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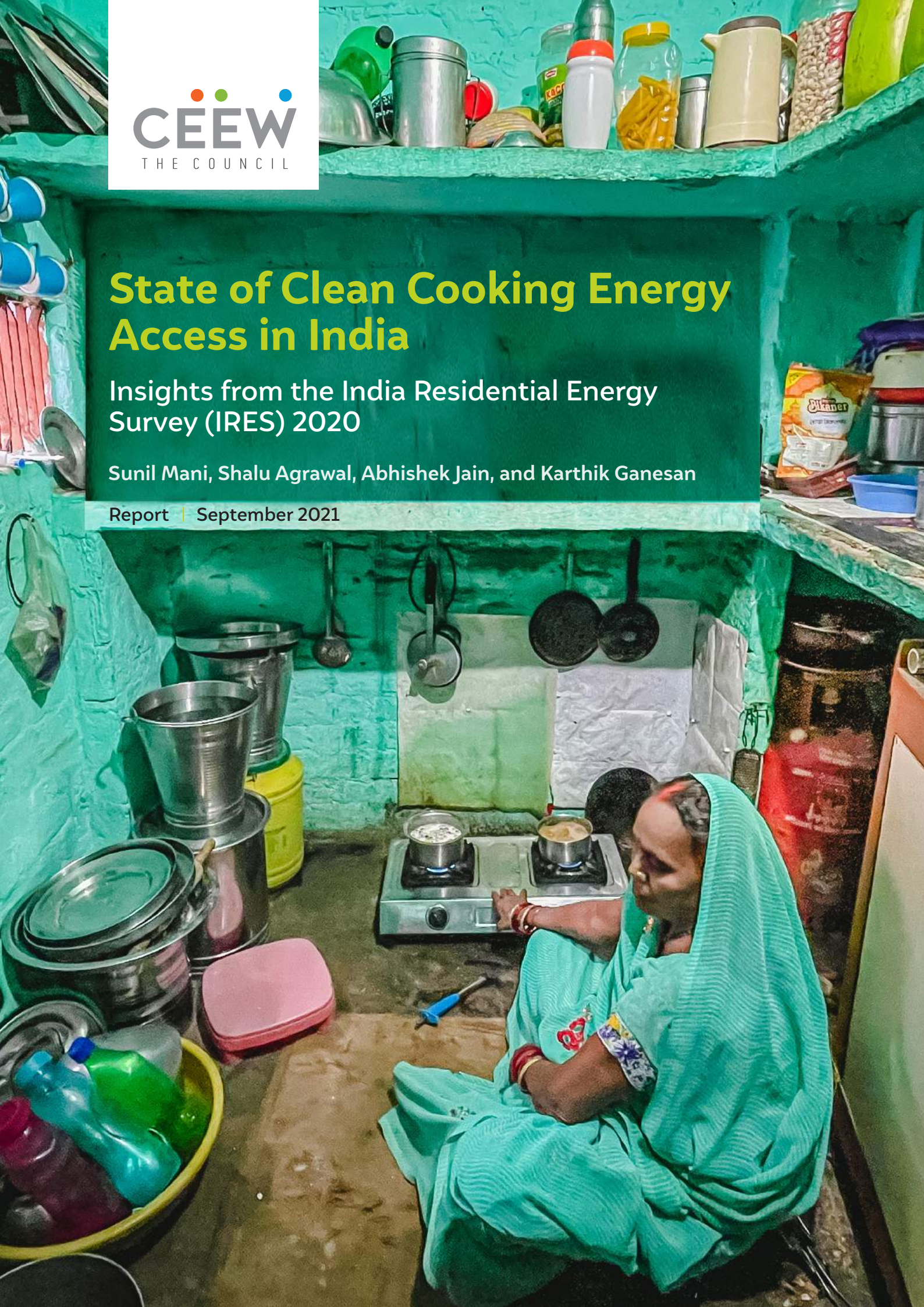
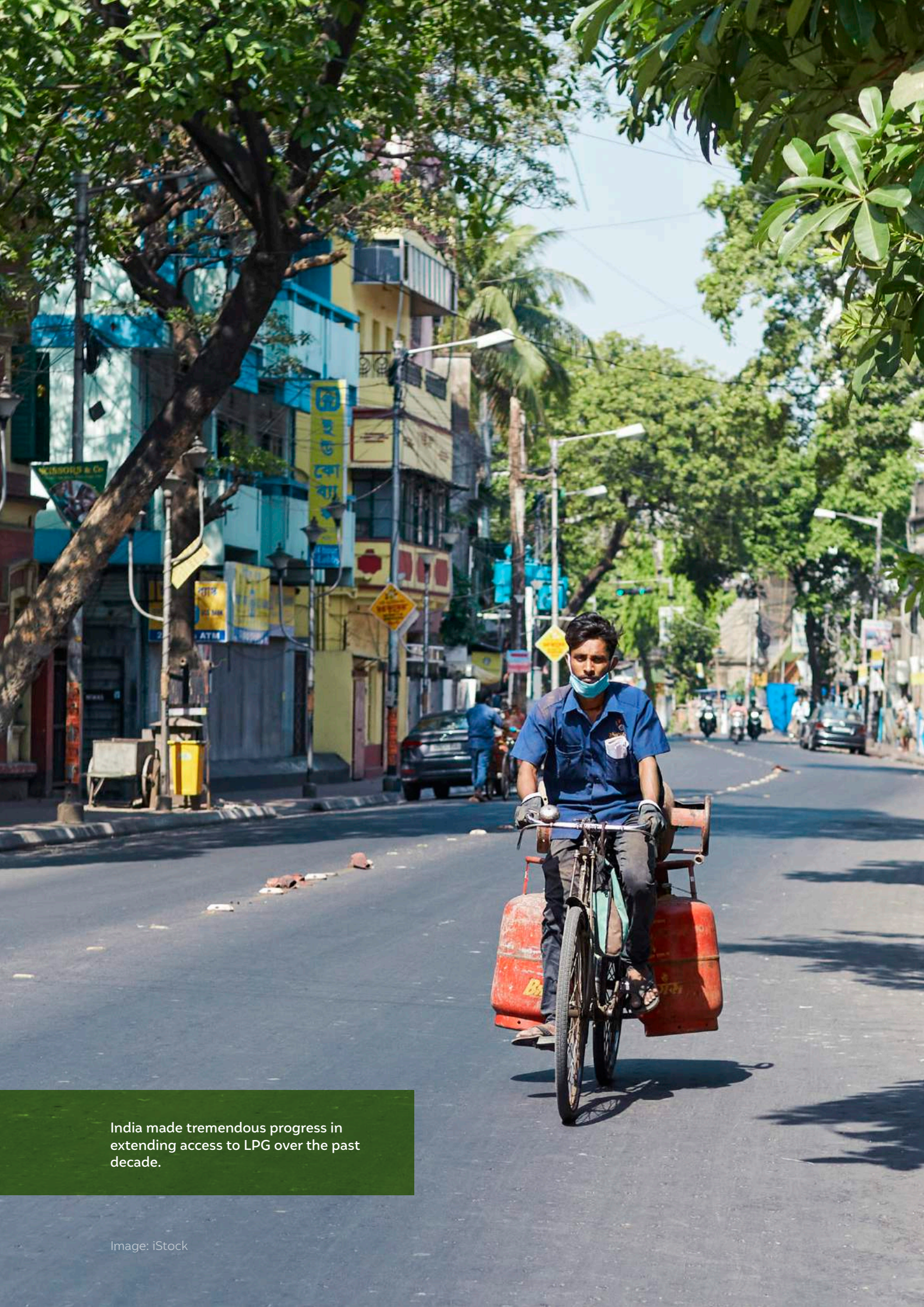
State of Clean Cooking Energy Access in India

Insights from the India Residential Energy Survey (IRES) 2020

Sunil Mani, Shalu Agrawal, Abhishek Jain, and Karthik Ganesan

Report | September 2021





India made tremendous progress in extending access to LPG over the past decade.

Image: iStock

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The Council on Energy, Environment and Water (CEEW) is one of Asia's leading not-for-profit policy research institutions. **The Council uses data, integrated analysis, and strategic outreach to explain — and change — the use, reuse, and misuse of resources**. The Council addresses pressing global challenges through an integrated and internationally focused approach. It prides itself on the independence of its high-quality research, develops partnerships with public and private institutions, and engages with the wider public.

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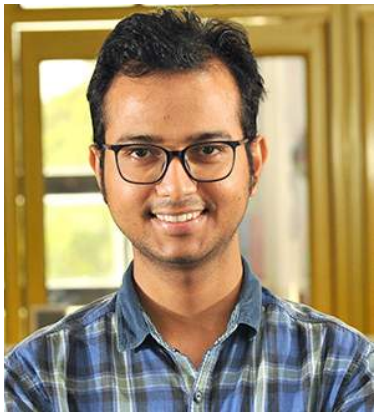
The authors



Sunil Mani
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A Programme Associate at The Council, Sunil's work over the last five years has centred on collecting and using primary data to understand and improve energy access at the household and community levels in India. He holds a master's degree in Economics from Shiv Nadar University, India.

"More and more Indian households were moving towards sustained use of LPG until the COVID pandemic hit. The pandemic-linked economic crisis significantly increased economic inequality and started reversing this clean cooking energy transition. Poorer households need targeted subsidy support to improve their clean cooking consumption, now more than ever."

Shalu Agrawal
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As a Senior Programme Lead, Shalu leads The Council's work on residential energy access, demand-side management, and power sector reforms. She uses data to study the changing energy landscape and devises strategies to ensure universal access to affordable, reliable, and sustainable energy. She recently led India's first comprehensive residential energy survey. A Chevening scholar, Shalu holds an MSc from University College London and a BTech from IIT Roorkee.

"Interventions to support the adoption of modern fuels like LPG are the first step in the journey toward transitioning to a clean cooking future. Periodically tracking our progress and solving for emerging issues, particularly affordability, would be critical to meaningfully realise SDG-7."

Abhishek Jain
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As a Fellow, Abhishek built and leads The Council's work on energy access, rural livelihoods, and sustainable food systems. He directs 'Powering Livelihoods', an USD 3 million initiative. He co-conceptualised and leads CEEW's flagship research on ACCESS (*Access to Clean Cooking energy and Electricity – Survey of States*). With a decade of experience, Abhishek has worked on multiple issues at the confluence of energy, economics, and the environment. He is an alumnus of the University of Cambridge and IIT Roorkee.

"Undoubtedly, the Ujjwala yojana has changed the landscape of clean cooking energy in India. Our report highlights important ways forward to build on that momentum and avoid regressing in the wake of the pandemic and subsidy cuts."

Karthik Ganesan
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As a Fellow and Director at The Council, Karthik has a bird's-eye view of CEEW's ongoing and planned research and ensures cross-team coherence for CEEW's research direction and imperatives. While being an active researcher with the power sector and air pollution programmes, he also dons the hat of internal adviser across research teams to strengthen CEEW's foundation for world-class research. Karthik is an alumnus of the Lee Kuan Yew School of Public Policy, National University of Singapore, and IIT Madras.

"Public health and improved indoor air quality in India's poorest households must be prioritised. The subsidy regime over decades has further disadvantaged the poor. This must be set right as a priority."

Contents

In rural India, around 90% of the firewood users collect it on their own to meet their cooking energy needs.

Image: Shaku Agrawal/CEEW

Acronyms

BEE	Bureau of Energy Efficiency
BPCL	Bharat Petroleum Corporation Limited
CSCs	common service centres
CAG	Comptroller and Auditor General of India
CI	confidence interval
DBC	double bottle connection
DBTL	Direct Benefit Transfer for LPG consumer
HHs	households
IIPS	International Institute for Population Sciences
INR	Indian rupee
IOCL	Indian Oil Corporation Limited
IRES	India Residential Energy Survey
kCal	kilo calorie
kg	kilogram
kWh	kilowatt-hour
LPG	liquified petroleum gas
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
NCT	National Capital Territory
NFHS	*National Family Health Survey*
NSSO	National Sample Survey Organisation
OMCs	oil marketing companies
OLS	ordinary least squares
PSUs	primary sampling units
PAHAL	*Pratyaksh Hanstantrit Labh*
PMUY	*Pradhan Mantri Ujjwala Yojana*
PNG	piped natural gas
PPAC	Petroleum Planning and Analysis Cell
PTI	Press Trust of India
RBI	Reserve Bank of India
SBC	single bottle connection
SDI	Socio-demographic Index
USD	United States Dollar
WHO	World Health Organization

State acronyms used in the study

AP	Andhra Pradesh
AS	Assam
BR	Bihar
CH	Chhattisgarh
GJ	Gujarat
HR	Haryana
HP	Himachal Pradesh
JH	Jharkhand
KA	Karnataka
KL	Kerala
MP	Madhya Pradesh
MH	Maharashtra
DL	NCT of Delhi
OR	Odisha
PB	Punjab
RJ	Rajasthan
TN	Tamil Nadu
TS	Telangana
UP	Uttar Pradesh
UK	Uttarakhand
WB	West Bengal

Executive summary

Image: Yousuf Tushar

For ages, humans have used solid fuels such as firewood, dung cakes, coal and agricultural residues to cook food and derive sustenance. However, burning of solid fuels to prepare food on simple cook stoves (*chulha*) in households with poor ventilation exposes families, particularly women and children, to the harmful impacts of smoke and household air pollution (HAP) (Smith 2014). In India, HAP is a significant contributor to the total disease burden, accounting for nearly 600,000 deaths in 2019 (*Global Burden of Disease Study* 2019).

Over the past decade, India has made significant strides in replacing the use of solid fuels with clean cooking options, primarily liquified petroleum gas (LPG). The most notable of these efforts is the *Pradhan Mantri Ujjwala Yojana* (PMUY) scheme, launched in May 2016. Under the programme, the government has provided subsidised LPG connections to more than 80 million Indian households (PIB 2019). While the rapid expansion in LPG access is

commendable, past research suggests that having an LPG connection does not ensure its sustained use by households. Various factors, including limited affordability, lack of timely availability of LPG cylinders, availability of free biomass, and cultural preferences propel households to stack LPG with solid fuels (Mani et al. 2020).

The absence of representative data to comprehensively assess Indian household energy choices hinders effective discourse on energy access in India

The absence of representative data that enables a comprehensive assessment of households' energy choices has been a persistent concern in the discourse on energy access in India. Between 2014 and 2018, the Council on Energy, Environment and Water (CEEW), in partnership with Columbia University, conducted two rounds of a multidimensional energy access survey titled *Access to Clean Cooking Energy and Electricity – Survey of States* (ACCESS). The ACCESS surveys covered nearly 9,000 rural households in six energy-poor states – Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh, and West Bengal – and improved our understanding of energy access. However, a pan-India assessment of the state of cooking energy access and the barriers hindering a complete transition to clean cooking fuels has been missing so far.

Study objectives

In this study, we reflect on the current state of clean cooking energy access in India, the progress made over the past decade, persisting gaps, and emerging trends. We do so with the help of the nationally-representative *India Residential Energy Survey* (IRES) 2020, conducted by CEEW in collaboration with the Initiative for Sustainable Energy Policy (Agrawal, Mani, Jain, and Ganesan 2020). The IRES covered 14,850 urban and rural households across 152 districts from the 21 most populous states in India. This study answers the following questions:

1. Have recent government schemes influenced LPG uptake in Indian homes, and why do gaps persist?
2. To what extent has an increase in LPG connections resulted in reduced solid fuel use in Indian kitchens, and what factors explain the continued gaps?
3. What strategies could enable sustained use of LPG among Indian households?

LPG adoption and use in Indian kitchens

According to the IRES 2020, around 85 per cent of Indian households have access to LPG. Further, LPG's share in primary cooking fuels increased from 28.5 per cent in 2011 to 71 per cent by March 2020 (Figure ES1).[1] The increase in LPG use can be attributed to recent government efforts, particularly the PMUY scheme.

According to the IRES 2020, around 85% of Indian households have access to LPG

The progress in LPG use for cooking purposes is perceptible across all Indian states. However, rural areas in eastern and central Indian states like Jharkhand, Bihar, Madhya Pradesh, West Bengal, and Odisha still have a low share of LPG primary users (possibly because of lower connection rates) (Figure ES2). Future efforts to promote clean cooking energy access must focus on these central and eastern states.

It must be noted that our estimate of 85 per cent LPG penetration is significantly lower than the government estimate of 97.5 per cent as of 1 April 2020 (PPAC 2020a). This difference is

1. In this report, LPG access implies ownership of an LPG connection. Primary cooking fuel is the fuel-type that households report relying on the most (a definition consistent across all surveys).

mainly because the Petroleum Planning and Analysis Cell (PPAC) estimates LPG penetration as the ratio of active domestic connections (278.7 million) to household population (285.8 million). However, it would be incorrect to equate active domestic connections with households using LPG. Despite past deduplication efforts, many households own more than one LPG connection (perhaps due to service delivery concerns) (CAG 2019).

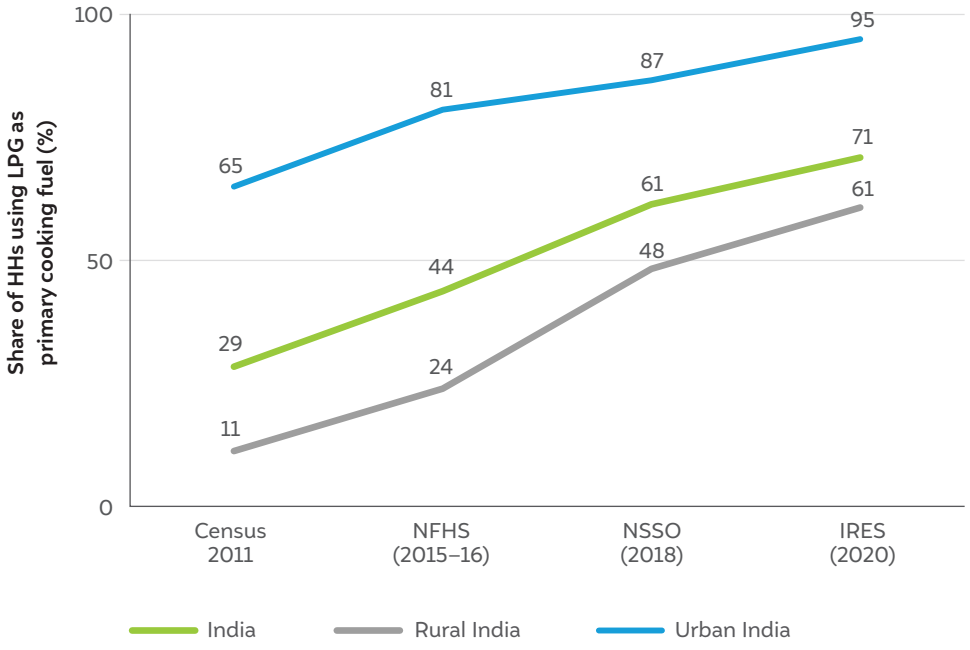
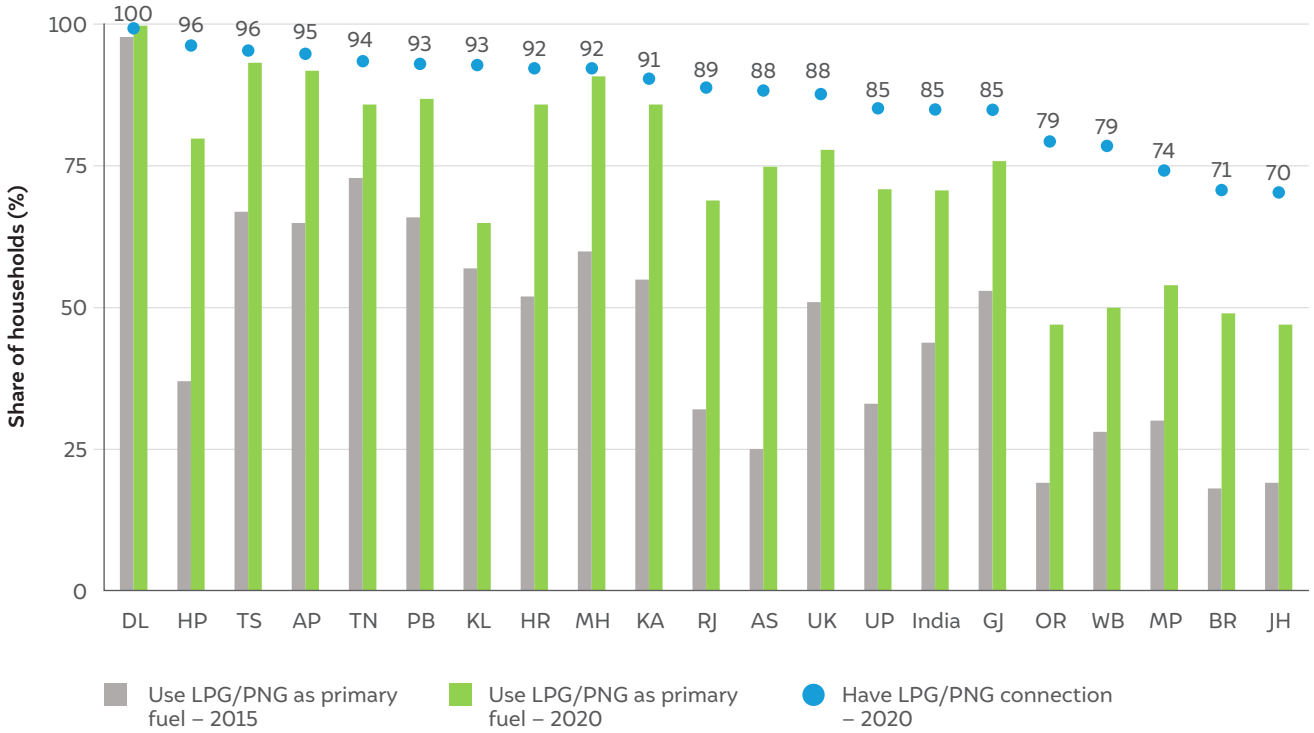


Figure ES1
LPG use as the primary cooking fuel has more than doubled in the last decade

Source: Authors' compilation using Census 2011; the fourth round of the National Family Health Survey (NFHS-4) 2015-16; 76th round of National Sample Survey Organisation (NSSO-76) 2018; and IRES 2020 data

Figure ES2 Despite progress, eastern and central India have the lowest access to clean cooking energy



Source: Authors' analysis using the fourth round of National Family Health Survey (NFHS-4) 2015–16 and IRES data

Note: PNG is a clean cooking fuel restricted to certain Indian cities, and, as per the IRES, only 0.4 per cent of all households in India use it.

