Electric Cooking in Peri-Urban Nepal: *Part 2*

Energy access needs for clean cookstove adoption

Transitioning households to electric cooking requires access to both quality electric appliances and reliable and affordable electricity. In Part 1 of this two-part series, we explored the impacts of electric stove adoption on household energy use in two peri-urban municipalities in Nepal, finding that families do indeed reduce their biomass and LPG use following the purchase of an electric cookstove, and in doing so, reduce their overall household energy costs. Here in Part 2, we examine the energy needs associated with electric cookstoves, and assess the current capacity of study households and local community infrastructure to meet that new energy demand. We found that most homes in our study required basic electrical improvements to safely accommodate electric cooktops, and that local improvements to grid infrastructure will be needed to regularly meet stated power quality targets–illuminating the critical need for community-scale infrastructure to be developed in tandem with electric appliance rollout.

A technician upgrades kitchen electrical wiring for induction stove use.

Key messages

- Sustained community adoption of electric cooking depends upon access to reliable and high-quality electricity.
- In a study of 28 households, measurements of available power fell within the Nepal Electricity Authority's target range only 40% of the time. Proximity to a transformer can significantly affect power quality: on average, voltage levels for homes within 100 meters were measured 2 Volts higher than those at a distance of 900 meters or more.
- Most households in our study would need to upgrade their breakers and replace wiring in order to accommodate the draw of electric cooktops. These upgrades are typically available at a cost of 1760—2350 NRs (US$15—20).
- To safely increase electric cooking, community readiness assessments are needed to evaluate electricity demand and infrastructure capacity in households and across the local grid.
- Systematic grid monitoring can support communities, and help maintain consumer safety and trust.

Introduction

More than 60% of households in Nepal rely on fuelwood and traditional or chimney mud stoves to satisfy daily cooking needs.[1] Emissions from these sources have led to high levels of indoor and outdoor air pollution, making household air pollution the third leading cause of early mortality and years of lost life in Nepal.[2] To address this problem, the Government of Nepal has established a goal of achieving universal access to clean cooking solutions by 2030. Since the country has immense potential for hydroelectric generation, the government plans to lean heavily on electricity to bridge this access gap.

Over the last several years, the Government of Nepal has implemented numerous programs that have led to unprecedented improvement in electricity access throughout the country. Households in many areas now enjoy far fewer grid outage events and more reliable service. This situation will likely improve as the government implements programs that will add an additional 5,000 megawatts of hydropower capacity over the next five years and 15,000 megawatts over the next 15 years.[3] With the prospect of sufficient electricity to meet growing demand, electric cooking appliances have emerged as an attractive means of providing clean cooking to households.

To achieve sustained use of electric cooking, it will be necessary to not only address market and knowledge barriers affecting the uptake and adoption of these appliances, but also provide access to reliable and high-quality electricity. This brief describes lessons learned about the state of the power system and grid infrastructure, and its readiness to support widescale uptake of electric cooking in peri-urban Nepal. The work highlighted here was collected as part of a 1.5-year study aimed at examining household experiences with induction and biogas stoves, their effects on energy consumption and stove use, and the potential barriers to scale-up.[4]

Maximizing benefits of clean cooking in peri-urban Nepal: monitoring electricity quality & consumption

A power meter was developed and deployed to remotely monitor the use of electric cooking appliances and the quality of electricity supply. Appliance usage and supply characteristics were logged at 10-second intervals. Power meters were deployed in 28 homes.

