Nairobi energy storage for demand response

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To meet growing global energy demands1 while combating climate change, much of the world"s present energy use needs to be electrified via renewable energy2. As most renewable energy sources, including solar, wind, and tidal energy, are intermittent (i.e., not consistent over time), they must be complemented by energy storage to create systems which can consistently meet energy demands3,4.

The need for energy storage applies to both developed and developing countries. In low- and middle-income countries (LMICs), off-grid energy systems containing solar photovoltaics (PV) and batteries are remarkably common, given their plentiful solar resources5 and their need to expand energy access to rural areas distant from existing grid infrastructure6. Indeed, standalone solar-and-storage systems are increasingly the norm for expanding off-grid energy access in LMICs, and have been shown to provide social, economic, and environmental benefits7.

Given the resource constraints in Kenya"s educational system, the high costs of using grid electricity compete with other critical school expenses. A 2019 study of 300 boarding schools in Kenya showed an average monthly spend of $4000 on electricity alone33; this is equivalent to the average cost of employing two teachers in the Nairobi area34. As such, with limited budgets available, schools may be forced to cut costs by employing fewer teachers or minimising electricity use, each of which negatively impacts learning.

An energy needs assessment was undertaken in 12 schools (eight in Kenya and two each in Uganda and Tanzania) via semi-structured interviews. These were selected on the basis of existing contacts and data access. Interviews covered: current energy use (including devices and hours of use), sources, costs, and satisfaction; energy use aspirations (i.e., what devices they would connect if energy were more abundant, reliable and/or affordable); whether they would consider an alternative source of energy, especially from a solar/battery system; and demographics.

Of the sampled schools, four schools in Kenya were characterised in more detail: two situated in Nairobi, and one each in Kagiado and Machakos counties, as listed in Table 2. Schools 1, 2, and 3 are grid connected, while School 4 is not electrified at present and uses a stand-alone biogas plant for school cooking needs. Schools 1 and 2 are urban while Schools 3 and 4 are rural. They are all state schools supported by the government.

Drawing from the needs assessment, Table 2 reports the average number of students per school, their required hours of electricity use, the maximum aspirational load of each school, and their annual electric bills. Note that School 1 uses electricity throughout all hours of the day as there was a reported need to provide continuous low lighting for security reasons at night.

Figure 3 illustrates the number of days the grid is needed to provide energy to School 1 for each scenario. This directly correlates to the capacity of the battery in the scenario and how many hours this could cover in the daily demand peak of the year. This varies between 20 and 100% for both energy storage system types studied here. These results show that the yearly dependency on the grid could be reduced to 25 days for the NB case and 113 days for the SLB case, in the 10 kW PV and 20 kWh storage capacity scenario.

Levelized cost of energy (LCOE) per scenario, including options with new batteries transported (NB-T), second-life batteries transported (SLB-T), local second-life batteries (SLB-L), and second-life batteries transported at minimum CAPEX (SLB-T-MC). Across the 12 system size options, SLBs reduce LCOE compared to NBs in almost all of the cases studied.