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Assessment and mitigation of the influence of rising charging demand of electric vehicles on the aging of distribution transformers

Abstract-

The world is currently moving towards more environmentally friendly modes of transport. As a result, the sales of electric vehicles (EVs) are growing exponentially, and the new charging-associated loads are influencing the operation of the power distribution networks and their elements. Given the stochastic nature of the additional load from EVs, it is difficult to predict such a load with analytical methods. In this regard, a fuzzy-logic-based tool to assess the influence of the charging load of EVs on the transformers’ aging was developed in the MATLAB-Simulink environment, and the impact of different EV penetrations was simulated and assessed. The fuzzy-logic-based model incorporates the influence of ambient temperature, power quality, and overloads. It comprises a diagnostic part, which warns a user about possible issues by providing actual information about the transformer's state, and a tuning part, which is aimed at optimizing the transformer's load level and the power factor at the secondary voltage side. Moreover, the effectiveness of photovoltaic generation units, shunt capacitor banks and battery energy storage systems, installed at the secondary voltage side, for distribution transformers’ service life extension were analyzed. The results show that, for high EV penetration levels, a combined grid reinforcement strategy allows to reduce the loss of life of the transformer by around 3–5 times.

Index Terms- Electric vehicles; Loss of life; Transformer's aging; Battery energy storage; Photovoltaic generation; Power distribution network; Reactive power compensation; Fuzzy logic

Citation: