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Putting the Cook Before the Stove: a User-Centred Approach to Understanding Household Energy Decision-Making

A Case Study of Haryana State, Northern India

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Cover photo: A village woman makes roti, a flatbread that is a local staple, on a griddle over her chulha stove.
All photos by Fiona Lambe and Aaron Atteridge.

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ABSTRACT

Globally, 1.4 billion people lack access to electricity and an estimated 2.7 billion rely on traditional biomass – wood, charcoal, animal waste and agricultural residues – for cooking and space heating. Roughly one third of this population lives in rural India. Over the past two decades, considerable efforts have been made to introduce improved cookstoves and/or cleaner cooking fuels in India, but as in other countries, these interventions have largely failed to bring about a large-scale transition towards cleaner, more "modern" cooking technologies. It has been argued that a central problem with most efforts has been that they paid too little attention to users' needs and cultural contexts, but rather over-emphasised technical factors such energy efficiency and emissions reductions.

This study seeks to better understand the most important influences over household energy choices, in order to identify practical ways to support communities shifting to cleaner energy use. We use a qualitative "generative" research methodology to investigate energy use and dynamics in four villages in Haryana State. Our results indicate a range of social, cultural and financial factors that influence the way people make decisions about energy and cooking, including the availability and flexibility of traditional fuels, the type of dishes prepared, the taste of food, problems with smoke, the aesthetic appeal of stoves, and how users perceive alternatives. These findings have implications for efforts to design effective cookstove interventions, most notably the Indian Government's ambitious National Biomass Cookstove Initiative, which aims to provide all Indian households currently using inefficient stoves with "next-generation" biomass stoves.

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1. INTRODUCTION

Household energy, livelihoods, and environment

Meeting the growing demand for energy services in developing countries is one of the foremost challenges of our time, with direct implications for livelihoods, health and environmental sustainability at the local, regional and global levels. In poor households across the developing world, cooking often accounts for 90% or more of total energy demand. Ensuring access to clean, safe and environmentally sustainable energy for household cooking is therefore at the crux of the energy access challenge.

Traditional biomass is typically burnt on open fires or inefficient stoves, and when used indoors produces levels of indoor air pollution many times higher than international ambient air quality standards, exposing particularly women and children to a major health hazard (Smith et al. 2011; Bruce et al. 2002). There is now consistent evidence that biomass smoke exposure increases the risk of childhood acute respiratory infections, particularly pneumonia (Bruce et al. 2002). It is estimated that globally, exposure to indoor air pollution results in 1.6 million deaths annually and accounts for 2.7% of the global burden of disease (Rehfuess 2006). Studies now demonstrate conclusively that replacing traditional cookstoves with more efficient stoves can reduce these risks: a randomised control trial found that improved cookstoves reduced the incidence of severe forms of respiratory infection by around 30% (Smith et al. 2011).

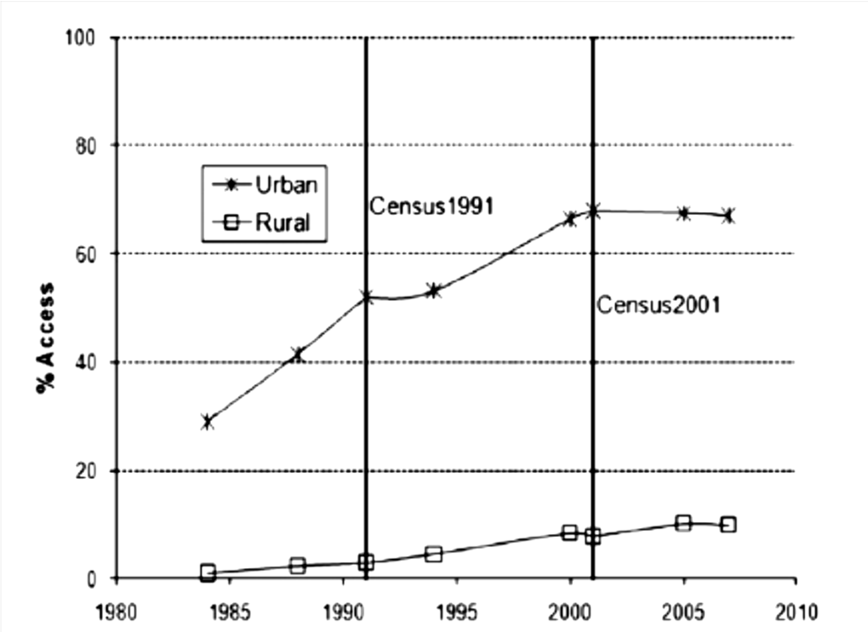
The traditional use of biomass also has significant repercussions for the environment, in terms of both deforestation and regional and global climate impacts. The poor combustion and efficiency of traditional biomass systems leads to high pollutant emissions and exposures, resulting in high greenhouse gas (GHG) and health impacts per unit of useful energy (Smith and Haigler 2008). Global inventories suggest that residential sources – mainly traditional cookstoves – account for almost 25% of emissions of black carbon, a powerful short-lived climate forcer (Bond et al. 2007; Bond et al. 2004).

Gathering fuelwood – a task that falls mainly on women and children – can take several hours per day, with significant socio-economic impacts for households. Freeing up that time to engage in income-generating and educational activities could contribute to the stability and advancement of families and communities. There are also safety risks for women and girls when they must travel long distances by foot alone or in small groups. Where fuel is purchased rather than collected, the costs can severely constrain household budgets (Rehfuess 2006).

Household energy consumption trends and patterns in India

Today, households account for approximately 30% of final energy consumption in India (Reddy and Srinivas 2009). Fuelwood was the primary source of household energy in India until the early 1970s, when urban dwellers began to use kerosene; by the early 1980s, 10% of urban households were using liquefied petroleum gas (LPG) for cooking (Reddy et al. 2009); that share had risen to 57% by 2004-05. The International Energy Agency estimates that urban households, which make up less than 30% of India's population, account for 75% of India's residential demand for LPG (IEA 2007). The same transition to cleaner fuels has not occurred in rural India, however, where today, biomass remains the main energy source for more than 80% of households (Pachauri and Jiang 2008), with only 13.9% using LPG for cooking (see Figure 1 below for trends in urban and rural fuel use). Only 1% of rural households have switched away from traditional biomass use since 1999-2000 (ibid.), and the total number of people relying on traditional biomass for cooking and heating increased from 580 million in 1992 to 668 million in 2005 (IEA 2007).

Figure 1: Trends in household access to modern cooking fuels



Source: Balachandra (2011).

Several reasons have been posited for the rural-urban divide in Indian household energy use. One common explanation for the low uptake of "modern" fuels in rural India is income: Rural households are often poorer, and if biomass is readily available at no cost there is little financial incentive for households to purchase the more expensive cooking fuels (Reddy and Srinivas 2009; Pachauri and Jiang 2008; Barnes et al. 1993). Further, the upfront cost of LPG stoves is often a major deterrent for rural households. Yet a significant percentage of high- (31.8%) and middle-income (61.8%) rural households rely on biomass for cooking, raising doubts that income is the key determining factor in fuel use (Reddy and Srinivas 2009). Availability of LPG and other cleaner fuels can also be an issue – often these fuels are not available, are in short supply at the market, or the long distances from household to retailer is prohibitive (ibid.). The use of electricity by Indian households is growing rapidly, although use of electricity for cooking is limited. Although 50% of rural households have access to electricity, most use it for lighting only. India is unusual among developing countries in that electricity access is relatively high, but so is dependence on fuelwood and dung for cooking (IEA 2007).

