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'If the gas runs out, we are not going to sleep hungry': Exploring household energy choices in India's critically polluted coal belt

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ABSTRACT

Despite a range of initiatives to introduce cleaner fuels, a large proportion of poor people in India continue to rely on solid fuels for cooking and heating, with severe implications for personal and family health. This paper seeks to open up the various fuel-supply strategies that underpin domestic energy use in low-income settings to explain the unconventional solutions (*jugaad*) that households employ to bridge the gap between energy needs and supply of various fuels, including liquefied petroleum gas. We draw on long-term ethnographic engagements in four severely polluted low-income urban settlements in central India's coal belt to investigate how communities, and primarily women, ensure domestic energy provision. As households struggle to secure a range of potential fuels with different benefits and drawbacks, we outline the socio-cultural and economic processes that shape household energy decision-making. These highly uncertain processes take place within an institutional structure that offers some possibilities, but is overall too rigid to fit the lived realties of low-income residents. Although households commonly understand that there are negative health effects from solid-fuel smoke, pollution and health are only marginal considerations for households facing daily struggles to reduce expenses. We argue that understanding the everyday *jugaad* of household energy provision is crucial for the possibilities to shift away from fuels damaging to both human health and the environment.

1. Introduction

As the light softens and evening commences, the first of the sigris, or movable coal-burning cook-stoves, are lit and placed outdoors in a lane of Dhuvan Basti in Korba. As the coal burns, the emanating smoke soon envelops the basti (low-income neighbourhood) in a thick fog. After about 30 min, the sigri, containing now glowing hot embers, is carried to an inner courtyard where the evening meal is cooked. Over about two hours, the burning of coal and associated smoke peaks and finally recedes, as many women ready their sigris: so that the main pollutants burn outdoors before bringing them inside. The neighbourhood is recurrently engulfed in dense coal smoke, as the process is repeated every morning and evening. On entering the basti, we, the authors, are viewed as both a curiosity and harmless observers. We are soon surrounded by groups of inquisitive onlookers – women, men, and children, intrigued by our presence and happy to indulge our interest in their everyday lives. 'There are six sigris burning in that lane, madam, take a photo from there,' says one woman, eager to please and showcase for our records a lane where multiple sigris simultaneously spew black smoke. The children are the most amused by our presence, and a large group follow us around – playful, giggling, taking selfies with us on their mobile phones and passing jolly comments such as 'Vikas's house has a lot of pollution, oh yes, even Jiten's house has a lot of pollution, let us take them there'[1].

The coal used by low-income households like those in Dhuvan Basti in the central Indian state of Chhattisgarh is widely available from unguarded mines, power-plant stockyards and along railway lines. Across central-eastern India, coal is, for this reason, a long-established household fuel, but also a source of livelihood for those who informally collect, transport and sell it to smaller industries, restaurants and households [1–3], in spite of the severe health effects when it is burned in poorly ventilated indoor spaces [4,5]. Beyond coal, low-income communities across rural India and in urban locations similar to Dhuvan Basti make use of a wide range of solid fuels including firewood, dung cakes and crop residue for cooking and heating needs [6,7]. In urban areas, uncertain energy provision has given rise to a sprawling informal household "energy market", beyond the officially supported market for natural gas, and to the development of informal "supply chains". The informal energy

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[1] This was observed on many of our visits to the dense basti, esp. in the evenings.

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market caters to poor households unable to access preferred energy such as Liquefied Petroleum Gas (LPG) or electricity. It provides a range of benefits and drawbacks in terms of costs, availability and practicality of use, which vary according to season, policy changes and other external factors. As widely discussed in the literature, informal solid fuels come at significant health costs as households and entire towns become engulfed in dense smoke in regions already facing severe air pollution challenges from industries, vehicles and other sources [6,8,9].

Moving away from solid fuel use holds great importance for the possibilities to combat global climate change as well as improve public health. A wide body of scholarship examines efforts to either transition households away from solid fuels or to mitigate their negative health impacts. These efforts include, among others, improved cook-stoves that vent smoke away from dwellings and interventions to make cleaner burning household energy, such as LPG or electricity, more affordable or otherwise practically feasible to use for different groups [6,10,11]. Decades of research as well as policy interventions across much of the Global South have yielded some positive changes, but have mainly confirmed the significant challenges involved in finding suitable household energy solutions for poor people [10–12]. In this setting, we find limited ethnographic scholarship on the social underpinnings of domestic energy use that helps explain why energy solutions frequently fail to cater to household needs [13–16]. Such studies take on special importance in the face of endemic public health concerns due to the air pollution from solid fuels, but are particularly relevant given the limited success of national programmes supporting cleaner burning household fuel [7,17–19].

This paper contributes to our understanding of India's inability to escape the '*chulha* (cook-stove) trap' [6] by exploring how low-income urban communities balance unhealthy, labour intensive, and frequently expensive household energy solutions. The paper draws on long-term research across low-income urban neighbourhoods in the cities of Raipur and Korba in the central Indian state Chhattisgarh, where we examine the uncertain everyday politics and socio-economic landscape of how poor people ensure energy; in so doing, we pose the question: How do communities ensure domestic energy provision and why are households unable to use cleaner energy alternatives? Fuel cost is clearly important in explaining the lack of results. We also find, however, structural and socio-cultural explanations for why (mainly) women struggle to find a functioning and healthy energy mix under conditions of uncertainty and scarcity.

In the following section we situate our ethnographic approach with respect to the wider social science literature on energy transitions. Next, we outline our methods, followed by three empirical sections, which direct attention to the interrelated themes of energy provision, household economics and the everyday politics of fuel supply. Finally, we provide concluding reflections on the possibilities to support healthy and affordable domestic energy for policy and research on household energy.

2. Energy poverty, household fuels and the everyday politics of scarcity

The dynamics of household energy use have often been conceptualised in terms of an energy ladder (e.g. [20,21]). In this model, households are assumed to behave as neoclassical consumers, displaying a linear progression from traditional fuels and cook-stoves to modern, clean and efficient fuels, as income increases. A growing body of literature has, however, critiqued the energy ladder model contending that energy transitions do not occur in a series of simple, linear or even discreet steps. Instead, the use of multiple fuels is common where households consume a portfolio of energy options simultaneously, known as fuel stacking [13,22,23]. To illustrate, Herington and Malakar [14] contend that households display a range of purposeful strategies in situations of energy insecurity and may reverse a transition to use traditional forms of energy or to retain traditional energy forms as backup. Likewise, Sehjpal et al. [13]: 475 argue that the relationship between income inequality and energy inequality is indirect, implying that household energy choice is also determined by factors other than merely income. This dynamic nature of household energy, with potential for reversals to older forms of energy use, is not fully recognised in the energy transition literature.