Inability to afford LPG – either the connection cost or recurring expense on fuel – was the reason most cited by households (by 80 per cent non-users) for not having an LPG connection. Three-fourths of households without LPG connections earn less than INR 10,000 (USD 137) per month and live in *kuchha* (temporary) or semi-*kuchha* homes. Further, most of these households rely on labour activities as their primary source of income. Other reasons for the non-adoption of LPG include a preference for food cooked on the *chulha*, lack of adequate documents to procure an LPG connection, poor LPG availability in their locality, and easy availability of biomass.

Despite improved access to LPG, 38 per cent of Indian households stacked LPG with solid fuels, mostly in rural India (Figure ES3). This underscores findings from past research that having an LPG connection does not indicate its exclusive use. Schemes and policies intended to drive clean cooking adoption need to also focus on promoting its sustained use. States like Odisha, Kerala, West Bengal, Jharkhand, Bihar, Madhya Pradesh, and Rajasthan have the highest share of households that stack LPG with solid fuels (Figure ES4).

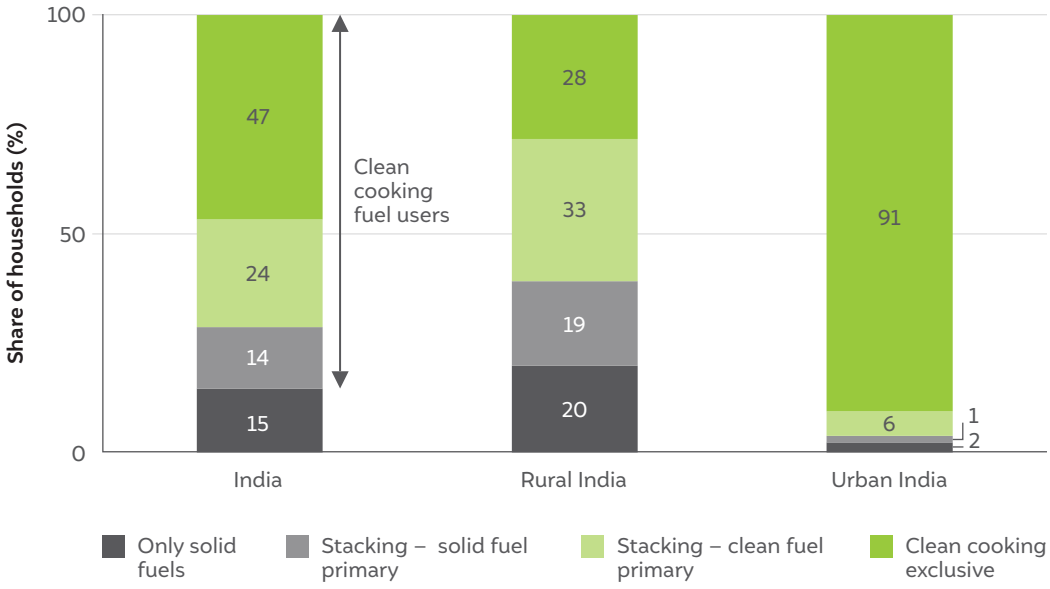
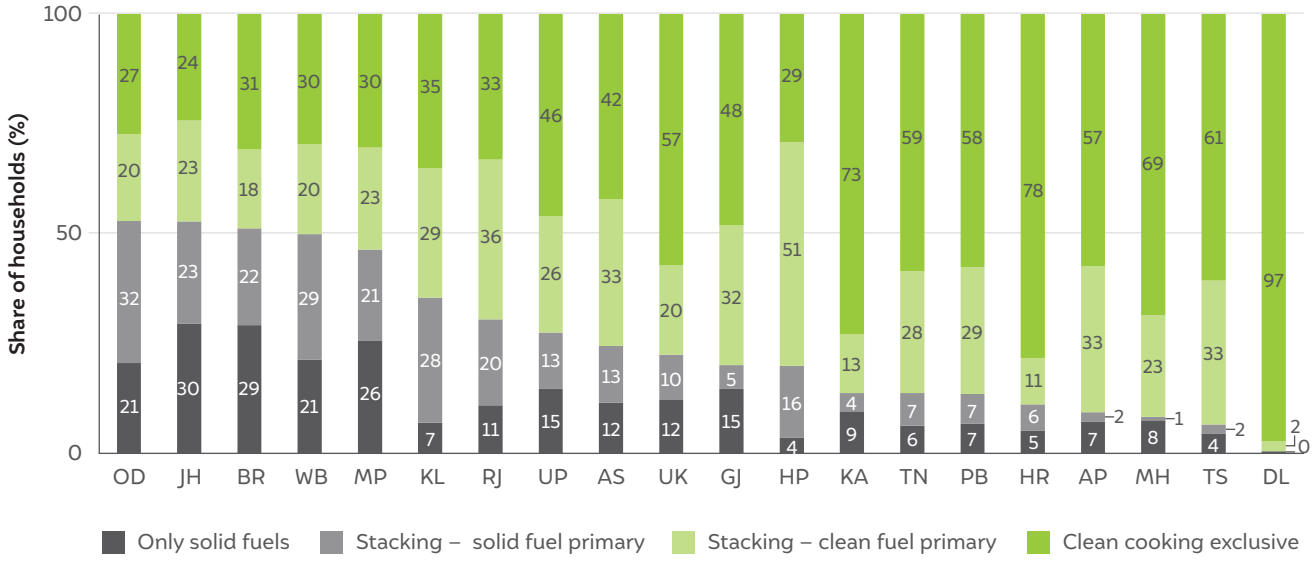


Figure ES3
More than half of rural households in India stack LPG with solid fuels

Source: Authors' analysis

Note: Here, clean cooking fuels refer to LPG (predominantly), electricity, and PNG.

Figure ES4 Eastern and central India have the highest levels of solid fuel use and stacking



Source: Authors' analysis

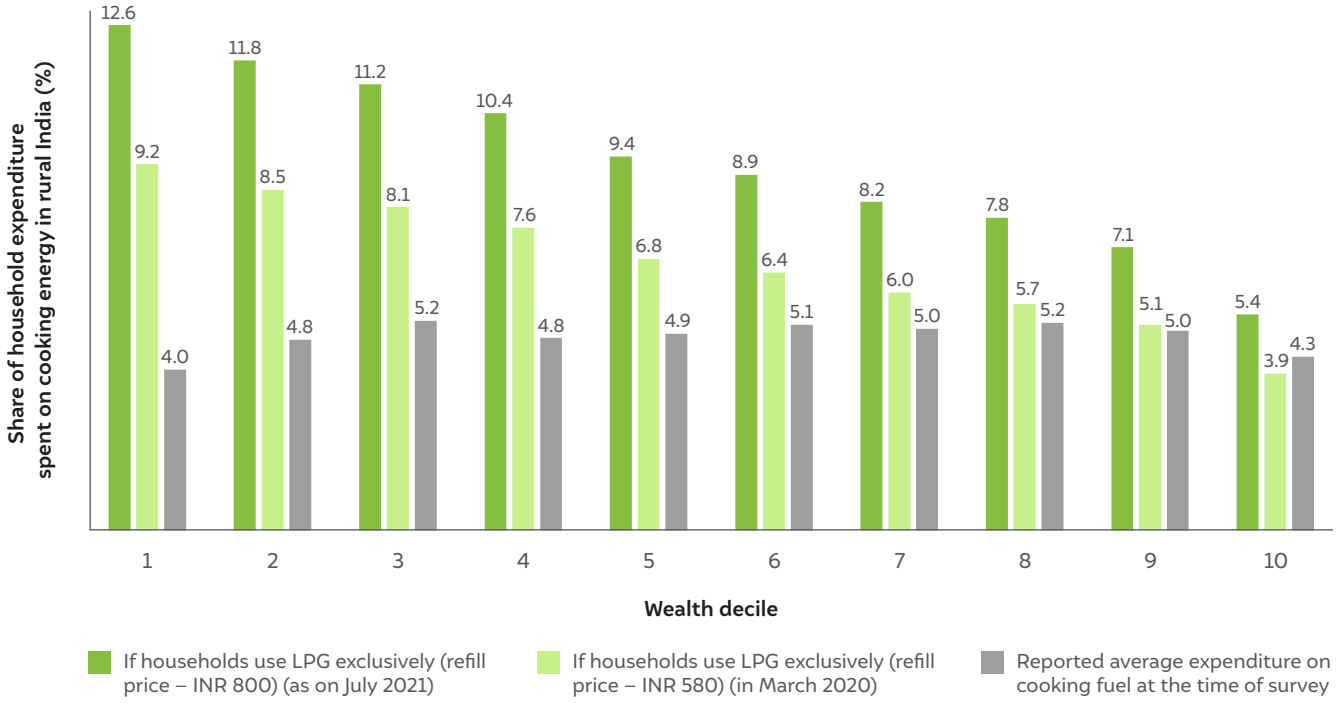
Note: From left to right, we have arranged states in the decreasing order of the sum of the solid fuel exclusive and primary use.

Factors influencing fuel stacking and the sustained use of LPG

The recurring expense associated with LPG refills is the most important driver for stacking among LPG users. At the time of the IRES survey, a typical rural Indian household would have had to spend 6.7 per cent of their total monthly expenditure on LPG to use it as an exclusive cooking fuel (at a subsidised LPG refill price of INR 580 or USD 7.94).[2] This is ~40 per cent higher than what rural households actually spent on cooking fuel at that time (4.9 per cent of the total monthly expenses). Further, exclusive LPG use was deemed affordable only by rural households in the topmost wealth decile (Figure ES5a).[3] This partly explains why fuel stacking is a common phenomenon in rural India. In urban India, a typical household will have to spend 5.1 per cent of their overall monthly expenditure to use LPG exclusively, which is only slightly higher than their current reported expenditure on cooking fuels (4.6 per cent) (Figure ES5b).

Our assessment also indicates that after the government suspended LPG subsidies in May 2020, the affordability barrier would have become even more daunting for households. At a refill price of ~INR 800 (USD 11) as of July 2021, a typical household would have to allocate a significantly higher share of its overall monthly expenditure (9.3 per cent in rural India and 7.1 per cent in urban India) to use LPG exclusively (assuming there has been no change in household income/expenses). Combined with the drop in household incomes due to the pandemic-induced economic crisis, high LPG prices pose a risk to its sustained use, particularly among low- and middle-income households.

Figure ES5a In rural India, most households would need to significantly increase their cooking energy expenditure to transition to exclusive use of LPG

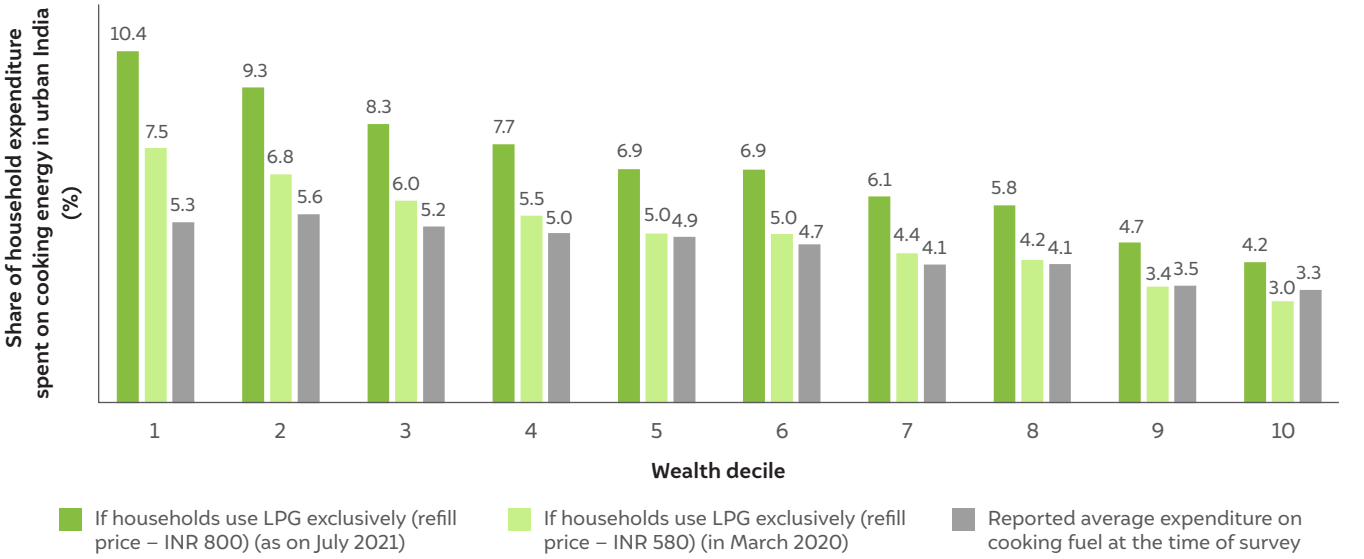


Source: Authors' analysis

2. We assume that rural households can meet their annual cooking energy needs through seven 14.2 kg cylinders, which is also the average consumption of exclusive LPG users (in five-member households) in rural India, as per the IRES. We use the currency conversion factor of INR 73/USD.

3. To assess the long run economic status of rural households, we computed the wealth index for each household using principal component analysis based on 11 indicators spanning house characteristics and ownership of various consumer durables and motorised vehicles. Based on the relative values of this wealth index, we divided rural households into 10 wealth deciles. Refer to the technical document (http://bit.ly/IRES1) for further details.

Figure ES5b Even in urban India, withdrawal of subsidies would render LPG unaffordable for low-income households



Source: Authors' analysis

Closely related to affordability is the issue of subsidy receipt. Until the discontinuation of the LPG subsidy in 2020, the subsidy amount was credited directly to the household's registered bank account after every refill. As per the IRES, 13 per cent of households did not receive the subsidy for their last LPG refill and 23 per cent did not know if they had received it or not. Subsidy non-receipt and lack of awareness of receipt were more pronounced among PMUY beneficiaries (59 per cent), perhaps because of ongoing loan adjustments (Figure ES6).[4] However, even among non-PMUY households, a significant share – 30 per cent – of LPG users face these issues. Besides the high refill price, the lack of information or uncertainty about subsidy (receipt) could further enhance the (perceived) cost of LPG and deter households from transitioning fully to clean cooking energy.

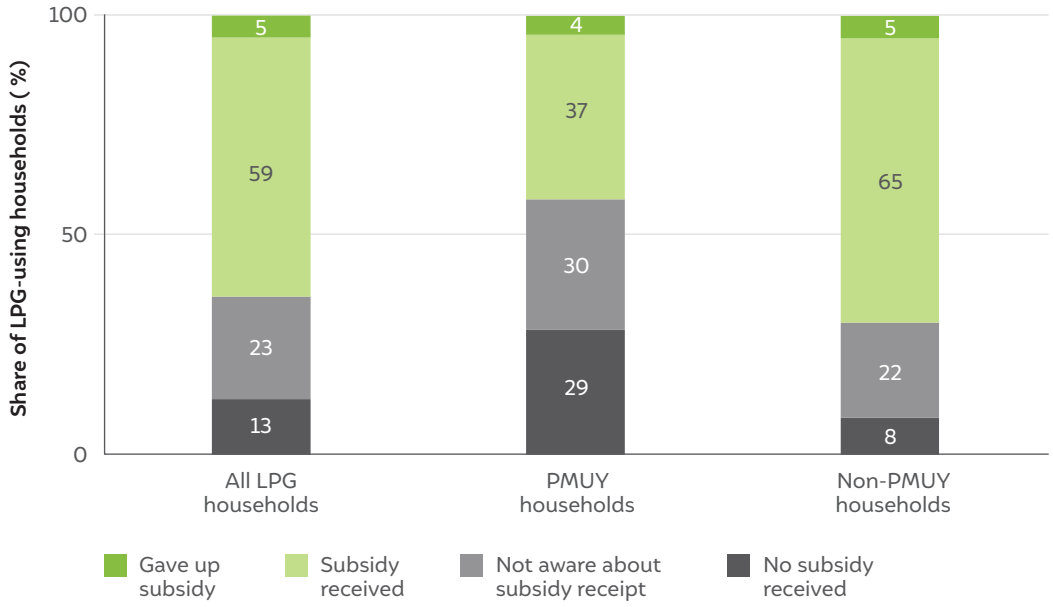


Figure ES6
Around one-third of LPG users either did not receive a subsidy on their last refill or were not aware of it

Source: Authors' analysis

4. Under PMUY, the government bears the LPG connection cost (~INR 1,600 or USD 22), which includes the installation cost, administrative charges, and security deposit. However, a PMUY beneficiary has to pay the remaining amount of INR 1,600 (for the LPG stove and cylinder) either upfront or through a loan from the oil marketing companies (OMCs). In case the consumer avails the loan facility, the subsidy amount for subsequent refills is first used to repay the loan. Consumers start receiving subsidy credits only after the full repayment of the loan.

Among households that stack LPG with solid fuels, the limited availability of refills is another key reason (cited by 46 per cent of them) for stacking. We found that only 64 per cent of all LPG users get their LPG refills delivered home. Urban households are more likely to get their cylinders home delivered (83 per cent) compared to rural ones (54 per cent).

Only two-thirds of LPG users in India get their refills delivered home

In the case of households that do not have access to home delivery, members have to travel an average one-way distance of 4.9 km in rural areas and 2.4 km in urban areas to get their cylinders refilled. The average distance to be covered to procure LPG in rural areas varies significantly between states – from as low as 1.3 km in Andhra Pradesh to as much as 8.4 km in Madhya Pradesh. Barring Bihar and West Bengal, which have high population densities, almost all central and eastern Indian states have poor home delivery rates. Further, states with a higher share of newly connected or PMUY households have poorer home delivery rates, possibly because of the lower demand for refills. Low consumer density in rural areas further drives down dome delivery rates, as distributors have to travel long distances to deliver cylinders without any additional financial incentive.

We also found that nearly three-fourths of LPG users in rural areas have single bottle connections (SBCs) and only 18 per cent of them receive LPG refills on the same day. Thus, lack of home delivery combined with the prevalence of SBCs and delays in receiving LPG refills result in rural LPG users' continued reliance on biomass.

Way forward

PMUY has accelerated India's progress towards attaining multiple Sustainable Development Goals (SDGs) – SDG 3: Good health and well-being; SDG 5: Gender equality; SDG 7: Affordable and clean energy; SDG13: Climate change; and SDG15: Life on land/forest degradation. However, the country needs to overcome several remaining gaps to ensure universal access to clean cooking energy.

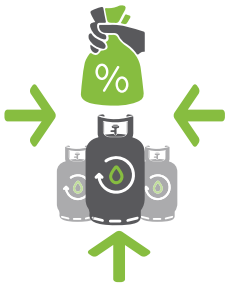
Facilitate LPG connections for households left out of PMUY

According to the IRES, 15 per cent of Indian households did not have an LPG connection as of March 2020, with unaffordability being the major barrier. The Indian government recently announced Phase 2 of PMUY in Budget 2021 to facilitate 10 million new connections (Press Trust of India 2021). PMUY 2.0 should aim to improve LPG access among the remaining households by improving the enrolment process and conducting awareness campaigns and targeted beneficiary identification. States such as Jharkhand, Bihar, Madhya Pradesh, West Bengal, and Odisha should receive special attention, as they lag significantly behind the national average for LPG penetration.

Provide adequate yet targeted subsidies to make LPG affordable

The unaffordability of LPG refills remains the biggest barrier to its uptake as the primary or exclusive cooking fuel. Since May 2020, the government has discontinued the subsidy on LPG refills. This suspension of the subsidy, combined with the increasing market price of LPG, puts many households at risk of abandoning LPG altogether. Providing an adequate subsidy is crucial in making LPG

affordable, sustaining the recent gains in LPG coverage, and weaning households away from using polluting solid fuels. We estimate that an effective price of INR 450 (~USD 6.2) per refill would bring the share of household expenditure on the exclusive use of LPG closer to the cooking energy expense borne by households at the time of the survey. However, even at this effective price, many low-income households may still find it unaffordable.



Limiting subsidy to 7–8 LPG refills could help save 13–15% of the annual subsidy outlay

It is also important to target subsidies to deserving households given the fiscal constraints and financial burden associated with universal subsidies. Three potential approaches could be explored for targeting LPG subsidies.

