

A world-wide paradigm shift of the electric power production and distribution platform, from monopolistic to decentralized operation, is observed in recent times. An upsurge in the number of independent power producers both on high and low voltage sides, have intensified the competitive nature of the market, escalating the operational complexity of transmission system operator or owner (Unni, Ongsakul, & Madhu M., 2019). Available transfer capability (ATC) is a crucial financial index for the transmission operator, which physically indicates the amount of transfer capability left over after allowing the currently committed bilateral transactions. It also provides the scope of future commercial activities (Li, Li, Ni, & Wu, 2003; Wu, 2007). Mathematically, ATC is computed as given in (1) (NERC, 1996).

$$ATC = \text{'}TTC\text{'} - CBM - TRM - \text{'}ETC\text{'}. \tag{1}$$

Where, TTC is Total transfer capacity and CBM is capacity benefits margin, which are not constant as per the infrastructure and policies of the power system. TRM represents Transmission reliability margin and ETC denotes Existing transfer commitments, which are the base indicators for ATC, since the rest are constants.

MOTIVATION

The most popular of the renewable energy resources, solar PV and wind power generation systems exhibit stochastic nature (Daus, Kharchenko, & Yudaev, 2018; Vasant, Zelinka, & Weber, 2019). The estimation of ATC should be subjected to the variations in generation and load, especially if renewable energy generation is involved. The works including the uncertainties of renewable generations as well as loads at the same time, are scarce. Many of the studies adopt a formulation that is time consuming and hence, less suitable for short-term dispatch. Hence, an attempt to formulate a network operator compliant, ATC estimation algorithm, that can consider the uncertainty associated with renewable energy sources and load, which can be used for short-term operational decision making.

BACKGROUND/RELATED WORKS

Popular deterministic methods available for calculating ATC include, continuation power flow, repeated power flow, power transfer sensitivity factors, optimal power flow (Wu, 2007) and DC-power flow methods (Chiang, Flueck, Shah, & Balu, 1995). Recent literature have introduced the application of machine learning techniques (Vaithilingam & Kumudini Devi, 2013) and hybrid mutation PSO (Farahmand et al., 2012) to determine ATC. Stochasticity associated with generations, including solar and wind systems and load induce both financial and technical risk into the scheduled operation scenario of TSO, which is not considered in the above literature. The effect of these deviations from the forecast is reflected in the ATC values of corresponding lines, affecting the various bilateral transactions. Probabilistic ATC estimation also gained ample research interests owing to these reasons. In (Rodrigues & Da Silva, 2007; Wei, Li, & Zhou, 2015), the stochastic effects of load change and equipment failure on ATC is considered.

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