It is widely established that a lack of reliable electricity supply, the dependence on burning solid fuels and the use of inefficient cook-stoves not only condition everyday life but also affect long-term health trajectories for large populations around the word [17,20,26,27]. Access to energy has strong links to poverty reduction through income, education, health and the environment, and the lack of access to energy in this context is seen as both an outcome and cause of poverty: it prevents households from being able to afford certain goods and services, but also constrains the potential for income generation [28–30]. The concept of energy poverty is defined and used primarily in higher-income countries with reference to the possibilities of heating one's house during cold winter months, although some have argued for widening the definitions to include other forms of energy deficiencies in relation to poverty, including cooling poverty, or energy for cooling needs, in hot countries [31,32]. The UNDP defines energy poverty as the 'inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset' [33]: 4. While electricity supply for minimum lighting needs is increasingly available across much of India, energy deficiencies in relation to modern fuels for cooking or heating remain widespread across large sections of the population. It is with these latter forms of energy poverty – for domestic cooking and heating – that this paper is concerned.

In this article we explore unfolding and ever-changing household energy solutions in two central Indian towns, with a focus on women as the main agents. We suggest that there is specific merit in taking a grounded approach to studying domestic energy choices to highlight household agency, which is always in the making via innovative strategies. The idea of *jugaad*, a colloquial Hindi word that means "workaround" or "hack", has received significant attention in literature on innovation and business management [24,25]. Understanding the material practices of such "frugal innovation", or jugaad, with respect to domestic energy may open up our understanding of households as recipients of national energy programs, that while having made small, incremental progress towards clean energy, have yet not adequately addressed needs of many.

A gendered lens is crucial to the study of jugaad energy solutions since women are primarily responsible for securing and using energy for domestic uses and are, therefore, usually those most exposed to the smoke and other negative effects of solid fuel use [34]. Women additionally have longer workdays than men, as the time they spend on domestic activities is significantly greater, and often in addition to work outside of the household in, for example, employment such as cleaners or construction workers. A move away from unhealthy energy has the potential to free up women's time for other opportunities in economic and social life with several ripple effects, including poverty reduction and improved public health [35,36]. As the women we study produce household energy security in the everyday politics of low-income bastis, we note highly variable energy use across seasons depending on the household's socio-economic position and location within the city. The result is, as we elaborate in subsequent sections, highly uneven, but also perhaps surprisingly variable, with frequent readjustments over time. Households may rely on just a few energy sources, but may also mix as many as five to seven different ones with divergent supply chains and conditions of usage including variable costs, in terms of money spent and time to collect, prepare and use domestic fuels. It is this variability that, we argue, requires a jugaad understanding of household energy security.[2]

[2] As the large literature on development and labour outline most of India's poor rely on the informal economy [37] which requires similar frequent readjustments and workarounds with highly unequal outcomes to those we discuss here relating to household energy [see e.g. [37–39].

The policies adopted by different authorities at city, regional and national levels are clearly important in shaping the possibilities to secure and use household energy. The women of central India operate within an environment of relatively egalitarian gender relations when compared to many other parts of India [34], and are, hence, likely to have a voice in household energy choices. In addition, they commonly contribute to household income. They do, however, operate within structures determined by a well-ingrained masculine coal economy, most apparent in the long-running ban on women taking up coal-mining work [40], but also evident in male dominance of democratic decision-making bodies and industrial-economic processes [41]. As wider institutional structures shape how the energy system is organised in combination with national and international energy markets, there are severe constraints on women's agency in the everyday provision and use of energy in low-income areas. The various effects that low-income energy users have to endure, including severe air pollution or precarious connections to overhead power lines, are, however, determined in context-specific settings where marginalised groups create and use energy resources shaped by everyday practices which play out across and within specific neighbourhoods in the coal towns of Chhattisgarh.

Informal household energy resources across urban landscapes may be understood as "available" for collection and use. While it is more difficult to access firewood in urban areas, it is clear that trees grow in and around urban neighbourhoods and coal can be pilfered along transport routes in central Indian coal towns. Seeing resources as available is a limited perspective, however, since a wide range of human activities and factors determine whether these and other resources are actually useful and affordable as energy for low-income households. A perspective which understands resources like energy as *produced* rather than simply *available* for use is therefore more appropriate [42]. Household energy production has women as the main agents, but with important links to the wider structures that make certain energy resources available, usable and (relatively) affordable. Social relations matter, as is clear from our urban male and female informants, who, for example, draw on family and village networks to either receive a backup LPG cylinder or to find low(er) cost supplies of firewood. Conversely, we find that migrant families, which lack both relatives within the region and the required documents to secure subsidised LPG cylinders, are commonly most disadvantaged in securing household energy supplies. In this paper we therefore argue that energy security for households is best understood from the examination of 1) the ways in which energy resources are produced across time and space, 2) the cost of collecting, making and using these resources, and 3) the everyday politics of adjustment, or jugaad, which is the family effort of ensuring energy security (mainly through the personal effort of the women in each household). Our purpose in examining jugaad, or frugal innovation, is not to romanticise or shine a positive light on such approaches – which are highly demanding of time and effort, and oftentimes come with deleterious consequences on health and well-being – but simply to unpack practices with a view to building a fuller understanding of strategies to secure domestic energy.

2.1. Research design and case studies

In a still largely agrarian state, industrial towns like Korba and Raipur – whose economies are centred on large and small-scale metal processing and coal energy operations – are focal points for a wide range of migrants, most commonly from within the state. Migrants and other residents who make up the urban precariat may aspire to jobs in the formal sector – in steel factories, power plants and industry [43] – but more commonly have to make do with informal jobs as shop assistants, haulers, cleaners, security guards or construction workers. Women are part of this informal labour market and may take up similar industrial jobs, or, as is commonly observed, work in more affluent households as domestic help. As villages on urban peripheries become incorporated within city limits, homesteads of the original villages typically remain, while farmlands convert to industrial use or urban sprawl. The residents of these neighbourhoods, hence, have a mixed profile; families of longstanding presence own their homes, while migrants rent.