- Limit subsidy provision to up to 7–8 LPG refills annually, which is the average consumption of exclusive LPG users in rural and urban India. This could help save 13–15 per cent of the LPG subsidy outlay.
- Use robust indicators to exclude all households with a high income/wealth status. For instance, the current income-based exclusion limit could be lowered from INR 1 million/year (USD 13,700) to INR 250,000/year (USD 3,425), which would help exclude a large share of households.
- Employ a consumption-linked subsidy approach, where the historic refill rate (from oil marketing companies [OMCs'] consumer data) could be used to provide higher subsidies to consumers with lower LPG consumption in recent years. The availability of anonymised administrative data on LPG refills in the public domain could facilitate a robust assessment of changing LPG consumption patterns and help identify innovative targeting approaches.

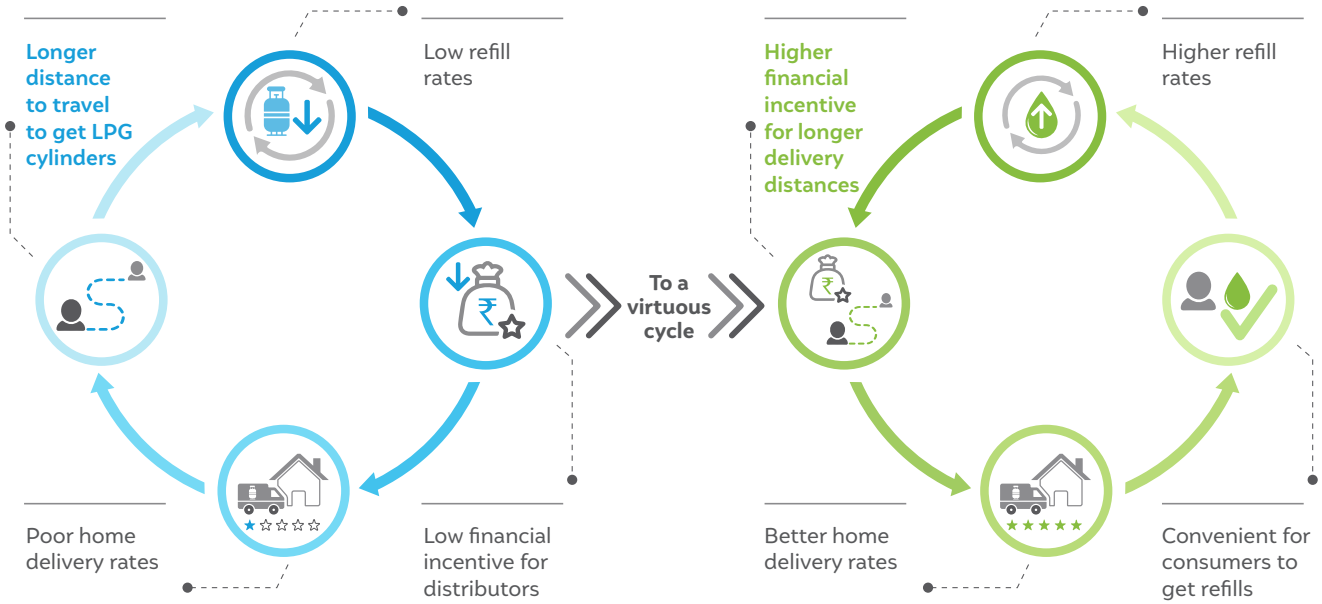
However, all targeting approaches pose the risk that households no longer eligible for the subsidy may turn to procuring multiple connections or exploit other loopholes in the targeting mechanism. Thus, appropriate deduplication and delivery authentication systems would need to be implemented in parallel.

In addition to subsidy provision and targeting, the government must also run information campaigns to encourage LPG consumers to check their bank accounts for the subsidy amount and inform the bank and the LPG distributor in case of any changes in their phone numbers or bank details.

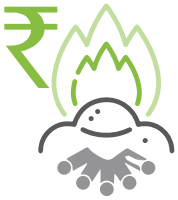
Strengthen the LPG distributor network and provide a higher distribution commission for rural areas

Beyond economics, availability also influences households' adoption of LPG as the primary or exclusive cooking fuel. OMCs could leverage datasets like the IRES and identify regions where poor availability of LPG is a significant reason for biomass stacking. This would include states with a large number of PMUY households, such as Odisha, Jharkhand, and Assam. The government should also incentivise rural distributors to provide home delivery by providing a higher commission per refill, which is currently uniform across the country at INR 62 (USD 0.85) per LPG refill. Providing differential commissions linked to connection density would further improve the last-mile delivery of refills and create a virtuous cycle (Figure ES7).

Figure ES7 Linking the distributor commission with connection density would incentivise home delivery of LPG



Source: Authors' illustration



Create an opportunity cost for biomass or an opportunity cost of time for those who procure and prepare biomass

Subsidy support for LPG may still be ineffective in face of the easy availability of the free-of-cost biomass. About 14 per cent of rural households in India rely on free-of-cost biomass exclusively, while another 50 per cent collect biomass to supplement clean fuels. Integrating the LPG programme with broader social assistance and rural development programmes would help enhance rural incomes. In addition, the government could pilot initiatives to promote decentralised biomass processing units that manufacture briquettes and pellets for industrial/commercial establishments using locally available biomass. Besides putting a monetary value to locally available biomass, this could create income opportunities for households currently gathering it for free.

Over the past decade, India has made significant strides in bridging the gaps in households' access to clean cooking fuels. Improving LPG's penetration among the deprived, enhancing its affordability for the needy, and boosting its availability for the hard-to-reach must remain a key priority to ensure that we completely eliminate solid fuels and the associated air pollution from Indian kitchens by 2030.

Many Indian households use dung cakes or firewood to supplement their cooking energy needs.

Image: CEEW/Market Xcel

1. Context and objective

In 2015, the United Nations General Assembly recognised universal access to clean cooking energy as one of the 17 Sustainable Development Goals to be achieved by 2030 (United Nations 2020). The health impacts of household air pollution (HAP) caused by the inefficient burning of solid fuels are one of the key drivers for global efforts to improve access to clean cooking energy.

Access to clean cooking is critical in achieving multiple developmental priorities

In India, HAP is the leading cause of air-pollution-related deaths, which numbered nearly 600,000 lives lost in 2019 (Global Burden of Disease Study 2019; Tripathi 2020). The use of solid fuels for cooking disproportionately affects the health of women and young children due to their higher exposure to it (Arora 2018). Moreover, women spend a significant amount of time on fuel collection and preparation, a predominantly gendered activity, which further limits their opportunities for education, employment, and leisure activities (Jha, Patnaik, and Warrier 2021; Patnaik and Jha 2020; Choudhuri and Desai 2020). Thus, access to clean cooking is critical in achieving multiple developmental priorities, including improved health, gender equality, equitable economic development, and environmental protection (WHO 2018).

1.1 Past efforts to improve clean cooking access in India

India has introduced several policies over the past decades to displace the use of solid fuels (such as firewood, dung cake, and crop residue) and increase the uptake of clean cooking options, primarily liquified petroleum gas (LPG). Due to rising incomes, increased scarcity of solid fuels, and massive subsidies, the share of urban households using LPG as their primary cooking fuel rose from 48 per cent in 2001 to 65 per cent in 2011 (Census 2011). However, the uptake of LPG in rural areas was limited to 11.4 per cent in 2011.

Along with efforts to improve LPG availability through distributor licences, the government also introduced initiatives such as the Direct Benefit Transfer for LPG (DBTL) scheme and the Give Up LPG Subsidy campaign to better target LPG subsidies and create fiscal space to distribute LPG connections to the poor (IISD n.d.).[5] However, the main thrust for improving LPG access among poor and rural households came from the *Pradhan Mantri Ujjwala Yojana (*PMUY*)*, which was launched in May 2016.[6] Under the PMUY, the government has distributed more than 80 million LPG connections at subsidised connection costs (PIB 2019).

5. The DBTL scheme, launched in January 2015, provided for the direct transfer of LPG subsidies into consumers' bank accounts. This eliminated the incentive to divert subsidised domestic LPG to the non-subsidised commercial sector. The Give Up LPG Subsidy campaign, launched in March 2015, aimed at nudging well-off households to voluntarily surrender their LPG subsidies. As on 11 November 2019, more than 10 million LPG consumers had given up their subsidies under this campaign.

6. In this report, we use PMUY and *Ujjwala* interchangeably.

Despite these efforts, HAP-related deaths have been reducing in India at a slower rate compared to China and other middle Socio-demographic Index (SDI) countries (Banerjee 2019).[7] This could be attributed to the fact that increase in LPG connections does not imply a commensurate increase in households' reliance on it as an exclusive fuel, which is necessary to eliminate exposure to HAP (Cabiyo, Ray, and Levine 2021; Giri and Aadil 2018). Past research indicates that the high recurring cost associated with LPG refills, the availability of free of cost biomass, and the preference for food cooked on traditional cook stoves are critical barriers to households' adoption of clean cooking options in India (Mani et al. 2020; A. Sharma, Parikh, and Singh 2019). However, a limited understanding of consumers' contexts, evolving challenges, and willingness to pay can subdue the effectiveness of public schemes designed to deploy clean cooking solutions (Patnaik, Tripathi, and Jain 2018).

Having an LPG connection does not imply its sustained use

1.2 Tracking the state of clean cooking access

The lack of representative data that enables a comprehensive assessment of households' energy choices has been a persistent concern in the discourse on energy access in India. The *Household Consumer Expenditure Survey* conducted in 2011–12 by the National Sample Survey Organisation (NSSO) is the primary source of information on household energy use in India, but it is limited in scope. The fourth round of the National Family Health Survey (NFHS-4), conducted in 2015–16, also provides some basic information on household cooking choices, such as the type of households' primary cooking fuel.

To better understand the drivers and barriers to household energy access, CEEW and Columbia University conducted a multidimensional energy-access survey titled Access to *Clean Cooking Energy and Electricity – Survey of States* (ACCESS), between late 2014 and early 2015 (Jain et al. 2015). ACCESS covered 8,568 rural households from six energy-poor states in India – Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh, and West Bengal. In 2018, the same households were revisited for the second round of the ACCESS survey to assess the impact of public schemes on household energy access (Jain et al. 2018).

The findings from the ACCESS surveys underscore the role of supply-side interventions in addressing the affordability, availability, and awareness barriers to energy access in rural India. A recent survey of rural and semi-urban households in Uttar Pradesh and Maharashtra highlighted that though there was high ownership of LPG (>90 per cent) in the two states, households continued to stack solid fuels with LPG (Kaul et al. 2000). However, in absence of an updated national-level household survey, a pan-India assessment of the state of cooking energy access and the barriers hindering a complete transition to clean cooking fuels has so far been missing.

1.3 Study objectives

Between late 2019 and early 2020, CEEW, in partnership with the Initiative on Sustainable Energy Policy, undertook a nationally representative survey to capture the state of energy access and use in Indian homes (Agrawal, Mani, Jain, and Ganesan 2020). This study uses the data from the *India Residential Energy Survey* (IRES), 2020, to analyse cooking energy access in India and answer the following questions:

7. SDI is expressed on a scale of 0 to 1 and is a composite average of rankings of income per capita, average educational attainment, and the fertility rate.

1. Have recent government schemes influenced LPG uptake in Indian homes, and why do the gaps persist?
2. To what extent has the increase in LPG connections resulted in reduced solid fuel use in Indian kitchens, and what factors can explain the continued gaps?
3. What strategies could enable households to use LPG as their primary and exclusive cooking fuel?

IRES 2020 is the first comprehensive, pan-India survey of residential energy use

1.4 The India Residential Energy Survey

The IRES 2020 covered 14,850 households – urban as well as rural – from 152 districts in the 21 most populous states in the country, which account for 97 per cent of India's population. The IRES employed a stratified multistage probability design for sampling, where districts were the primary sampling units and households were the ultimate stage units.[8] About 96–97 households were surveyed in each of the sampled districts. A team of 154 trained enumerators and 40 supervisors conducted the surveys in-person, using handheld tablets, between November 2019 and March 2020. The surveys typically lasted for 35 minutes (median value) and were conducted in 11 Indian languages (Figure 1).

The IRES captured diverse household information, including demographics, economic status, types of energy sources used, quality of energy services, and usage patterns, among other things. We conducted thorough data quality checks to address diverse sources of errors typical to any survey data. A key limitation of the IRES data is the high non-response rate (26 per cent), primarily in areas with a higher share of urban and economically better-off households. Thus, our assessment of parameters that are strongly correlated with household income levels is likely to be conservative. Further, the estimates presented in this report are entirely based on survey responses, and, hence, they could be prone to recall bias and social desirability bias. Throughout the study, we have used design weights to account for the unequal probabilities of selection while estimating population estimates unless specified otherwise.

Figure 1
IRES 2020 employed a stratified multistage probability sampling method and covered 152 districts across 21 Indian states

Source: Authors' illustration

1.5 Organisation of the report

We have structured the report as follows. In Chapter 2, we provide a descriptive assessment of the cooking energy access situation among Indian households and identify the reasons for existing gaps. In Chapter 3, we examine the prevalence of fuel stacking and discuss how we can promote sustained LPG use. In Chapter 4, we synthesise the study findings and provide suggestions and recommendations for policymakers and various state-level actors.

8. A detailed description of the study design can be accessed here: http://bit.ly/IRES1.

Timely and doorstep delivery of LPG will be a key ingredient for India's success in completely switching away from polluting solid fuels.

Image: iStock

2. Access to clean cooking energy fuel in India

Until recently, solid fuels like firewood, crop residue, and dung cakes were the mainstay of primary cooking fuels for most Indian households. In 2011, 70 per cent of Indian households primarily relied on solid fuels to meet their cooking energy needs (Census of India 2011). To further clean cooking energy access in India, the Indian government distributed subsidised LPG connections to more than 80 million poor households under *Pradhan Mantri Ujjwala Yojana (*PMUY*)* between 2016 and 2019 (Bhaskar 2019).

2.1 Clean cooking energy access

As per our survey, government efforts have helped drive a tremendous increase in LPG penetration. As a result, the share of households reporting use of LPG as the primary cooking fuel increased from 28.5 per cent in 2011 to 71 per cent in 2020.[9] Figure 2 shows the steep increase in LPG penetration after the launch of the PMUY – an eight per cent annual growth rate. This growth was seen in all the IRES states (see Annexure 1). This is clear evidence of how targeted efforts under PMUY have helped LPG become the most commonly used cooking fuel in India. The scheme also significantly influenced the reduction in social inequities in access to LPG in India (Box 1).

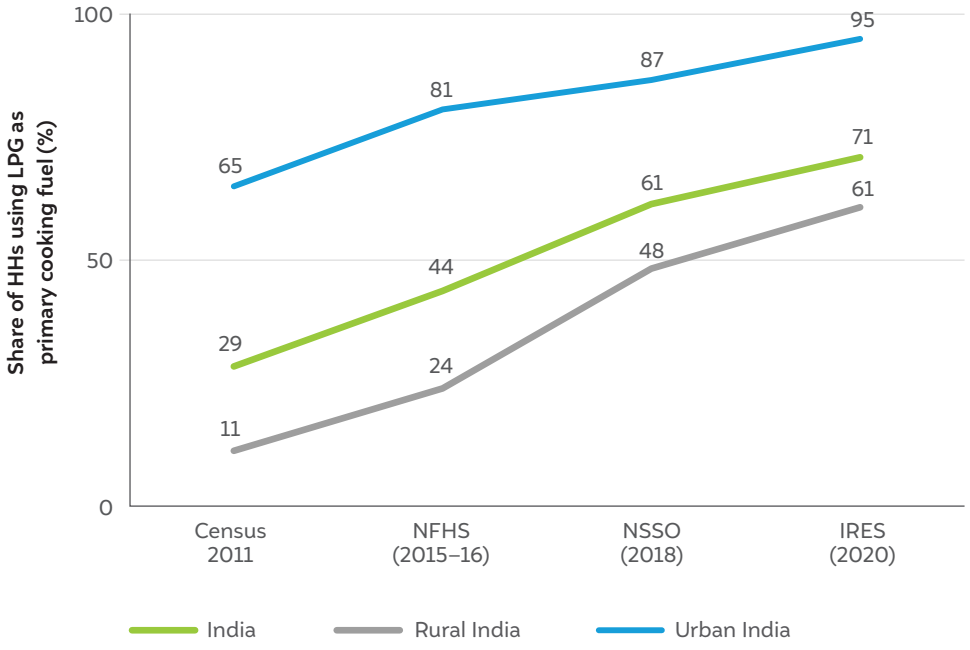


Figure 2
Use of LPG as the primary cooking fuel in India has more than doubled in the last decade

Source: Authors' compilation using Census 2011; the fourth round of the National Family Health Survey (NFHS-4) 2015-16; 76th round of National Sample Survey Organisation (NSSO-76) 2018; and IRES 2020 data

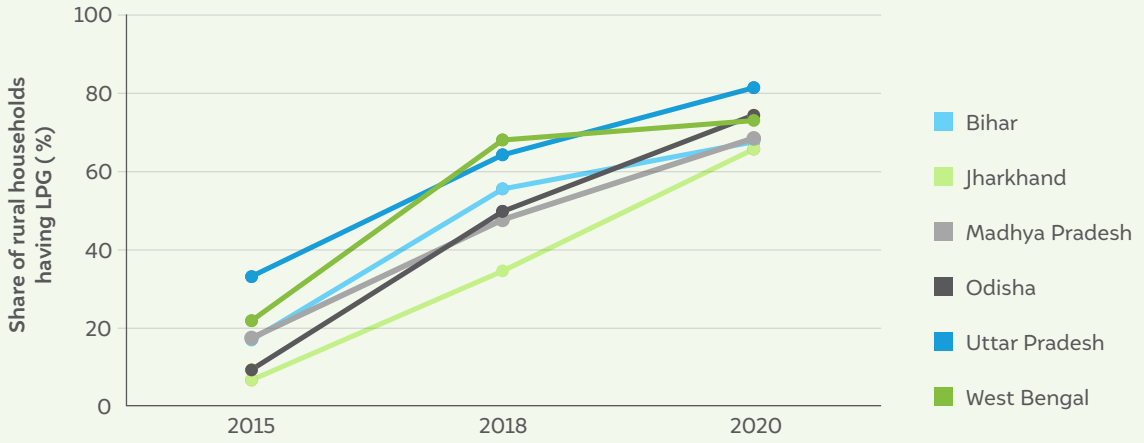
9. Ninety-five confidence interval (95% CI) for use of LPG as the primary cooking fuel in IRES: 70.14–71.61.

BOX 1 Evolution of access to LPG in energy-poor states and among different socioeconomic groups

Recent literature suggests that PMUY has reduced inequities in clean cooking energy access in India to a significant extent, and its impact has been particularly dramatic in rural areas (Pelz, Chindarkar, and Urpelainen 2021). In 2015 and 2018, CEEW conducted the first and second rounds of the ACCESS survey targeting around 9,000 rural households in six Indian states – Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh, and West Bengal. We rely on insights from these two surveys to determine the trends in Figures 3a and 3b. Six ACCESS states – which have historically been the energy-access-deprived – saw a massive rise in LPG access (connection rates) from 22 per cent in 2015 to 73 per cent in 2020 (Figure 3a).

We find that more than 40 per cent of LPG users in five of these six states (except Uttar Pradesh) are PMUY beneficiaries (Lok Sabha 2019). This suggests that LPG dissemination under PMUY helped improve access to clean cooking fuels in traditionally deprived states, allowing them to catch up with states with better access. Jharkhand and Odisha recorded the biggest rises, and the proportion of PMUY consumers in these two states are 59 per cent and 56 per cent, respectively (Lok Sabha 2019).

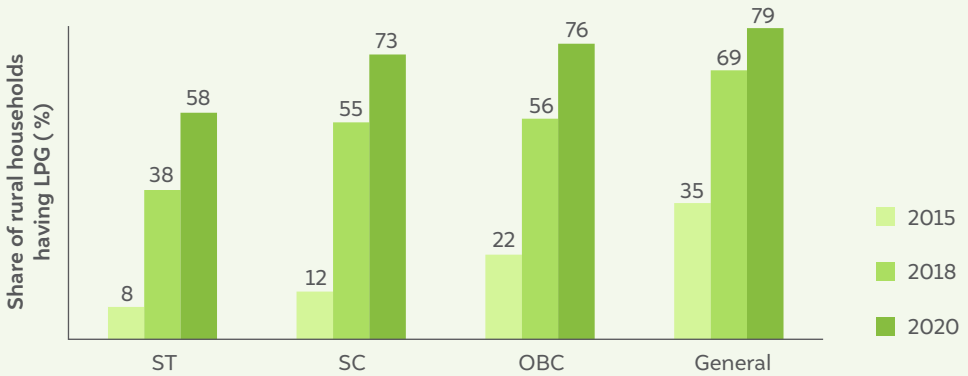
Figure 3a In rural areas in the six ACCESS states, there has been a massive improvement in LPG connection rates



Source: Authors' analysis

Figure 3b shows the change in LPG connection rates over time for major caste categories in India. We observe that LPG access has improved across all caste groups. Despite this, LPG access among Scheduled Tribe (ST) households remains low and highlights the need for concerted efforts to bridge the remaining gaps.