Power meter system

Power meter deployment in a peri-urban home

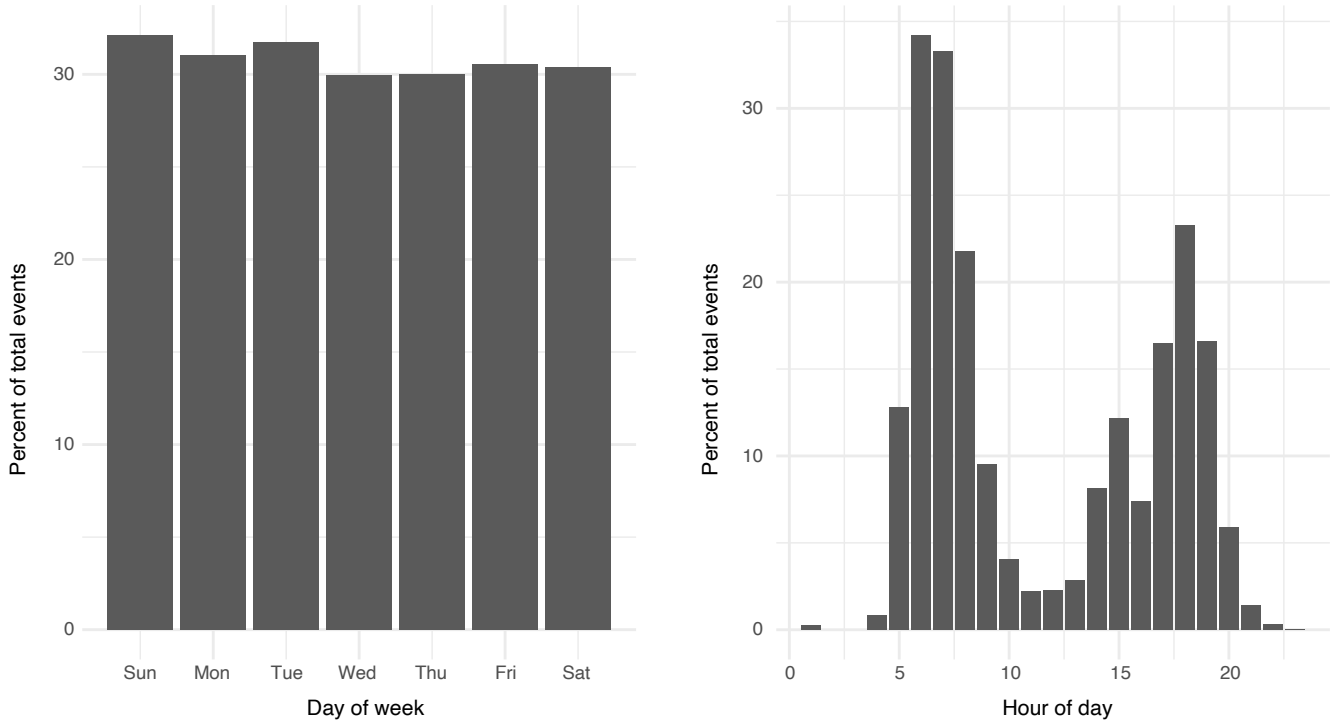
Household Use of Electric Cooktops

Distribution of induction stove cooking events show three distinct periods of use throughout the day. The most intensive use occurs during the morning (6:00—8:00), when people prepare their morning tea and meal, accounting for an average of 42% (Standard deviation [SD] = 10%) of total stove use. The second and smallest peak occurs in the midafternoon (14:00—16:00), accounting for 7.5% of total use (SD = 4.8%). The third peak occurs in the early evening (17:00—20:00), accounting for 33% (SD = 13%) of total use. Distribution of individual cooking events reflect a similar percentage breakdown across the three periods of use.

The average duration of a stove use event performed on an induction cooktop was 13 minutes (SD = 4), with a range from 12 to 108 minutes; total daily use averaged 90 minutes. Daily energy consumption of an induction stove was 0.73 kilowatt hours (SD = 0.55), with an average power draw of 811 Watts.[5]

Power meter connected to an induction stove

Figure 1. Percentage of induction stove use events by day of week (left) and hour of day (right)



Note: Results are based on data collected from 22 households and an average of 198 usage events captured per household.

