

Article

Dissemination Challenges of Liquefied Petroleum Gas in Rural India: Perspectives from the Field

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Received: 13 January 2020; Accepted: 12 March 2020; Published: 17 March 2020



Abstract: We look at infrastructure and policies in India around the distribution of liquefied petroleum gas (LPG) to rural communities and incorporate the experiences and perspectives of dissemination personnel. This qualitative study is part of a larger case control study aimed at examining strategies to promote adoption and sustained use of clean cooking technology, particularly among the rural poor in southern India. Our focus on dissemination personnel helps illuminate extant policy implementation and strategies to increase LPG uptake among the poor. Thematic analysis of 13 semi-structured interviews points to gaps in workforce training, infrastructure, and interface of the technology with social norms. Reduction in refill costs and removal of LPG subsidies was widely suggested to increase uptake and use. Themes identified underscore that policies promoting LPG for the poor will have limited success in the absence of commensurate infrastructure for LPG dissemination and awareness. Despite being primary policy beneficiaries, the under-representation of women within energy governance such as LPG distribution systems identified in this study presents a gap that interventions should focus on. Perspectives from those at the frontiers of implementation of a national energy policy provide insights into the high points as well as operational setbacks to help understand dissemination strategies within energy systems.

Keywords: LPG; dissemination; clean cooking; implementation; energy policy; energy poverty

1. Introduction

The United Nations Sustainable Development Goal (SDG) 7 aims to end energy poverty by providing universal access to affordable, reliable, and modern energy services by the year 2030 [1,2]. Achieving this goal is central to India's developmental ambitions and is closely tied to other development goals of alleviating poverty, improving access to education, ensuring gender equality, promoting health and well-being, climate action, and creating sustainable communities. The SDGs aim to improve global health by reducing mortalities from preventable diseases. Among the 30 leading causes of death worldwide in 1990, deaths due to lower respiratory infections were nearly 4.3 million, whereas, deaths due to chronic obstructive pulmonary disease were approximately 2.2 million, and deaths due to Tuberculosis were about 1.9 million [3]. The situation has not improved in the two decades hence. Worldwide, pollution-related deaths prematurely claimed nine million lives in 2015 with the largest increase in pollution-related deaths being in India and Bangladesh [4]. In low- and middle-income countries, several respiratory and chronic diseases occur because of higher levels of household air pollution (HAP). Traditional cookstoves utilize non-commercial fuels which release a variety of pollutants into the ambient environment [5]. According to projections by the Government of India's highest planning body, HAP is one of the largest contributors to Disability Adjusted Life Years (DALY) in India and is inextricably linked to traditional fuel usage [6]. The high prevalence of

premature deaths due to respiratory infections and the established link with HAP necessitates urgent action prompting a number of interventions in this space by the central government.

1.1. Energy Use in the Cooking Sector

About 70% of the Indian population continues to depend on biomass and traditional fuels for their everyday energy needs [7]. Fuel sources like kerosene, charcoal, biogas, liquefied petroleum gas (LPG), electricity, and solar energy are also used to varying degrees. Of these sources, electricity and solar are the cleanest, but their reach and availability have been limited. Among non-renewable sources of energy, LPG has been promoted as a clean alternative to traditional biomass as it is considered a low carbon fossil fuel [8]. The difference in usage and availability of these fuels is often a factor of household income, and to a certain extent, intra-household power relations [9]. Fuel usage in India correlates with income levels: lower income households tend to use more fuelwood and higher income households tend to use more LPG and electricity [5,10]. Other behavioral factors such as cooking preferences, market networks, cultural, and social norms, as well as safety concerns are also influential in decision making [5,10–12]. There is an urban–rural divide in the usage of LPG with over 60% of urban households in India using LPG, as opposed to over 70% of the rural population that depends on biomass [8]. Dependence on traditional fuel sources demands a significant amount of time and effort in collection and usage, primarily on the part of women and children [5,8,13–15]. Additionally, traditional fuels are not energy efficient and are a major source of HAP. In India, therefore, access to modern and clean cooking fuels continues to be an issue despite numerous initiatives taken by government and non-government actors.