Figure 3b All social groups see a significant improvement in LPG access over the last five years



Source: Authors' analysis based on data from ACCESS 2015, ACCESS 2018, and IRES 2020

While the share of households using LPG/PNG as the primary fuel is 71 per cent, this is still lower than the share of households than own an LPG/PNG connection (85 per cent). LPG/PNG penetration is significantly higher in urban areas (97.6 per cent) than in rural areas (80 per cent). Despite improvements in LPG use, half of Indian households continue to use firewood, and nearly a fourth report using dung cakes and other solid fuels for cooking (Figure 4). Most solid fuel users are in rural India, where despite 80 per cent of households having an LPG connection, 67 per cent use firewood for at least some of their cooking needs. The practice of stacking solid fuels with clean fuels is a concern due to households' continued exposure to HAP (see Chapter 3).

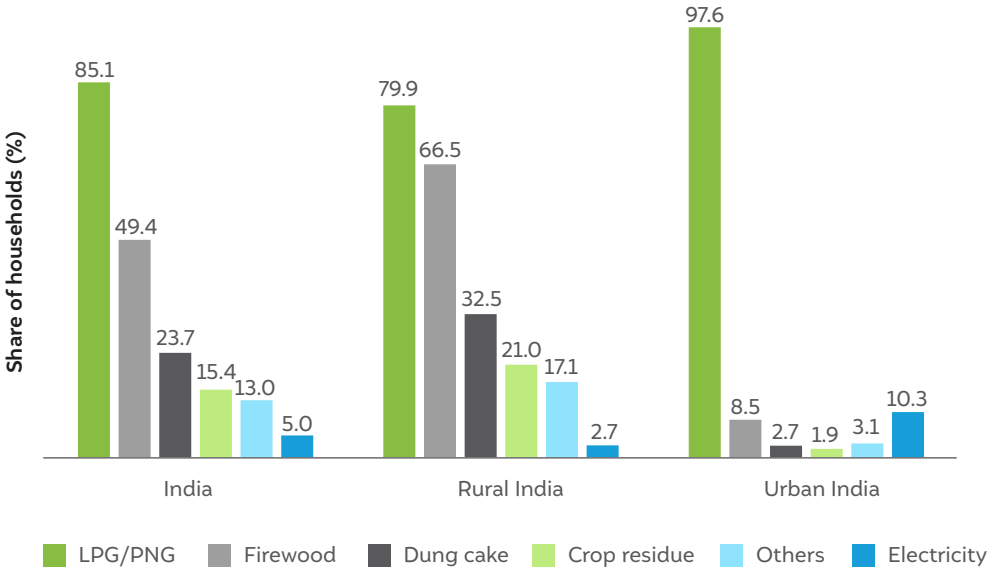


Figure 4
Six out of every seven Indian households now have an LPG/PNG connection

Source: Authors' analysis

Note: The chart shows the diverse cooking fuels used in Indian homes. We have clubbed together PNG and LPG, as PNG adoption is very low: 1.3 per cent of urban households and 0.4 per cent of all Indian households use PNG. The 'others' category includes coal, charcoal, lignite, and kerosene.

In contrast to our estimates, a report by the Petroleum Planning and Analysis Cell (PPAC) cited a significantly higher LPG penetration of 97.5 per cent as of 1 April 2020 (PPAC 2020a). The difference of 12.5 percentage points can be attributed to the PPAC's estimation approach – they calculate LPG penetration as the ratio of total active domestic connections (278.7 million) to the total household population (285.8 million).[10] However, the number of domestic connections should not be taken as a proxy for households using LPG, as despite past deduplication efforts, the data does not account for a substantial share of households that have more than one LPG connection (possibly due to service delivery concerns) (CAG 2019).

In response to a Lok Sabha query, the concerned ministry replied that OMCs had blocked more than 45 million duplicate, fake, non-existent, and inactive LPG connections by October 2019 (Lok Sabha 2019). However, the issue of double-counting seems far from resolved. The Indian government announced PMUY 2.0 under the Budget FY2021–22 to reach one crore more beneficiaries (Press Trust of India 2021). This also confirms that the estimated coverage of 97.5 per cent was an overestimation on the PPAC's part.[11]

There is also the fact that with 215 million households electrified, the Ministry of Power's *Saubhagya* portal claims to have electrified almost 100 per cent of households, but with 279 million LPG connections, PPAC estimates 97.5 per cent LPG penetration. This clearly indicates that a substantial proportion of households have multiple connections.

10. The PPAC estimates the household population as 285.767 million by applying the decadal growth rate of 2001–11 to the Census 2011 population.

11. As per the PPAC, LPG coverage has increased to 99.8 per cent as on April 2021 (PPAC 2021a).

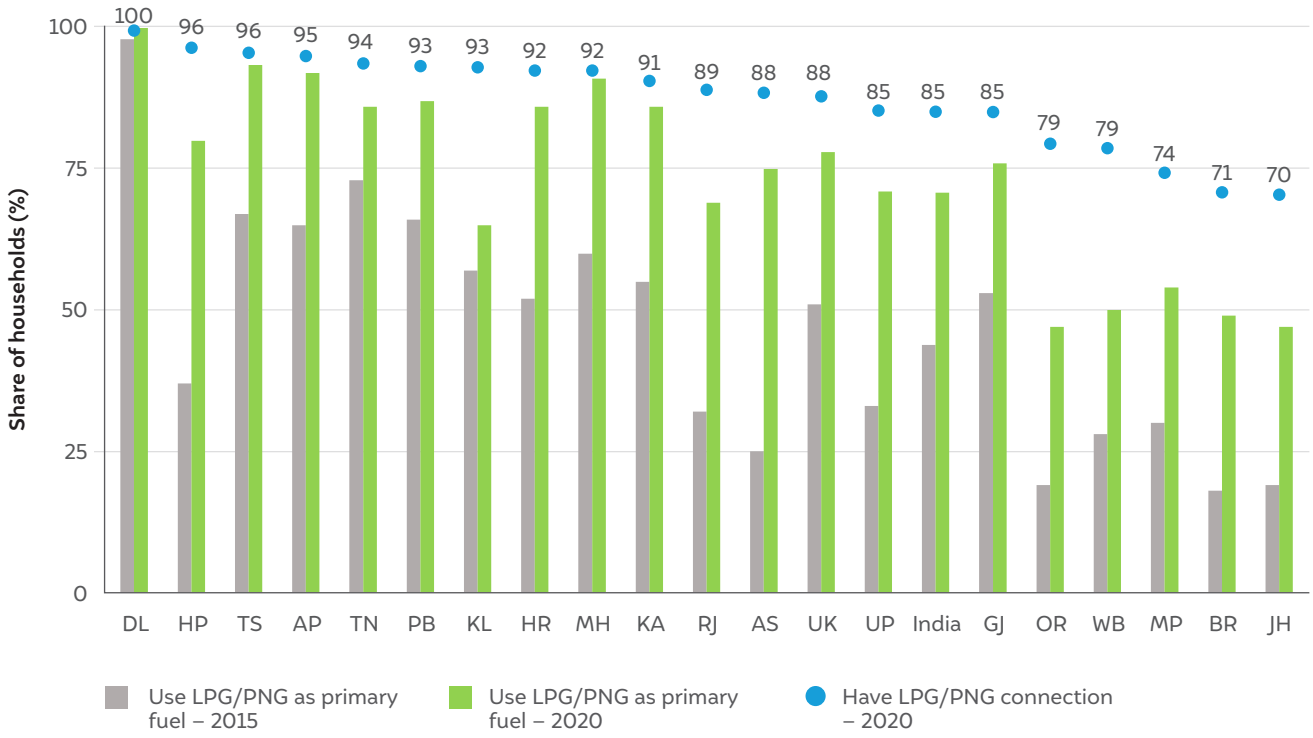
Recent insights from the fifth round of the *National Family Health Survey* (NFHS-5) also indicate that LPG connection rates in select states are considerably lower than the PPAC estimates (IIPS 2020). PMUY 2.0 should focus on identifying households without an LPG connection in these states and target them for new connections.

2.2 Variations across Indian states

Figure 5 shows that all states in India have made progress in enabling access to modern cooking fuels like LPG/PNG. There has also been a marked increase in the use of LPG/PNG as the primary cooking fuel, especially in Assam, Himachal Pradesh, Uttar Pradesh, and Rajasthan. Except for New Delhi, an urban metropolitan region, no other state has achieved universal access to clean cooking energy.

Eastern and central Indian states like Jharkhand, Bihar, Madhya Pradesh, West Bengal, and Odisha have the lowest LPG/PNG connection rates. In these traditionally energy-poor states, less than 80 per cent of households have an LPG/PNG connection and less than half use cooking gas as the primary fuel.

Figure 5 Despite progress, eastern and central India have the lowest access to clean cooking energy sources[12]



Source: Authors' analysis

Note: We use NFHS-4 (2015–16) and IRES 2020 data for this comparison. However, since the sources of data (and the sampling strategies employed) are distinct, the comparison over time should only be seen as indicative.

12. We exclude Chhattisgarh from all state-level analyses, because the IRES Chhattisgarh sample is not representative at the state level.

2.3 Why do some Indian households still not have LPG?

We asked all households without an LPG connection (15 per cent of the total) their reasons for not having one. Inability to afford LPG emerged as the most critical barrier: 80 per cent of households without an LPG connection (non-LPG households) cited the high connection cost or the recurring expense of LPG refills as the reason for not taking an LPG connection (Figure 6).[13]

An LPG user typically needs to pay INR 3,200 (~USD 44) for a new connection, which includes the connection cost (INR 1,600), the cost of an LPG stove and safety hose (INR 1,000), and the LPG refill cost (~INR 600 for a 14-kg cylinder) (Kumar 2018). Under the aegis of PMUY, the government subsidised only the LPG connection cost, and consumers had to pay the remaining amount either through a loan from OMCs or in cash. Both the initial and recurring expense represents a substantial outlay for them. Three-fourths of households without LPG connections earn less than INR 10,000 per month and live in *kuchha* (temporary) or semi-*kuccha* homes. Further, a majority of these households rely on labour activities as their primary income source.

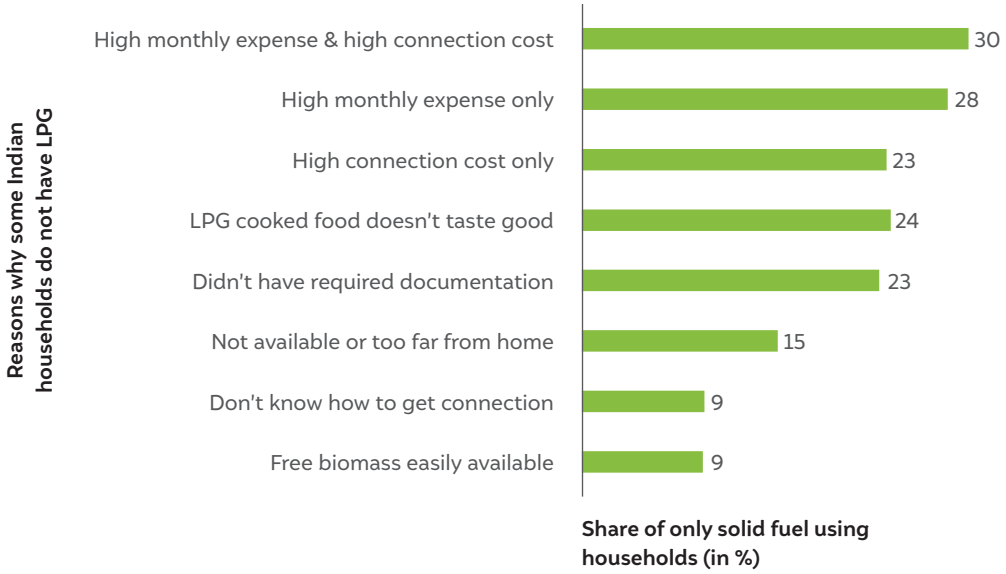


Figure 6
Most households cite unaffordability as the reason to not take an LPG connection

Source: Authors' analysis

Around a quarter of non-LPG households reported that they do not like the taste of food cooked on an LPG stove. Households' lack of the required documentation or awareness about the enrolment process also emerged as barriers to taking LPG connections. This is even though PMUY aimed to simplify the enrolment process by reducing documentation requirements and introducing a quick application process through outreach camps (Giri and Aadil 2018). Some households also highlighted the non-availability of LPG in their vicinity and the easy availability of biomass as reasons for not having an LPG connection. We also list some key gaps noticed during the implementation of PMUY that may have affected LPG uptake (Box 2).

13. Some households reported that they did not know how to apply for an LPG connection but also did not have the required documentation. We cleaned their responses and only count them under households with documentation issues. We did this under the assumption that households that are aware that they do not have the required documentation must have some knowledge of the process of getting an LPG connection.

It is important to note state-level variations here. While the high monthly expenditure on LPG refills was cited as the biggest bottleneck in states such as Bihar, Madhya Pradesh, Uttar Pradesh, Chhattisgarh, Tamil Nadu, and Jharkhand, the high connection cost was the biggest barrier in Karnataka and Uttarakhand. Further, a relatively large share of non-LPG households in West Bengal cited documentation-related challenges (34 per cent). These findings indicate that OMCs need to deploy state-specific or even district-specific efforts to ensure LPG access for the remaining households.

BOX 2 Gaps during the implementation of the PMUY scheme: additional insights from the field

Like in the case of any scheme of such magnitude, some implementation challenges were reported during the rollout of **PMUY** as well (Rao et al. 2020). We list some of them below, based on our field visits during the survey and our interaction with a few key informants in the LPG sector.

1. Mediators increase the upfront cost barrier for potential LPG adopters

During our field surveys in Sultanpur district in Uttar Pradesh, some households reported that they had to pay the local-level mediator/broker to get an LPG connection, as they were not familiar with the process. These informal costs further inflate the LPG adoption cost and act as a significant deterrent for households whose willingness to pay for an LPG connection is already low.

2. Limited focus on safety from accidents while distributing LPG connections

Most PMUY beneficiaries are first-time LPG users and may not be aware of the safety measures to be followed when handling LPG. However, in their haste to achieve time-bound PMUY targets, LPG distributors often fail to train beneficiaries on safety measures. Several instances of PMUY beneficiaries following unsafe LPG practices have been reported (for example, stoves placed below the cylinder level) (CAG 2019). Unsafe LPG usage behaviour can lead to fatal accidents (Sharma 2016). Therefore, future schemes must focus on providing training to LPG users in vernacular languages through mass media and must also account for distributors' limited capacity to educate consumers about safety measures.

3. Inadequate commissions for LPG distributors

We also found that distributors only receive a commission of INR 100 (USD 1.4) for every new connection (under the PMUY), though the actual cost of distribution ranges from INR 150 (USD 2.1) to INR 250 (USD 3.4). The distributor commission (from the sale of subsequent refills to PMUY beneficiaries) was supposed to help them recover these losses. However, many PMUY beneficiaries did not buy subsequent refills, which resulted in significant losses for many distributors. To offset these losses, some distributors compromised on the quality of LPG stoves and hose pipes (by selling low-cost, poor-quality LPG stoves and non-standard hose pipes), which further increased the likelihood of accidents.

OMCs should adequately address such challenges in the implementation of PMUY 2.0 so that neither beneficiaries nor any other implementing actor has to suffer additional losses.

2.4 Chapter conclusion

As per our analysis, India has made phenomenal progress in improving household access to clean cooking fuels. However, 15 per cent of Indian homes still do not have access to clean cooking energy. Most households without an LPG connection are located in traditionally energy-poor states. The major reasons why some households have not applied for an LPG connection, though they vary across states, include affordability and administrative hurdles.

Government support through schemes like PMUY has been effective in bridging the access gap. With the roll out of PMUY 2.0, there is an opportunity to identify and support more households from marginalised socioeconomic backgrounds. However, more than one-fourth of the non-users we surveyed explicitly cited that the high recurring expenditure on LPG refills was the reason they did not have an LPG connection. Thus, efforts to improve LPG access would need to be supplemented by incentives to make LPG consumption affordable.

Household surveys are an important tool to understand how consumers' energy choices and behaviour evolve over time.

Image: iStock

3. Ensuring the sustained use of LPG

Providing connections for clean fuels like LPG is necessary but not sufficient to entirely displace the use of traditional fuels for cooking. Fuel stacking is a major deterrent to reducing HAP in Indian homes. This chapter discusses the extent and drivers of fuel stacking in Indian kitchens and ways to address it.

3.1 Fuel stacking in Indian homes

As per the IRES, while 85 per cent of Indian households use clean cooking fuels, only 47 per cent use them exclusively (Figure 7). Thus, almost half of LPG users in India stack them with polluting solid fuels.[14] Almost all of the households that stack solid fuels are located in rural India, where around two-thirds of the households that use clean cooking fuels engage in stacking. Worryingly, around one-fourth of clean fuel users continue to use solid fuels as their primary cooking fuel in rural India.

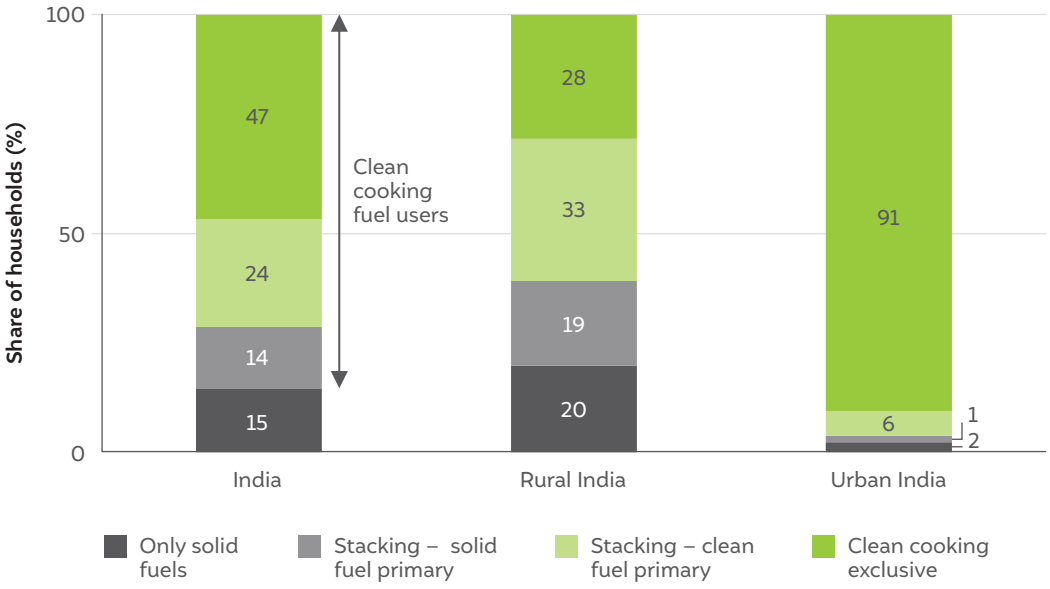


Figure 7
More than half of rural households in India stack LPG with solid fuels[15]

Source: Authors' analysis

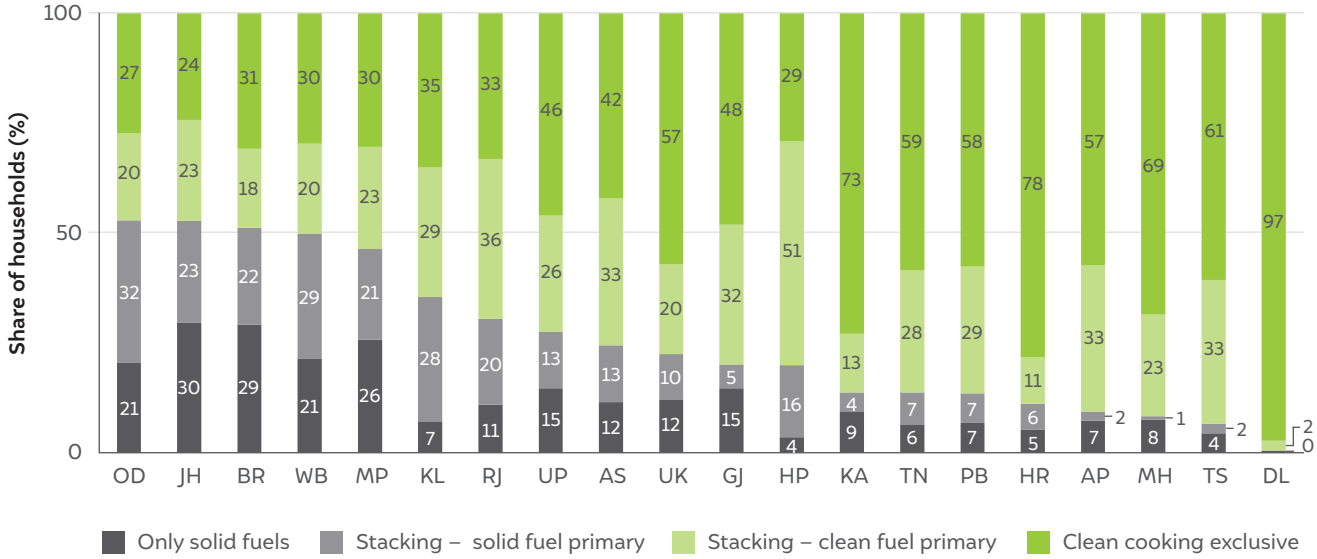
Note: Out of the 52 per cent of households that stack clean cooking fuels with solid fuels in rural India (the sum of the light green and grey bars), 0.46 per cent do not use LPG and stack electricity with solid fuels.

