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Stochastic sizing of isolated rural mini-grids, including effects of fuel procurement and operational strategies

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Abstract— The governments of developing countries struggle to guarantee the universal access to electricity on their territory and 1.2 billion people are still without any service, especially in remote areas. Hybrid mini-grids can be an effective solution since they exploit local renewable resources integrated with energy storage devices, reduce the use of fuel generators, and defer the construction of long and expensive grids until the growth of demand makes it profitable. Off-grid mini-grids are typically operated with simple load-following dispatching strategies, but predictive approaches can provide better performances, although at the expense of additional computational requirements. This paper investigates the benefits of using rolling-horizon dispatching strategies during the mini-grid design stage, also comparing how the optimal size of components is affected by several technical and economical parameters. Moreover, we propose the use of a stochastic sizing procedure that captures the uncertainties related to the load, to the renewable generation, and to the time required for the fuel procurement and delivery. A case study with real load data collected from an existing mini-grid placed in Habaswein, Kenya, is presented and discussed. The optimal sizing of some components turns out to be almost unaffected by the operational strategies, so their preliminary design can be simplified to avoid time-consuming simulations. Conversely, the optimal sizing of the diesel generator and of its fuel tank is strongly related to both the local economic parameters and the operational strategy of the mini-grid, which must be properly simulated.

Index Terms— Mini-grid; Isolated system; Fuel management; Monte Carlo; Optimization; Rolling-horizon dispatching

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