Health and socioeconomic impacts of household energy use patterns in India

According to the World Health Organization, emissions released while cooking indoors with biomass fuels cause more than 400,000 premature deaths per year in India, mostly from acute respiratory diseases (WHO 2007). The average level of particulate matter (PM) from biomass cookstove smoke in India is 2,000 micrograms per cubic metre ($\mu g/m^3$)[1] – far higher than the 150 $\mu g/m^3$ standard set by the U.S. Environmental Protection Agency (Smith 2000). This pollution lingers inside homes. Using a disability-adjusted lost life-year approach, Reddy and Srinivas (2009) estimate that indoor air pollution accounts for 4 to 6% of the Indian national

[1] Available data show a distribution of indoor PM_{10} 24-hour concentrations in Indian solid-fuel-using households which can be well over 2000 $\mu g/m^3$.

burden of disease. Astonishingly, acute respiratory infections in India are the largest single disease category in the world, accounting for 2.5% of the global burden of ill health (WHO 2007). Eye infections and blindness caused by exposure to indoor smoke are also common. It is estimated that 18% of partial and complete blindness among people aged 30 and older in India can be attributed to biomass fuel use (Mishra et al. 1999).

In India, as in most developing countries, the negative impacts of traditional biomass energy use are felt most acutely by women and children, who are responsible for gathering fuelwood and dung, primary cooking fuels for 140 million households (IRADe 2009). According to a study by the Indira Gandhi Institute of Development Research (Laxmi et al. 2003), the impacts are disproportionately high for adult women. The costs of treatment and lost work days due to these illnesses, combined with the time spent gathering biomass, adds up to 29 billion rupees (approximately 429 million Euros)[2] per year in the rural areas of Rajasthan (ibid.). In rural northern India, roughly 30 billion hours annually or 82 million hours per day are spent gathering fuelwood (Reddy et al. 2009).


A woman cooks in an outdoor kitchen in a rural village in Haryana State, in northern India.

Linking residential cooking to black carbon in the Delhi region

Black carbon aerosols are formed through incomplete combustion of carbonaceous materials, for example, in stoves, vehicle engines and wildfires. Black carbon particles directly absorb sunlight and thereby affect the regional climate by heating the atmosphere, dimming the surface and disrupting hydrological cycles (Ramanathan and Carmichael 2008).

In parallel with this study, research by Stockholm University and the Indian Institute of Tropical Meteorology has examined the contribution of different sources to black carbon pollution in the Delhi urban area.[3] Preliminary findings indicate that while fossil fuel combustion, mainly from vehicles, is the largest source (as expected in a dense urban area), the contribution of biomass burning is highly significant, contributing in the range of 33 to 56% of total black carbon emissions. The contribution of traditional biomass sources to regional background levels of black carbon in other parts of India is expected to be higher (Gustafsson et al. 2009).

Black carbon has a short atmospheric life (a few weeks), unlike CO_2, which means that measures to tackle black carbon emissions can have immediate benefits – slowing climate change, reducing regional warming and precipitation disturbances, improving human health,

[2] One Indian rupee equals 0.0147990 euros (per http://www.xe.com, 11 April 2012).

[3] The research conducted by SEI in Haryana State is part of a larger project: *Climate and health-afflicting "brown air" in northern India: evaluation of sources, advice on mitigation options and advocacy for action*. The Department of Applied Environmental Science at Stockholm University and the Indian Institute of Tropical Meteorology in Delhi are leading the work on assessing the sources of black carbon in the Delhi region.

and potentially saving millions of lives (UNEP and WMO 2011). In addition, reducing the use of traditional biomass for household energy can ease the pressure on strained ecosystems.

2. GOVERNMENT POLICY MEASURES TARGETING HOUSEHOLD ENERGY

The Indian government provides direct subsidies to consumers for kerosene and LPG for domestic use, while compensating Indian oil marketing companies for the difference between the consumer price and the import parity price (Government of India 2006). Households currently pay 9 rupees per litre of kerosene (31% of the current market price) and 281 rupees per 14.2 kg cylinder of LPG (56% of the current market price)[4] (Government of India 2010).

Although the stated purpose of LPG subsidies is to improve access to energy for poorer rural households, they primarily benefit richer urban households who use more fuel (IEA 2007; Modi 2005). An expert group appointed by the Indian government found that LPG-using rural households in the four lowest income deciles use 5.1 to 6.6 cylinders per year, while urban households in the top five deciles all average more than 10 per year (Government of India 2010).

All subsidised LGP is supplied by the state oil companies, but the distribution networks to rural areas are severely underdeveloped. The high upfront cost of purchasing LGP cylinders, coupled with supply shortages of LPG, has been offered as one factor that has prevented rural households from shifting to this fuel for cooking (IEA 2007). Although the oil companies have complained that expanding distribution to the rural areas is difficult and currently not profitable, there is no specific federal plan in place for expanding LPG accessibility in rural communities (ibid.).

Kerosene's use as a primary fuel for lighting and cooking has been on the decline and it is now not commonly used as a cooking fuel in India, other than for igniting biomass-fuelled stoves (Rao 2012). Kerosene is heavily subsidised by the state, and almost 90% of kerosene supply to the rural area is distributed through a public distribution system (IEA 2007). Households already using LPG are only entitled to half the normal quota of subsidised kerosene if they use a single LPG burner, and they cannot get any if they use more than one LPG cylinder (ibid.). Given that kerosene is such an important fuel for lighting in rural areas, having to choose between LPG and subsidised kerosene could be a powerful deterrent to households moving from biomass to LPG for cooking.

Under the Electricity Act of 2003 and the subsequent National Rural Electricity Policy of 2006, the Government of India affirmed its commitment to extending the supply of electricity to all households by 2012, primarily through grid extension (Modi 2005). However, currently 400 million Indians (approximately 30% of the population) still lack access to electricity (IEA 2010), and the government's policy on rural electrification has been criticised for failing to address the issue of reliability and quality of electricity supply and for focusing only on providing single-point lighting connections to households, without meeting broader household energy needs (Kishore and Ramana 2002).

[4] At crude oil price of $75/barrel, kerosene should be priced at around 29 rupees per litre, but it is sold for 9 rupees per litre. At the crude price of $75/barrel LPG should cost more than 500 rupees for a 14.2 kg cylinder. Instead consumers pay 281 rupees per cylinder (Government of India 2010).

3. REVIEW OF PAST IMPROVED COOK STOVE INITIATIVES

Over the past two decades, a large number of initiatives, some led by the Indian government, others driven by local or international NGOs, have sought to introduce improved cooking technologies with the aim of reducing fuel use and indoor smoke emissions. The results of these initiatives have been mixed.

In 1984 the Indian government launched the first National Programme for Improved Cookstoves (NPIC), to address local deforestation by reducing biomass use at the household level, while improving household health and easing the burden of fuelwood gathering for rural women and girls. The NPIC aimed to supply 120 million energy-efficient cookstoves to households in 23 states and five union territories (administrative units under the control of the central government). The government subsidised 50% of the cost of the stoves, and by 2002, roughly 34 million stoves had been distributed across India. However, subsequent impact assessments suggest that the real benefits of the programme in terms of fuelwood and monetary savings at the household level are likely to be far lower than the claims made in the annual reports of the MNES (Kishore and Ramana 2002).