Our research sites include the social diversity of low-income neighbourhoods and changing land-use depending on the geographical location or history of the habitation. Our research seeks to capture the dynamic of domestic energy choice in the fluctuating, everyday context of the urban precariat via in-depth engagement in low-income neighbourhoods. The case study research design is well-suited to the examination of *how* and *why* questions of an explanatory type [44], and is further valuable, we argue, for a complex elucidation of phenomena [44,45]. Our research questions relating to how communities ensure domestic energy provision and why households are unable to use cleaner energy alternatives lend themselves to a case-study design, examined within an embedded ethnographic setting. Mitchell [46] emphasizes that the logic of case study research is not to look for typicality or representativeness and that the search for a typical case or the apt illustration is likely to be less fruitful than the search for the telling case.

Primary data from the two industrial cities of Raipur and Korba comes via observation, personal interviews and focus group discussions as we seek to "socialise" [47] energy. We seek to build a range of low-income settings and fuel-use contexts into our sample to indicate diversity and change rather than seek strict comparisons across cases. Within each city, we identified two sites as focal points for in-depth engagement and qualitative data generation. In Raipur, we selected sites (referred to as Ward X and Ward Y) in residential neighbourhoods of the industrial *peri*-urban Urla area. The selected sites are home to both communities with longstanding presence – as former villages became incorporated into Raipur city limits – as well as more recent migrant workers, commonly from other regions of Chhattisgarh. In Korba, qualitative material is from a low-income residential area located along the railway tracks (a site we refer to as Dhuvan Basti). We also draw on observations from a location on the Peri-Urban outskirts of Korba around the BALCO Aluminium factory (we call this Korba Peri-Urban).

In Korba, our sample, Dhuvan Basti, is one among several bastis which are engulfed in smoke every morning and evening, similar to many locations across India's coal belt. For a broader understanding, and to build in diversity, in our site Korba Peri-Urban, we include locations where LPG, as well as firewood, is routinely used. Beyond the above-outlined sites, we also draw on data from 29 focus group discussions and observations from wider engagements across low-income neighbourhoods in Raipur and Korba.

Our reliance on qualitative methods and a case study has specific advantages. As Mitchell explains, for instance, close engagement with the field situation and knowledge of relationships among actors and events can be telling and also reveal interconnections of theoretical importance [46: 239]. From engagement over time in Korba and Raipur, we observe that many locations share important characteristics of our research sites, and hence we suggest that our research findings are relevant to the everyday habitations of the urban poor across industrial towns in central India. These towns are usually located in states that are relatively poor, with growing urban sprawl, and witnessing widespread land use as well as socio-economic changes that influence energy systems. We further view the shifting energy use patterns we observe across our sites as snapshots in time, certain to continue to change in the future.

While we maintain that the reliance on qualitative methods, and long-term, in-depth engagement, is critical to building narratives and explanations based on multiple rather than one-off research engagements, a shortcoming is that the study does not present a statistical overview of the data, on, for instance, the relationship between income, family size, migration status and energy expenditure. Nor does the study attempt to collect and present general price data on different household energy expenditures to compare with the findings in our case locations. Our research engagements in Raipur and Korba point to some methodological challenges and lead us to suggest that there are limits to the accuracy of data that survey methods may generate on, for instance, fuel

expenses as they relate to household composition. However, our analysis would be enriched by data for larger population groups on, for instance, LPG connections, supply and refill over time from secondary sources such as LPG supply agencies.

3. Producing household energy

During our investigations in Raipur and Korba we identified seven different household energy sources actively used in the neighbourhoods we studied – coal chunks, coal cakes, LPG, firewood, cow dung, husk cakes and electricity. Each of these has specific costs and considerations for health and usage. As we untangled the different forms of energy, we came to see the separate, and often quite intricate, informal supply chains that exist to serve low-income households. With no single energy form able to provide an affordable and practical solution to energy needs, there is great variability from one neighbourhood to the next even within the same town. Our research further indicates significant changes – not only across seasons, but also over time – as some fuels in recent years become less available, while the supply of others increases. The use also varies significantly from fast and clean burning but expensive LPG to slow burning and smoky but low cost coal chunks, coal cakes or dung cakes (refer to Table 1 below for an overview of domestic energy sources and use).

In Korba, residents of low-income neighbourhoods close to coal mines and along transport routes can scavenge coal chunks. Coal picking is typically carried out by women and takes place very early in the morning, since competition is high and supply of free coal along transport routes is limited. We also note the dangerous practice of scavenging coal directly from parked or slow-moving trains, and additionally from trucks, loading points and industrial sites. Coal chunks may also be bought from informal suppliers in the neighbourhoods or next to industrial plants; this is especially practical for the monsoon season, when coal picked in the open is too wet for immediate use. The coal chunks can be used directly as a household fuel with kerosene as a starter and firewood or cow dung cakes as kindling. A closely related fuel is the coal cake, known locally as *koela laddu* (coal cake; a laddu is an Indian sweet); this is made from waste coal dust, available from various industries, mixed with, for example, cow dung, sawdust or rice starch and then dried in the sun. Both forms of coal are typically burnt outdoors on the street for about one hour – the most intensely polluting phase – before it can be used for cooking in an inner courtyard. The peak pollution load is temporary and highly localised, typically with a spread of not more than a few hundred metres away from the source.[3]

Lakdi (firewood) can be gathered as branches in urban peripheries but is also bought in processed form as wood chips left over from furniture or packaging industries. While scavenging for firewood is challenging in urban contexts, and is usually not an option for most low-income households, some individuals collect branches in the areas where they live, often drawing on personal social networks to gain access to wood from private houses. Lakdi is also commonly sourced from rural village networks, or bought in small quantities as wood chips from industry or as logs from local traders. Firewood is useful as a fuel on its own, as a starter for different coal fuels and as a fuel used in combination with *cheena* (dung cakes).

Cheena is made from cow dung and rice husk combined in the form of flat cakes that are dried in the sun before use. Both cow dung and rice husk are widely available locally at a low cost or even for free to urban residents in Korba and Raipur, given that dairy cows tend to live in and around low-income neighbourhoods in these cities. Cheena does not burn as well as coal or firewood and is usually used in combination with other fuels, or as a backup. One benefit, in addition to its low price, is the possibility of storing cheena over long time periods, for example, during the monsoon when other dry fuels may be scarce. It is, thus, not sufficient to have only coal or firewood or cheena; there is a need for a combination of inputs.

