Electric Cooking in Peri-Urban Nepal: *Part 1*

Impacts of clean cookstove adoption on household energy use

Transitioning households to electric cooking requires access to both quality electric appliances and reliable and affordable electricity. In this two-part series, we first explore the impacts of electric stove adoption on household energy use in two peri-urban municipalities in Nepal connected to the central grid. We found 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. 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 induction stoves, 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

- In this study group, 95% of households currently using liquefied petroleum gas (LPG) would save an average of 15% of their cooking energy expenditures by replacing their LPG systems with electric induction stoves.
- Those households that purchased induction stoves during this study reduced their minutes of traditional biomass stove use by 15–30% and LPG stove use by 15–20%.
- Communities with reliable electrical service and high LPG use are therefore promising markets for early adoption of clean cooking appliances.
- Households with an electric cookstove may be limiting their use of that appliance for fear of incurring large electric bills. Enabling households to view their current status of electricity use and spending—and providing rate comparisons to LPG—could likely increase electric appliance utilization.
- Clean energy strategies must also be developed for those energy-intensive tasks which are not yet supported by electrification, such as cooking for animals and heating large volumes of water; these solutions may also be critical for mitigating an important source of ambient (community) air pollution.

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.[1] To address this problem, the Government of Nepal has established a goal of achieving universal access to electricity and electricity-based cooking by 2030.[2] Since Nepal has immense potential for hydroelectric generation, the Government of Nepal plans to lean heavily on electricity and electric cooking appliances to bridge this access gap.

Over the last decade, LPG has emerged as the predominant source of clean cooking energy in Nepal. With few alternatives capable of meeting demand, it has become the second most common household cooking fuel nationally. This growth has increased the share of the population with access to clean cooking fuels, but at a significant economic cost to the country. Between fiscal years 2004 and 2014, annual LPG imports increased from 78 metric tons to 258 metric tons (an increase of 233%). Subsidies used to stabilize LPG prices for the public totaled $27.2 million in 2015 and are projected to reach $158 million within 15 years.[3] This further motivates the Government of Nepal to move from LPG to electricity, which doesn't require imported fuel.

A sustained transition to clean cooking in Nepal will require reliable appliances and energy sources that households can depend on. Cooking appliances will need to be able to perform critical household tasks in order to mitigate the high emissions from traditional cooking devices that lead to health and environmental burden.

Demand for electric appliances throughout low- and middle-income countries has spurred innovation for appliances that are affordable and efficient. Induction stoves, by inducing an electric current in the cooking vessel itself, can achieve efficiency levels of 85%—nearly double that of LPG and five times greater than traditional biomass cookstoves. Enabling access to and increasing use of these and other electric appliances could decrease reliance on biomass and LPG, improve household welfare, and increase residential demand for electricity, which would sustain on- and off-grid generation and distribution infrastructure.

Maximizing benefits of clean cooking in peri-urban Nepal: overview of study design and methods

The study enrolled and followed a cohort of 1,102 households across 10 wards of Panchkhal and Mandandeupur municipalities of Nepal from May 2018 through October 2019. During the course of the study, efforts to reduce barriers related to the appliance supply chain were implemented, including assistance by female community health volunteers in procuring stoves. Stove costs were not subsidized.[6]

Energy audits were conducted in 105 households over three seasons to measure the amount of energy that families were consuming, on which stoves, and for which tasks, using a modified Kitchen Performance Test procedure.[7] 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 with induction stoves or rice cookers.

Temperature sensors were placed on non-electric cookstoves in 1,102 houses to measure daily use for up to one year. Sensors logged the use of the stove at 10- to 20-minute intervals every day for more than 250 days on average. To measure changes in stove use due to uptake of clean cookstoves or other study activities, only households with sensor coverage of all stoves in the home were used for analysis. The effect of induction stoves on the daily use (hours and events) of traditional and LPG stoves was estimated using generalized estimating equations, adjusted for season and household size, and accounting for repeated measures in homes. Only households with data on all the stoves owned were included for this analysis (N = 31 of 170 purchasers of induction stoves).

To inform strategies aimed at increasing the adoption of electric cooking appliances in Nepal and displacing polluting practices, research into the possible barriers to scaling up electric cooking and the benefits of transitions was needed. This two-part brief summarizes findings from a 1.5-year study conducted in peri-urban Nepal. Over the course of the study, programs for reducing market barriers were implemented and quantitative and qualitative measurement instruments deployed to assess household experiences with induction stoves, their effects on energy and use of other stoves in the home, and the potential barriers to scale-up.[4]

In this brief, we describe our findings of changes in the use of non-electric stoves after the introduction of electric induction stoves, the household economics of transitioning from LPG to electric cooktops, and strategies for overcoming some adoption barriers.

