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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Context: Autonomous solar microgrids are now considered to foster electricity access in many isolated areas. They aim to achieve a moderate levelized cost of electricity (LCOE) for a good quality of service level (QSL). Different storage/PV fleet configurations typically allow achieving a same QSL and the one that minimizes the LCOE is usually retained as the design configuration (Fig1). This design configuration may however significantly depend on the updated costs of the system and one could expect this configuration to be not really robust to updated cost variations, such as those observed nowadays for storage and PV panels.

Objective: Evaluate the robustness of design and LCOE to prices variations

Method and data:

- SODA radiation : 15min, 2009-2011, 0,05°x0,05°
- Analysis of 15 grid points in different regions
- Analyses for 3 demand profiles : domestic, productive and mix of them
- Design QSL criterion;: the demand of each hour in a day has to be satisfied 95% of days
- Calculation of storage requirements for different PV capacities and selection of the least cost option in terms of LCOE (Fig2)

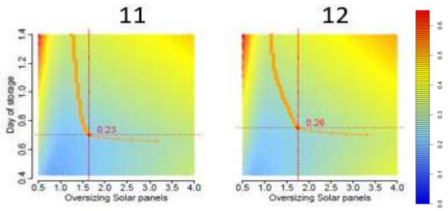


Fig 1: LOCE (in $ / kWh) for 2 different grid points as a function of the size of the PV panel fleet (x-axis corresponds to the oversizing factor (normalized PV capacity)) and of the storage capacity (y-axis to the (normalized by daily demand).

Orange curve : configurations for which 95% of the demand is satisfied. Red point : the least cost option (the one which minimizes the LCOE)

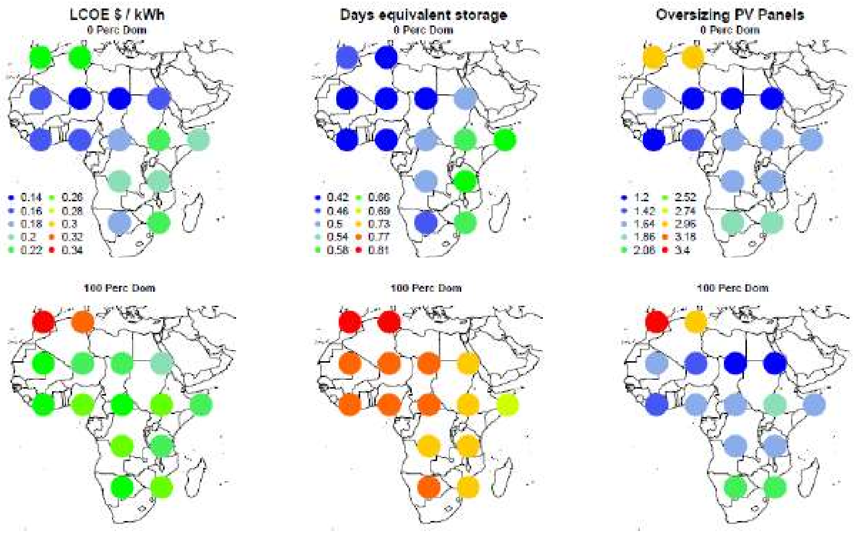
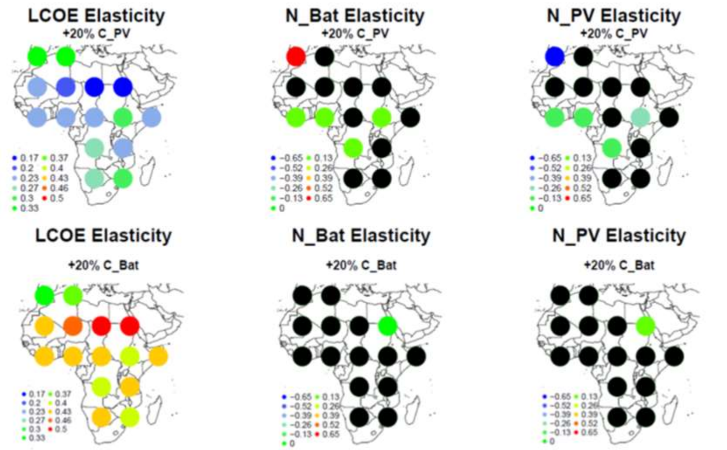


Fig 2: least cost design and associated LCOE (in $ / kWh) : LCOE (left), Required number of batteries (equivalent days of storage) (center) and size of PV panels fleet (right) (oversizing factor). Results for 2 demand profiles : 100% productive (top) and 100% domestic (bottom)

The LCOE is is up to 50 % higher for a domestic profile than for a productive one.
The required storage is always less than 1 day equivalent of mean demand. It depends on the demand profile. The required size of the PV panel is larger for high latittudes. It does only slighlty depend on the demand profile.

Fig 3: Robustness of LCOE and optimal design to variations of the unitary costs of PV panel (top) or batteries (bottom). Robustness (described here by the Elasticity (in % per %) of the variable) of optimal LCOE (left), storage capacitiy (center) and PV size (right). Black points : points with a very high robustness (Elasticity is 0). Results are presented for domestic demand. Results for a productive profile are similar..



Conclusion:

- A better subdaily match between the solar resource and demand reduces the amount of required storage and the LCOE
- For a given demand profile, the optimal design is very robust, and fairly independent on the unitary prices of storage and PV. This is very convenient for actors of electricity access
- The optimal configuration is location dependant : it almost fully determined by the resource demand co-variability structure.

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