School of Electrical, Computer and Energy Engineering

PhD Final Oral Defense
Probabilistic Power Flow Studies to Examine the Influence of Photovoltaic Generation on Transmission System Reliability

by
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Abstract
Photovoltaic (PV) power generation has the potential to cause a significant impact on power system reliability since its total capacity is projected to increase at a significant rate. PV generation can be described as an intermittent and variable resource because its production is influenced by ever-changing environmental conditions.

The study in this dissertation focuses on the influence of PV generation on transmission system reliability. This is a concern because PV generation output is integrated into present power systems at various voltage levels and may significantly affect the power flow patterns. This dissertation applies a probabilistic power flow (PPF) algorithm to evaluate the influence of PV generation uncertainty on transmission system performance.

A cumulant-based PPF algorithm suitable for large systems is used. Correlation among adjacent PV resources is considered. Three types of approximation expansions based on cumulants namely Gram-Charlier expansion, Edgeworth expansion and Cornish-Fisher expansion are compared, and their properties, advantages and deficiencies are discussed.

Additionally, a novel probabilistic model of PV generation is developed to obtain the
probability density function (PDF) of the PV generation production based on environmental conditions.

Besides, this dissertation proposes a novel PPF algorithm considering the conventional generation dispatching operation to balance PV generation uncertainties. It is prudent to include generation dispatch in the PPF algorithm since the dispatching strategy compensates for PV generation injections and influences the uncertainty results. Furthermore, this dissertation also proposes a probabilistic optimal power dispatching strategy which considers uncertainty problems in the economic dispatch and optimizes the expected value of the total cost with the overload probability as a constraint.

The proposed PPF algorithm with the three expansions is compared with Monte Carlo simulations (MCS) with results for a 2497-bus representation of the Arizona area of the Western Electricity Coordinating Council (WECC) system. The PDFs of the bus voltages, line flows and slack bus production are computed, and are used to identify the confidence interval, the over limit probability and the expected over limit time of the objective variables. The proposed algorithm is of significant relevance to the operating and planning studies of the transmission systems with PV generation installed.