Bhutan energy storage for load shifting

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In Rukubji, like many other mini-grids, the power supply is sufficient during off-peak times. However, during preparation of morning and evening meals, the use of high-power kitchen appliances regularly causes electrical demand of the village to exceed the available supply and brownouts to occur. The lowered voltage that characterizes a brownout causes lights to dim, televisions to flicker, and electrical appliances, such as rice cookers, not to function properly; the corresponding drop in frequency may cause flickering in magnetic-ballast fluorescent lights and reduced speed in electric motors (refrigerators, power tools).

The GridShare system involves installing a device in every household and business connected to the mini-grid that provides two mechanisms to alleviate brownouts: indication of the current state of the grid and an enforcement mechanism to limit load when the grid is overburdened (figure 1). The implementation of this project in Rukubji has provided a more reliable electrical service to the village.

Figure 1. BPC electrician installs a GridShare and breaker box near the electrical meter (a). LED indicator lights with an instructional sign are installed near the rice cooker (b). Borrowing from familiar power-indicating graphics on cell phones, the yellow bars next to the green LED remind users that when the green light is lit, the grid is at "full power" and any appliances may be used, while the empty bars next to the red LED suggest that the red light means the grid electricity is limited and only low power appliances can be used.

Isolated mini-grids deliver electricity service to populations that are inaccessible by centralized electrical grids due to rough terrain and/or remote locations (ESMAP 2000, Martinot et al 2002, Terrado et al 2008, Modi et al 2005, REN21 2005, Palit and Chaurey 2011). Because mini-grids have finite generation resources, when consumers have unrestricted access, overloading and brownouts are common (Dorji 2007, Greacen 2004,

Dorji et al 2012). This problem occurs worldwide; for example, in a survey of Thai mini-grid systems, respondents in 48 of 59 villages surveyed complained of low voltages (Greacen 2004).

Hydroelectric mini-grid systems are a common source of electricity in rural Bhutan, with 10 such systems in operation and the potential for more (Chhetri 2012, Dorji et al 2012, Uddin et al 2007). In some of these systems, rice cookers and electric water boilers account for 50%-70% of the peak load (Dorji 2007). Primarily due to these appliances, the electrical load of these villages exceeds the power generated for a few hours each day. During all other times, the hydroelectric generator supplies excess power, which is often rejected as heat via a dump load.

The GridShare system is designed to restrict electricity use only when the demand on the system exceeds the supply. This adaptive approach offers a distinct advantage over simple load limiters, which is particularly important for hydroelectric mini-grids, where the power produced throughout the day is relatively constant while demand varies greatly. In addition, unlike simple load limiters, the GridShare provides information to users about the status of the grid and whether they are being restricted. By combining these features with an education program focused on load-shifting, the GridShare enables more efficient use of the available generation resource.

The GridShare device is installed at the electrical service entrance of every residence and business connected to the mini-grid, while the LED indicator box is installed indoors near the high-power cooking appliances. Each GridShare device acts independently; there is no communication between devices or with the utility.

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