The NPIC was discontinued in 2002. One major shortcoming that has been cited is its top-down approach (Greenglass and Smith 2006). The central government subsidy went directly to stove producers, yet it is apparent that many producers did not consider consumer preferences when designing and marketing stoves, and many households discarded the new stoves within a matter of months (Hanbar and Karve 2002; Kishore and Ramana 2002). The subsidy may also have stifled efforts in the private sector to innovate and produce better stove models (Greenglass and Smith 2006). The NPIC has also been criticised for failing to ensure that the stoves, which were made by networks of trained local artisans, met minimum quality standards (Hanbar and Karve 2002). Moreover, the improved stoves often failed to improve upon the efficiency of their traditional counterparts (Bhattacharya and Cropper 2010), so users did not always see net benefits in fuel savings or reduced smoke levels.

The lessons learned implementing the NPIC have influenced a "new wave" of improved cookstove programmes across India over the past decade, initiated by domestic and international non-government organisations and by business organisations at the grassroots level. In contrast to the NPIC strategy, these have generally adopted a more commercial and bottom-up focus, based on demand-driven marketing techniques in rural communities (Greenglass and Smith 2006). However, to date these initiatives have also failed to significantly transform the rural household energy market (Balachandra 2011).

In late 2009, the Ministry of New and Renewable Energy (MNRE) launched the National Biomass Cookstoves Initiative (NBCI), with the aim of bringing improved cooking stoves to all Indian households that rely on traditional biomass for cooking. The project involves the development of "the next-generation of household cookstoves, biomass processing technologies and deployment models", and it aims to achieve a level of energy services "comparable to that from other clean energy sources such as LPG" (MNRE 2009). These next-generation cookstoves commonly have advanced features such as induced or forced air flow to maximise fuel combustion and allow for cleaner burning. Researchers at the Indian Institute of Technology have estimated that successful implementation of the NBCI could not only massively reduce premature deaths among poor women and children but also reduce over 4% of India's estimated GHG emissions. However, they see "formidable" technology development and deployment challenges, including potentially much-higher costs per stove (Venkataraman et al. 2010).

The need to better understand household energy dynamics in India

Although the technical challenges are significant, a more fundamental issue will also be ensuring that these advanced stoves meet users' needs in other ways, since ultimately this will determine the extent to which households are willing to buy and use the stoves. User acceptance will depend not only on technical efficiencies (which translate as fuel savings) but also on how well other design features match people's preferences – in other words, the social, cultural and economic suitability of the new stoves. These "softer" factors are less easy to quantify, perhaps explaining why to date they have been largely ignored in efforts to scale up access to improved cookstoves.

Currently, the only criteria being considered in the selection of stoves for support under the NBCI are technical and relate to the efficiency and emissions gains achievable. There does not appear to be any equivalent protocol for evaluating how appropriate the technology is in terms of other user preferences.

Previous analysis of household energy decision-making dynamics has tended to emphasise certain socioeconomic variables such as income, gender and household size as key determinants of household energy choice (Gupta and Köhlin 2006; Ouedraogo 2006; Heltberg 2004), while the user's experience of product specific factors such as safety, indoor smoke, usage cost and stove price have largely been ignored (Takama et al. 2011). Yet there is now a growing awareness among cookstove programme implementers, donors and researchers of the importance of understanding household preferences for various cookstove parameters – and how individuals "trade off" between factors.

4. STUDY OBJECTIVES, RESEARCH QUESTIONS AND METHODOLOGY

The aim of this research is to better understand household cooking practices and decision-making about energy options, in order to pinpoint how opportunities might be created to assist communities in shifting to cleaner energy use. Behaviour shift in this context may mean making more efficient use of an existing fuel (such as a higher-efficiency biomass stove) or an alternative fuel with fewer detrimental local impacts (such as a shift from fuelwood or charcoal to gas or electricity). We also seek to identify barriers that might prevent people from switching to improved cookstoves, including any combination of political, financial, cultural, social, logistical, ergonomic or other factors.

A recent SEI project looked at the household energy problem from the perspective of cookstove users/consumers, to better understand the dynamics of household-level choices on stoves and fuels.[5] The research team found that prior studies had focused too much on the influence of particular broad socioeconomic factors such as income, and had neglected the role of product-specific factors such as the price and smoke level of the cooking stove (Takama et al. 2011).

In 2008-2009, SEI conducted a study focused on Sub-Saharan Africa, applying a stated preference survey to nearly 1,200 households in Ethiopia, Tanzania and Mozambique. Discrete choice analysis was used to understand how households "trade off" between various product-specific factors when deciding which stoves and fuels to purchase (Takama et al. 2011). The study found that both socio-economic and product-specific attributes play important roles in household choices, and provided useful insights. For example, in the case of Ethiopia, the study showed that lower income households would be willing to pay for the

[5] The *Household Energy Economic Analysis* project was implemented by SEI's household energy research team from 2008 to 2010.

cleaner burning but relatively expensive ethanol fuelled stove provided that the running cost (i.e. the cost of the ethanol fuel), remained below that of kerosene. Such information is crucial for stove producers, policy-makers and programme developers interested in targeting particular markets because it shows not only which stove characteristics matter most to consumers, but also by *how much* consumers value one stove attribute over another, or how trade-offs are made at the individual level (Takama et al. 2011).

One limitation of household energy economic analyses such as this, however, is that the survey questions are determined in advance, so households are only asked about a specific set of trade-offs. Other important factors influencing decision-making will not show up in the model results. These tools also don't explore the underlying causes of particular problems faced by households nor how these might best be addressed. There is clearly a need to understand the fuller context, including social, financial, cultural and technical factors.

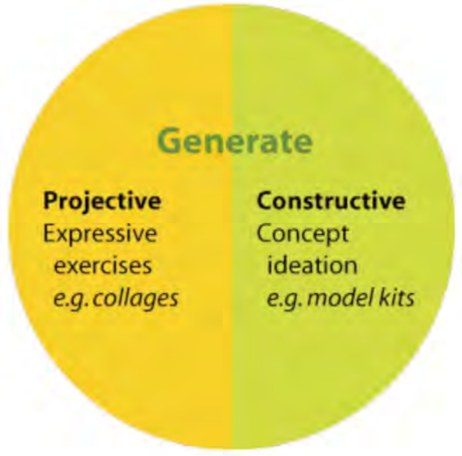
The approach taken for the study in Haryana State is to combine a quantitative methodology with more qualitative research. The latter is conducted upfront to bring to light important information about current household practices and their motivations, as well as barriers to (and opportunities for) change. We used a similar approach in a study in Lusaka, Zambia, in 2010 (Atteridge et al. 2012, forthcoming). The goal is to ensure that key contextual information is included in the subsequent survey design, to produce a more robust quantitative approach

The current project includes two phases. The first – the results of which are the primary focus of this paper – was a **baseline assessment of household energy options and practices** in the biomass energy economy within the New Delhi region (in nearby Haryana State), including data collection, site visits, and a comprehensive literature review on cookstove programmes in the region. The research also included an in-depth **qualitative analysis of the drivers behind household energy practices**. Field research in late 2011 involved semi-structured interviews as well as observation of cooking and the household environment.

The second phase will consist of further **qualitative and quantitative assessment** of the way in which households make trade-offs about energy purchase and use, particularly for cooking. This will involve a second stage of field research in 2012, either using a stated preference survey or a similar tool. The survey design will be informed by the results of the first phase of research. It will model expected fuel and technology choices amongst different demographic group and analyse in more detail the willingness and capacity of households to change energy practices.