Across our two towns and four sites, we note a perhaps surprising availability of different forms of coal, firewood, rice husk and cow dung in spite of the urban settings. These fuels and their various permutations rely on a set of starter fuels – such as husk, kerosene or wood dust – to ignite and burn, and these, too, are largely available across our urban sites.

Our sites also display wide availability of the modern energy forms – electricity and LPG. A sizeable part of low-income households and virtually all middle-income households use LPG for cooking, and electricity supply is increasingly stable with poor households connected to the grid. Electricity is, however, almost solely used for the purpose of lighting and running smaller electrical appliances such as a fan, television or cooler. For everyday cooking needs, electricity is perceived to be expensive unless it is accessed via an illegal connection. Although common in Dhuvan Basti until a few years ago, the use of illegal connections decreased when the voltage in the overhead electricity lines increased from 220 to 440. The illegal use of overhead electricity lines continues in the Korba Peri-Urban site, where the voltage remains at 220 V and government authorities appear to overlook illegal use. Here, electricity is used for occasional cooking on a low-cost electric coil. However, while the coil was free to use on an illegal connection, it was considered slow for cooking purposes and was liable to break with fluctuating voltage. Likewise, use of the faster electric induction stoves is virtually unknown, and they are considered too expensive to run and unsuitable for family needs.

LPG, the standardised and officially supported household fuel, comes in a cylinder which (to date) cannot be adulterated or modified. It thus burns cleanly, is marginally subsidised for all users and is widely available in urban areas of Chhattisgarh. Over the past two decades, several programmes have sought to promote the use of LPG and aid the transition to cleaner burning fuels, with the Prime Minister Ujjwala Yojna (PMUY) (which in Hindi means brightness scheme) being the largest to significantly expand LPG connections, seeking to penetrate low-income urban neighbourhoods as well as rural locations. For the token sum of Rs. 200, the LPG connection under the Ujjwala Yojna, includes registration with an authorised agency for LPG supply in the name of a woman, one cookstove and the first LPG cylinder. Once enrolled at this attractive token expense, the customer is expected to refill her cylinder at the market rate, although a small subsidy is paid directly to the customer's bank account a few days after the refill. Apart from the high cost of the refill, a concern for residents from our sites is the challenging paperwork that allows them to access a connection and LPG cylinders. While migrants may lack the address or identity documents that facilitate a connection, other needy residents are unable to register if they lack a Below Poverty Line (BPL) card, or they may be unavailable within the registration dates for the scheme.

Table 1 below presents an overview of the various household energy sources used across our sites and their advantages and disadvantages for users. While the officially promoted LPG is convenient and has increasingly reliable supply chains, it remains expensive, especially for large households. Among the four main solid fuels we discuss, lakdi is preferred, given that it emits less smoke than either coal chunks, coal cakes or cheena, takes less time to light in comparison to coal, and offers more control over the heat it generates to reduce overall time for cooking. Coal chunks and cakes are the most time consuming in terms of preparation, and come with the most severe pollution during use, but are also, monetarily, the cheapest to use. Burning cheena generates

[3] Legal pollution-control limits are usually set as annual averages. In India, this limit for PM2.5 is 40 micro grams/m^3 whereas the WHO recommends 10 Âµg/m3. There is also a 24h average in India set to 60 micro grams/m^3. The PM2.5 spikes coming from coal cooking may, however, not result in significantly higher average values seen over a 24-hour period. No short-term exposure limits exist in Indian or WHO pollution standards, resulting in a lack of clarity on how to relate spikes in exposure from coal cooking to legal norms and medically recommended limits.

Table 1
Portfolio of domestic fuels: Cost, supply and use.

Fuel	Cost	Time to collect/prepare	Suppliers	Practicality/use
Lakdi (Firewood)	Rs. 6–7 per kg in the city. Cost is less outside the city.	In the city – firewood is typically bought, but sometimes gathered. Preparing a wood-fired stove is time consuming, but less so than coal. In locations of predominant LPG use and hence low demand for firewood – certain households collect firewood relatively easily from vacant plots or building enclosures (through personal relationships).	Traders of leftover wood from industry (shavings/chips/planks). Sometimes gathered from vacant plots of land or building compounds, but limited to those who may have restricted access. From family networks.	Commonly preferred fuel (if easy to gather) Less smoky than cheena but used in combination with cheena (with a view to lower costs). Significantly less smoky and less time intensive than coal.
Cheena (dung cakes)	Sold at Rs. 5 per cake Small quantities sometimes exchanged for free by women Viewed as inexpensive – as materials informally available, often free.	Rice husk and cow dung. Cheena cakes are prepared by women and stacked for the year over winter months.	Rice husk is easily available post-harvest even in *peri*-urban areas. Cow dung is usually gathered or sometimes purchased from within low-income areas.	Commonly used in combination to economise on the more expensive firewood. Used also in combination with coal-dust laddu. Cheena may be used on its own, without firewood, but this is smoky and inconvenient.
Koela (coal) - chunks	Commonly, coal chunks are gathered at no cost from railway lines May be bought from traders for food businesses or in the rainy season.	Gathered along the railway lines. Very time-consuming on most occasions – half an hour of coal gathering by 1–2 individuals results in coal for 1–3 meals, and hence a near daily exercise for many women. Quantity of coal gathered from rail lines is uncertain and variable, dependent on accidental or intentional spillage from trains.	Only available in select locations, such as along railway lines that ply coal trains, or near coal-based industries. Stocked by traders. Traders need to avoid the police and security staff who attempt to control commercial coal pilfering while allowing personal use. Usually unavailable to gather in the Monsoon, as mining and transport activities are reduced and coal is damp.	Preparation of the coal cookstove is time consuming, effort intensive, inconvenient and smoky. Coal allows cooking for larger households compared to LPG which is suitable for smaller families. Preparation time is between 40 and 60 min for each use.
Koela Laddu Made from coal dust, clay, husk and rice starch	There are no established market prices for laddu. Coal dust is particularly inexpensive. A cartload is about Rs. 750 – this lasts more than a year.	Koela dust is available in localities adjoining coal-based industries. It is not useful for industrial combustion, and is hence dumped or traded at cheap rates via illegal routes. Time consuming to prepare.	Secured from industrial waste. Clay, husk and rice starch are locally obtained. Usually collected independently by households but may also be traded.	A coal dust sigri works like a coal sigri in terms of preparation time. Koela laddus are burned with the help of starter fuels – kerosene, kindling wood or cheena.
Bijli (Electricity)	Electricity is not used for cooking or heating appliances when electricity is metered – as this is considered expensive. There are special slab rates for BPL customers. However, these do not always reflect cardholders or the poor. There is a complex structure of electricity rates.	Households had electricity connections from legal (metered) or illegal (hook-up) routes. The illegal connections used to be common a few years ago, but an increase in the voltage from 220 to 440 V has made it more difficult to connect. They remain common in certain areas. Chhattisgarh State Power Distribution Company Limited is the supplier, and supplies are increasingly reliable.	Either metered electricity from official meters or electricity sourced from illegal 'hook-up' from passing overhead lines.	An electric coil stove is slow and inconvenient to use for main cooking in large families. Other electric appliances such as induction stove, kettle or microwave oven are rare since these are too expensive.
Cooking Gas/LPG	Upfront cost Rs. 800–1200 per refill (with a subsidy of Rs. 150–300). LPG is viewed as expensive.	Refill of LPG via a LPG agency – a smooth process in the areas under study. Convenient and easy to use, with low preparation time for urban areas. Rare; unfamiliarity with LPG cooking for some seniors.	One of several LPG supply agencies serve a locality.	Convenient, preferred fuel, but expensive, especially for the standard extended family. Commonly used in combination with other fuels.
Bhusi (husk)	This is usually free.	Readily available – used in preparation of dung cakes and for starting-up a coal or lakdi fire	From farms after the rice harvest.	Convenient to start up a coal or lakdi fire.
Kerosene	Per litre	Easily available, and required in small quantities.	Market	Convenient to start up a coal or lakdi fire.