14. As 99 per cent of households using clean cooking fuels use LPG, we use LPG users and clean fuel users interchangeably in the context of stacking.

15. We separately asked respondents about which cooking fuels they used as well as their primary cooking fuel. Based on this information, we divided households into four different categories: i) using only solid fuels, ii) using only clean fuels, iii) stacking LPG and solid fuels, but using LPG as the primary fuel, iv) stacking LPG and solid fuels, but using solid fuels as the primary fuel.

Figure 8 shows the level of stacking by state. Odisha has the highest proportion of households that use solid fuels as the primary cooking fuel while stacking with clean fuels (32 per cent), followed by Kerala, West Bengal, Jharkhand, Bihar, Madhya Pradesh, and Rajasthan. In southern India, Kerala is the only state that exhibits a high degree of stacking. Interestingly, Himachal Pradesh has the highest proportion of households that stack (67 per cent). This is primarily because a high share of households in this state use energy for space heating (85 per cent) and water heating (99 per cent) given its temperate climate (Agrawal, Mani, Aggarwal, et al. 2020). Thus, in Himachal Pradesh, fuel stacking is also driven by non-cooking energy needs. To identify robust solutions to reduce stacking, we discuss various reasons for stacking at the national and state levels in the next section.

Figure 8 Eastern and central Indian states have the highest level of solid fuel use and stacking

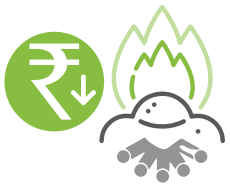


Source: Authors' analysis

Note: From left to right, we have arranged states in the decreasing order of the sum of solid fuel exclusive and primary usage.

3.2 Why do LPG users stack solid fuels for cooking?

We asked all households owning LPG but not using it as the exclusive cooking fuel the reasons for stacking it with solid fuels. We find that, similar to LPG non-adoption, fuel stacking is also an affordability issue. Most stacking households cite high expenditure on LPG refills as the reason for stacking (Figure 9). This follows other reasons, including a preference for *chulha*-cooked food, easy access to free biomass, and the lack of timely LPG refills. A significant share of households using solid fuels as the primary fuel reported these constraints, suggesting that more interventions would be required to help them transition to sustained LPG use.



Similar to LPG non-adoption, fuel stacking is also an affordability issue

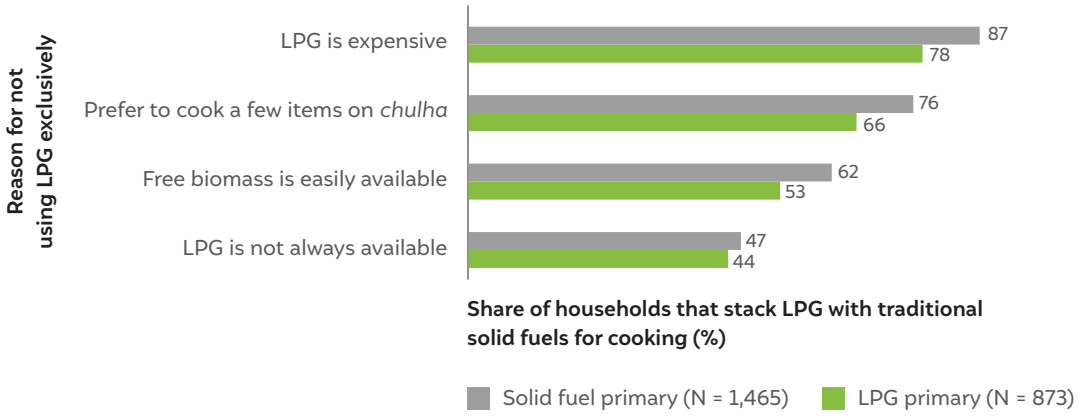


Figure 9
Households cite multiple reasons for stacking solid fuels with LPG

Source: Authors' analysis

Note: Even though 5,434 sample households reported that they stacked LPG with solid fuels in the IRES, our assessment is based on the responses of only 2,338 households that explicitly reported that they do not use LPG exclusively.

We also find that the drivers for fuel stacking differ widely across states, as shown in Table 1. Even though the issue of LPG affordability is prevalent across most states, the availability of free of cost biomass significantly reinforces it in states like Himachal Pradesh, Odisha, Jharkhand, and Uttarakhand. In Haryana, Kerala, and Rajasthan, cultural preferences for cooking on *chulhas* emerged as the top most reason, thus implying that such states would require concerted efforts to bring about behaviour change. Chhattisgarh, Madhya Pradesh, and Rajasthan are three states where LPG availability is also a dominant concern. Our analysis suggests that each state in India would require a specific strategy to incentivise exclusive LPG use.

Table 1 Drivers for fuel stacking vary widely across states in India

Region	State	LPG is expensive	Prefer to cook a few items on *chulha*	Free biomass is easily available	LPG is not always available
		As a share of LPG users that also use solid fuels for cooking (in %)			
North	Haryana	84	92	22	14
	Himachal Pradesh	96	57	92	36
	Punjab	86	54	25	25
	Uttarakhand	83	40	94	40
Central	Chhattisgarh	88	90	75	82
	Madhya Pradesh	89	78	73	75
	Uttar Pradesh	93	71	65	59
East	Assam	67	57	67	43
	Bihar	93	46	39	29
	Jharkhand	89	51	81	52
	Odisha	72	88	93	24
	West Bengal	84	75	16	23
West	Gujarat	52	84	56	54
	Maharashtra	88	60	56	73
	Rajasthan	84	90	80	73
South	Andhra Pradesh	64	55	55	9
	Karnataka	59	60	40	27
	Kerala	79	88	73	36
	Tamil Nadu	83	26	34	34
	Telangana	43	71	67	0
	India	84	72	59	46

Source: Authors' analysis

Note: The sum is greater than 100 per cent for all the states, as households cited multiple reasons for fuel stacking.

3.3 LPG consumption trends

The LPG refill consumption rate is a useful proxy to track households' transition to the clean cooking fuel. As per the IRES, an average LPG-using household in India consumes 6.7 LPG refills (or ~95 kg of LPG) in a year. The refill rates are higher among urban households, despite smaller family sizes (Figure 10a), primarily due to the low prevalence of stacking (Figure 7). A typical household that stacks LPG with biomass, but uses the latter as the primary cooking fuel, consumes four refills annually on average. On the other hand, households that consume LPG exclusively require 7–8 refills in a year.

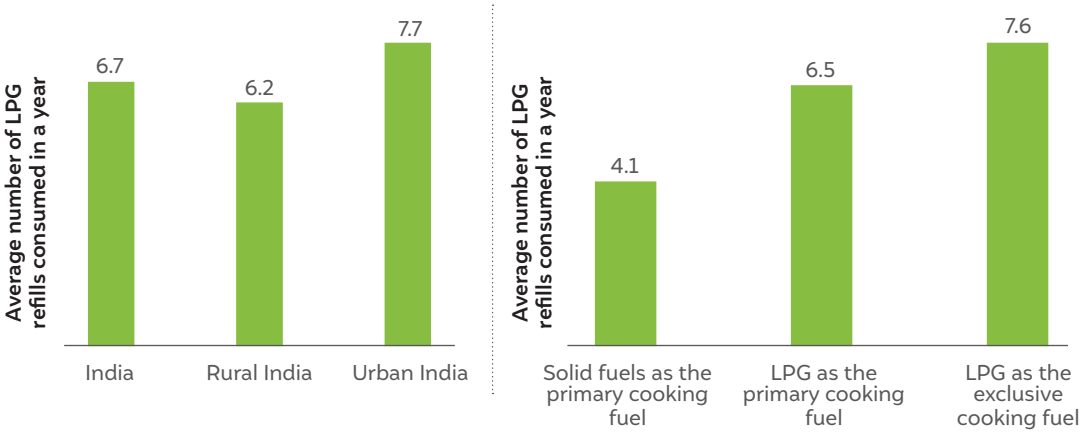


Figure 10a
LPG refill consumption is higher in urban India and highest among exclusive LPG users

Source: Authors' analysis

We also observed that households with older LPG connections have a higher refill rate (Figure 10b). This is partly because households get used to the convenience of LPG-based cooking over time. In addition, they have also had more time to adjust their cooking habits/practices and to adjust their household cash flows to accommodate the recurring expense of LPG refills (Mani et al. 2020).

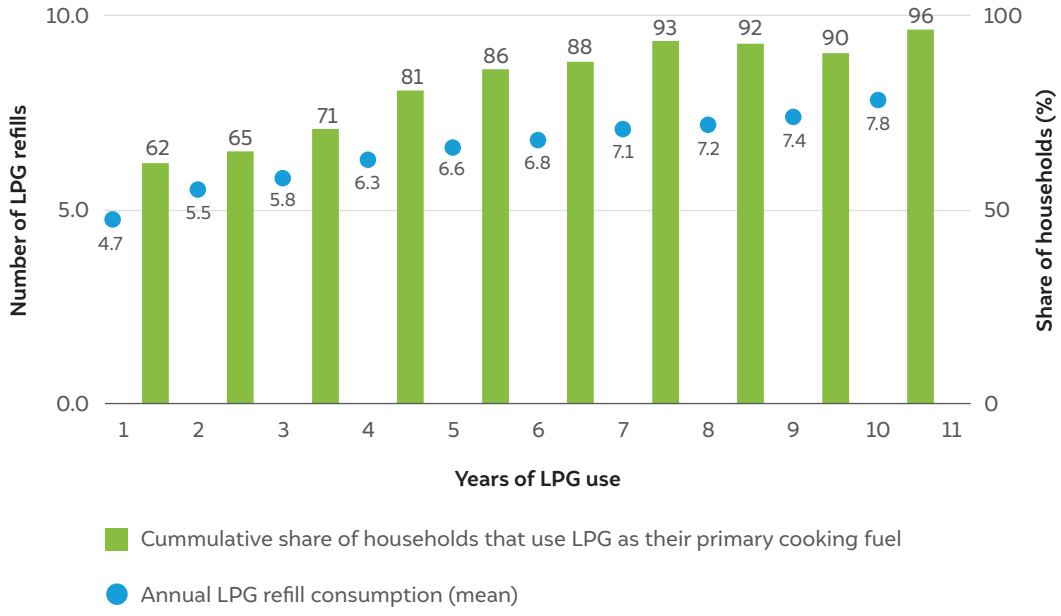


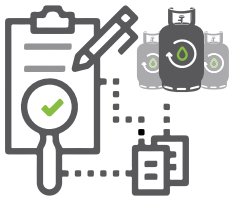
Figure 10b
Average LPG refill consumption is higher among households with older connections

Source: Authors' analysis

Note: To estimate average refill rates, we grouped households by their years of LPG usage. Ideally, multi-year panel data should be used to observe changes in LPG consumption over time.

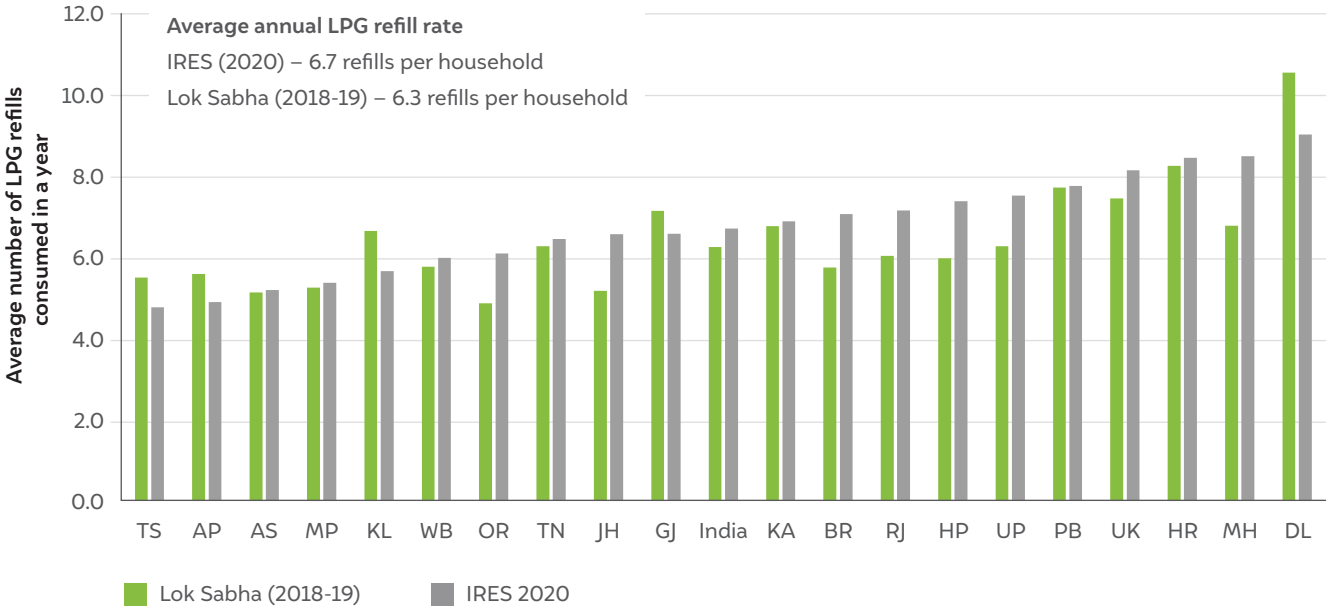
Average refill rates also vary widely across states. Delhi has the highest average refill rate of nine LPG cylinders (14.2 kg) per annum, while households in Andhra Pradesh, Assam, Madhya Pradesh, and Telangana reported the lowest refill rates (Figure 10c). The low refill rates in Assam and Madhya Pradesh appear to be linked to the high prevalence of stacking among rural households, large number of new connections, and low home delivery rates.[16] In contrast, low refill rates in Andhra Pradesh and Telangana could be partly attributed to smaller family sizes. See Annexure 4 for an assessment of the determinants of LPG consumption among surveyed households.

A comparison of self-reported refill rates from the IRES and administrative data from a Lok Sabha report suggests that the former reports higher refill rates for many Indian states (Figure 10c).[17] In another study in Karnataka, 78 per cent of the surveyed households overreported their LPG consumption (Kar et al. 2020). This could either be because of the presence of duplicate connections in the government data or social desirability or recall bias during a survey. The availability of administrative refill data in the public domain could facilitate a more robust assessment of changing LPG consumption patterns in the country.



The availability of administrative refill data in the public domain could facilitate a more robust assessment of changing LPG consumption patterns in the country

Figure 10c Survey estimates of LPG consumption are sometimes higher due to recall bias or presence of duplicate connections



Source: Authors' analysis

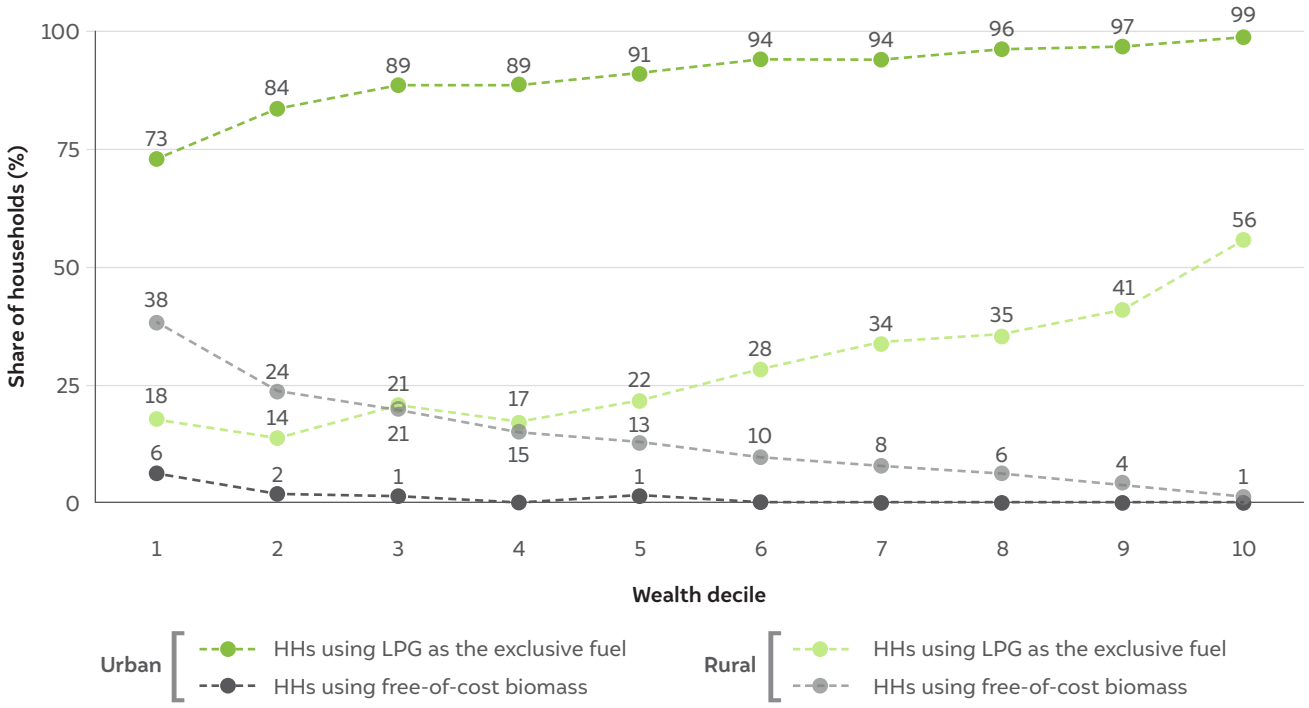
3.4 Evaluating LPG affordability for Indian households

We find that the unaffordability of LPG refills, combined with the availability of free of cost biomass, are major hurdles to households transitioning to exclusive LPG use. As evident in Figure 11, the share of households currently using LPG as the exclusive cooking fuel increases with households' purchasing power (wealth decile). It is then worth asking: is LPG at current prices affordable for all Indian households?

16. LPG refill rates at the state level are strongly, positively, and significantly correlated with average household expenditure (0.81), LPG connection age (0.61), and home delivery rates (0.56). Refill rates are also negatively correlated with the share of stacking households in the state (-0.60).

17. Administrative data is the information held by OMCs on the number of LPG refills procured by each consumer.

Figure 11 With increasing household wealth, exclusive use of LPG rises and reliance on free-of-cost biomass for cooking drops



Source: Authors' analysis

One popular measure used to assess the affordability of energy services is the 'affordability ratio', defined as the ratio of the monthly expenditure on energy services to the overall household expenditure (Fankhauser and Tepic 2007). The higher the affordability ratio, the lower the affordability of an energy service. Using this approach, we evaluated the affordability of LPG for both rural and urban households across wealth deciles, assuming all households rely exclusively on LPG.[18]

We estimate the clean cooking energy affordability ratio as the ratio of expenditure needed for exclusive LPG use and the household average monthly expenditure in each wealth decile. We assume that rural households can meet their annual cooking energy needs through seven 14.2-kg cylinders (the average consumption of exclusive LPG users in rural areas as per the IRES). Annexure 2 shows the distribution of LPG refill consumption across households. We assume the LPG refill price to be INR 580 (USD 7.95), the subsidised LPG price in Delhi at the time of the survey (IOCL 2021; PPAC 2021b). We do not consider other monetary or non-monetary costs that households might incur while procuring LPG cylinders.

We find that the affordability ratio for exclusive LPG use among rural households ranged from 4 per cent to 9 per cent across wealth deciles, at the time of the survey (Figure 12a). On average, rural households would have had to spend 6.7 per cent of their total monthly expenditure on LPG to use it exclusively; this is ~40 per cent higher than their current expenditure on cooking fuels (4.9 per cent of the total household expense). Moreover, exclusive LPG use was deemed affordable only for rural households in the topmost wealth

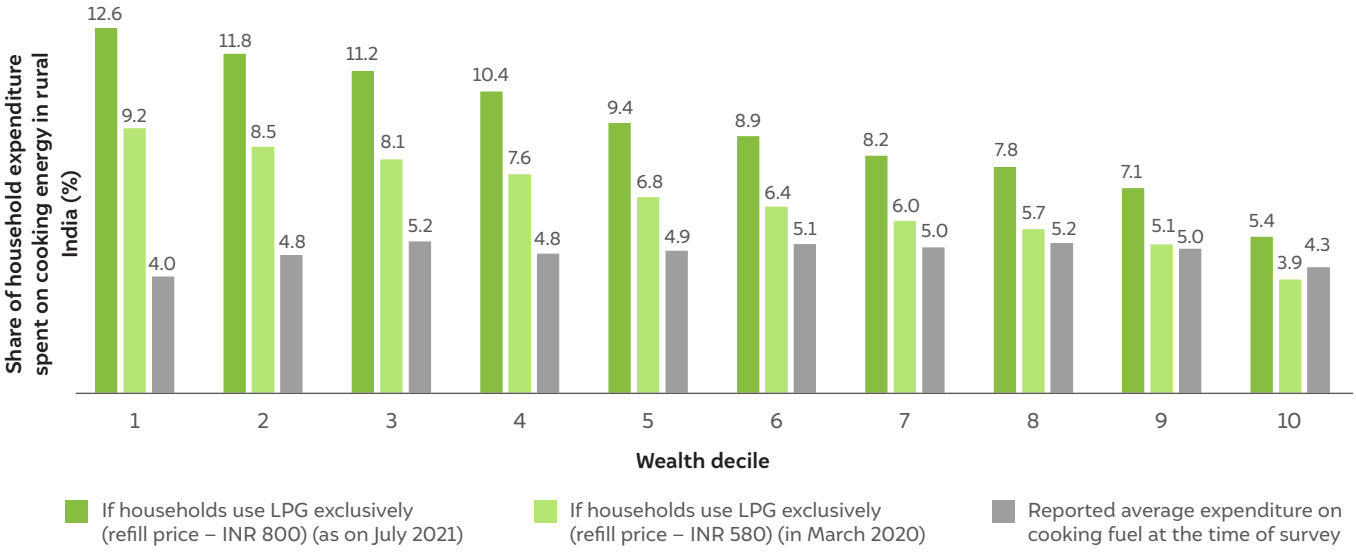
Exclusive LPG use was deemed affordable only for rich rural households

18. We computed the wealth index for each rural household using principal component analysis on select 11 indicators that capture the long-run economic status of a household. These include house characteristics and ownership of various consumer durables and motorised vehicles. Based on the relative values of this wealth index, we divided rural households into 10 wealth deciles. Please refer to Agrawal, Mani, Jain, Ganesan, et al. (2020) for further details.

decile (Figure 12a). This partly explains why fuel stacking is a common phenomenon in rural India.[19] In urban India, the average affordability ratio (5.1 per cent) was only slightly higher than the average household expenditure on cooking fuels (4.6 per cent); households mainly in the first four wealth deciles would find it unaffordable (Figure 12b).