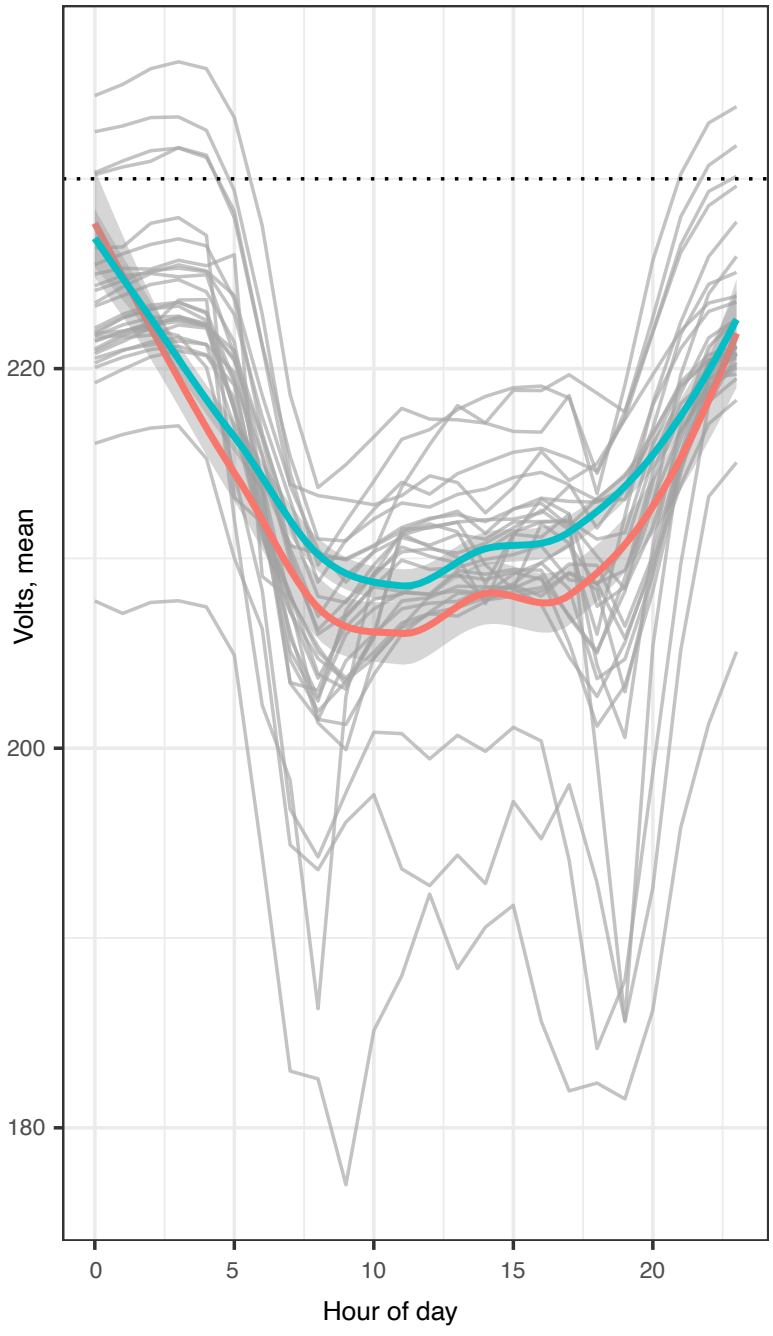
Readiness of electricity supply and distribution

An essential requirement for enabling households to transition to electric cooking technologies, regardless of the appliance type, is a reliable electricity supply. The reliability and quality of supply is important for ensuring that households can use their cooking appliances when they need them and that the appliances' components do not degrade over time. Reducing the frequency of grid outages was a critical first step, but it must be accompanied by efforts to improve both electricity infrastructure for homes and community distribution networks, which are needed to deliver high quality electricity.

We observed two types of voltage drifts from data collected from power meters. The occasional drop in voltage (below 200 volts [V]) could result in some appliances losing efficiency, not turning on at all, and degrading more quickly. These voltage deficiencies were most common during cooking hours, which coincided with peak demand. They were most apparent at 7:00 and 18:00 (**Figure 2**), coinciding with peak cooking times (**Figure 1**). Extended periods of low voltage were also observed. If voltages drop too low, over time, this can result in appliances not functioning at all. **Figure 2** shows both extended periods of low voltage during daytime hours and a large variation in the extended drop across homes. Both scenarios can lead customers to suspect that their appliances are not working properly, and over time, ruin those appliances. In addition to the potential economic and social harm of product failures, this can contribute to reducing consumer confidence in electric cooking products and market spoilage.

Most households in the community experienced both extended and occasional voltage drift, raising concerns about the ability of the local grid to support community-scale use of electric cooking. The Nepal Electricity Authority's policy is to

Figure 2. Mean voltage by hour of day, measured by power meters



Note: Colors represent the moving average of homes less than 900 meters from transformers (blue) and greater than 900 meters (red); individual homes are shown in gray. Reported values are based on an average of 2.5 months of data for each house collected at 0.1 hertz. A nominal voltage reference (ideal level of voltage at all times) of 230 V is indicated by a dashed line.

provide a nominal 230 V power to homes and maintain that voltage within 5% of the 230 V target.[6] Voltages measured in 28 homes averaged 213 V (SD = 5.6 V); realtime measurements indicated that voltage levels were within NEA's target nominal voltage range only 40% of the day. During use of an induction stove, voltage levels dropped by an average of 9 V (SD = 5). From nominal voltage this would still be within target range; however, all homes monitored were already below nominal voltage. The variability in these measurements can be affected by several factors, including the load placed on transformers by other customers and the home's distance from a transformer; homes within 100 meters of a transformer had voltage levels an average of 2 V higher than those that were 900 meters or more from a transformer.

