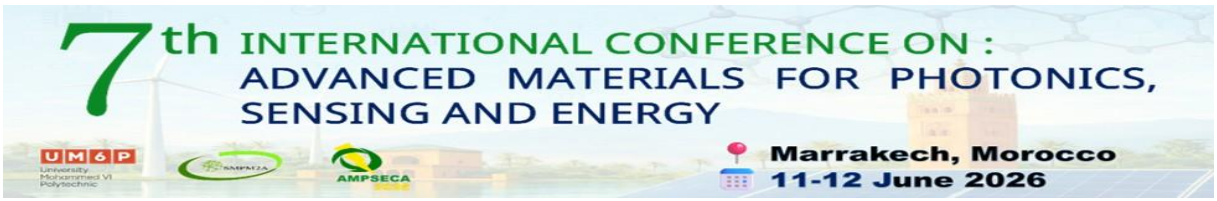


# Machine Learning–Based Transient Stability Assessment of Renewable Energy Integrated Power Systems

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**Abstract:** The use of renewable energy sources (RES) in modern inverter-based power systems is rapidly increasing and poses serious challenges to stability due to the reduction of system inertia and the erratic nature of power generation. Conventional time-domain methods are computationally very laborious and too slow for real-time stability assessment, and smart grids require a data-driven model for real-time monitoring of renewable energy. This paper proposes a machine-learning (ML) based method for fast and accurate transient stability assessment of modern power systems, by utilizing python based open-source simulation environment. A model of the IEEE 14-bus test system is modeled using PandaPower, where solar photovoltaic (PV) and wind generators were integrated at different penetration rates such as 20%, 40%, and 60%. The simulations were conducted considering comprehensive disruption scenarios such as line outages, load variations, and generator trips under different levels of renewable energy penetration. To classify stability, voltage magnitude, line loading, and voltage phasis deviation variables are considered as input characteristics. A Random Forest (RF) and Logistic Regression (LR) model is developed, trained and evaluated including metrics of accuracy, recall, precision, and F1-score. The simulation results demonstrate accuracy of the RF and LR models is 100% and 98.3%, respectively. The analysis reveals weak buses are most sensitive to stability degradation. The proposed models allow millisecond predictions that highlight importance of machine learning based on stability monitoring systems. The method provides modern, practical and scalable stability assessment solutions for next generation for inverter dominated smart grids.

**Keywords**: Transient stability assessment, Machine learning (ML), Smart Grids, Grid Integration, Low-inertia power systems

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