Source: Triangulation of data from multiple observations and interactions 2018–2020.
Note: The prices of different fuels presented are not intended to enable strict comparisons of the cost of the heating value of different fuels, or the cost to a household from exclusive use of a fuel. This information is difficult to collect and also not always relevant because solid fuels are usually used in combination with each other (except for firewood, which does not require a separate starter fuel).

significant smoke and is time consuming and inefficient used on its own.

Our investigations from 2017 to 2020 show widespread reliance among households on many energy sources, with great variability from one neighbourhood to the next, but also between households in the same neighbourhood, depending on availability, policy and market changes, fluctuating family income and ever evolving practical circumstances. This picture of urban neighbourhoods with highly diverse and shifting patterns of domestic fuel use is noteworthy from both an academic and policy perspective. In the subsequent two sections, we first unpack the economics of household energy and then study how households strategize to secure domestic energy.

4. Household economics and household energy

For households that rely almost exclusively on LPG, estimates for use are by and large consistent with family size: a household of four–five

persons replaces a LPG cylinder approximately every two–three months at a fixed price. For the large number of households with mixed fuel use, however, our interviews and observations capture wide fluctuations in month-on-month expenditure for cooking and heating, making it impossible to obtain precise estimates. The interview question, 'What are the usual monthly energy expenses for your household?' did not evoke straightforward responses. We interpret this as resulting from the high variability of costs over time as expenditure varies across individual circumstances, different fuel sources and from respondents either counting or discounting the value of effort to prepare and use different energy forms. As an illustration, while lakdi is a preferred solid fuel, its price of Rs. 6–7 per kilogram is viewed as expensive. Individuals may seek cheaper sources, such as a cartload of firewood from rural relatives, sufficient for household needs over many months. The firewood is then available at a low price one year, but not the following year, depending on various factors, including, for instance, availability, or change in familial relations. Similarly, for a variety of reasons including ill health or migration, households may not be able to produce koela laddu before the monsoon rains when drying becomes impossible. They may then be forced to spend money on LPG or firewood or on borrowing wood or other fuel from neighbours. These observations – of imprecise month-on-month fuel costs – are noteworthy from a methodological perspective, and lead us to argue for greater attention to qualitative data and longer-term engagements when investigating household energy costs and decision-making.

For virtually all households across our sites, securing household energy is a substantial investment – a combination of financial resources, personal effort and time. Fuel use is, furthermore, a telling marker of social and economic status, illustrated for instance in casual characterisations of households in terms of their main source of cooking or heating energy. Making a broad distinction between traditional and modern sources, we commonly hear statements such as they (or we) are the '*bhusi-chulha* people' - those that use solid fuel cook-stoves, or alternately the 'gas people'. Although there is fluctuation on energy use across time, there is often a distinction between long-term or exclusive users of LPG and those who primarily use solid fuels. In such contexts, the labels relate energy use to the overall household socio-economic position. This makes the direct relationship between LPG use and income apparent, and this is confirmed from even casual observations of neighbourhoods according to economic criteria.

Established middle class neighbourhoods, which are usually recognisable by the quality of housing and land tenure status, rely almost exclusively on LPG. In localities of mixed fuel use we notice, as expected, the direct relationship between LPG use and household income, reflected in the statement, 'Those who are *shamta* (financially secure) use gas; we all use *chulha* or *sigri*, not gas. How will a poor person refill gas?' (Darri, Korba Focus Group Discussion). Middle-class households tend to have a longstanding LPG supply arrangement – a connection usually obtained from a private supplier prior to 2016–2017, when the national Ujjwala program was introduced. Across low-, middle- and high-income areas, the supply of LPG cylinders is experienced as reliable. Refilling a cylinder, however, depends on a household's willingness or ability to pay the full cost upfront, which is a matter of income and cash flow. While the net expense for a refill is subsidised – between Rs. 150 to Rs. 300 deposited to the bank account a few days after the refill – the cost of LPG is not viewed as subsidised as at the time of purchase, the full price needs to be paid upfront while the subsidy is sent later to the account holder's bank account.

Hence, while many households signed up for a LPG connection via the Ujjwala scheme for a token sum of Rs. 200 (approximately US$ 3), most low-income households rarely refill the cylinder. This is a clear indication of the unaffordability of the upfront cost of LPG replacement. In the words of our respondents

When the program came about, in our area many people got an Ujjwala connection. They [the government] gave the connection for Rs. 200 so many people were tempted and got a connection. Now for the refill cylinder, they are asking for Rs. 1000, Rs. 1100 (US$ 14–15) … so it is beyond budget… now all those connections are useless (Focus Group Discussion 4, Pathari Para)'.

