Dynamic Game-Theoretic Cooperative PWM-Based Energy Management for EV Charging Infrastructures

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Abstract. This paper proposes a Dynamic Game-Theoretic Cooperative PWM-Based Energy Management Algorithm (DGTE-PWM) for electric vehicle (EV) charging infrastructures, implemented on the smart grid demonstrator at University Cadi Ayyad, FST Marrakech. Each system component (including EV batteries, storage units, photovoltaic (PV) generation, and the main grid) is modeled as a strategic player in a dynamic non-cooperative game. Cooperative Nash equilibria are achieved through PWM duty cycle modulation to simultaneously minimize energy losses, voltage deviations, and battery degradation. MATLAB/Simulink simulations demonstrate that DGTE-PWM dynamically adapts to fluctuating PV generation, improves battery lifespan, optimizes energy costs, and fairly allocates resources among multiple EVs. Comparative results indicate that DGTE-PWM outperforms conventional Greedy and Proportional PWM strategies, providing smoother and more responsive control. demonstrating superior adaptability and efficiency. The proposed approach represents a robust framework for intelligent energy management in smart EV charging infrastructures.

Keywords: DGTE-PWM, EV charging, energy management, PV integration, smart grid, battery storage