1.2. Policy Interventions

The government of India has a long history of interventions promoting clean cooking solutions [16–18]. In the last two and a half decades, these initiatives have encompassed subsidization, direct cash transfer schemes, and programs like the “Give It Up” campaign that encouraged the well-off to voluntarily give up their LPG subsidy to target the benefits to the underserved and rural poor [19]. Since the positioning of LPG as a cleaner alternative to traditional biomass fuels, central and state governments in India have devised multiple policy initiatives to propel this technology toward the rural poor. In 1999 the Deepam scheme, a targeted capital subsidy program, was launched in the southern state of Andhra Pradesh [18]. Scheme beneficiaries are primarily women, especially those belonging to self-help groups (SHGs) and those who qualified as below poverty level (BPL) households. Additionally, the scheme was designed to reduce the dependence on firewood and associated drudgery, and to improve health outcomes especially for women, with an overall aim of improving the indoor and outdoor environment. Evaluations of this scheme show stratified usage patterns, a clear urban–rural divide, as well as cost-based deterrence despite initial capital subsidy [5,20].

While Deepam was localized to the southern states of Andhra Pradesh and Telangana, the Pradhan Mantri Ujjwala Yojana (PMUY), was launched in May 2016 to provide LPG connections free of cost to women in BPL households nationwide [16]. These households can access 12 subsidized cylinders annually; any additional cylinders are available without subsidies. Spread across 631 districts throughout the country, the central government scheme aims as much at improving environmental health as facilitating women’s empowerment. Under PMUY the consumers need to link their bank accounts to Aadhar, a form of universal identification issued by the Government of India, in order to receive the subsidies on LPG refills. Launched in 2013, PAHAL (Pratyaksh Hanstantrit Labh), or Direct Benefits Transfer for LPG (DBTL), a scheme under the aegis of the Ministry of Petroleum and Natural Gas also requires consumers to have Aadhar, to avail LPG subsidy [17]. Schemes like PMUY and Deepam have been lauded as they are seen as investments in public health and social change rather than merely subsidy programs [21].

1.3. LPG as A Sustainable Fuel for the Rural Poor

It is worthwhile here to discuss the relevance of LPG especially in resource poor communities in low- and middle-income countries (LMICs). About 2.7 billion people, primarily in the global south, lack access to clean cooking facilities [22]. The global burden of health owing to solid fuel burning for household energy needs is faced disproportionately by women and children in the poorest communities around the world [15,23]. Energy policies in countries in South Asia, Latin America, and Sub-Saharan Africa have prioritized LPG as a cost-effective way of providing clean energy access to communities. While it is true that LPG is fossil fuel reliant, it is cleaner than traditional fuelwood and kerosene used by many poorer households and offers immediate benefits such as no black carbon residue and reduced CO₂ emissions compared to biomass burning [24]. LPG is one of the most effective and easily available alternative to solid fuels particularly in LMICs; reductions in HAP associated with LPG, as compared to burning biomass at home, make it a viable and useful alternative. For instance in Brazil, LPG was introduced in the 1930s and has since played an important role as a transition fuel critical to the country's sustainable development with social and environmental advantages [25]. LPG therefore helps meet the energy needs of rural poor in LMICs while facilitating a shift to cleaner fuels [24]. In terms of energy equity, LPG is considered an optimal transition fuel for poorer communities that have historically had the lowest carbon emissions [26]; the potential to extend health, environmental, and social benefits especially to energy-poor communities makes it a critical player in countries' sustainable development trajectories. Further, as India undergoes a push toward renewable sources of energy [1], dissemination insights from current energy policies will be essential to the success of these future programs.

1.4. Challenges to Clean Cooking Technology Dissemination

Existing literature shows that dissemination realities routinely fall short of their projected potential [5,27]. A number of recent research papers have examined barriers and enablers to sustained uptake of LPG in India especially among the energy poor, who predominantly reside in the rural interiors [19,28–30]. These studies highlight the complex interface of economic and social determinants influencing the uptake, use, and abandonment of clean cooking technologies. A review of relevant literature suggests that the methodologies to perceive these challenges have primarily involved the perspective of experts in the field or consumers and end users [12,31]. While they provide a strong theoretical and empirical basis to measure evidence and progress against, these analyses have not reflected the experiences of those at the helm of dissemination activities. This paper addresses this gap using semi-structured interviews to analyze perspectives of those at the other end of the dissemination spectrum in India: suppliers, mediators, and distributors of LPG in rural areas. The key questions guiding this inquiry are:

- What are the barriers and enablers impacting sustained dissemination of LPG in resource poor communities of India?
- What are the strategies employed by LPG suppliers in rural India to address barriers to dissemination?

