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Sequentially Pruning Phase Rebalance Schedule: Load Profile Learning Approach

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TR2024-143 October 17, 2024

Abstract

As low-voltage (LV) distribution networks evolve with the rise of prosumer behavior, traditional reactive load management strategies fall short of addressing the voltage phase imbalances caused by unpredictable load variations. Voltage imbalances pose significant risks including inefficiency, power outages, and equipment failures. Existing optimization solutions lack the adaptability to address this problem extensively with such dynamic environments due to the computational time budget limit. In response, this paper presents a novel method utilizing an Imitation Learning (IL) framework implemented through Ensemble Random Forests to prune the process of sequential load phase swapping, previously determined by solely running at all times costly multi-objective optimization. We maximize classifier recall performance to ensure reliable pruning. Tested across various Solar Photovoltaic (PV) penetration levels (30-100 percent) on a standard 13-bus LV test feeder, our method demonstrates substantial improvements in mitigating voltage imbalance, reducing operational costs, and decreasing feeder testing time by 83 percent. This marks a significant step forward in smart grid technology, offering utilities a robust tool to enhance system reliability with considerable time efficiency.

IEEE PES Innovative Smart Grid Technologies Conference - Europe (ISGT Europe) 2024

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