Our interviews with representatives of private LPG agencies in Raipur and Korba support earlier this statement, and earlier research findings from rural areas, that cylinder refill rates are very low for Ujjwala LPG connections (e.g. [17]). In the words of a LPG agency representative:

We gave out the new gas connections under the Ujjwala program; in fact, there are many more who would like an Ujjwala connection if it was available[4]. But Ujjwala customers don't refill… The users who refill are those who signed up for a gas connection independently or privately. Those who have a private gas connection refill regularly. They only use gas (Interview, Raipur, February 2020).

While there is a direct relationship between LPG use and income, LPG use is usually not exclusive and also relates to family size. Smaller households of two–five people may exclusively rely on LPG, and their 14 kg LPG cylinder needs to be replaced approximately every two–three months. The more common larger families of five–nine people, or joint family households of 10–20 people, find the use of LPG expensive, as they need to replace the cylinder more frequently, often monthly or even every two–three weeks. We thus encountered statements such as, 'We have a large family, how is it that we are going to use gas?' (Interview Ward X, Raipur, February 19, 2020). Respondents commonly expressed such statements as self-evident or a truism. Larger families, instead, typically use solid fuels for cooking the main meals and for heating water for domestic uses such as washing. The LPG use is restricted to, for example, the preparation of tea in the afternoon or times when there may be visitors. The LPG stove thus finds use when the solid fuel stove is not ignited, or under time constraints. Our observations support other, primarily quantitative studies, from India, which find an inverse relationship between family size and the use of LPG [48]. In our investigation, we additionally observe that family size influences the economies of scale, which underpin solid fuel use. This is because larger families tend to share resources and labour among family members. The larger number of household women can procure, produce and store solid fuels, making it easier to cook with the slower solid fuels. While individual circumstances undoubtedly differ, smaller families may be less able to accommodate the additional time and personal effort required for solid fuel use.

There is, likewise, a direct relationship between how long a family has resided in the neighbourhood and income levels, which along with security of tenure have an effect on LPG use. This was expressed (as above) as a self-evident truism by long-term residents: 'Here we all use gas. Only those who are on rent (*kiraya*) use chulha/sigri' (Korba, Purani Basti 1, 2019). We find that migrant workers who live in rented accommodation are commonly users of solid fuels, as the additional expense of paying rent usually leaves little in the household budget to pay up front for cooking LPG. Furthermore, the rented address is not sufficient documentary evidence to allow a household to register for an Ujjwala connection. Since households do not wish to sign up for a more expensive connection from private LPG agencies in what may be a temporary setting, they have to rely on other more polluting forms of domestic energy.

We note, however, that the cost of LPG is not always significantly higher than it is for traditional fuels, especially firewood bought in urban centres. In cases where costs are equivalent, we see a greater shift to LPG, but also observe that families sometimes prefer the cash-flow advantages offered by firewood. As noted above, in low-income urban neighbourhoods, firewood is difficult to gather, and the cost of buying wood at Rs.7 per kilogram is prohibitive. For exclusive use of firewood, a family of four–five people needs to spend approximately Rs. 400 (about

[4] the registration period was over at this time, and no further registrations were being accepted.

US$ 5) per month. This is almost equivalent to the cost of cooking LPG, at Rs.800 after a subsidy, for a cylinder that lasts two–three months.[5] Thus, purchasing firewood is usually not economical for the urban poor, and gathering it is not an option for many. However, unlike LPG, firewood can be bought in small quantities to tide over daily needs while households work on other jugaad energy options. In sum, while income is a clear determinant of energy choice, other considerations relating to household circumstances or cash flow mediate economic decisions on energy. In the following section we unpack the everyday jugaad (workaround) of securing household domestic energy, examining also the related topic of perceived health effects of air pollution and how they may affect decisions on fuel use.

5. The everyday jugaad to secure household energy

There is no real rule [for how to secure energy]. Depending on *jarurat* (need) and *saadan* (means) there is a combination of what actions you take. If you really need it, then you can buy lakdi. Cheena is also available. People can use this alone although there is more smoke and it takes longer. If there is lakdi in combination with cheena you only need one–two branches [and can thus save on lakdi]. When there are lots of trees and bushes, then you can get dry lakdi easily. When they burn lakdi, they use the ash as fertiliser in the fields. In the agricultural season it is spread out. In the city lakdi is expensive. In my own case, my relative brought me a cartload of lakdi for a cheap price of Rs.1000, including transport costs. It will last for a long time (Interview Raipur, February 19, 2020).

Jugaad, an innovative or creative hack, involves ever-changing and highly flexible, frugal solutions, often catering to immediate needs. We argue that the Hindi word *jugaad* captures the range of variable, short-term household approaches to domestic energy security; it is highly dependent on income, on household social networks and personal circumstances, and on resource availability in the extremely uncertain microenvironments where people live and work. From these initial observations, in this section we explore how households work out a range of creative solutions to secure domestic energy needs under conditions of scarcity and uncertainty, and observe the high dependence on family and neighbourly relations. As previously noted, our intention is not to put a positive spin on the survival strategies of poor households; indeed, available energy solutions often require high expenditure and come with deleterious health consequences. Rather, we use the concept of jugaad to capture everyday circumstances that require highly flexible, short-term, innovative strategies and solutions.

Reflected in the concept jugaad we find the overriding motivation of households to secure energy while minimising expenses, therefore always seeking more affordable energy options when balancing needs (jarurat) and means (saadan). In rural areas the possibility to gather the preferred firewood is clearly better than in the urban locations we studied, but cities contain a perhaps surprising amount of wood available from forested areas, empty plots, larger building compounds and industrial sites. That said, these are usually, not available to the majority of the urban precariat but to specific people able to access these sites. As we noted earlier, the other informal energy option in Korba is the electric cook stove, termed colloquially the *heater*. This method is very slow for everyday meals, but is nevertheless useful in certain settings. The heater is typically only employed in neighbourhoods where households can access “free” electricity by hooking a wire to an overhead electricity line. One resident in Dhuvan Basti stated that:

earlier, everyone used the electric heater – as everyone had the “hooking system”. About three years ago, high-voltage transmission lines were installed and with these, electricity meters. As a result, people stopped using the heaters and moved to increase the use of coal.

In this manner, households – with women as the main agents – are always seeking new potential energy sources as old ones disappear, become less feasible to access, or more expensive.