A successful and sustained transition to electric cooking appliances will depend on a strengthening of electricity distribution infrastructure. Responsible scale-up of electric cooking should consider the quality of power in urban and rural communities, and this will require expanded efforts to systematically monitor power quality. These can include using low-cost sensors, community surveys, and other instruments.

To safely and reliably operate electric cooking appliances, it will be necessary to upgrade wiring and service panels in many homes. Survey assessments performed as part of the study found that most homes would need to upgrade from 5-amp to 15-amp breakers and replace wiring to safely accommodate electric cooktops. For example, an induction cookstove alone draws a current of 4—5 amps during normal operation. A survey conducted in 772 households found that only 11% of the homes had the electric wiring in their kitchens that is considered the preferred/standard for operating cooking appliances (22 American wire gauge). This upgrade will be especially important to handle a drop in voltage levels during stove operations and appliances attempting to compensate. Over time, these fluctuations may degrade wiring in the home and damage appliances. Wiring upgrades were offered to households as part of enrollment in the study; a total of 78 households accepted, all of whom eventually purchased induction cooktops. At a price of 1760—2350 NRs (US$15—20), the cost of wiring upgrades adds an additional 25—65% to the upfront investment cost of an induction stove but is important to support the sustained use of these technologies and maintain consumer safety and trust.[7] Given this importance, we suggest that the Government of Nepal provide a subsidy to households to help cover these upgrades.

Summary and Calls to Action

Measurements conducted as part of the study suggest that poor electricity quality and substandard electric wiring in homes may become barriers to the large-scale and safe uptake of electric cooking appliances.

Based on these findings, the study developed the following calls to action:

CHALLENGE	ACTIONS
In many communities, electricity transmission infrastructure may not be ready to meet the demands of electric cooking at scale.	Develop a community energy readiness assessment to evaluate local grid infrastructure, household wiring status, and local energy demand characteristics.
Communities are subject to load shedding events (blackouts) and voltage drift which will affect the performance of their electric cooking appliances.	Develop and integrate systematic monitoring of local grid health, to support both maintenance protocols and grid planning for local demand.
Many homes lack the appropriate wiring and breakers to adapt to fluctuating grid power—which can damage appliances and create fire risk.	Upgrade homes from 5-amp to 15-amp breakers and replace electrical wiring to safely accommodate electric cooktops and devices. Incentivize manufacturers to include voltage protection within cookstove appliances.

Opportunities

Development agencies: Partner with government agencies to develop readiness tools and conduct household surveys. These tools and surveys should estimate current and future community electricity demand, identify which households need electrical retrofits to enable safe use of electric appliances, and assess impacts of this increased load on the local grid infrastructure. Facilitate innovation and quality assurance for robust electrical appliances suitable for weak-grid environments.

Government: Utilize demand information generated by grid monitors to drive service upgrades. Expand subsidies designed to promote the use of electric cooking to include household electrical retrofits. Require distributors to provide durable electric appliances that meet performance standards designed for weak-grid applications.

To safely and reliably operate electric cooking appliances, it will be necessary to upgrade wiring and service panels in many homes.

Notes

1. World Bank, Energy Sector Management Assistance Program, *Nepal—Multi-Tier Framework for Measuring Energy Access Household Survey* (2017).
2. Institute for Health Metrics and Evaluation, *Global Burden of Disease* (2019).
3. https://www.moewri.gov.np/storage/listies/May2020/white-paper-2075-with-annex02.pdf.
4. Additional program activities are summarized as part of companion policy briefs https://www.cleancookingalliance.org/news/04-19-2021-nepal-health-demonstration-project-policy-briefs.html and described in the full report https://www.cleancookingalliance.org/resources/606.html.
5. The maximum power draw will vary by stove model, but typical induction stoves purchased by households had a range of 900–2000 watts.
6. https://www.nea.org.np/admin/assets/uploads/supportive_docs/Electricity_Regulation_2050-english.pdf.
7. Market prices for induction stoves ranged from NRs 3500-4000 depending on brand and merchant. If new induction-compatible cooking vessels are required, that may cost an additional NRS 3500-4000.

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