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Temporal variability of the solar resource in Africa for off-grid power systems

Nicolas Plain (1,2,3), Benoit Hingray (1), Sandrine Mathy (2), David Gualino (3), and Thomas André (4)

(1) Univ. Grenoble Alpes, CNRS, Institut des Géosciences de l'Environnement (IGE), F-38000 Grenoble, France, (2) CNRS, Grenoble INP, INRA, Univ. Grenoble-Alpes, Laboratoire d'Economie Appliquée de Grenoble (GAEL), F-38000 Grenoble, France, (3) Schneider Electric, Strategy and Innovation, F-38000 Grenoble, France, (4) Schneider Electric, Sustainable Development, F-92500 Rueil-Malmaison, France

Approximately 1.2 billion people lack access to electricity in the world today, of which 80% live in rural areas. 600 million are located in Sub-Saharan Africa (SSA) which is the only continent where this number will grow in 2030 reaching 645 million mainly because of an economic growth which can't follow the demographic one. In remote rural areas, the development of solar power electric microgrids is expected to partly fulfill this electricity access challenge. The mean solar resource was indeed estimated to be large enough for the development of such off-grid systems in most isolated locations of Africa. Driven by astronomic features and weather, the resource can however present significant temporal variability. The sub-daily variability and intermittency of the production, the seasonality of the resource or the frequency and duration of low resource situations could indeed prevent delivering a power service as reliable as expected. This can make the development of solar off-grid systems inappropriate for several locations.

A comprehensive characterization of the solar resource variability is thus required to better assess the potential meteorological reliability of off-grid systems based on solar resource only.

We give here a first picture of the local scale variability of the solar resource for Africa. We study the global horizontal irradiance (GHI) using the high resolution (0.05°) SARAH v2 data derived for a 21-year period (1995-2015) from Meteosat satellite data. We first characterize the mean annual resource and its seasonality. We focus next on low resource situations. We characterize the frequency and duration of sequences where the daily resource is below a given percentage of the mean annual resource. We next study the 5th percentile of the daily GHI distribution. This variable can give a first guess on the size of the microgrids required to meet a given daily demand for 95% of the days. We give next some insight on the persistence of the low resource situations. We assess how the number of days in a low resource situation can be reduced when some energy storage facility is introduced in the microgrid.

This work is based on satellite radiation data which are obviously limited for an accurate estimate of the resource. Ground measurements should be ideally obtained for a reliable estimation. Ground measurement are however sparse, scarce and are mostly never available for more than 2-3 years. We finally assess the inter-annual variability of the resource and estimate how many years of measurements would be needed to get estimates of these different resource indicators which are close to the long-term value.