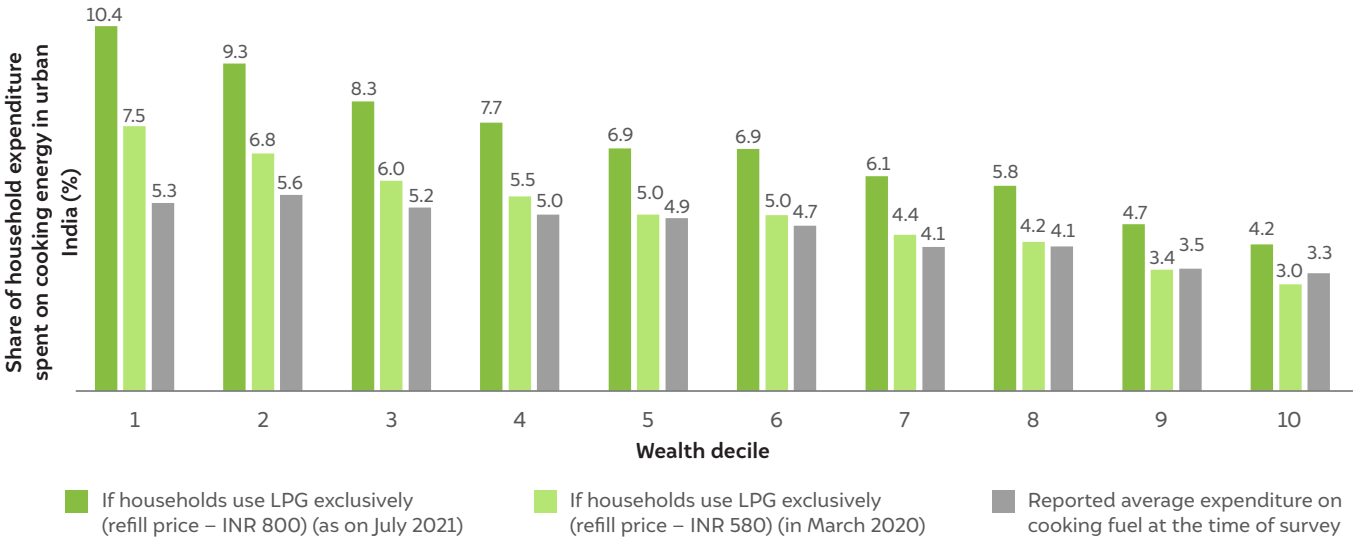
Our assessment indicates that the affordability barrier would have become even more daunting for households after the suspension of LPG subsidies in 2020. At a refill price of ~INR 800 (USD 11), the average affordability ratio for exclusive LPG use would be significantly higher at 9.3 per cent and 7.1 per cent in rural and urban India, respectively (assuming there are no changes in household income/expenditure). Combined with the drop in household incomes and monthly expenditure due to the pandemic-induced economic crisis (Basole et al. 2021), high LPG prices pose a risk to its sustained use, particularly among low- and middle-income households.

Figure 12a Most rural households would need to significantly increase their cooking energy expenditure to transition to exclusive use of LPG



Source: Authors' analysis

Figure 12b Even in urban India, withdrawal of subsidies would have made LPG unaffordable for low-income households

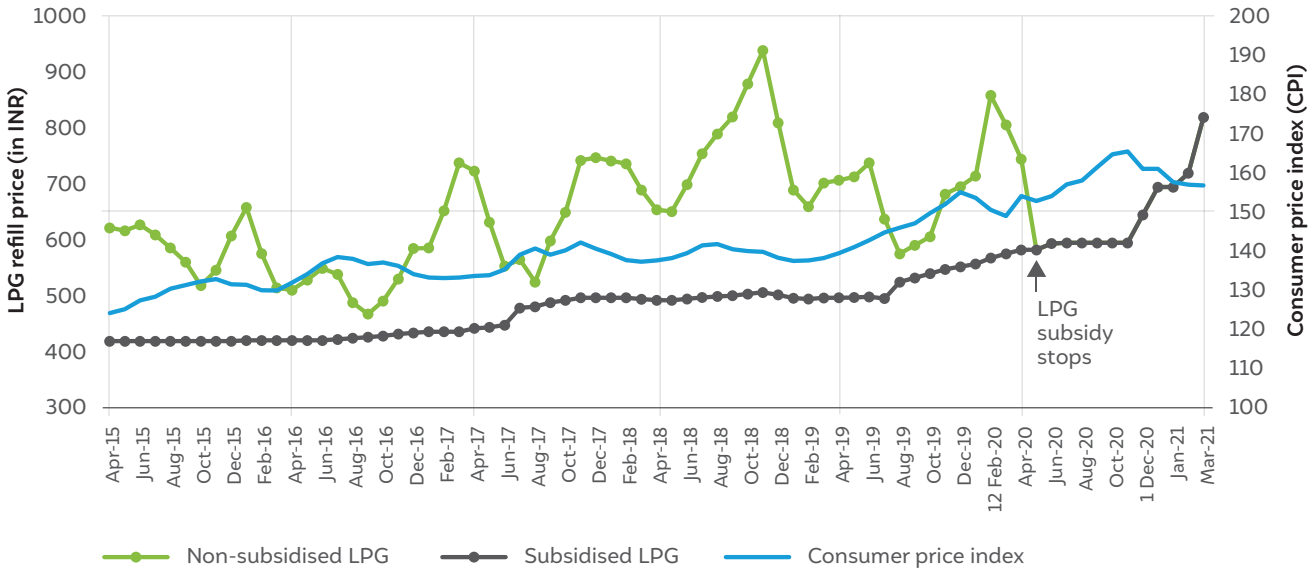


19. Households in the topmost wealth decile, where the actual expense ratio is higher than the affordability ratio, stack solid fuels predominantly due to a preference for *chulha*-cooked food (Annexure 3).

3.4.1 Targeted subsidies to make LPG affordable

LPG refills in India have been historically subsidised to i) make the fuel affordable for users; and ii) insulate the population from price fluctuations induced by global oil price movements.[20] However, the price of LPG refills for domestic consumers has almost doubled from ~INR 420 in April 2015 to more than ~INR 800 in March 2021 (Figure 13) (PPAC 2019; 2021b). Between 2015 and 2020, the subsidised LPG refill price increased by 40 per cent (from INR 420 to INR 580). Further, after the suspension of subsidies in May 2020, prices increased by another 40 per cent in a year. Overall, this translates to an annual compounded price growth of 11.6 per cent over the past six years. In comparison, the price of food commodities (consumer price index for food and beverages) grew by 4.4 per cent per year during the same period. Due to the continuous rise in LPG's market price, and the subsidies on LPG being withdrawn, more and more households are shifting back to traditional cook stoves (ET Energy World 2021).

Figure 13 The LPG refill price for domestic consumers has nearly doubled over the past six years



Source: Authors' analysis using OMCs' data (on LPG refill prices) and RBI (2021) data on inflation

Our analysis suggests that the provision of an adequate subsidy would be crucial in making LPG affordable, sustaining the gains in LPG penetration made under PMUY, and supporting households' transition away from solid biomass. Using the IRES, we estimated that an effective price of INR 450 (~USD 6.2) per cylinder would be needed to ensure that the average affordability ratio for exclusive LPG use reduces to 4.8 per cent or the average share of actual household expenditure on cooking energy at the time of the survey. So, any subsidy that can bring down the net out-of-pocket expenditure on one LPG refill to INR 450 could be a good starting point. At the July 2021 market price of ~INR 800 per refill, a subsidy amount of INR 350 per refill would be needed.

However, the fiscal burden associated with universal subsidies is very high. It is important to target subsidies to deserving households. Below, we discuss some approaches that could be piloted for targeting LPG subsidies.

20. Around 56 per cent of the LPG consumed in India is imported (direct or as crude oil) (PPAC 2021c).

Subsidising up to 7–8 LPG refills annually for domestic use

Before the discontinuation of LPG subsidies, households received subsidies for 12 LPG refills in a year. As per the IRES, a typical household relying exclusively on LPG for cooking consumes around 7–8 refills in a year. Limiting the subsidy to 7–8 LPG refills annually (as against 12 refills) could reduce the subsidy bill by 13–15 per cent.21 This will also result in better targeting, as three-fourths of exclusive users consuming more than seven refills annually belong to the top five wealth deciles. The exact limit could be further validated through an assessment of administrative data on LPG consumption.

Provision of adequate and targeted subsidies would be crucial to make LPG affordable

Leveraging robust indicators to exclude households with high income/wealth status

In 2018, the Ministry of Petroleum and Natural Gas (MoPNG) announced the exclusion of households with an annual income greater than INR 1 million (USD 13,700) from the LPG subsidy. However, only 4.6 million individuals fall in this category, making up less than 2 per cent of Indian households (assuming one such individual from one household) (Financial Express 2020). Reforming the income-based exclusion limit to INR 250,000/year (USD 3,425) would help exclude a greater share of households.22 Even assuming annual consumption of 12 refills, households earning more than INR 250,000/year (USD 3,425) would spend less than 4 per cent of their monthly income on LPG without subsidies.

However, significant inclusion errors are possible while relying on income tax declarations alone, partly because the LPG connection and tax returns may belong to different individuals within the same household. More research is needed to identify robust measures of targeting economically weaker households. For instance, excluding households that own a non-commercial four-wheeler vehicle or real estate worth certain amounts.

Using historic consumption data to provide differential subsidies

As per our analysis, households that are lower in the economic ladder exhibit lower refill rates, ceteris paribus (Annexure 4). The administrative data on LPG refills could be used to better study linkages between households' LPG consumption behaviour and its affordability. This assessment could be used to target subsidies to consumers with low refill rates – a consumption-linked approach. For instance, consumers with an annual consumption of up to three refills (in the past 1–2 years) could be given a higher subsidy per refill than those with a historic consumption of 4 to 7 refills.

More research is needed to identify robust measures of targeting economically weaker households

It must be noted that any targeting measure would likely incentivise households that would no longer be eligible for the subsidy to take up multiple LPG connections or exploit other loopholes in the targeting mechanism. The presence of multiple connections is

21. Based on an assessment of refill rates reported in the IRES as well as administrative data from an OMC.

22. During the financial year 2018–19, nearly 57.8 million individuals in India filed their income tax returns. Of these, nearly 47.5 million individuals declared an annual income greater than INR 25 million. Assuming one such individual represents a separate household and a household population of 250 million, excluding them from subsidy could excludes ~20 per cent of households (*Financial Express* 2020).

already a serious issue (see Section 2.1). Thus, periodic deduplication efforts and a delivery authentication code (DAC) system would be essential to address this concern.[23]

It is also important to highlight that the above suggestions are based on the evidence available from various studies (including the IRES) and stakeholder consultations. There may be various implementation challenges with each of the suggested approaches, and the final targeting strategy should only be based on robust evidence from pilot projects.

3.4.2 Tracking subsidy receipt on LPG refills

Besides subsidy provision, ensuring timely subsidy receipt is also important. Since 2015, the LPG subsidy was directly credited to consumer' registered bank accounts after every refill (Jain, Agrawal, and Ganesan 2018). However, there have been instances of the subsidy getting transferred to the wrong account or there being no subsidy receipt at all (*The Hindu Business Line* 2018; Anbuselvan 2019). Thus, it is important to monitor whether households are aware and able to access the subsidy transferred to their accounts.

In the IRES, all LPG users were asked whether they received any subsidy on their last LPG refill. Sixty per cent of LPG users confirmed receiving the subsidy and another five per cent reported that they had given it up.[24] However, 13 per cent of households did not receive the subsidy, and 23 per cent were not aware of it (Figure 14). We also found that the issue of non-receipt of LPG subsidies is highest in certain states such as Bihar, Madhya Pradesh, Jharkhand, and Gujarat (Annexure 5).

We also find that the issue of subsidy non-receipt or lack of awareness is more pronounced among PMUY beneficiaries. As per our survey, around 30 per cent of PMUY households paid for their LPG connection cost through a loan from the OMCs. This suggests that loan adjustment could be the reason for the non-receipt of LPG subsidies among PMUY households.

However, even after excluding PMUY households, non-receipt of LPG subsidies remains a concern for eight per cent of LPG users, which is still a significant share (Figure 14). This reflects gaps such as i) the user's mobile number is not registered with the bank, ii) the household's primary bank account is not linked with Aadhaar or the LPG account, or iii) household indifference or inability to access mobile messages informing them of the subsidy transfer. Our analysis highlights the need for information campaigns to encourage LPG consumers to check for the subsidy receipt in their bank accounts and update their phone numbers or bank details on a rolling basis.

Information campaigns could help encourage LPG consumers consciously check subsidy receipts in their bank accounts

23. In the DAC system, an individual receives an OTP on the registered mobile number after making a booking. At the time of delivery, that code has to be shown to receive the LPG cylinder. While the Government of India mandated DAC for LPG refill delivery, field reports suggest that deliveries are still taking place without the DAC.

24. 'Give Up LPG Subsidy' was a campaign launched by the Indian government in March 2015. It aimed at motivating better-off households to voluntarily surrender their LPG subsidy. As of 11 November 2019, more than one crore LPG consumers have given up their subsidy under this campaign.

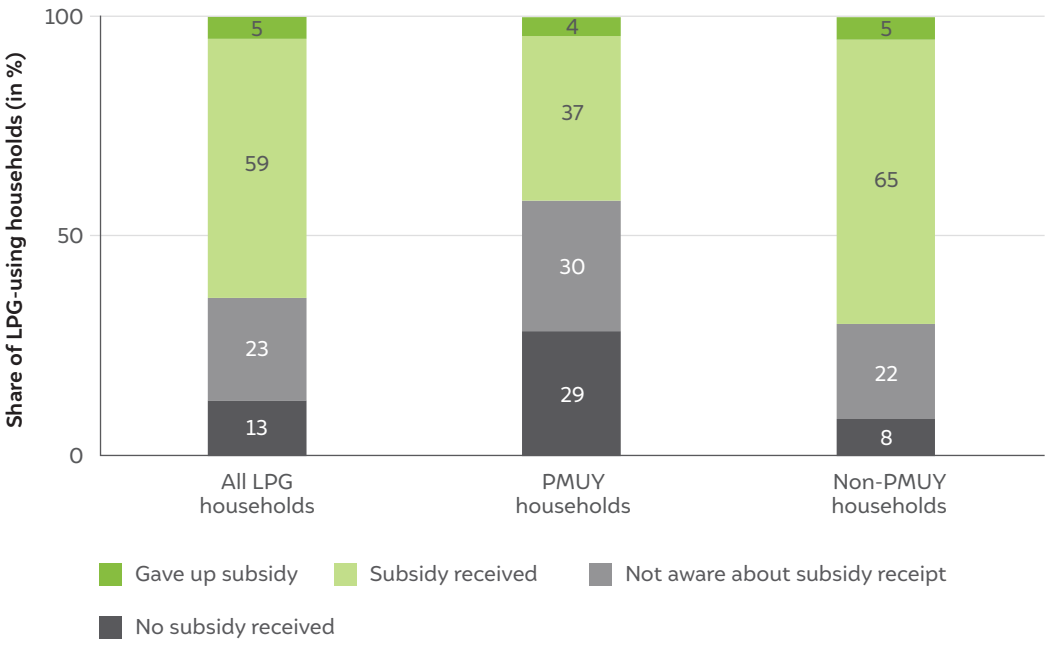


Figure 14
Around one-third of LPG users either did not receive a subsidy on their last refill or were not aware of it

Source: Authors' analysis

3.5 Measuring ease of LPG availability

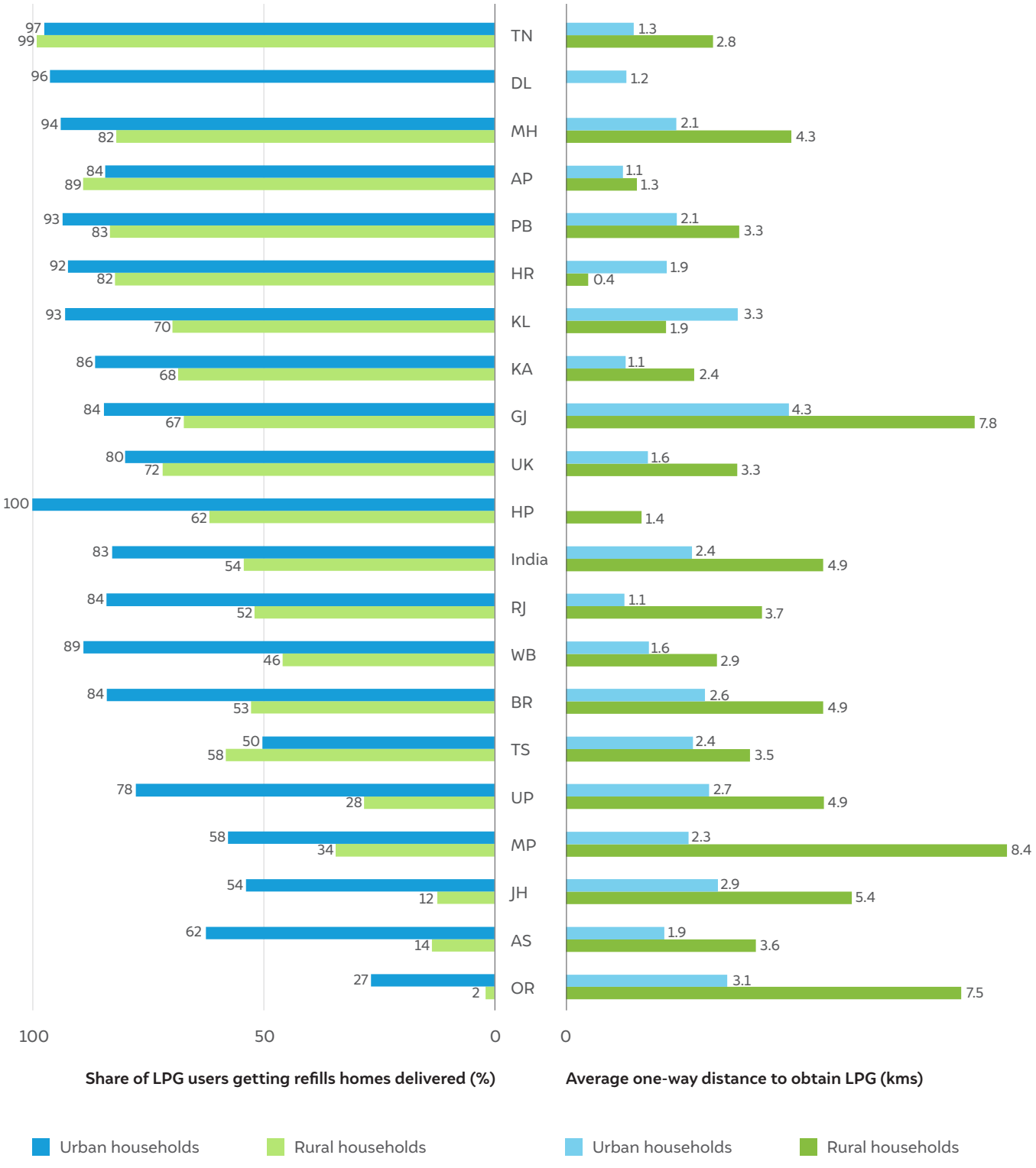
Apart from affordability, the limited availability of LPG refills is another key reason cited by 46 per cent of households for stacking LPG with solid fuels (Figure 9). Ease of LPG availability depends on several factors: i) access to home delivery; ii) travelling distance (and the associated economic implication) to procure an LPG cylinder (if there is no free delivery), and iii) the time taken for delivery after placing the order. Below, we discuss the key insights from the IRES for each of these factors.

As per the IRES, only 64 per cent of LPG users in India receive home delivery for their LPG refills. About 83 per cent of urban consumers and only about 54 per cent of rural consumers receive home delivery of LPG. In the absence of home delivery, households have to travel an average one-way distance of 4.9 km in rural areas and 2.4 km in urban areas.

