How Valuable is the Reliability of Residential Electricity Supply in Low-Income Countries? Evidence from Nepal

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Access to reliable electricity services is essential for poverty reduction and economic growth (World Bank, 2017). However, many developing countries face severe electricity shortages, leading to frequent power outages. The causes of such shortages are numerous, and include high technical and commercial losses, insufficient revenues to finance investment in infrastructure, and many others.

Valid estimates of the willingness to pay (WTP) for reliable power supply are thus critical for both power system planning decisions and regulatory policies aimed at improving the quality of the electricity services. This is especially important for the residential sector, where low energy consumption makes electricity cost recovery a challenging problem.

This paper estimates the value of lost residential electricity service in Nepal, a low-income country that has experienced chronic load shedding in the last decade. The load-shedding crisis over the period 2007-2016 has imposed high economic costs on Nepal's economy. Recent estimates suggest that load shedding may have cost the country up to 7% of its GDP annually. At the end of 2016, however, the daily load shedding of residential customers ended due to improved electricity dispatch, increased electricity production, and imports from India, though households may still experience unscheduled outages (World Bank, 2019).

We use contingent valuation to elicit the willingness to pay of residential customers in Nepal for improved power supply. We rely on a nationally representative survey of Nepali households. Our study design exploits the fact that the survey was done shortly (i.e., less than a year) after the residential load shedding had been eliminated. The respondents were asked to indicate their willingness to pay to avoid the number of days with outages they had experienced before the termination of the load shedding schedule of October 2016. This takes advantage of the respondents' *actual experience* with improved reliability of power supply. Using supplemental data on *actual outages* at the transformer substation level, we can validate the quality of respondents' recall.

Our analysis starts with calculating the WTP per kWh lost (i.e., the Value of Lost Load, VoLL) given assumptions about the load or exact information about the kWh used in a typical day. We then calculate the WTP per outage-day avoided and analyze its key drivers. Finally, we assess the internal validity of our estimates by regressing the WTP on the number of outage-days reported by the respondents, controlling for a variety of household characteristics. To our knowledge, our study is the first contingent valuation study to address measurement error in the good to be valued by instrumenting for it, which should avoid biased inference. We instrument for the number of outage-days using the frequency of all types of outages at the substation level.

We find that households, on average, attach economically significant value to a reliable power supply. The average WTP is about 123 NR ($1.11) per month, or 65% of the actual average monthly bill at the time of the survey, even though about 26% of the households are not willing to pay anything at all.

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When we convert the WTP to a VoLL (i.e., the WTP per kWh lost), our preferred estimates are in the range of 5 to 15 NR/kWh (¢4.7 to ¢14/kWh), and thus bracket the average price per kWh from the grid paid by the respondents at the time of the survey. Surprisingly, our average VoLL estimates are no larger than those from a survey conducted more than a decade ago, when the load-shedding crisis started (Karki et al., 2010), even though the country's GDP per capita has grown by 42% since.

For the sample as a whole, the VoLL is higher for service lost in unscheduled outages than for service lost during scheduled load shedding. This finding is consistent with expectations, as households presumably can make arrangements to limit the damages and the inconvenience from the outages themselves. But when we restrict the analysis to the "attentive" respondents—namely those who appear to have recollected exactly the number of outages in the month a year before the time of the survey—the VoLL is identical for unscheduled and scheduled lost electricity consumption.

Households that use rechargeable batteries (i.e., inverters) or solar equipment as backup equipment report systematically *lower* WTP. This result is in sharp contrast with earlier studies in developing counties (e.g., Oseni, 2017), where households that own diesel generators with high running costs reported a higher WTP for reliable power supply. However, when we adjust the VoLL of those with rechargeable batteries and solar equipment to the VoLL implicit in the purchase of such equipment, we obtain higher estimates ranging from 9 to 22 NR/kWh. These results indicate that, in the absence of effective public policies, households internalize their WTP for reliable power supply by investing in power backup equipment.

Finally, although most households have an economically meaningful willingness to pay for a reliable power supply, our VoLL figures appear to be below the marginal cost of avoided load shedding (i.e., utilizing high-cost operating reserves or importing electricity at times of high demand). These findings suggest that if the government's goal is to improve the quality of residential electricity consumption, it must either lower the cost of generation, transmission, and distribution or resort to demand response—if technologically feasible and acceptable to the public.