International Journal of Energy Optimization and Engineering
Volume 10 • Issue 1 • January-March 2021

A Probabilistic Optimal Power Flow in Wind-Thermal Coordination Considering Intermittency of the Wind

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ABSTRACT

This article specifically aims to prove the superiority of the proposed moth swarm algorithm (MSA) in view of wind-thermal coordination. In the present article, a probabilistic optimal power flow (POPF) problem is formulated to reflect the probabilistic nature of wind. Modelling of doubly fed induction generator (DFIG) is included in the proposed POPF to represent the wind energy conversion system (WECS). To reduce DFIG imposed deviation of bus voltage ancillary reactive power support is considered. Moreover, three different optimization techniques, namely, MSA, biogeography-based optimization (BBO), and particle swarm optimization (PSO) are independently applied for the minimization of active power generation cost for wind-thermal coordination, considering different instances in case of IEEE 30-bus and IEEE 118-bus system. From the simulation results, it is confirmed and validated that the proposed MSA performs considerably better than BBO and PSO.

KEYWORDS

Biogeography-Based Optimization, Doubly-Fed Induction Generator, Moth Swarm Algorithm, Particle Swarm Optimization, Probabilistic Optimal Power Flow, Wind Energy Conversion System

NOMENCLATURE

σ_j^t Dispersal degree

μ^t Variation coefficient

$x_{r^1}^t$ Donor vector of t-iteration

L_{i1}^t, L_{i2}^t Two independent identical variables

DOI: 10.4018/IJEOE.2021010105

$best_g$ Global best solution

$2g / G$ Social factor

$1 - g / G$ Cognitive factor

r_1, r_2 Random number between [0, 1]

L_p Heavy tail Lévy-flights

ε_1 Randomly drawn samples from the Gaussian stochastic distribution

$\varepsilon_2, \varepsilon_3$ Evenly distributed random numbers within an interval [0, 1]

C_1, C_2 Acceleration coefficients of PSO

W Inertia weight of PSO

1. INTRODUCTION

The high rate of fossil fuel depletion and devastating pollutant effects from fossil-fuelled power plants attract researchers into renewable energy-based power generation for socio-economic growth (Kharchenko and Vasant 2018). Wind accounts for the largest share of renewable energy in the environment and has an exceptional role in producing of cleaner power (Kharchenko and Vasant 2019). In recent years, the wind power unit has been integrated along with the conventional thermal unit (CTU) to ensure the economic balance of power production cost and also to maintain a pollution-free, clean environment (Kharchenko and Vasant 2019). When the wind energy conversion system (WECS) is integrated with CTU, the formulation of optimal power flow (OPF) becomes more complex because the intermittency of wind introduces more constraints and additional cost functions into the OPF problem (Hetzer et al. 2008). In order to uphold a balance between economic and environmental concerns of electrical power productions, it is necessary to formulate a probabilistic OPF (POPF) framework that deals with a significant number of probabilistic aspects in view of production and economy concerns of power imposed by the intermittent wind.

2. BACKGROUND

The available power in the wind does not always match with the estimated one because of the wind-intermittency. This occurrence includes two scenarios - a) under estimation scenario - when the available power of the wind is more in comparison with the estimated, b) over estimation scenario- when the accessible power of the wind is a deficit with respect to the estimated (Jabr and Pal 2008). In (Panda and Tripathy 2014), the authors clearly stated that during under estimation of wind power, the independent system operator (ISO) compensates for a penalty amount for not using the available wind power, and in the over estimation scenario, the ISO must consider a reserve cost along with the cost of the active power generation. In this context, Ortega-Vazquez and Kirschen carried out research on how different cost functions are related to the intermittency of the wind (Ortega-Vazquez and Kischen 2010). So it can be very easily understood that- incorporating WECS along with the OPF problem is not a very easy task for the power system engineer. To realize the wind intermittency, a probability density function (PDF) known as Weibull distribution was implemented (Panda and Tripathy 2014). Roy and Yadav presented the optimization of the total active power generation cost of the wind integrated thermal power system along with the emission issues (Roy and Jadav 2015).

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