Findings and Implications

Induction stoves can reduce consumption of biomass and LPG

Reducing use of traditional stoves is critical to realize the health and environmental benefits of clean cooking solutions, while using less LPG is critical to reduce reliance on imported fuels. **Results from the study suggest that a household's purchase of an induction stove resulted in its reduced use of traditional biomass and LPG stoves.**

Households that purchased an induction stove reduced the use of their traditional stoves by a daily average of 35 minutes and 0.63 cooking events, after adjusting for the season and household size. For a typical family, the induction stove led to a 15%–30% reduction in traditional stove use, corresponding to an estimated annual household savings of 0.3–0.7 tons of wood.

Among households that used LPG, the purchase of an induction stove led to an 11-minute reduction in daily use, corresponding to a 15%–20% reduction in operating time and an annual reduction of 15–20 liters of LPG per household.

Within the study community, 95% of households using LPG would save money by transitioning to an induction stove, under current energy prices.[8] Considering current consumption and pricing rates of electricity and LPG captured as part of energy audits, **we estimate that the average LPG-using household in the study community would save 188 Nepalese rupees (NRs) per month by transitioning from LPG to induction, or an average savings of 15%.**[9] For homes with larger 15-amp breakers, monthly savings are only slightly lower at 186 NRs.[10] A less-efficient electric cooktop with resistive heating coils would yield less savings, at 82 NRs per month (SD = 59), but still be economically favorable for nearly all LPG-using families.[11] Adjusting the local cost of LPG down by 7% to match the national average has minimal effect on the overall conclusion. Addressing knowledge gaps around cost savings may help increase use of induction stoves and displace a larger portion of LPG to reach these savings potentials.

The role of electric cooktops in households

During the study, 170 households (25% of the study population) voluntarily purchased an induction cookstove, increasing community ownership 20-fold over 1.5 years. In-home fuel audits revealed that similar tasks were performed on LPG, biogas, and induction stoves, suggesting that they may be suitable replacements for one another. The most common tasks included preparing meals and snacks (i.e. instant noodles), and reheating food, milk, and tea.

Induction stoves can meet many but not all the needs in a home. Bundling clean technology solutions may result in more benefits than promoting a single clean device and may be necessary to address high pollutant emissions from cookstoves. Two of the most energy-intensive tasks conducted by families—cooking animal feed and heating large quantities of water—are rarely performed on induction, LPG, or biogas stoves, but typically consume more energy than preparing all of the meals for a day.[12] **It is still critical to understand major energy-consuming tasks and their performance requirements, and to identify and develop suitable solutions, to reduce high levels of emissions from households.**

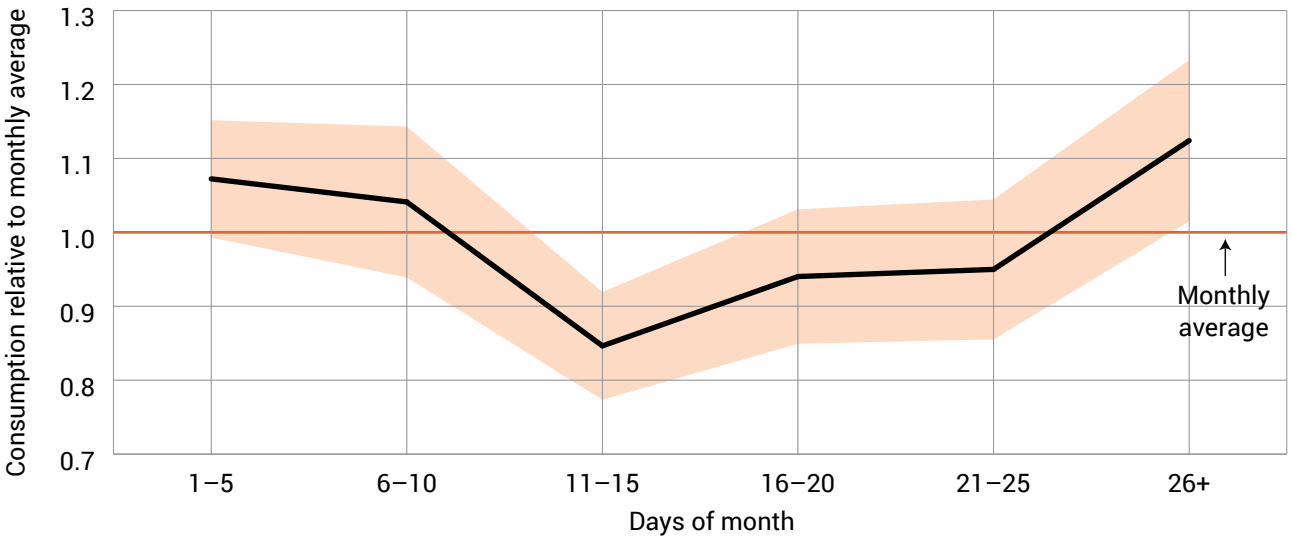
Empowering households, especially those using LPG, with information on their electricity consumption