Only 64% of LPG users in India receive home delivery for their LPG refills

Figure 15 illustrates home delivery rates for LPG cylinders by state. Except for Bihar and West Bengal, almost all central and eastern Indian states have very poor home delivery rates. For instance, only one-tenth of LPG users in Odisha and one-fifth of LPG users in Jharkhand and Assam receive home delivery of LPG refills. Households in these states (more so in rural areas) also have to travel the longest distances to collect their LPG refills. Except in a few states, there exists a wide disparity in LPG home delivery rates between urban and rural consumers. Similarly, there is a wide rural–urban variation in the one-way distance travelled in almost all the states except Andhra Pradesh.

Figure 15 Consumers in states with low LPG home delivery rates have to travel the farthest to procure it



Source: Authors' analysis

Note: The long distance travelled for rural households in Gujarat was mainly because LPG distributors in the surveyed districts were on strike when it was being conducted.

Figure 16 shows the correlation between the share of households getting LPG home delivered and other relevant factors. We observe higher rates of home delivery in states with households using older LPG connections and having higher refill rates.[25] Further, in districts with a higher share of PMUY households and more newly connected households, the home delivery rates are poorer (Annexure 6). This could be because distributors have a low incentive to incur high travel costs despite low demand. This issue is compounded by low consumer density in rural areas, as distributors have to travel long distances to make home deliveries without any additional financial incentive.

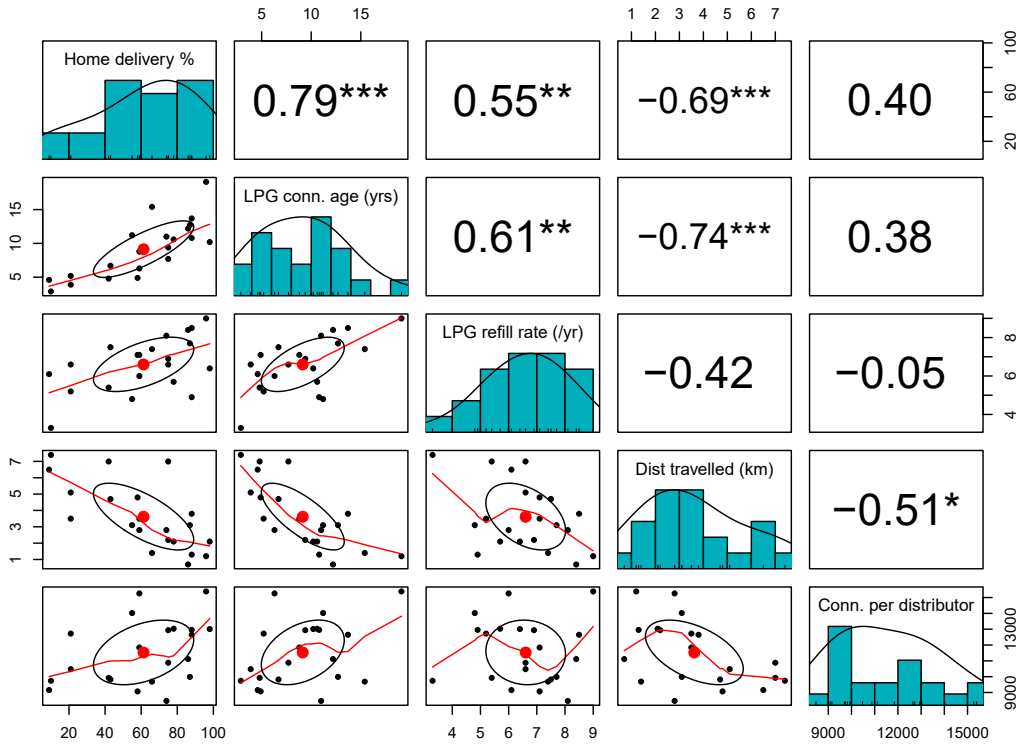


Figure 16
LPG home delivery rates are higher in states with higher refill rates, older connections, and higher connection density

Source: Authors' analysis

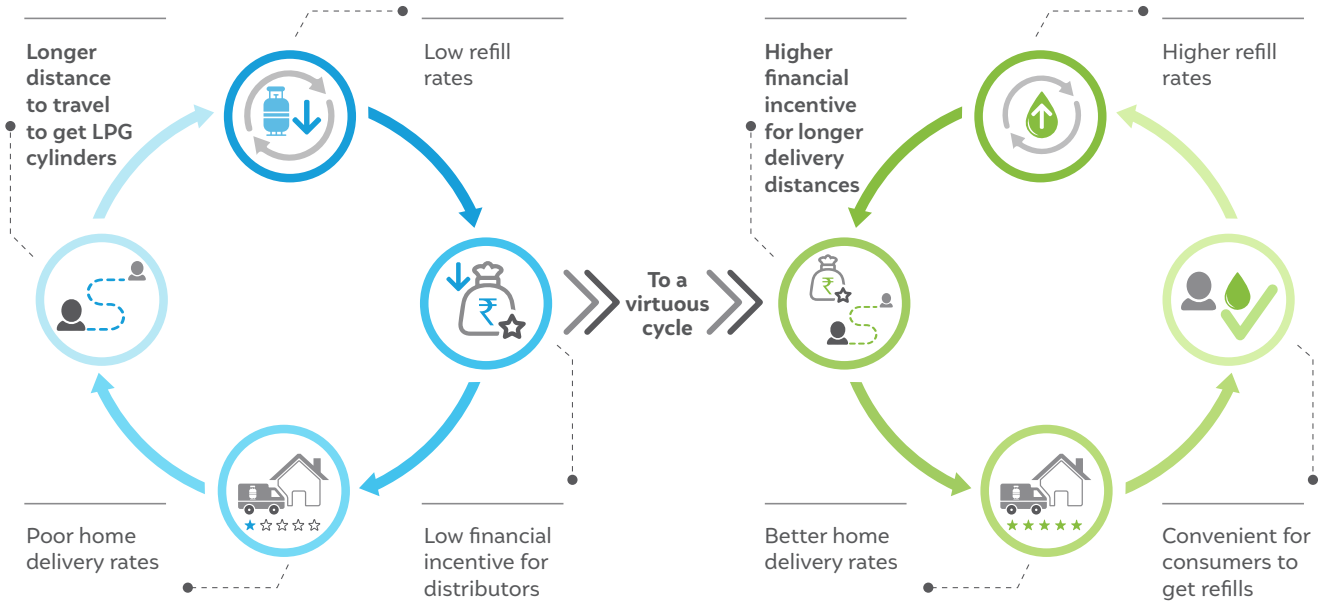
Note: The plot shows the Pearson correlation coefficient between home delivery rates across states and other factors such as the average age of the LPG connection, average annual refill rate, the one-way distance travelled by households for procuring LPG (in the absence of home delivery), and connection density per distributor, as per PPAC (2021a). The stars show the significance level of the correlation coefficient.

Our analysis underscores the need to incentivise rural distributors through higher commissions per refill. At present, the distributor's commission for home delivery is uniform across the country at INR 62 per LPG refill (PPAC 2019; 2020b). However, it should be computed based on the cost of service provision and cylinder sales per month (Pai, Sreenivas, and Josey 2021). Figure 17 shows how differential commission provision linked to connection or settlement density could help the distributors and consumers break out of this vicious cycle.

Further, the LPG distributor network needs to be strengthened in the eastern and central states like Odisha, Jharkhand, Assam, and Madhya Pradesh. These states can consider a decentralised LPG delivery system by, for example, looping in self-help groups (SHGs) federations, and common service centres (CSCs), to achieve demand aggregation for distributors. Even though MoPNG is already trying out CSCs for LPG delivery in certain regions, there has been no public information about the model's effectiveness.

25. The correlation coefficient between home delivery rates for LPG refills and the proportion of PMUY consumers at the state level (for 21 IRES states) is -0.86.

Figure 17 Linking the distributor commission with connection density could incentivise home delivery of LPG



Source: Authors' illustration

3.5.1 Timely delivery of LPG cylinder

In India, consumers can book an LPG refill either online or by calling a centralised mobile number. Once booked, the distributor is expected to deliver the LPG cylinder within 48 hours (*The Times of India* 2013). The time gap between placing an order and LPG delivery gains importance mainly for households with only one LPG cylinder (single-bottle connection [SBC]). As per the IRES, around two-thirds of LPG users in the country have an SBC, and more than 80 per cent of them do not receive same-day delivery for LPG refills (Figure 18).

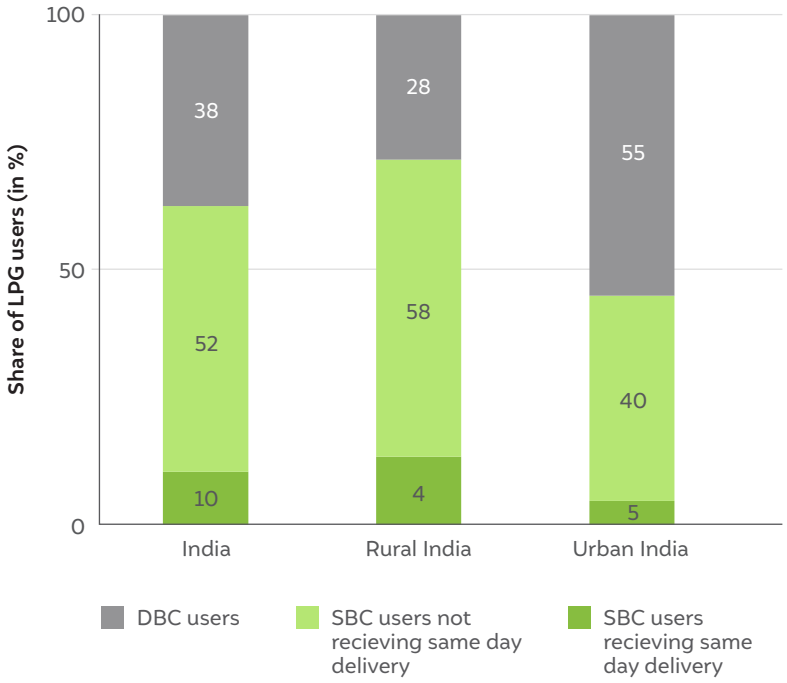


Figure 18
More than 80 per cent of LPG users with a single bottle connection do not receive same-day delivery for LPG refills

Source: Authors' analysis

Note: DBC = double-bottle connection (more than one LPG cylinder at home), SBC = single-bottle connection (only one LPG cylinder at home).

In the absence of timely delivery of refills, SBC consumers may need to rely on alternative fuels in the interim. Here, we observe contrasting trends in urban and rural India. A significant share of LPG users in both rural (58 per cent) and urban areas (40 per cent) own an SBC connection and do not receive same-day delivery; yet, 91 per cent of such households in urban areas use LPG exclusively, but this share is just 30 per cent in rural areas.

Strengthening the LPG supply chain infrastructure and incentivising same-day delivery would boost LPG use as well as local jobs

This difference may be explained by variations in the local context. Due to higher settlement density, better home delivery rates, and high DBC ownership (55 per cent), urban consumers can easily arrange LPG refills from neighbouring consumers (who have a DBC).[26] This is a common practice in urban areas, where households exchange extra cylinders for contingency purposes. In most rural areas, this opportunity to do so is more limited due to lower settlement density, poor home delivery rates, and low DBC ownership (28 per cent). The easy availability of free of cost biomass further weakens rural households' incentive to rely on LPG as an exclusive cooking fuel. About 14 per cent of rural households in India rely on free of cost biomass exclusively, while another 50 per cent collect biomass to supplement clean fuels.

One way to resolve this issue is to provide everyone with a DBC, so that households can keep an additional LPG cylinder at home. However, this would be a costly proposition. Switching from SBC to DBC requires an investment of INR 1,450 (USD 19.9) as a refundable deposit against the second cylinder along with some extra administrative charges (BPCL n.d.). Even if the government helped households finance the second cylinder through a loan, there would be a huge risk of non-recovery. OMCs are still struggling to recover the loan amount for the single cylinders they had given against loans under the PMUY (Kumar 2018). Providing DBCs free of cost to all SBC consumers would cost INR 26,000 crore, comparable to the LPG subsidy outlay in FY 2019–20 (INR 34,000 crore or USD 4.65 billion).[27]

Thus, a better alternative would be to strengthen the LPG supply chain infrastructure and incentivise same-day home delivery so that households that stack because of poor availability of LPG reduce stacking and increase their LPG refill consumption. The addition of home delivery infrastructure and the associated improvement in the refill rate can also help in job creation up to the last mile.

3.6 Chapter conclusion

Our analysis of the cooking energy choices of Indian households indicates a high prevalence of fuel stacking, mainly in rural areas. Akin to the reasons for gaps in LPG access, affordability and availability of LPG along with taste preferences and easy biomass access continue to hinder sustained LPG use in the country. Further, most households that stack LPG with traditional cooking fuels are concentrated in certain states. To reap the benefits of all the investments made in the PMUY scheme over the past four years, India must address the barriers hindering sustained LPG use. Making LPG affordable by resuming subsidies would be the first step. However, in place of a universal subsidy scheme, it would be fiscally prudent to target deserving households.

26. We find that more than 60 per cent of SBC households who use LPG exclusively receive their refills within a couple of days. This makes the duration of these exchanges very small.

27. As per the IRES, 64 per cent of LPG consumers in India do not have a DBC. Since the total number of domestic LPG consumers is ~280 million, ~179.2 million LPG consumers do not have a DBC. If we assume the cost of providing one extra LPG cylinder to be around INR 1,450 (~USD 20), it will cost around ~INR 26,000 crore (USD 3.56 billion).

Some households still prefer the taste of *chulha*-cooked food. Addressing such cultural barriers would require concerted and decentralised outreach to convince people of the benefits of using LPG and nudge behaviour change. Through LPG panchayats, the government runs awareness campaigns about the adverse health impacts of using biomass.[28]

To wean households away from solid fuels, we would need to create an opportunity cost for using the freely available biomass by, for instance, creating local biomass processing value chains, such as small-scale briquetting and pelletising units (Mani et al. 2020; Sharma, Parikh, and Singh 2019). The government of India came up with the *Sustainable Alternative Towards Affordable Transportation (SATAT)* scheme in 2018 to incentivise the setting up of compressed biogas production plants to process the abundantly available biomass in the country. However, the implementation of the SATAT scheme has been slow due to various reasons including unavailability of raw materials, shortage of storage space, lack of segregation of wastes, absence of an established biomass pricing mechanism, delays in regulatory approvals, and non-availability of financing (Abidi 2020).

Efforts are also needed to strengthen the LPG supply chain to improve its availability, particularly in states with new connections. We also need to introduce higher commissions for distributors that serve rural consumers or operate in areas with low consumer density.

Finally, it is important to note that just addressing one of the barriers in isolation might not be sufficient to ensure sustained LPG use in the future. All of these interventions will have to be implemented in tandem with each other.

28. LPG panchayats were an initiative of the MoPNG to create awareness about how using LPG is beneficial for household health and the environment. The panchayats also include creating awareness of safe practices, quality of service provided by the LPG distributors, and availability of refill cylinders in their campaigns. In one panchayat, around 100 LPG customers of nearby areas share their experiences of using LPG with each other.

4. Conclusion and policy recommendations

India has witnessed unprecedented progress in improving clean cooking energy access over the last decade, with households' use of LPG as the primary fuel increasing from 29 per cent in 2011 to 71 per cent in 2020. This change can be attributed to government efforts to improve LPG availability and affordability through increased distributorships and fuel subsidies over the past decade. However, a major thrust to improve LPG access among poor and rural households, particularly in energy-poor states, came in the form of the PMUY scheme. As of March 2020, more than 85 per cent of Indian households had an LPG connection, but unaffordability still remains a major barrier for non-consumers. Thus, PMUY 2.0, announced

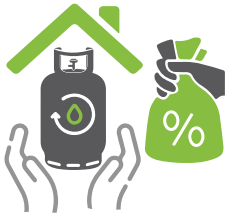
in the Budget 2021, should target and identify the remaining vulnerable households. Also, states such as Jharkhand, Bihar, Madhya Pradesh, West Bengal, and Odisha should receive special attention under PMUY 2.0, as they lag behind the national average for LPG penetration.

85% of Indian homes have an LPG connection, but high refill prices are a major barrier to its sustained use

In addition to new connections, sustained use of LPG has also improved, but it is far from attaining desirable levels. About 53 per cent of Indian households rely on solid fuels for some or all of their cooking. Use of solid fuels along with LPG – fuel stacking – means continued exposure to harmful HAP despite having an LPG connection. While affordability was found to be the biggest barrier for sustained and regular use, other factors also played a role: a preference to cook a few items on a wood fire or *chulha*, easy availability of free-of-cost biomass, and gaps in LPG availability. Interestingly, these factors play out differently across the country: households in Haryana and Kerala cited taste preferences as the biggest reason for stacking. In comparison, in Odisha and the hilly states of Himachal Pradesh and Uttarakhand, easy availability of biomass trumps all other reasons. By leveraging data through large surveys such as the IRES, OMCs and the government can devise a state-specific, or still better, a district-specific, targeting approach to address key barriers.

Despite these variations in households' reasons for stacking, affordability remains the biggest barrier to LPG adoption. For decades, the government has tried to address this challenge through recurring subsidies on LPG use. But the recent suspension of subsidies, despite the increasing market prices of LPG, puts many vulnerable households at risk of abandoning LPG altogether. Lack of reliable alternatives and habit formation over time mean that the middle to higher income groups will likely continue to use LPG despite the higher prices. However, the poor need to receive targeted support to sustain their LPG use. We estimate that an effective price of INR 450 (~USD 6.2) per refill would bring the average affordability ratio for exclusive LPG closer to the cooking energy expenditure borne by households at the time of the survey.

Overcoming affordability concerns



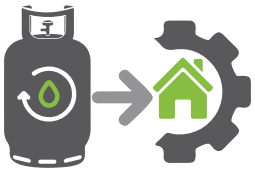
An easy-to-administer subsidy targeting approach that helps the poor continue to use clean cooking fuels is the need of the hour

Considering the COVID-linked economic crisis, both the Government of India's ability to subsidise LPG and people's capacity to pay for non-subsidised LPG have reduced. The only way out of this will be to develop an easy-to-administer targeting approach that helps the poor continue to use clean cooking fuels without putting additional pressure on government resources.

We discuss three potential approaches for targeting LPG subsidies.

- One, capping the subsidy provision to up to 7–8 LPG refills annually, which is the average consumption of exclusive LPG users in rural and urban India.
- Two, using robust indicators to exclude households with high income/wealth status. Here, the current income-based exclusion limit could be lowered from INR 1 million/year (USD 13,700) to INR 250,000/year (USD 3,425).
- Three, exploring a consumption-linked subsidy approach, where historic refill data could be used to provide higher subsidies to consumers with lower LPG consumption in the recent past.

However, all the targeting approaches pose a risk that households no longer eligible for the subsidy may turn to procuring multiple connections. Thus, appropriate deduplication and delivery authentication systems would be needed.



Integrating the LPG programme with broader social assistance and rural development programmes can promote LPG use

On the other side of the affordability equation, enhancing rural incomes should also be a focus. Thus, integrating the LPG programme with broader social assistance and rural development programmes is important. The transition from biomass to LPG will free up several hours of productive time for women who can possibly leverage those hours to perform livelihood activities promoted by the livelihood missions of their respective states. Similarly, the *Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)* can provide women workers with the option of booking an LPG cylinder against three days of work. This may also address the issue of women's lower agency in influencing LPG purchase decisions, which are otherwise usually made by the family's male head (Jha, Patnaik, and Warrier 2021).

Subsidy support for LPG and improving household incomes may still fall short of entirely closing the gap between LPG and the free-of-cost biomass. About 14 per cent of rural households in India completely rely on free of cost biomass exclusively. Creating an opportunity cost for biomass, or an opportunity cost for the time spent procuring and preparing biomass, is imperative. Promoting decentralised biomass processing into briquettes and pellets to be used in local industrial and commercial establishments can put a monetary value to the biomass, creating a potential income for those involved in gathering it.

Improving LPG availability

Beyond economics, LPG's availability also influences its sustained use. Only 54 per cent of rural consumers receive home delivery. Those who do not receive, travel about 5 km one-way to procure the cylinder, sometimes risking their daily wages in the process. The average distance to be travelled to procure LPG also varies significantly between states: from as low as 1.3 km in Andhra Pradesh to as much as 8.4 km in Madhya Pradesh. Here, again, by leveraging datasets such as the IRES, OMCs could prioritise regions where the poor availability of LPG features as a significant reason for biomass stacking. Also, incentivising rural distributors through higher commissions to cover the disproportionately high delivery costs would help improve home delivery rates and LPG's sustained use in rural areas.

Over the past decade, India has made significant strides in enhancing access to clean cooking fuels. Improving LPG's penetration among the deprived, enhancing affordability for the needy, and boosting availability for the hard-to-reach must remain the government's focus to ensure that we completely eliminate solid fuels and the associated air pollution from Indian kitchens by 2030.

