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Optimal design and Levelized Cost of Electricity of 100% solar power microgrids in Africa: robustness and sensitivity to meteorological and economical drivers.

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Autonomous micro-grids based on solar photovoltaic (PV) are one of the most promising solution to bring electricity access in many off-grid regions worldwide. The sizing of these microgrids is not straightforward. It is especially highly sensitive to the multiscale variability of the solar resource, from sub-daily to seasonal times scales (cf. Plain et al. 2019). Because of this, achieving a given level of service quality requires to provision 1) storage and 2) extra PV production capacity, the main challenge being to also deliver electricity during times with no solar resource (night) and during periods with low solar resource (e.g. winter). Different storage / PV panel sizes can produce the same level of service quality. The optimal design is typically identified to minimize the levelized cost of electricity (LCOE). The cost optimization however obviously relies on a number of technical and economic hypothesis that come with large uncertainties, such as the installation and maintenance costs of both PV and batteries, the system lifetime or the temporal profile of the electricity load.

This work explores the robustness of the optimal sizing to variations of different such parameters. Using irradiance data from Heliosat SARAH2 and temperatures from ERA5 reanalysis, we simulate the hourly solar PV production of a generic array of PV panels for 200 locations in Africa over a 8-years period. We then identify the configurations (storage, PV panel surface) for which 95% of demand hours are satisfied. For different PV/storage costs' ratios and different electrical demand profiles, we then identify the configuration with the lowest LCOE.

Our result show that the optimal configuration is highly dependent on the characteristics of the resource, and especially on its co-variability structure with the electric demand on different timescales (seasonal, day-to-day, infra-day). It is conversely very robust to changes to costs hypotheses.

These results have important practical implications. They especially allow us to propose simple design rules that are based on the only characteristics of the solar resource and electrical demand. The storage capacity can be estimated from the 20% percentile of the daily nocturnal demand and the PV surface area can be estimated from the mean daily demand and the standard deviation of

the mean daily solar energy.

These rules are very robust. They allow to guess the optimal configuration for different costs' ratios with a good precision. The normalized root mean square error is 0.17 for the PV capacity, 0.07 for storage capacity and 0.02 for LCOE.

Plain, N., Hingray, B., Mathy, S., 2019. Accounting for low solar resource days to size 100% solar microgrids power systems in Africa. Renewable Energy. https://doi.org/10.1016/j.renene.2018.07.036