Qualitative research methods

For the qualitative analysis of phase one, we selected an ethnographic approach sometimes referred to as generative research. Generative methods originate in the social sciences and focus on drawing both overt and tacit knowledge from "users" (in this case, households) which brings to light some understanding of people's needs and desires (Hanington 2007). Sometimes an earlier "exploratory" research phase is considered separately, which focuses on obtaining an in-depth understanding of people and the context in which they live. Both exploratory and generative methods "are typically ethnographic in nature, and may include participant observation, artifact analysis, photo and diary studies, contextual inquiry, cultural probes, and other methods designed to sample human experience" (ibid.). Here, we incorporate elements of both under the single label of a "generative" methodology.



Model of generative research. Source: Hanington (2007).

Both *projective* and *constructive* methods can be used in generative research (see Figure 2). Projective methods focus on drawing out thoughts, feelings and desires, often through indirect (or "expressive") means, since these may be difficult to communicate verbally. Projective methods are typically ambiguous, rather than tightly controlled, and often use an artifact – a real or hypothetical cookstove for instance (both were used at times in this study) – as a trigger for people to engage in relaxed and open conversation. Constructive methods are used as a second step to get more detailed input on specific questions and identify concrete parameters for the desired product (Hanington 2007).

Our approach in this phase of the study leans more heavily towards projective research, though some interview questions discussing specific attributes of improved cookstoves probably fall into the constructive category. In any case, the two are part of the same spectrum of methods aimed at understanding people's needs and desires.

In the design process, generative research is often followed by a process of "evaluative" research, the purpose of which is to measure people's expectations against particular products (i.e. specific stove models), evaluating the usefulness and desirability of those products. The proposed methodology for the second phase of this study will involve both constructive generative research and evaluative research methods.

Contextual interviews and observation of cooking practices

A crucial part of our first phase of research was a series of in-depth, open-ended interviews with 13 households over two days. These were informal discussions with the people responsible for cooking and fuel provision, all women, with guidance from a set of prepared questions. Crucially, interviews were conducted "in context" – that is, in people's homes, often while they were cooking or preparing to cook. Details related to the physical environment, living quarters, cooking area, stove use, fuel storage, food preparation and cooking process were carefully recorded through notes and photographs. The interviews typically lasted one to two hours.

A woman prepares tea on a *chulha* stove.

A Day in the Life

As part of the interviews, we gathered information to create a descriptive "walk-through" of typical tasks and activities carried out by women. For example, interviewees were invited to describe an average morning – when they get up, the various stages in preparing breakfast – or to tell us about going to the market: the full sequence of events from deciding to go, to going there, making purchases and returning home. The purpose is to understand the broader context of the stove users' lives, and how it might affect their attitudes towards stoves and fuels. This method was particularly useful for understanding in detail the full sequence of activities related to the preparation of each meal.

Project site, demographics and household selection

The households interviewed were in four villages, Mothuka, Nyagaon, Arrua and Chainsha, all part of Ballabhgarh Tehsil in District Faridabad, Haryana State, approximately 40 km southeast of New Delhi. Livelihoods in this area are predominantly derived from farming (wheat, rice, vegetables and millet) or government employment. Interviewees for this study are described by field guides as being low- to middle-income households.

The households were selected by researchers at the Indian Institute of Technology, New Delhi, with support from local organisations, using basic criteria supplied by the authors. The study parameters required that they belong to demographic groups that rely primarily on biomass energy sources, and that they be spread out across a community or several villages, rather than in a single location. Although the sample of 13 households was relatively small, the interviews nonetheless revealed many common patterns in verbal responses and observed behaviours.

5. RESULTS OF HOUSEHOLD INTERVIEWS

Profile of fuel use

Dung cakes

All of the households rely on a combination of dung "cakes" (flat disks of dried cow dung, approximately 10 cm in diameter) and fuelwood for cooking, and use a traditional clay stove known as a "chulha". All but two of the families interviewed own at least one buffalo which produced enough dung to meet their annual cooking needs; one buffalo produces on average 15 kg of dung per day. The two households that do not own cattle purchase dung from relatives and neighbours. They pay 150 to 300 rupees for an "arm's length" of cow dung, which lasts them about three weeks.

Cow dung cakes laid out to dry.

Dung cakes are made during the cooler months, September to February. Wet dung is gathered, shaped by hand into cakes, left to dry for three to seven days, and then stored in communal spaces on the outskirts of the villages, for use throughout the year. Households report that the younger female family members are responsible for producing the dung cakes, though we saw women of all ages making them.

During cooking, dung cakes are broken up by hand and fed into the fire. Dung creates a significant amount of smoke when it is first lit, but once it is burning the smoke subsides, users report there is less smoke than with wood. The dung does not burn as hot as wood, so households see it as good for purposes such as boiling milk.


Agithis burn dung for slow cooking.

Many households also use dung as fuel with another stove type, the "agithi", a bowl-shaped device made from clay and cow dung. The agithi is commonly used to boil milk and water, and those households with buffalo also use it to prepare gruel to feed the animals. Some households reported using the agithi to preserve milk by keeping it at a constant heat. The agithi's slow-burning nature means it can be left unattended for long periods, a trait appreciated by its users.

Fuelwood

Fuelwood is typically gathered by women and girls either from the household's own land, if they have it, or from "common lands" close to the villages. The frequency of gathering varies between households interviewed: three gather every two to three months; four gather every month; three gather several times per month; two gather several times per week; one did not gather at all, instead purchasing cow dung. Some households reported that both men and women are involved: men cut the wood, and women carry it home. A mixture of larger logs and smaller twigs is preferred. Large branches are good but can't always be found. Usually the branches are cut, and the trunk is left; the trees reportedly grow back within a year. None of the households reported experiencing fuel shortages, although one respondent expressed concern that the communal land available for gathering fuelwood may become scarcer due to development by private companies.

Fuel combination

Households' preference for cooking with a mix of cow dung and fuelwood is an important observation. The common pattern is that firewood is used for quick cooking tasks where a hotter flame is useful, for example, to boil water for tea, while cow dung is used mainly for slower cooking/simmering. When asked about fuel preferences, households consistently replied that both are necessary for a good fire, and that it would be very difficult to burn one fuel only. Cow dung is often introduced to the stove while wood is burning, in order to regulate the heat by reducing the strength of the flame. Many interviewees mentioned that using cow dung allowed them to perform other tasks while cooking, as the fire could be left attended. Households indicated that an average meal requires approximately 3 to 4 kg of cow dung and 1 to 1.5 kg of fuelwood.

Several households said part of their motivation for investing in one or more buffalo was to get dung for energy. By implication, this means that if households stopped using dung as fuel, it would diminish the value of their investment.

Profile of stove use

Every household interviewed used a chulha as the primary cooking stove. The chulha is a U-shaped stove, with one side left open to feed the fire. It is only used for cooking – not for space heating.

Many households had more than one chulha, often one portable and one fixed to the ground, though most use only one stove at a time. There is no real push for "parallel cooking", though one or two households suggested this might be good (but don't do it with their existing stoves). When they do cook in parallel the agithi is used, since it does not need much tending.

Two versions of portable chulhas.

Chulhas are handmade by the households themselves (usually the mother or daughter) using clay, which is shaped to form the stove and then allowed to dry in the sun. The process takes several hours, spread over two or three days to allow for drying of the clay layers. No innovation in the design of the chulha was observed in any of the households interviewed; all of the stoves are almost exactly the same shape and size.

Mothers teach their daughters how to make the stoves. The women interviewed seemed to appreciate the aesthetics of the chulha, finding the shape "beautiful", and emphasised the importance of being able to build a "good" chulha, although it was difficult to ascertain what, specifically, the key features of a "good" chulha are. Most indicated that they have sometimes made a chulha that didn't burn as well as it should.

