Derisking Mini-Grid Generation Investment Through Diverse Load Integration

Customers in rural areas face challenges not only due to low electricity consumption but also due to highly inconsistent and unpredictable loads. For example, a household might use 5 kWh in a single special event day, about as much as it consumes typically in an entire month. If the system is built to handle those rare peak days, it will sit underutilized most of the time, which drives up costs. This handout highlights two approaches for reducing mini-grid generation costs. First, connecting more households aggregates demand and smooths load variability. Second, integrating diverse load types (households, businesses, agro-processing, and irrigation) creates complementary usage patterns that improve system utilization.

Connecting more households to a mini-grid helps even out the demand swings. A steadier, less variable demand means the system is utilized more fully, which in turn lowers the cost of generation. Figure 1 illustrates this effect using real household data from Lamwo, Uganda. In our analysis, we simulated communities of various sizes by randomly grouping households to share a solar-battery mini-grid. Results showed that generation costs declined significantly from 20-household communities to 100-household communities. Further increases in household aggregation continued to reduce costs but at a slower rate, until stabilizing when approximately 400 or more households were connected.

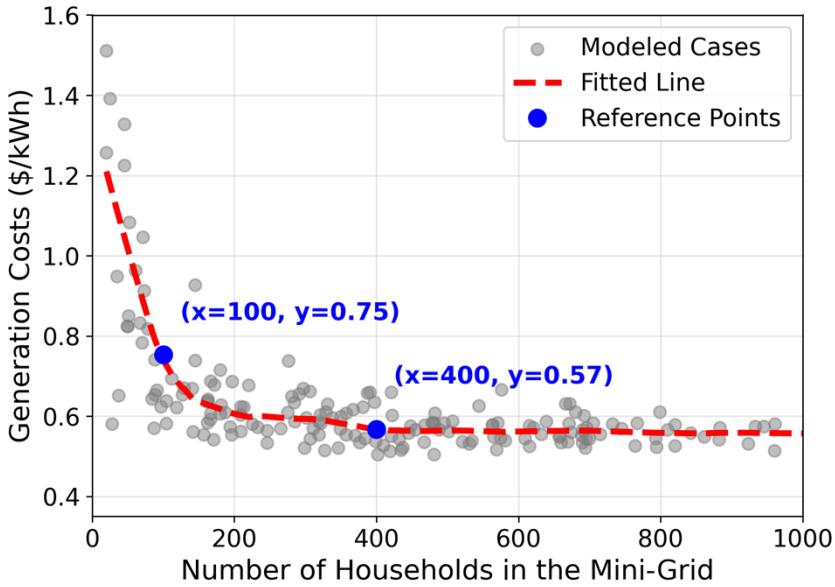

Figure 1 – Generation costs across modeled mini-grids serving 20 to 1,000 households.

Another approach to reducing costs is combining different electricity demand types on the same mini-grid. As shown in Figure 2 from our Paloga village (Lamwo district in Uganda) analysis, individual load categories (household, business, and grinding mill) have generation costs between $0.58-0.73/kWh. When any two of these customer groups are powered together, the cost per kWh drops. If all three groups (households, businesses, and the mill) are served by one system, the cost falls further to about $0.53/kWh. Most notably, the surplus energy from this optimized three-category combination-designed system could support 6.5 hectares of irrigation, reducing overall generation costs to $0.36/kWh when spread across total demand.

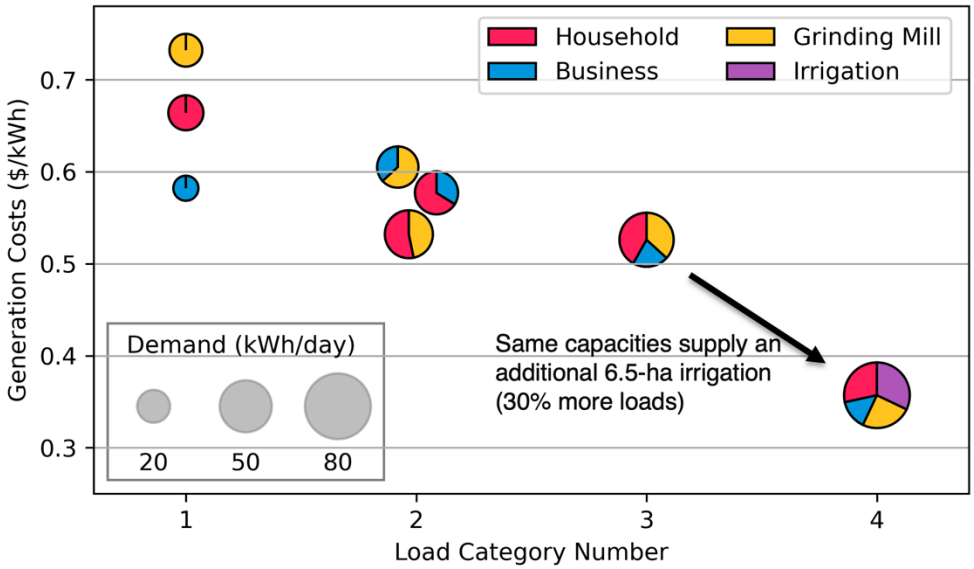

Figure 2 – Generation costs for different load type combinations in Paloga village, Lamwo, Uganda.

Integrating diverse patterns improves load consistency throughout the year, addressing seasonal variations in agricultural villages (holidays, cropping, harvest) with complementary usage. Many productive activities (like running a grain mill or powering machinery) happen during the day, which means they can directly use solar energy, without needing battery storage. For instance, irrigation is a flexible daytime load that can take advantage of excess solar power. The most successful mini-grids may serve both productive uses and households together, ensuring the system is efficiently used and financially viable.

In summary, mini-grid development should consider two diverse load integration approaches: integrating more households and combining different load categories. Both strategies can significantly improve the generation system efficiency and reduce costs. More details about models, assumptions, and additional clarification can be provided upon request.