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Cost of seasonality for 100% solar minigrids in Africa and the interest for optimal tilt angle of PV panels

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In many regions worldwide, the electrification of rural areas is expected to be partly achieved through micro power grids. Compliance with the COP21 conference requires that such systems mainly build on renewable energy sources. To deliver a high power and quality service level (QSL) at an affordable price may be difficult to achieve, especially when micro-grids are based on variable renewable sources. For 100% solar microgrids (SMG), Plain et al. 2019 show that achieving a given QSL should account for low solar resources days in the design of the system. Oversizing the SMG by a factor 1.5 to 2.5 is enough to satisfy the electricity daily demand 95% of the days in most parts of Africa. Their analysis considered however a constant electricity daily demand throughout the year. The QSL actually achieved with a given SMG may be rather different in case of a seasonal demand or conversely.

In this work, we explore how the seasonality of the demand would influence the SMG size required to keep a given QSL. We focus on the African continent where large expectations have been claimed in the recent years for the electrification of remote areas. Using high resolution satellite data (0.05°, 30mn) of global tilted irradiance (GTI) for a 11-year period (2005-2016), we show that the required size of solar PV panels surface can be up to a few tens of percentages larger or smaller than the size estimated for a constant daily demand. The difference depends a lot on the co-variability between the seasonal patterns of the solar resource and the demand. Results vary thus a lot from one region to the other.

In a second part, we explore how the tilt angle of solar PV panels can modify the temporal variability of the local solar resource and how this could influence the sizing of SMG. We estimate the tilt angle that minimize the surface of solar PV panels required to satisfy a given QSL. We further compare it to the surface obtained for the typical "design tilt angle" typically set to the latitude of the location under consideration. For specific patterns of demand seasonality and locations, the optimal tilt angle can allow a gain up to 15%. The estimation of this optimal tilt however requires to know the seasonality of the demand, which may be not really possible a priori for a number of new projects. We finally assess the implications of a uncertain knowledge on the seasonality pattern in the case where a given QSL has to be achieved whatever the configuration (implications of the optimal tilt angle, and on the SMG size).