The lifespan of a chulha ranges from one to three years, depending on maintenance and exposure to the elements, particularly the monsoon rains. Many of the households interviewed reported that they typically construct a new chulha every year to replace one damaged in the rains (this was most common when the fixed chulha was outside, where it inevitably gets destroyed during the rainy season). For regular maintenance, most families re-plaster the stove after every cooking session, using a thin layer of mud. This treatment, which takes a few minutes, both cleans and strengthens the stove.

Lighting a chulha: dung is very smoky when first lit.

Asked whether they have any major problems with the chulha, women say no. However, there is a widespread desire expressed (both explicitly and tacitly) to use less fuel and to cook with less smoke. Smoke is a major problem, especially during rains when cooking takes place indoors. Women reported problems with their eyes, headaches while cooking, and health problems among their children that they perceived to be linked to smoke from cooking fires. Although some households used an LPG burner for fast cooking, for example to make tea, many households interviewed were unfamiliar with alternatives to the chulha, and few had cooked with other kinds of stoves.

Roti making

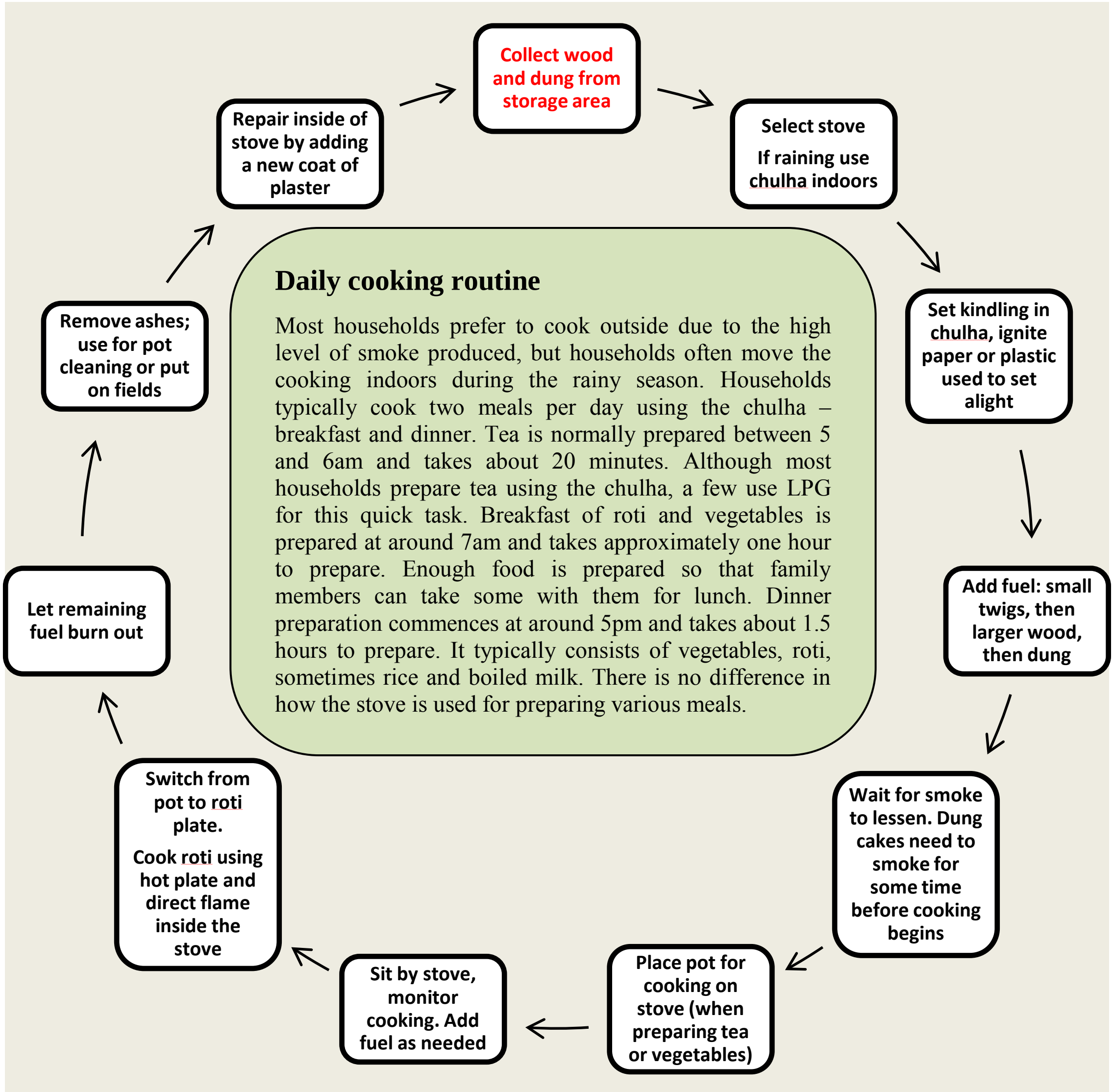
All households prepare "roti", a disk-shaped flat bread that is the local staple eaten with every meal. Roti is usually the last dish to be cooked for each meal. Once the dough is prepared, the fire is lit in the chulha. Commonly, the fire is initially set using cow dung, and then the heat is increased as needed by feeding fast- burning woody "reeds" and thin pieces of firewood into the chamber. A cast-iron plate is placed on top of the chulha, and when the fire is hot enough (after a couple of minutes), the roti is dropped on the hot plate. The roti is fried for a couple of minutes on both sides, then transferred into the main fire chamber for baking. The roti is placed on its edge against the flames of the fire, and after a minute or so, it puffs up, indicating that it is ready, at which time it is removed by hand.

Given the choice, the women interviewed stated that they would rather cook using a combination of cow dung and fuelwood (rather than fuelwood only) as the combination allows them to increase and decrease the heat of the fire during the roti baking sessions. One mentioned that it was technically possible to bake roti using an LPG stove, but said she prefers to bake roti on the traditional chulha. Many of the women also mentioned that they appreciate the particular taste of roti cooked with cow dung.

The two steps in making roti: frying (left), and baking on an open flame (right).

Figure 2 outlines the entire sequence of stove use in a typical household.

Figure 2: Stove use sequence



Several households had an LPG bottle and two-burner cookstove, yet made minimal use of it. One woman used her LPG stove to cook indoors when it was raining, but she prefers using the chulha because the food tastes better. Similarly, although it is possible to bake roti on a gas stove by placing the half-cooked bread directly on the gas flame, women said it "does not taste as good".

Energy alternatives: an LPG stove (left), electricity meter (right).