Coal is clearly a well-known fuel but needs to be processed to become useful for households. Coal chunks in Korba simply need a good starter fuel like kerosene to burn, but in Raipur Ward X of the Urla Industrial area, it is only possible to collect coal from industries in the form of dust, since there are no nearby mines. To make the coal dust into a domestic fuel requires labour-intensive mixing of the dust with wet soil and starchy water left over from boiling rice. It is common to observe piles of coal dust in vacant lots or at street corners in residential areas across *peri*-urban areas of Raipur, and next to these, coal laddus dry in the sun. This backyard coal-dust stockpile remains a back-up option over the entire year – a stockpile to dip into depending on the season and the time to create coal *laddus*, or in case of cash flow constraints for households that typically use other domestic fuels. Coal dust was previously free to collect from industries that wanted to rid themselves of this by-product, but over the years an informal supply chain developed to make the dust available to households as a commodity, albeit at a relatively inexpensive price. As the informal supply chain developed, the cost of personal effort increased, not to mention the exposure to smoke. The possibility of storing laddus was useful as a jugaad backup, even for households that mainly use less-smoky fuels such as lakdi or LPG, for times of cash crunch or when other fuels may be in short supply.

Ward Y of Raipur is a denser neighbourhood lacking coal dust supplies. In this area, gathering firewood is not feasible, and buying it in the market is expensive at Rs. 7 per kilogram, or approximately the same monthly cost of cooking LPG, in our estimate. Based on the combination of limited saadan (options) and high jarurat (need), families in Ward Y commonly use the more expensive LPG. This is in spite of people in Ward Y having similarly low incomes as those in Ward X. Our findings indicate, then, the uncertain jugaad nature of domestic energy with mixed, temporary and highly flexible solutions and with frequent transitions up and down the energy ladder, where income is only one influencing factor.

Returning to the different forms of household energy in Table 1, it is noteworthy how many separate supply chains exist with gathering, preparation and management of energy resources traditionally allotted to women. Gender relations in Chhattisgarh have been relatively egalitarian compared to other parts of India, and women play prominent roles in economic activities outside of the household as well [49]. Nevertheless, the everyday domestic production of energy remains firmly the role of women. But the possibilities to stock up on solid fuels or replace a LPG cylinder often involve other family members or wider social networks of both men and women. To illustrate the importance of gender relations, let us return to Dhuvan Basti of Korba where primarily women roam the nearby railway tracks at sunrise to scavenge, in their words, ‘a fistful of coal’ (*mutthibhar koila*). Such scavenging typically lasts for 30–45 min per session and is a frequent activity, carried out multiple times per week, as coal gathered is often adequate for only 1–2 meals. Similarly, the everyday gathering of firewood is a woman’s job, as is the production of cheena cakes from a mixture of locally sourced cow dung and rice husk. To make coal cakes, the coal dust may be procured or collected from industries by men, and men are also likely to be involved in sourcing firewood from home villages in the countryside. But it is women who do the manual work of mixing coal dust with rice starch, clay or husk to prepare laddus, and to dry them in the sun. Women also commonly share such produced fuel among neighbours or relations in friendly, interdependent exchanges. The production of household energy depends on custom, women’s networks and individual circumstances, with at best limited logistical help from male family members.

We observe that in some central Raipur neighbourhoods almost all households use LPG, and yet there are a few that continue to use lakdi as

[5] Both the price of gas and the subsidy amount fluctuate from month to month. Between January 2018 and March 2020, the price of a refill cylinder was in the range of Rs 800–1000, with the gas subsidy being Rs. 150–300. A 14 kg cylinder lasts for two–three months for a family of four–five persons.

their main fuel. This is noteworthy, as there are not readily observable differences in household income among the households. Renuka explained this as follows:

I am from Bastar (the forested, southern part of Chhattisgarh state). I have two gas cookers and a gas connection, but I like using lakdi. I work in two houses as domestic help. I know a lot of people [jaan pehchan] in the neighbourhood and apartment buildings I work in. They let me take the branches or sticks that may have fallen from trees in their compound. They know that I can use them, so they say, "Let her have them".

Renuka is happy with the pay she receives, and her children are either working or in college. All readily observable characteristics indicate that Renuka's household is not particularly different from her LPG-using neighbours.

Younger women in the neighbourhood, on the other hand, commonly lack familiarity with the use of the firewood chulhas, and in a group discussion they dismissed solid fuel use, saying with a laugh:

Nowadays it [cooking] has all moved to gas: all the trouble of the chulha – lighting the fire, tending it, all of this. Who is going to do that? We don't do all this…We have no knowledge about it (Group discussion with women, Panchpedi Naka, Raipur February 2020).

Renuka, however, has a cultural inclination to use lakdi, and her everyday occupation as domestic help and the relations this job entails, allows her the rare opportunity to gather it. In sum, we see how urbanisation and the greater penetration of LPG has brought about a slow change in habits and culture across generations. But we also see that those familiar with firewood, for example, may continue to use this fuel.

In the jugaad of domestic energy needs and variable options across our research locations in Raipur and Korba, it is important to point out how air pollution and its negative health effects appear to influence energy choices only marginally. The two cities already face intense air pollution from industrial and other sources, and in such a context the domestic burning of solid fuels adds an intense, additional layer of smoke [50,51]. In our focus group discussions, participants typically identified a range of important environmental concerns other than solid fuels – including sewerage, water quality and residential waste management – and rated these as more important than air pollution. In more pointed conversations on air pollution, our informants highlighted the deleterious effects of fly ash, emissions from industry or coal-fired power plants, increased traffic, dust and the dwindling of green cover rather than the smoke from solid fuel in the home. This, in spite of our informants consistently identifying the negative health effects of breathing polluted air – with symptoms such as shortness of breath, skin allergies, a burning sensation in the eyes, fatigue and respiratory tract infections such as a cold and cough (FGD and interviews across our sites).

This widespread acknowledgement and nuanced articulation of the harmful implications of solid fuel combustion on both indoor and ambient air quality did not change the understanding of solid fuels as an unavoidable, everyday part of life. One informant stated (with a touch of humour):

We have all the knowledge (*jaankari sab hain*) madam, but from the fear of sickness (*bimari*) from pollution, are we going to not cook? Stay empty stomach (*khali pet*)? Hungry? Should we worry about the pollution or feeding ourselves (Focus group discussion, Raipur May 2019)?

In Dhuvan Basti of Korba, we even find attitudes of unquestioning nonchalance surrounding domestic coal since its use is very widespread. We commonly observed groups of people conversing in the evenings and children playing together in the midst of dense smoke. Coal burning is here recognised as a part of life which includes the ills of pollution. Or as one of our research associates expressed after her first week in Dhuvan Basti: 'They have accepted pollution like a family member' (Interview, Korba, January 2019).

