Burkina faso energy storage for demand response

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This study investigated three scenarios based on the existing microgrid"s characteristics: conventional standalone diesel generators, PV/diesel without battery storage and PV/diesel with a battery storage system which are the main technologies used for off-grid rural electrification in Burkina Faso. The levelized cost of electricity (LCOE) was used to assess the economic performance of each scenario, and the calculations were made using the HOMER software.

It was found that the best among the scenarios considered is the PV/diesel/battery configuration which has the lowest LCOE of US$ 0.524/kWh. The battery storage system for the optimal configuration has a capacity of 182 kWh with about 8 h of autonomy.

It can be inferred from this study that a storage unit is necessary for an optimal management of a PV/diesel microgrid. Indeed, the storage unit significantly reduces the operating and maintenance costs associated with running diesel generators, as well as the excess electricity. The storage system also allows for a greater reduction in CO2 emissions compared to systems without storage.

Access to reliable electricity is essential for the socio-economic development of any country. In sub-Saharan Africa, the electricity access rate is very low, which negatively impacts the region"s economic growth and living standards [1].

Renewable energy sources have been identified as the most suitable alternative to fossil fuel sources for power generation in most developing countries. They are abundant in nature and environmentally friendly compared to fossil fuel sources [4, 5]. They can help reduce fuel costs and challenges due to technical and economic constraints associated with grid expansion systems [6].

PV/diesel hybrid systems without battery storage units, based on the flexy energy concept, have been developed and implemented for electricity generation in off-grid areas, especially in Burkina Faso and Mali [9, 10]. As shown in previous studies cited below, battery storage was excluded in the flexy energy concept to reduce the replacement cost in the system and the environmental concerns associated with batteries at the end of their lifetime.

Azoumah et al. [9] performed a simulation of three power-generating scenarios, namely diesel generators only, a PV/battery system, and a PV/diesel without battery system. From their analysis, they reported that the PV/diesel without battery system scenario was the most optimal system among the three considered in terms of LCOE and CO2 emissions. They concluded that PV/diesel hybrid systems based on the flexy energy concept could be a better alternative in rural and peri-urban areas if their design management is improved.

Yamegueu et al. [11] carried out experimental work on a PV/diesel system without a battery storage system. The study assessed the behavior of the PV/diesel hybrid system for different ranges of load profiles, representing different nominal power levels of the diesel generator, namely 40%, 62%, 82%, and 105%. It was found that the contribution of the PV array affects the output performance of the diesel generator because the generator was operating at a lower-rated capacity, which results in high fuel consumption and consequently to a high electricity production cost.

However, eliminating batteries from the PV/diesel system has its drawbacks, such as the excess electricity produced by the system is not put into any productive use, stability problems, extended operating hours, high operation and maintenance (O& M) costs, and a short lifetime for diesel generators.

Bilgo village is the selected location for this study. It is located in the Pabre commune, a section of Kadiogo Province in the Central Region of Burkina Faso. The village is about 30 km from the city capital Ouagadougou and lies between latitude 12? 31.8 N and longitude 1? 40.8 W. According to the 5th general population and household census report [20], there were about 2483 inhabitants in Bilgo in 2019. The primary sources of household earnings in Bilgo village are agricultural activities and livestock rearing.

Access to electricity in Bilgo village was a challenge before the installation of the PV/diesel power plant in 2016 due to the absence of an extension of the electricity grid reaching the village. Most households relied on inefficient lighting sources such as touch lights, oil lamps, candles, and small thermal generators. The problem of electricity access in the village was a major setback towards the quality of living, better health services, quality education, water supply, and small businesses. The commissioning of the power plant is expected to stimulate development in the village.

The solar resource data were obtained from the National Aeronautics and Space Administration (NASA) database for the given latitude of Bilgo village. The monthly solar radiation for the site location ranges between 5.09 to 6.43 kWh/m2/day, with an annual average solar radiation of 5.76 kWh/m2/day. The average clearness index for the location was found to be 0.59, which indicates a good potential for PV system applications.