Despite potential cost savings from transitioning to an induction stove, our measurements suggest that households may not have used electric cooking appliances as often as they could because they feared incurring high electricity bills. Data from energy-use monitors deployed in a subset of households for more than five months indicated a 10%–20% decrease in the use of electric stoves during the middle of the month, coinciding with visits from electricity meter readers (**Figure 1**). All these households used LPG. These results support anecdotal reports from household members, suggesting that strategies for electric cooking scale-up may need to look beyond matching appliances to needs.

It is reasonable for households to be concerned about the cost implications of using an electric cooking appliance. Unlike other purchased fuels, the way in which electricity is purchased is neither familiar nor intuitive when compared with widely used cooking fuels (e.g., cylinders of LPG and bundles of fuelwood). Because of the tiered pricing structure of electricity in Nepal, households that use more electricity save less money by transitioning from LPG to electric cooktops; actual savings potentials vary depending on their energy consumption characteristics (**Figure 2**). Households with a baseline of 20–30 kilowatt hours (kWh) of electricity per month that displace 0.25 LPG cylinders per month (and that increase electricity consumption accordingly) can expect savings of around 43 NRs per month; displacing 1 cylinder per month increases their savings to 232 NRs per month. A household that uses 150–250 kWh per month would effectively break even by displacing 0.25 cylinder per month, and it would slightly increase its costs by displacing 1 cylinder/month, due to higher-tier electricity costs.

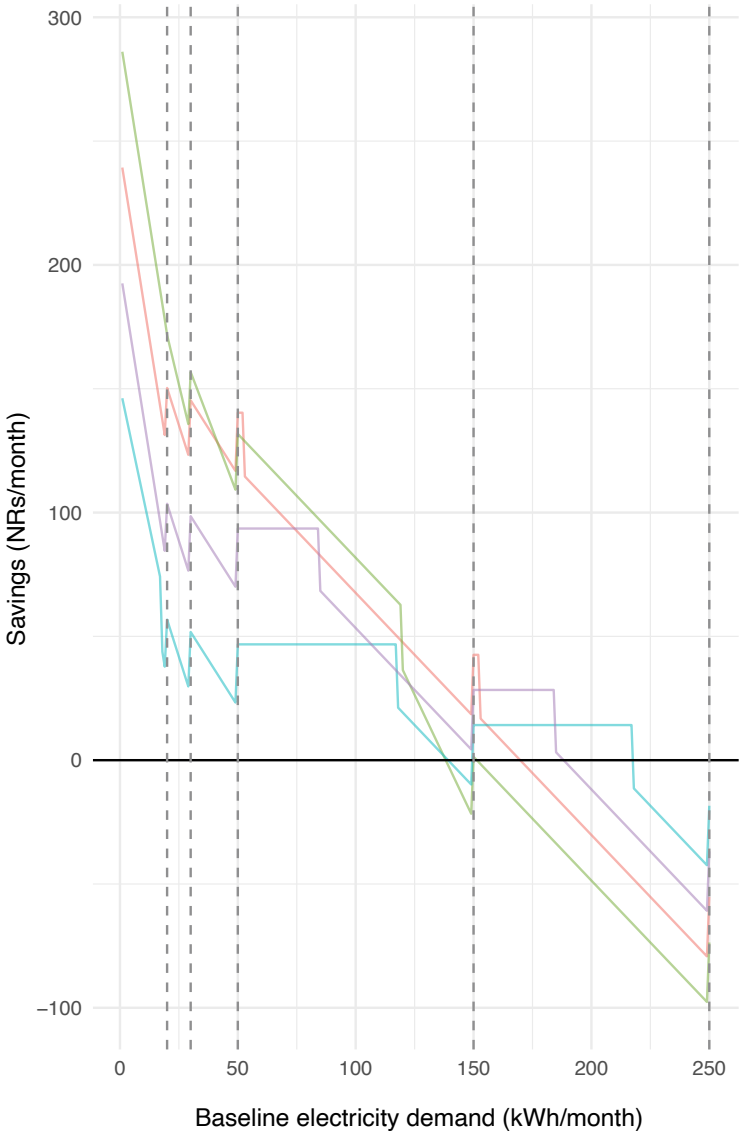
Considering electricity use in a typical study household, the addition of an induction stove operated at 800 watts would represent the single largest electric load in nearly all households, easily doubling electricity expenditures (although not necessarily increasing overall energy expenditure). Projections based on energy data collected as part of this study suggest that the average LPG user would increase their electricity consumption by a factor of about 2–3 times, if all needs met with LPG were transferred to an induction stove.