At the same time, our informants report that coal smoke has reduced over time with the move towards LPG (Dhuvan Basti, February 2019). The LPG-using households do not directly contribute to the intense pollution in the neighbourhood and yet have to suffer the consequences. One LPG-using resident stated that 'sometimes the smoke in the morning is so thick that it is difficult to breathe, and I feel that I should run away or remove myself from the location (Interview, Dhuvan Basti, February 2019)'. The main response among LPG users, however, was understanding or even empathy with solid-fuel users, rather than animosity: 'What are they going to do? They are poor and hence they use the sigri. They use it to save a bit of money' (Interview, Dhuvan Basti, February 2019). The slightly better-off households that use LPG are able to enjoy higher status for themselves and do not appear to seek reduction in overall smoke from their neighbours. And given the uncertain reliance on subsidised LPG with ever higher prices, they may soon find themselves under more difficult economic circumstances and again, like their poorer neighbours, return to using coal or other solid fuels.

6. Discussion and conclusion

The urban precariat of Chhattisgarh's coal towns clearly share the unfinished transition to clean, affordable and healthy energy with most of rural India's hundreds of millions of residents [6,10]. Acknowledging this, and the messy picture of household energy use in contexts of urban poverty, is important for both scholarship and related policy on domestic energy, given the relative neglect of urban India in such scholarship. Beyond this, our paper contributes to and argues in favour of qualitative research in examining domestic energy, including its links to air pollution. Although the simultaneous use of multiple fuels and fuel stacking is recognised in the academic literature [23], the everyday dynamic of producing household energy – the enormous variety of energy options which households juggle in uncertain and labour-intensive processes with women as the main agents – is underappreciated. While a range of factors shape domestic fuel use, and income is of importance, links between household income and energy choices are not always direct or linear, and there is a need for context specificity. As is evident across the neighbourhoods in this research, multiple factors – including fuel cost, ease of availability, family size, migration status and traditions – all influence energy choices in the household.

Our observations of the transient, shifting and jugaad nature of household energy use points to the importance of qualitative methods and attention to longer-term perspectives in understanding the household energy mix and possibilities for healthier energy. Policy better attuned to the diverse economies and lived realities of poor households could support the necessary shift away from solid fuels. Middle- to higher-income households exclusively rely on cleaner burning fuels, and those able to use LPG may be seen in their neighbourhoods as middle class, even if otherwise having limited means. Our findings of the highly fluctuating nature of domestic energy raise a cautionary note for research seeking quantitative measures of expenditures on domestic energy as it relates to household incomes. They point, moreover to the need for engaged, grounded approaches employing a longer-term lens.

Large national programs in India intended to improve energy infrastructure and change socio-cultural preferences support an ongoing, but frustratingly slow, change towards healthier LPG. Our research finds that apart from rare and exceptional cases favouring traditional fuels and cooking methods, everyday attitudes support clean and efficient domestic fuels. Cooking with LPG is not only convenient but indicates desirable middle class characteristics. It is noteworthy that household attitudes unanimously welcome a shift to cleaner and more convenient sources of energy, and unlike [52,53] in the rural context, we find little evidence of traditions holding back such a shift. Clean energy programs are increasingly providing wider and more reliable LPG supply across urban centres. Furthermore, social policy recognises women as primary producers and users of household energy, and interventions specifically target women by, for instance, mandating registration of new LPG connections in their names and transferring any LPG refill subsidies directly to the woman's bank account. However, ensuring cleanly burning household energy clearly remains challenging, especially for lower-income households, and within this group, for migrants.

Household production of solid fuels comes with significant costs in

terms of time and effort, but such household production of solid fuel tends to be perceived as available for free, for example in nearby forests (for wood) or along railway tracks (for coal). The labour requirements are recognised by households, but are disregarded in a setting of underemployment where monetary opportunity costs are negligible, and income is low. Making own domestic fuels in these settings may enable small savings or free-up money for other needs. While we note the importance of the economic drivers shaping cooking gas use, we also understand that costs of LPG are not always significantly higher than traditional fuels, especially firewood in urban centres. Solid fuels offer cash-flow advantages in frugal conditions where the upfront expenditure on LPG remains a significant barrier. Solid fuels can be purchased in smaller quantities, bartered or even acquired on credit to tide over immediate needs. While Kar et al [17] find that in a district of Karnataka state, non-subsidised customers refill LPG cylinders about twice as often as Ujjwala users, our findings reveal even lower refill rates. We observe, for instance, that the government has introduced the five kg cylinder, which is cheaper to refill but has had little uptake. Our interviews with LPG suppliers reveal that this is because customers are anxious about giving up their 14 kg cylinder since they view the five kg cylinder as a demotion. There is little trust that the rigid system will allow users to switch back to the larger cylinder should the customer want to use it in the future. There also remain challenges of coverage since subsidised LPG connections under the national Ujjwala program are only offered to people eligible under specific poverty alleviation programs.[6] This excludes a large part of the population that cannot afford the regular rate for a LPG connection. Also notable from a policy perspective is the insignificant place the LPG subsidy occupies in the imagination of our informants with relation to price. The subsidy is considered negligible and is not factored into price calculations either by LPG users or by those unable to afford LPG in spite of offering up to 30% cost reduction.

While it is ubiquitously recognised that solid fuels, and especially the burning of coal, are highly polluting and have deleterious consequences to human and environmental health, these remain minor concerns for households for whom other fuels are unaffordable. While the focus of this research is not on environmental influences on domestic energy changes, it is striking that even in dense residential habitations with poor ventilation, there is widespread tolerance of, and empathy towards users of solid fuels, even for neighbours who use exceptionally polluting coal. This perhaps reflects the relatively flat social structure in Chhattisgarh's low-income neighbourhoods, as well as an ethic of non-interference, but does not speak well for the possibilities to reduce domestic fossil fuel use in the future. The per capita use of fossil fuels may be low in India, but the large total number of households nevertheless ensures continued major carbon emissions [54] with no apparent low-fossil alternative. Although present public programs do provide significant benefits, they remain unable to adjust to the lived realities of households. Our research emphasises the need for more fine-grained attention to the situated realities of the urban poor and to variable household circumstances, where many, if not most households, rely on multiple fuels.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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