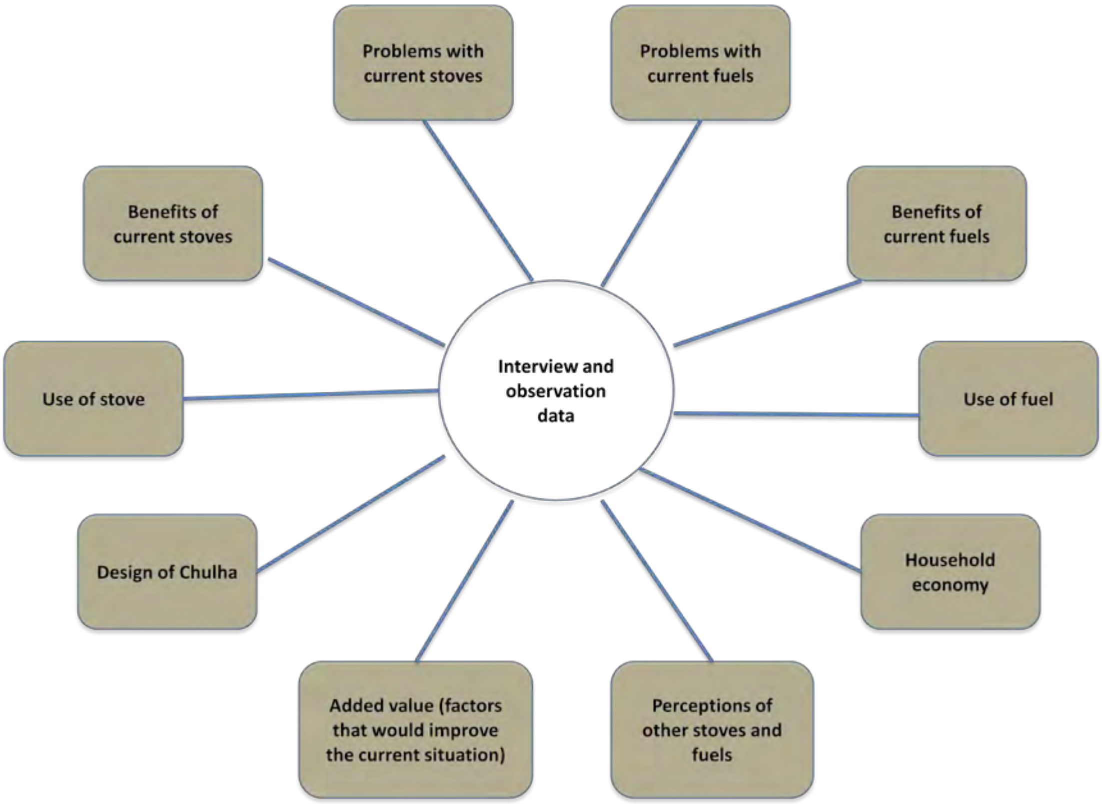
LPG is also expensive and, as discussed previously, it is unlikely that reliable supplies of LPG will reach rural areas in the short term. Households reported that uncertainty about supply and the high price of the canisters and fuel were key reasons for them not to use LPG.

6. ANALYSIS OF THE DATA

Stage one: Clustering the insights

The raw data gathered during the interviews were analysed and broken down into "insights", which are essentially statements made by the households. Data were in the form of direct quotes/statements or the researchers' own observations during interactions with households. In total, more than 100 data points were gathered. The process of clustering the data under headings involved two main stages. First the data were clustered according to basic common threads or areas that repeatedly came up during the interviews. Then each cluster was categorised under the main headings presented in Figure 3 below.

Figure 3: Categories of insights



Stage two: Pattern recognition

Once categorised in this way, it was possible to "go beyond" the data points themselves and begin to recognise patterns. For example, all households interviewed reported using cow dung and fuel wood in tandem depending on what they cook: for faster cooking, they add more firewood, and for slower cooking, they rely more on cow dung. What we can extract from such recurring statements is the importance for the stove users of having control over the strength of the flame – in other words, the ability to regulate the fire depending on what is being cooked. These patterns provide important clues as to the key drivers related to decision-making around household fuel and stove use. The clustered information can then be used to draw out observations about: (i) incentives to change; (ii) barriers to change; and (iii) household economy and willingness to pay.

Incentives to change

Incentives to change can be expressed either explicitly (i.e. verbally) or tacitly (i.e. through non-verbal behaviours). Recurring insights about users' needs and desires and how these reflect opportunities for inducing change in current practices are presented in Table 1. These translate as broad design parameters that could make improved cookstoves more attractive to households in this area.

Table 1: Incentives to change

Recurring insights	Incentives to change
The agithi allows women to tend to other tasks while cooking.	Ability to leave the stove unattended.
Would purchase an improved stove if it consumed less fuel and produced less smoke.	Save fuel. Reduce smoke.
Would be willing to cut up wood fuel into small pieces for use in an improved stove as long as there was on overall fuel saving.	Save fuel.
Would like to have a stove that can be used either inside or outside.	Portability.
Purchased an electric stove because heard from neighbours that it is fast.	Cook quickly.
If time gathering firewood could be reduced, it would be used for farming.	Reduce time collecting fuel.
The household that had tried a Biolite[6] stove would be willing to purchase it to save time, save fuel and to have the ability to charge appliances.	Save fuel. Reduce time spent both cooking and collecting firewood. Additional utility of generating electricity that could meet other household energy needs.
Women report always making the stove the same way – if they were to make it differently, some said they would make it smaller and more portable.	Small stove size. Portability.
Would like to be able to use all pot sizes on the stove, even smaller ones.	Able to use different pot sizes, including small pots.
Prefer to cook outside – too smoky inside. Smoke leads to health problems.	Reduce smoke. Ability to cook indoors.
When it rains, need to cook inside as there is no shelter for the chulha.	Portability.
Better to cook sitting down, because "if I stand up the heat is directly in my face".	Reduced heat stress for users (e.g. via stove insulation).
Pots become very black when using fuelwood.	Cleaner fuel burning (to reduce blackening).
"I don't manage to gather enough fuelwood, so I also purchase cow dung".	Save fuel.
For fast cooking firewood is used, for slow cooking cow dung is often used.	Ability to regulate heat.
A small number of households use a portable LPG stove for boiling water for tea.	Cook quickly.
The portable chulha often breaks when lifted/moved	A "sturdy" portable stove.

Barriers to change

We recorded a large number of recurring insights about the various perceived benefits of current fuel and stove use, which could represent potential barriers to households switching to other stoves and fuels. Key barriers identified are listed in Table 2. Interestingly, although very few interviewees had seen or tried alternatives to the chulha, those who have offered some pertinent observations that may reflect barriers to wider acceptance of alternatives.

[6] Biolite is an improved, forced draft cookstove capable of charging mobile phones. It is currently being pilot tested in rural India. See http://biolitestove.com/BioLite_HomeStove.html.

Table 2: Barriers to change

Recurring insights	Barriers to change
Agithi is used for warming milk, heating water and preparing feed for the cattle.	The current cooking technology serves many different needs, i.e. is versatile and meets needs of people.
Agithi is used for preserving milk.	Current technology useful for preserving milk.
Most households use both the chulha and agithi – both are made by households themselves from locally available materials (clay and straw).	Current stoves are not purchased.
It would be a problem if I had to use only one fuel for cooking I use fuelwood to cook quickly and cow dung for slow cooking. Households use fuelwood and cow dung in tandem to regulate the heat depending on the dish is being prepared.	An appreciation of multiple fuels rather than single fuel. Understanding that multiple fuels are better. Current fuel combination seen as versatile, allows for the necessary heat regulation for cooking specific dishes.
My family likes the taste of food cooked on the chulha – they associate the taste of food cooked using LPG with "city life".	Attachment to the taste of food cooked on the chulha.
Cow dung is less smoky than fuel wood.	Perception that cow dung is cleaner than fuel wood.
We are purchasing cow dung from our relatives.	Some individuals are earning income from the sale of cow dung. There is some economic rationale to dung use.
I get cow dung from our own cattle and fuelwood from the land; it is always possible to find.	The current supply of fuels for cooking is free, accessible and dependable. There is some economic rationale for households to use dung (i.e., where they have invested in buffalo).
My family likes the taste of food cooked with firewood/cow dung.	Attachment to the taste of food cooked with current fuels.
Cooking with cow dung is slower – I can attend to other tasks.	Current fuel combination seen as versatile, allows for heat regulation.
We own several chulhas – three or four in total. We have several "spares".	Cheap and easy to fabricate chulha stoves – possible to have "back-up" stoves in case one breaks.
If we have guests we use more than one chulha at the same time.	Existing stove use enables multiple-pot cooking if needed.
I would be afraid to use a metal stove – I might get burned (touching the metal body).	Fear of metal stoves – clay body of the chulha is perceived as being cool and safe.
I am frightened of electricity	Fear of electric stoves, lack of familiarity.
The electric stove cooked too quickly, so I could not leave it unattended to take care of other tasks; I couldn't relax.	Faster stove not necessarily useful for households.
It's not a good idea to use a mix of materials when building a stove; it leads to a weaker stove.	Chulha is perceived as being sturdy and dependable.

