Design and Evaluation of a Smart Neighborhood Framework for Secure Energy Trading Among Interconnected Microgrids

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This project proposes the design, modeling, and evaluation of a Smart Neighborhood (SN) framework that enables resilient, affordable, and equitable decarbonization of electricity supply through local energy trading among multiple interconnected microgrids operating particularly under weak-grid conditions. The research directly addresses Net-Zero pathways in both developing and developed energy systems by mainly focusing on decentralized coordination, user participation, and intelligent market mechanisms in environments characterized by supply constraints and frequent outages.

Each microgrid within the Smart Neighborhood integrates distributed renewable generation, primarily rooftop photovoltaic systems, along with energy storage units, controllable loads, electric vehicles, smart metering, and monitoring infrastructure. Through coordinated control strategies and market-based energy trading, the SN operates as a local energy ecosystem that enhances reliability, improves utilization of renewable resources, reduces dependence on carbonintensive diesel generation, and creates economic value for participating users. The framework is explicitly human-centered, emphasizing user participation, fairness, and transparent incentive structures in local energy markets.

The project systematically investigates alternative technical and market designs, including centralized versus decentralized trading architectures, cooperative versus competitive participant behavior, and grid-connected versus islanded operation. Advanced energy management and trading algorithms, spanning optimization-based, game-theoretic, and learning-based approaches, are developed and comparatively evaluated under realistic uncertainty, network constraints, and cyber-physical considerations.