Figure 1. Induction stove use and electricity consumption, by period of the month



Note: Electricity consumption of stoves falls around mid-month, coinciding with visits by the Nepal Electricity Authority to read meters. Error bands correspond to the 95% uncertainty interval of the mean. Results are based on daily measurements, performed in a subset of six homes that were measured daily for five months.

Figure 2. Estimated savings from transitioning from LPG to induction stoves



It appears that the economics of this transition matter for households, but navigating these calculations is neither straightforward nor intuitive. **Giving households information about their current electricity consumption and its cost, and the savings potential associated with electric cooking appliances, may empower them to make more informed decisions.** This may help families feel more comfortable about consuming electricity and also accelerate displacement of LPG and biomass.

The average LPG-using study household would save 15% by transitioning to induction, but many feared unexpectedly high electricity bills.

Note: These calculations assume a standard LPG cylinder containing 14.2 kilograms (kgs) of LPG, LPG costs of 1,450 NRs/cylinder, and households with a 15-amp breaker. Colored lines correspond to different baseline LPG consumption: 1 cyl/month (green), 0.75 cyl/month (red), 0.5 cyl/month (purple), 0.25 cyl/month (blue). Grey dashed lines correspond to cutoff thresholds for tiers 1–5. The average baseline across 80 households monitored was 43 kWh/month (SD = 51) and 0.6 cyl/month (SD = 0.54). The table summarizes average savings given baseline (pre-electric cooker) electricity demand and rate of LPG consumption (low/high).

	Baseline electricity consumption (kWh/month)					
LPG displaced (Cylinders/ month)	**< 20**	**20—30**	**30—50**	**50—150**	**150—250**	**250—400**
0.25	103 NRs/month savings	43	38	34	1	-18
1.0	232 NRs/month savings	153	133	70	-9	-74

Targeting early adopters

Early adopters of electric cooking appliances will not necessarily be the poorest, nor the ones that would benefit the most from access to clean cooking technologies. The results of the study provide encouraging evidence that electric cooking technologies are a viable replacement for LPG and can partially displace use of biomass in Nepal. However, achieving universal access to electric cooking appliances will require reaching households not accustomed to paying upfront for energy, and therefore will require innovative strategies.

The average income of households that purchased an induction stove was not significantly higher than the average income of households that didn't. However, 95% of households that purchased an induction stove during the study already owned an LPG stove. These results suggest that early adopters are already accustomed to recurring cooking energy expenditures.

Households that purchased an induction stove reduced the use of their traditional stoves by a daily average of 35 minutes and 0.63 cooking events.

Making electric cooking accessible to more households will likely require measures to reduce the upfront and running costs of using electricity as a source of cooking energy. These measures include flexible financing mechanisms that allow households to spread out the payments of their electric appliance, to avoid high upfront costs. Also needed are distribution networks that make these appliances available to families for purchase.

Within the study community, the increase in electricity consumption resulting from use of an electric cooktop would shift most households from electricity tiers 1 or 2, to tier 3 (31–50 kWh per month) or 4 (51–150 kWh per month).

While there may be some value in extending the lowest electricity tariff tier (lifeline tariff) beyond its current 20-unit cap, the electricity in tiers 3 and 4 account for the majority of total cost, and so reducing rates at these tiers would provide a greater economic incentive for households.