There is a common misconception among improved stove practitioners/experts, both in India and internationally, that lower-income households only rely on cow dung for lack of alternatives – that fuelwood would otherwise be the cooking fuel of choice. However, all of the households interviewed describe using this fuel combination as a way to regulate the heat output of their cooking stoves: fuelwood produces a hotter flame, speeding up cooking, and is necessary for boiling water or baking roti, whereas adding cow dung creates a "lazier" flame and slows down the cooking process, useful when dishes require longer simmering.

Household economy and willingness to pay

When asked directly, all households stated that they would consider paying for an improved stove if it saved fuel. Along with fuel savings, most respondents said that a stove emitting less smoke would motivate purchase, while two women said an ability to cook faster (and thus save them time that they could then use for farming) would be a motivation.

Willingness to pay was not accurately quantified by our study, but in discussion interviewees typically offered without hesitation a range between 100 and 250 rupees as an acceptable price for an improved stove.

Most interviewees indicated an ability to pay upfront, though one household stated a preference for paying in instalments. To get a sense of households' purchasing power, we also inquired about their monthly expenditures and larger one-off purchases. This information, combined with observations of living conditions and household assets, provided a good indication of their ability to pay and, crucially, about those goods and services to which households assign particular value.

Table 3 presents the average costs of the most commonly purchased items in the villages visited. Note that except for school fees, none of these expenses applies to all households, though most households are paying for electricity and mobile phone credit.

Table 3: Evidence of households' capacity to pay

Item	Cost
School fees	IR 300 per month per child
Electricity	IR 200-1,000 per month
Mobile phone credit	IR 100-600 per month
Roti plate	IR 150-200 (lasts for 2 years before needing replacement)
Fuel (dung)	IR 400 per month
LPG stove	IR 800-15,000
LPG fuel	IR 450-700 every 3-4 months
Buffalo	IR 40,000 (one off)

This coarse overview of common purchases demonstrates that households have some ability to cover significant costs, and when needed, most have access to finance for larger purchases. For example, one woman reported that in order to buy a buffalo she had secured a loan from a local lender with whom she had a good relationship. The agreement stipulated that repayment would begin as soon as the buffalo begins to produce milk, and a one-year repayment period was agreed upon. A number of households mentioned that access to small loans for such purchases was not a problem and that it was easier to acquire finance for smaller purchases from local lenders than from regional/corporate banks, which typically have a loan threshold of 10,000 rupees.

7. DISCUSSION

The results above illustrate a number of elements that influence the household dynamic around energy use and cooking practices, which have implications for the potential to induce behavioural change amongst biomass users in this part of India.

On the whole, the chulha stove and existing fuel use practices are accepted and appreciated by people. These practices have been passed down through generations and are well understood and over time women have learned how to meet their needs – such as for regulating temperature, cooking different dishes – within the constraints of these stoves. Using different fuels in combination and using the agithi stove and chulha in combination provides ways in which cooking temperature can be regulated. It is inferred that using multiple fuels also provides some diversity in supply, reducing the problems which may be caused by temporary shortage in one or other fuel. The fact that households make their own stoves means they can afford to have several at any one time, creating flexibility (can cook indoors or outdoors), allowing cooking on multiple pots simultaneously (for instance, if guests come by) and imposing no financial burden on the household. Those people who have tried alternative cooking technologies also generally consider food to taste better when prepared via traditional methods. In combination, these factors provide barriers to behavioural change that are not trivial.

At the same time, observations of and discussions with households suggest a number of opportunities for catalysing change, in the form of needs and desires that are not well met by current practices. Specifically:

- Existing practices produce a lot of smoke, which is experienced as an irritation and health problem by women.
- Households expressed a desire to spend less time cooking and gathering fuelwood, linked to the amount of fuel required by the chulha's inefficient combustion.
- The current chulha design makes it difficult to use smaller pots. Households would like to have the ability to use a range of pot sizes
- Even the portable chulha is difficult to move around as it can easily break. A more easily portable stove would be desirable.

Based on our initial findings, therefore, there appears some space for more efficient cookstoves to compete with the chulha. However, a number of key features/characteristics will need to be met before the alternatives make sense for users and are sufficiently attractive to motivate household purchase. These are summarised in Box 1.

Box 1: Key stove design parameters for meeting household needs and desires

- The ability to regulate temperature is essential, both for preparing different dishes and to provide greater freedom to women to perform other tasks at the same time as cooking.
- It would be advantageous if alternative stoves accommodated both wood and dung as fuel.
- The stove needs to allow easy preparation of roti bread (a core part of the local diet), requiring access to an open flame.
- Portability is desirable, to enable cooking indoors and outdoors.
- The appearance of the stove is important. Women generally consider the clay Chulhas to have aesthetic appeal, and in some instances have painted or decorated their stoves. By contrast, those asked did not like the appearance of metal stoves they have seen;
- Though a general willingness is expressed to pay for an improved stove *that meets user needs*, stove price will need to take account of the fact that households currently do not spend money on stoves or, in most cases, fuels.

Other considerations when introducing a new stove

As in many tight-knit rural communities, word of mouth is an important mechanism for the spread of new ideas. When asked about their purchase of certain products around their homes, many households mentioned that they had first seen their neighbours using a product and had tried it out before making the decision to purchase themselves. In the same way, if a neighbour has had a negative experience with a product, households are unlikely to invest in this product. When asked about switching to a new cooking stove, most households said that they would like to try it out first. Such assertions demonstrate the importance of "social marketing" for these communities in learning about the benefits of a new product, as well as the need for first-hand experience of a product prior to purchasing.

Various cooking devices and methods are presently used to satisfy different needs. For instance, households rearing cattle used the agithi stove for slowly heating large volumes of liquid (milk or water) and for preparing a mash that is fed to the cattle. If a new cookstove cannot be used for this purpose, then it should be accepted that some portion of biomass will continue to be used via traditional practices.

Implications for India's National Biomass Cookstove Initiative (NBCI)

To qualify for a government subsidy under the NBCI, stoves must be approved under laboratory test protocols for efficiency and emissions (the Indian Standards for Testing of Biomass Cook-stoves). As of late 2011, four stove models had been approved – the Vikram, Harsha, Philips Energy Efficient Cookstove and the Oorja. The first two are natural draft stoves, while the latter two are forced draft (which means they utilise a small built-in electrical fan to ensure a constant flow of oxygen into the chamber during cooking, to increase combustion efficiency). All claim to be smokeless and to significantly reduce fuelwood use over the traditional chulha.

Although we have only preliminary results from a small field sample, we have drawn on our findings, along with published technical parameters about the stoves, to offer some broad, though limited, comments on how appropriate these models may be for the households of Haryana State, outlined in Box 2.

