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Coupling economic multi-objective optimization and multiple design options: a business-oriented approach to size an off-grid hybrid microgrid

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Abstract-

Achieving the maximum economic profitability is a priority for microgrid developers. However, although economic indicators usually dominate the business decision making, rarely numerical indicators are fully able to capture the entire sociopolitical, technical and geographical circumstances affecting the business environment, especially in rural areas of developing countries. Typical planning approaches achieve a single solution, or a set of solutions in multi-objective approaches, and near-optimal solutions are usually discarded even when they may better fit the specific multi-faceted circumstances of a project. In this paper, we propose a multi-objective approach that not only calculates the traditional Pareto-frontier but also compiles near-optimal solutions that enlarge the options portfolio for microgrid developers. The proposed iterative approach stores all the simulated solutions, and post-processes them to provide the developer with multiple design options (MDO). A modified version of Multiple-Objective Particle Swarm Optimization (MDO-MOPSO), with improved convergence criteria based on quadratic mean of the crowding distances and spread, is developed and used. A numerical case study of a Kenyan hybrid microgrid using real data confirms that near-optimal solutions can correspond to extremely different design solutions, even ±100% w.r.t. the Pareto-efficient ones, with only very limited disparities in the economic objective functions. The results, supported by a Key Performance Indicator (KPI) analysis, based on diversity measures, show that MDO methodology can successfully support the business decision making and help developers size microgrids considering several nearly-equivalent sizing options.

Index Terms- Multiple Design Options (MDO); Multiple-Criteria Decision Making (MCDM); Solution pool; PV-Wind-Battery-Diesel hybrid energy system; Mini-grid; Multi-Objective Particle Swarm Optimization (MDO-MOPSO)

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