Bhanchha Smartphone Application: Currently, households wait for monthly meter reader visits to learn how much electricity they have consumed. Survey discussions and in-home measurements suggest that fear of high bills may be affecting electric cookstove use. The study developed a demonstration "Smart Bhanchha" Android-based mobile application to enable households to monitor their energy consumption and cost of cooking in real time.

In the short term, it will be important to concurrently develop other clean cooking technologies, such as biogas, that have higher upfront but minimal operating costs and perhaps fewer infrastructure barriers, depending on the community.[13] Areas with high rates of LPG use and electric infrastructure may already be good candidates for program scale-up, regardless of income level.

Summary and Calls to Action

Results suggest that some households in the study community were open to investing in electric cooking appliances, would use them regularly, and would rely less on traditional biomass stoves and LPG stoves. For nearly all households using LPG, transitioning to induction stoves entirely would lead to economic savings, however, knowledge gaps related to the cost of electricity may be inhibiting use of electric appliances. Nearly all households that purchased induction stoves already used LPG, suggesting that households not accustomed to recurring energy payments are less likely to be early adopters of electric cooking.

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

CHALLENGE	ACTIONS
Households are having to make decisions about which energy resource to use, without being able to see their electricity consumption or predict the costs associated with a given activity.	Deploy and maintain household sensors or other real-time tools that allow customers to monitor their electricity use.
Areas with reliable electricity and high use of LPG could be promising markets for electric cookstove adoption, but households may need additional capital to make this change.	Develop credit and financing pathways for households and for vendors who provide cookstove sales and repair.
Communities lack local access to affordable electric cookstoves, as well as repair and replacement services.	Develop policies that encourage appliance distributors and service providers to increase their presence across underserved communities and offer a broader range of product offerings. Incentivize life-cycle strategies, including maintenance, warranty, and recycling. Provide job training for cookstove repair.

Opportunities

Development agencies: Finance and pilot test sensors and real-time tools. Build demonstration programs in target communities to adjust finance packages for best fit. Collaborate with government agencies on private-public partnerships to support electric cookstove distribution. Support the development of quality assurance and workforce training programs.

Government: Deploy and integrate household sensors into electricity billing and power quality monitoring. Consider subsidies and other household strategies to facilitate adoption of safe, durable appliances. Adopt quality assurance programs for electric cooking devices, that include warranty, maintenance, and recycling. Provide local job training programs for appliance maintenance and repair.

Nearly all households that purchased induction stoves already used LPG.

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. Government of Nepal, Ministry of Energy, Water Resources, and Irrigation, *Current status and future roadmap of energy, water resources, and irrigation sector* (Singhdurbar, Kathmandu, 2019), 34.
4. R. Bhandari and S. Pandit, "Electricity as a Cooking Means in Nepal—A Modelling Tool Approach," *Sustainability* 10, no. 8 (2018): 2841.
5. Additional program activities are summarized as part of companion policy brief 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
6. While stoves themselves were not subsidized, a subset of study participants received financial compensation of 1000 NRs for their participation in a cooking competition and/or an electricity consumption and quality study. For transactional ease, this was disbursed as a discount on the stove purchase. Market prices for induction stoves ranged from NRs 3500-4000 depending on brand and merchant.
7. N. L. Lam et al., "Seasonal Fuel Consumption, Stoves, and End-Uses in Rural Households of the Far-Western Development Region of Nepal," *Environmental Research Letters* 12, no. 12 (2017): 125011.
8. Energy prices include the cost of LPG and electricity tariff rates; the base demand for electricity in each home (non-cooking loads) is accounted for as part of these calculations.
9. This is based on the 52 households that consumed LPG during the 48-hour assessment window, of 108 households monitored as part of energy audits. At baseline, the average household in this group consumed 43 kilowatt hours (kWh) per month (SD = 51) of electricity and 8.9 kilograms (kgs), or 0.6 cylinders (SD = 7.9 kgs), per month of LPG.
10. The Nepal Electricity Authority has different tariff rates for 5- and 15-amp breakers. It is recommended that households using induction and other electric cooking appliances upgrade to a 15-amp breaker.
11. Using rates for a 15-amp breaker, these savings are 80 NRs/month (SD = 56).
12. Similar results were identified in a multi-season study conducted in Nepal (Lam et al. 2017).
13. See our separate policy brief describing lessons from biogas assessments.

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cleancookingalliance.org

@cleancooking
@cleancookingalliance
@cleancookingalliance
info@cleancookingalliance.org