Box 2: Matrix of improved cooking stoves

Technical Parameters	Vikram 	Harsha 	Philips 	Oorja 
Must be able to use multiple fuels, or to regulate the heat	✓	✓	Prepared fuelwood only	Can be regulated
Must be able to burn currently available fuels	✓	✓	Prepared fuelwood only	✗
Must reduce smoke	✓	✓	✓	✓
Must save fuel	✓	✓	✓	✓
Should have a large enough chamber to fit roti	✓	✓	✗	✗
Should be portable	✓	✓	✓	✓
Should be safe to leave unattended	✓	✓	?	✗
Preferably not require fuel preparation / specialised fuel	✓	✓	✗	✗
Should resemble a chulha	✓	✓	✗	✗
Preferably not metal	✗	✗	✗	✗

The Harsha and Vikram natural draft stoves, while less technically advanced, appear to encapsulate more of the desirable stove qualities expressed by households in Haryana.

The Oorja and the Philips stove are smokeless and do allow for heat to be regulated, both of which are important characteristics to households interviewed for this study. However, both stoves are top-loading only, meaning that the fuel must be fed into the chamber from above, a trait which makes it impossible to bake roti inside the stove chamber. Dung cannot be used in either stove, which diminishes their attractiveness, given that dung currently supplements fuelwood in the study area. Both stoves also require much more frequent re-loading of fuel during cooking sessions, so they cannot be left easily unattended, which our findings show could be problematic since many women want to be able to multi-task while cooking. Finally, both require access to an electrical charge for four hours once every week. Although most (not all) households interviewed had an electricity connection, many used the power for one appliance only (e.g. a light or a refrigerator), and it is unclear whether they would be willing or able to use their connection for charging a cooking stove.

The Oorja and Philips stoves are also significantly more expensive. An acceptable market price will vary according to location and the positive "selling points" of the stoves themselves, although our research suggests that when a product makes sense to households, they are willing to pay, and may be able to obtain financing if needed (typically by borrowing from friends and neighbours).

Balancing technical standards with real-world usability

The NBCI approval granted to the stoves listed in the matrix above is valid for one year only, and at the time of writing the short-listed stoves were being re-evaluated at one of the newly established test facilities sponsored under the initiative. Given that stoves approved under the NBCI will be expected to demonstrate substantial improvements on the chulha in terms of thermal efficiency and emissions reductions, a set of revised test protocols and standards for these parameters are now being applied. However, it is not yet clear how other parameters related more to the user's experience of the stove will be assessed by the NBCI.

A field study of some of the more advanced biomass stove models in Indian homes found that aspects such as efficient fuel combustion were not decisive factors for households in their evaluation of the stoves and that, similar to our findings, the ability to regulate heat in a more efficient manner was of more importance to users (Dhoble and Bairiganjan 2009). Indeed, a field study of improved cook stoves conducted recently in Sub Saharan Africa found that although improved biomass cookstoves were capable of substantial fuelwood savings, households had very different experiences and preferences depending on the type of food being cooked, with 75% reporting that even if they owed an improved stove, they would continue to use a three-stone fire for some cooking tasks (Adkins et al. 2010).

This highlights a fundamental problem with relying only on technical parameters to evaluate cooking stoves intended for real-world use. Although it is crucial that an improved stove be capable of reducing indoor air pollution and saving fuelwood, if a household is not willing or able to switch to the new stove, these technical advancements won't make an impact – after all, an improved stove that is not used has a fuel saving of zero. Thus, there would appear to be a strong case for an additional set of "usability" or "ease of use" parameters to be included in the NCBI test protocols.

The development of such usability parameters would necessitate, as a starting point, a broad understanding of the users' underlying motivations and needs in each given context. Admittedly, undertaking this type of analysis is challenging. It requires the researcher to unpack various elements of complex human behaviour to get to the core of what motivates people's choices, which can be a difficult and time-consuming process. However, in the long run, ensuring that this groundwork is conducted prior to the development of a product or service will greatly increase the chances of adoption by the user.

8. CONCLUSIONS AND POLICY MESSAGES

This paper presented the findings from an initial phase of research conducted to identify the key drivers of household-level decision making related to cooking fuels and stoves in Haryana State, in northern India. A qualitative "generative" research methodology was used, partly to address some perceived gaps in more quantitative approaches. This proved to be extremely useful for uncovering the motivations behind household behaviour and decision-making and for ensuring that the full context of the stove user is taken into consideration when looking at energy use and cooking practices. Furthermore, since generative research is often used to develop a design "platform" for a new product or service, the insights that it unearthed also indicate some specific design parameters for improved stoves intended to be used in this context.

The findings in this paper are preliminary and will be further examined during subsequent stages of research. Nonetheless, their legitimacy is in our view strengthened by our research method – combining in-depth interviews and direct observations of stove users in their daily settings – since these allow for cross-comparison and hence greater verification of conclusions.

What this study makes clear, even at its preliminary stage, is that understanding the broader context regarding fuel availability and use is central to identifying users' needs and, from there, the necessary design parameters for a new stove that makes sense to people and could motivate behavioural change.

Our findings also challenge some commonly held assumptions about biomass users and their desires. For instance:

- The importance of the use of cow dung and fuelwood in tandem as a means of regulating the heat of the fire cannot be overstated when it comes to developing alternative stoves for the households interviewed. It is often assumed that cow dung is highly undesirable as a cooking fuel and only used by households when they have no alternative, but our research shows that this is not at all the case in the villages visited; on the contrary, cow dung is viewed as an essential component for allowing the cook control and precision while cooking various dishes. Furthermore, the taste that cow dung gives to the food, particularly roti, appears to be widely appreciated by households.
- Another assumption widely held by stove designers is that households wish to cook faster – with the result that "speed of cooking" is commonly highlighted as a selling point for a new stove. However, our research indicates that speed is not the only important factor. Cooks also prioritise having control over the cooking process through heat regulation, which sometimes enables slower cooking.
- Also contrary to common perceptions, our research found that households do have the ability to pay high upfront costs for items such as stoves by, for example, taking loans from family or neighbours. Households will make these investments provided they perceive sufficient benefits, and interviewees said that often appliances are tried and tested before being purchased, which highlights the importance of careful product

testing and social marketing. More research is needed to better understand both willingness and capacity to pay, including access to finance, at different income levels in these villages.

The goals of the NCBI are highly commendable, and the programme has the potential to address the negative health, socio-economic and climate impacts of traditional biomass use in India. The challenge will be to design stoves capable of reducing emissions and saving fuel, while also meeting users' needs. Success of the program will depend not only on the technical performance of the approved stoves but most critically, on user acceptance. As we have shown, this is influenced by a range of social, economic and even cultural factors and not just efficiency calculations. Hence, achieving the longer-term goals of the NBCI will require that the evaluation criteria are widened to include criteria related to the acceptance of stoves by intended users – even if they are harder to quantify than technical parameters.

Understanding how to achieve this will require knowing more about how households and individuals "trade off" between various parameters when evaluating cookstoves. This will be the focus of the second phase of this project.

We should note that although the demographics may be similar in other parts of rural India, the villages studied in Haryana are just one case study. The results are therefore not directly transferrable to other settings, since different factors may have sway in different communities – with the implication that a cookstove designed for one community may not be appropriate or accepted in other settings. Thus it is important to understand stove users in their own unique settings. The wider value of our findings here, then, is in pointing to the types of factors that need to be brought to light if people's needs and desires are to be understood and met and, by implication, if biomass energy economies are to be successfully transformed by shifting to less damaging, more efficient practices.

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