Annexures

Annexure 1 LPG use as households' primary cooking fuel over the last decade in Indian states

We have compiled data on Indian households' use of LPG as the primary cooking fuel from various sources, including the *Census of India* (2011), the fourth round of the *National Family Health Survey* (NFHS-4), the 76th round of the survey (Drinking Water, Sanitation, Hygiene and Housing Condition in India) conducted by the National Sample Survey Organisation (NSSO), and the *India Residential Energy Survey* (IRES) (Table A1). The government surveys and census exercise capture information on households' use of LPG as the primary cooking fuel but not on whether the household has an LPG connection. Thus, actual LPG penetration at any point of time would be equal to or greater than the estimates of LPG use as the primary cooking fuel.

State	Share of households using LPG as the primary cooking fuel (%)			
	Census (2011)	NFHS-4 (2015–16)	NSSO (2018)	IRES (2020)
Andhra Pradesh + Telangana	36	65	86	92
Assam	19	25	59	75
Bihar	8	18	49	49
Delhi	90	98	94	100
Gujarat	38	53	67	76
Haryana	44	52	69	86
Himachal Pradesh	39	37	52	80
Jharkhand	12	19	33	47
Karnataka	33	55	81	86
Kerala	36	57	59	65
Madhya Pradesh	18	30	48	54
Maharashtra	43	60	76	91
Odisha	10	19	33	47
Punjab	55	66	85	87
Rajasthan	23	32	48	69
Tamil Nadu	48	73	87	86
Uttar Pradesh	19	33	50	71
Uttarakhand	44	51	70	78
West Bengal	18	28	43	50

Table A1
Progress of LPG as a primary cooking fuel in the last decade in Indian states

Source: Authors' analysis

Note: Since Telangana was not formed in 2011, we club it with Andhra Pradesh to show the state-level comparison.

Annexure 2 LPG refill rates among Indian households

We summarise the reported LPG refill consumption pattern from the IRES in Figures A1 and A2

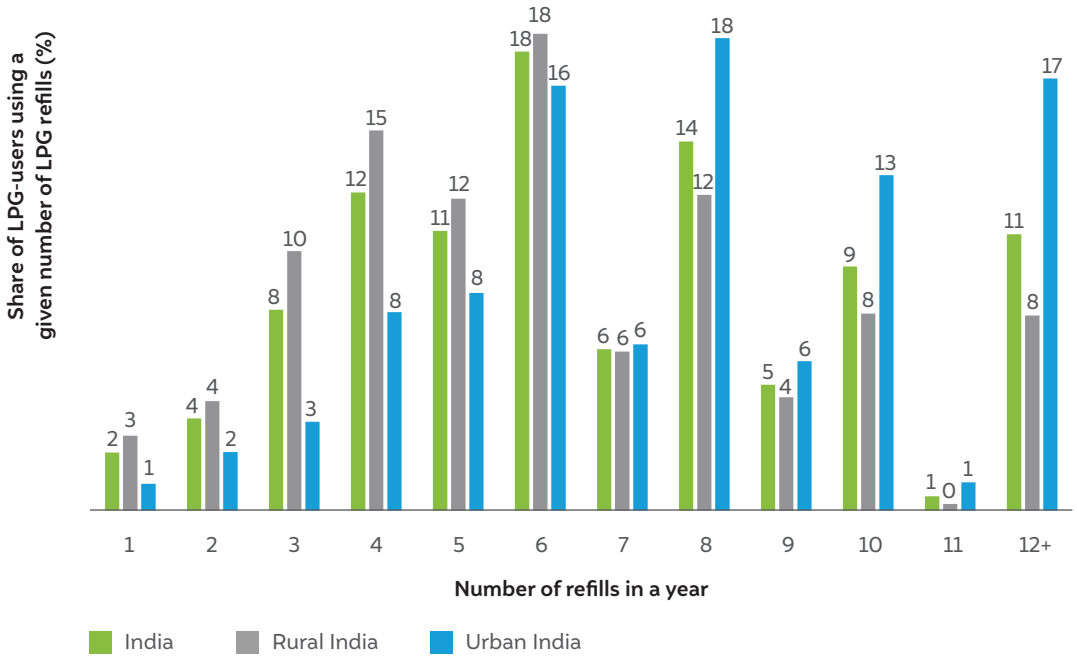


Figure A1
While the modal LPG consumption in rural India is six LPG refills in a year, it is eight refills in urban India

Source: Authors' analysis

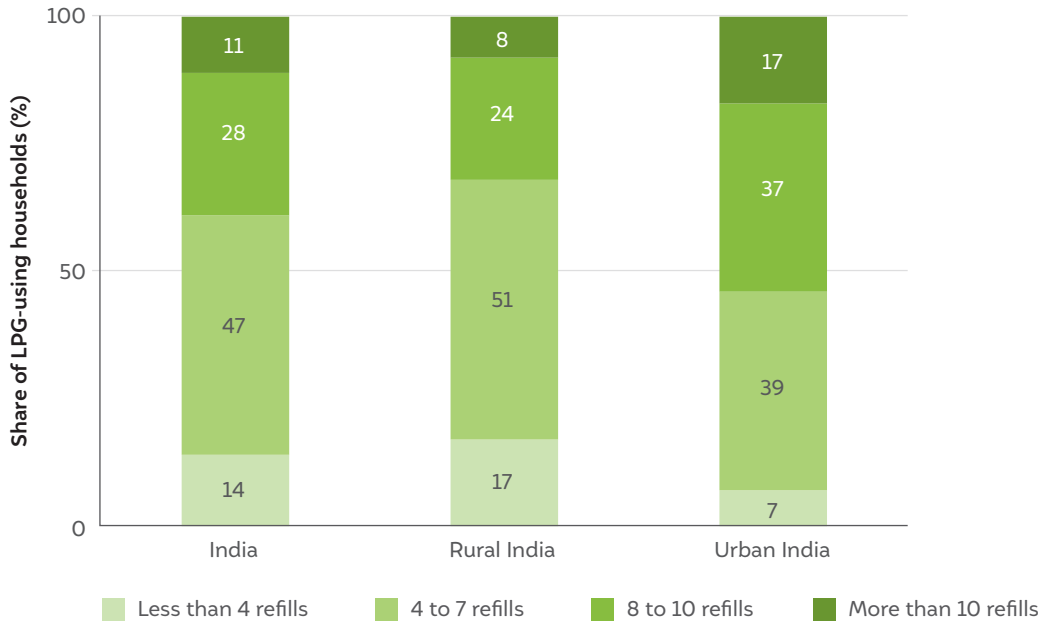


Figure A2
Around 70 per cent of rural India and 50 per cent of urban India consumes up to seven refills in a year

Source: Authors' analysis

Annexure 3 Reasons for stacking LPG with solid fuels by purchasing capacity

We asked LPG-using households their reasons for stacking it with solid fuels. We then segregated the reasons by different asset deciles (Figure A3). We find that affordability is less of a concern for wealthier households.

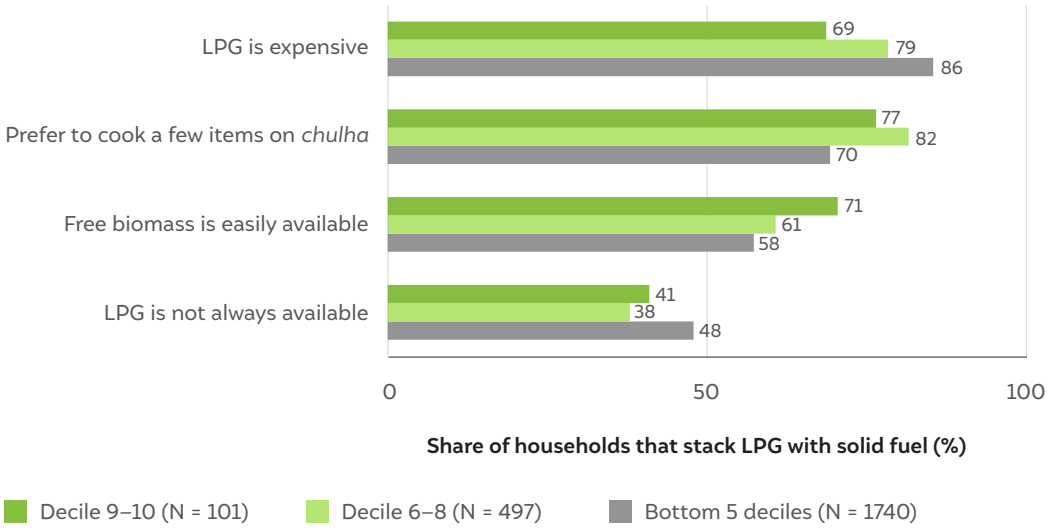


Figure A3
Unlike poorer households, lack of affordability is not the biggest reason for stacking among wealthier households

Source: Authors' analysis

Annexure 4 Determinants of LPG consumption at the household level in rural and urban India

We carried out a linear regression using the ordinary least squares (OLS) method to understand the determinants of household LPG consumption in both urban and rural areas. We used reported values of the annual LPG refill rate as the dependent variable. Table A2 illustrates the regression results. Factors including household economic status (captured by wealth index), family size, and women's agency in decision-making are strongly and positively associated with higher LPG consumption. In contrast, the need to travel long distances to obtain LPG refills and being a PMUY beneficiary are associated with lower LPG consumption, *ceteris paribus*.

Table A2 OLS estimates for determinants of LPG consumption among surveyed households

Dependent variable: Number of LPG refills consumed in a year by the household (reported)				
	Rural		Urban	
Independent variables	Estimates	se	Estimates	se
Intercept	1.30***	0.20	0.24	0.43
Wealth index	0.28***	0.02	0.12***	0.02
Number of family members	0.19***	0.01	0.33***	0.02
Primary source of income in the household – agriculture (base category – labour)	0.08	0.07	-0.12	0.22
Primary source of income in the household – salaried (base category – labour)	0.06	0.08	0.40***	0.11
Primary source of income in the household – self-employed (base category – labour)	0.22*	0.09	0.34**	0.12
Whether female members play a role in decision-making	0.22***	0.06	0.30***	0.07
Whether the household belongs to the General caste (base category – all other castes)	-0.08	0.06	0.03	0.08
Whether any member in the household has a secondary education or above	0.07	0.07	0.27*	0.11
Whether the household is a Pradhan Mantri Ujjwala Yojana (PMUY) beneficiary	-0.76***	0.07	-0.74***	0.15
One-way distance travelled by the household to collect delivery refills	-0.55***	0.07	-0.45***	0.11
For how many years has the household been using LPG?	0.03***	0.01	0.04***	0.00
What proportion of LPG users in the village/ward use it as the primary cooking fuel?	0.03***	0.00	0.03***	0.00
The total distance travelled in a week to collect firewood	-0.06***	0.01	0.00	0.04
Total monthly spend on biomass (in INR)	-0.00*	0.00	-0.00**	0.00
Observations	**7392**		**4723**	
R^2 / R^2 adjusted	**0.355 / 0.352**		**0.308 / 0.303**	

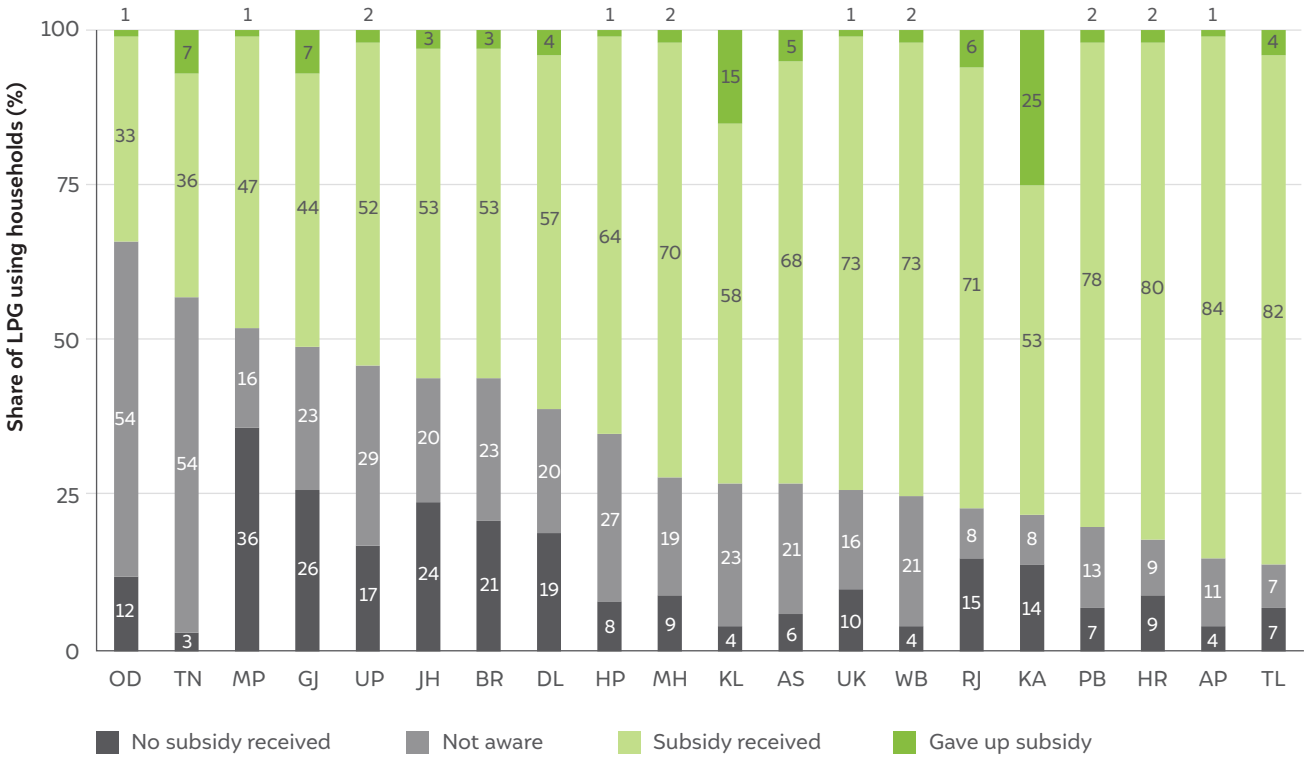
Source: Authors' analysis

Note: *p<0.1; **p<0.05; ***p<0.01

Annexure 5 LPG subsidy receipt status in Indian states

Figure A4 presents state-level variations in subsidy receipt and shows that lack of receipt and unawareness are highest in Bihar, Madhya Pradesh, Jharkhand, and Gujarat. Incidentally, in Odisha and Tamil Nadu, every second LPG-using household was found unaware of subsidy receipt.

Figure A4 More than half of LPG users in Odisha and Tamil Nadu are not aware of subsidy receipt



Source: Authors' analysis

Annexure 6 Factors related to LPG home delivery at the district level

Figure A5 shows the Pearson correlation coefficient between the share of households getting LPG home-delivered within the surveyed districts and influential factors such as the annual refill rate, average LPG connection age, and distance travelled by households that do not get LPG home-delivered (a proxy for distance to be travelled by the distributor). Table A2 shows the results of a linear regression analysis (OLS) with the home delivery rate within a district as the dependent variable.

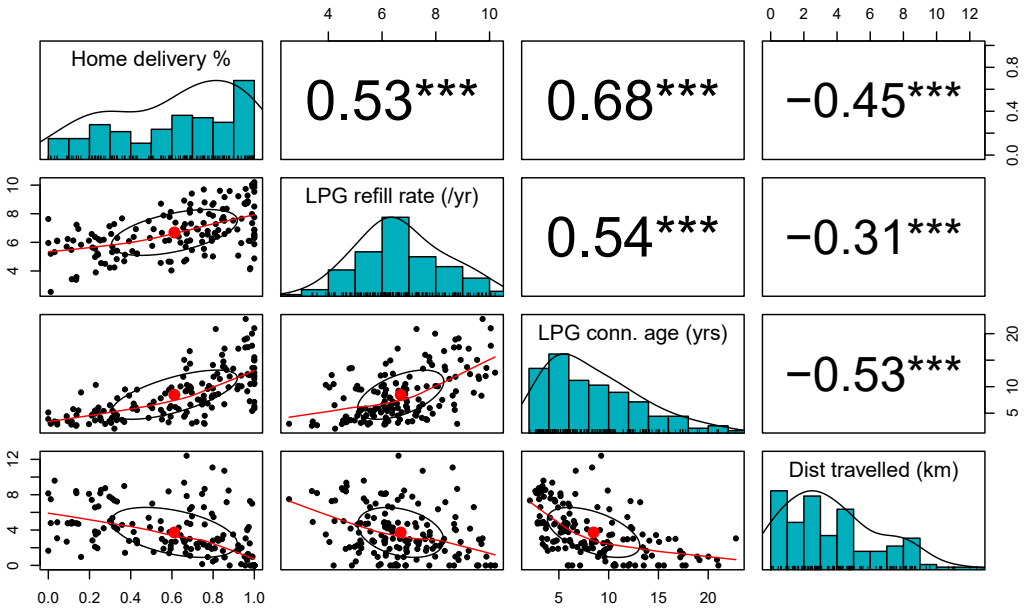


Figure A5
LPG home delivery rates are higher in districts with higher refill rates, older connections, and higher consumer density

Source: Authors' analysis

Dependent variable: Share of LPG users getting home delivery		
Independent variables	**Estimates**	**se**
Intercept	0.171	0.151
Average LPG refill rate	0.041***	0.013
Average LPG connection age	0.030***	0.006
Average distance travelled	- 0.014*	0.007
Share of rural households	- 0.059	0.106
Observations	152	
R^2/ R^2 adjusted	0.507/ 0.493	
Residual Std. Error	0.218 (df = 147)	
F Statistic	37.719*** (df = 4; 147)	

Table A3
OLS estimates for drivers of home delivery rates within surveyed districts

Source: Authors' analysis

Note: *p<0.1; **p<0.05; ***p<0.01

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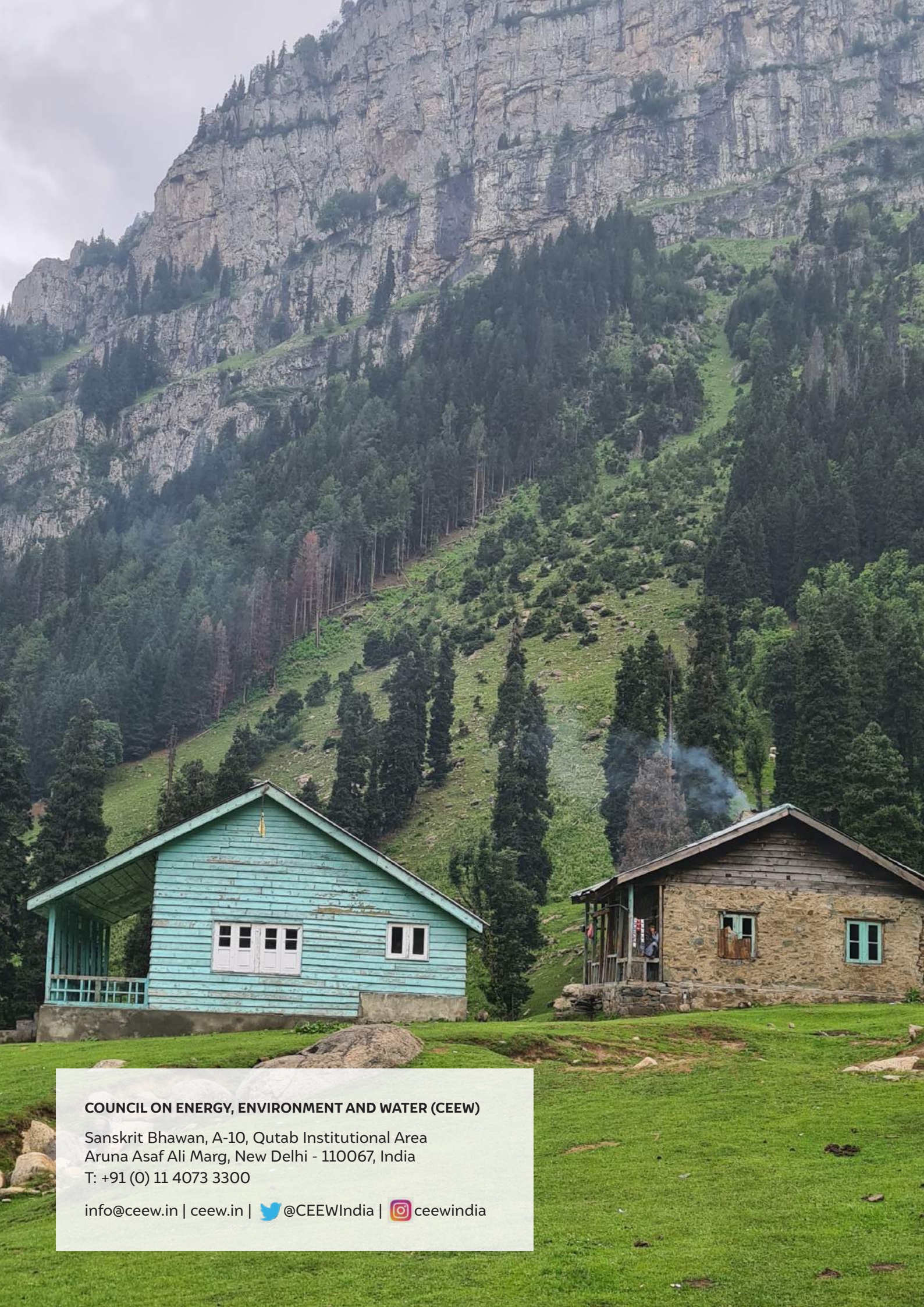
Distributors in rural India need better incentives to provide doorstep delivery of LPG refills.

Image: iStock



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