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Title

Optimized Dynamic Transmission Network Expansion Using Improved Binary PSO: A Case Study for Power System Planning

Abstract

Kenya's electricity demand continues to increase with industrial growth and national electrification targets under Vision 2030. Renewable sources currently supply about 87% of total generation, comprising approximately 47% geothermal, 16% wind, 4% solar, and 20% hydro. However, the transmission system faces efficiency challenges due to ageing infrastructure and technical losses of about 23%. These losses limit the evacuation of renewable power from generation zones to major load centres, leading to congestion and voltage instability. This study presents a Dynamic Transmission Network Expansion Planning (DTNEP) model solved using an Improved Binary Particle Swarm Optimization (IBPSO) algorithm. Voltage limit violations are incorporated as penalties in the objective function, while active power losses are modelled as variable operational costs within a 10-year planning horizon. The method determines the optimal location and number of new transmission lines at minimum total investment cost without violating voltage (±5%) or thermal loading limits. The model was implemented in MATLAB and validated on Garver's 6-bus test system. Results show that the IBPSO-based DTNEP reduces transmission-line construction cost by approximately 5 % and system power losses by 23 % compared with the conventional BPSO approach. The findings demonstrate that incorporating voltage limits in dynamic expansion planning enhances system adequacy, alleviates congestion, and can be extended to actual power system networks facing similar operational challenges.

Photo

Biography

Irene N. Muisyo received her B.Sc. degree in Electronic and Computer Engineering (2010) and M.Sc. degree in Electrical Engineering (2018) from Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya. She earned her Ph.D. in Electrical Engineering (Power Systems) from the Pan African University Institute for Basic Sciences, Technology and Innovation (PAUSTI) in 2022. She is currently a Lecturer and the Founding Chairperson of the Department of Electronic and Computer Engineering at JKUAT. Her research interests include Renewable Energy Systems, Power Electronics, Electric Mobility, and Machine Learning applications in driving Sustainability. She has participated in international collaborative projects such as the JICA Project Type A and B, and the Sakura Science Exchange Program. She also leads university–industry collaborations with companies such as ROAM Electric, ARC Ride, IBM, and SEACOM, focusing on innovation and student mentorship. Dr. Muisyo serves as an Editor of the *Journal of Sustainable Research in Engineering (JSRE)* and as a Technical Committee Member for IEEE AFRICON and IEEE Power Africa Conferences (PAC), among others.