The paper analyzes factors influencing dissemination of clean cooking technology in rural poor communities as envisaged by LPG distribution networks. Energy policies in India, particularly around cooking fuels, have largely focused on LPG as discussed in Section 1.3. Analysis of current practices in LPG dissemination can therefore inform future policies around renewable cooking technologies that are slowly gaining credence.

2. Materials and Methods

2.1. Selection of Participants

This qualitative analysis is part of a larger case-control study aimed at developing long-term, pro-poor strategies to promote adoption and sustained use of clean cooking technology in rural India [32]. The current study examines strategies employed by suppliers to increase LPG uptake and adds to discussion on enablers and obstacles to LPG dissemination from the perspective of suppliers and dissemination workforce. Sample size determination in qualitative methods depends on research questions being explored and the homogeneity of groups [33–35]. Qualitative researchers have deemed 16 or fewer interviews to be adequate for theme identification in homogenous groups while 20–40 are considered more suitable for heterogenous groups [33]. The dissemination personnel interviewed for this study service the geographical area where the case-control study is currently being conducted and represented a relatively homogenous group [32]. Interviews were carried out in March 2018 in collaboration with Foundation for Ecological Security (FES), an Indian organization working on social-ecological projects across India for over two decades. The PI and co-PI for the project have engaged extensively with the organization over various research initiatives, and the field teams have been actively involved in the local communities. The research team identified the agencies and a list of personnel from the agency offices. Potential respondents were contacted about their availability for interviews. Semi structured interviews were conducted with 13 dissemination personnel, encompassing an array of roles, representing two major LPG agencies in the southern state of Andhra Pradesh using non probabilistic, purposive sampling [33]. The interviews were conducted by two members of the FES field team after a two-day training led by the co-PI. The training was designed to familiarize the team with the overall purpose of the study, including project goals, interview strategies, as well as mock-trials within the group to familiarize them with the questionnaire and prompts as needed. Interviews were conducted after obtaining informed consent, at a time and place of convenience to the respondents. Each interview took between 40–60 min and was conducted in the local language, Telugu, by interviewers fluent in the language. The interview guide is attached in the Appendix A.

Table 1 provides a list of the roles and positions of these personnel, the geographical areas served by them, and the name-codes assigned to each respondent to maintain confidentiality. Questions were designed to understand the personnel's experiences with LPG dissemination strategies. They were asked about their experiences in the field, their opinions and observations about gaps in policy, and specific implementation strategies they employed during dissemination and challenges therein. The Institutional Review Board (IRB) at Boston College has approved this study and all study procedures. Ethical and cultural approvals were sought and obtained from the IRB.

Table 1. Overview of interviews conducted and codes for respondent names.

Role	Number of Respondents	Areas Covered	Name Codes
Mediators	3	Thambalapalle and Kalicherla	2.RK, 4.SS, 14.PS
Delivery personnel	6	Peddamandyam and Thambalapalle,	3.NN, 6.RS, 7.PK, 8.AS, 10.PB, 11.MS
Computer Operator	2	Thambalapalle	5.GS, 13.MS
Manager/Distributor	2	Peddamandyam and Thambalapalle	12.KR, 9.RS

2.2. Data Analysis

This paper adopts a thematic analysis approach to identify and analyze patterns in the interview data [36]. This qualitative method helps to provide insights into factors influencing LPG dissemination. Patterns in the data were ascertained through an iterative process of data familiarization, data coding, theme development and revision. This analysis provided the meta-themes for the study [33,37].

Qualitative data analysis included the following steps:

1. Identification of possible themes based on a review of dissemination literature pertaining to LPG both in India and internationally.
2. Open coding was simultaneously performed on the 13 interviews with LPG suppliers by two coders. One coder used Qualitative Analysis software, Atlas TI version 8.4.4, while the other used Microsoft Word to code interview transcripts in order to have two parallel coding processes that were reconciled after discussions to increase inter-rater agreement, and coding validity [38]. A second round of coding was done to collapse the number of codes and to combine codes into larger categories.
3. The two coders worked together to outline major themes that emerged from the coding exercise. About 150 codes were generated in the first iteration. These were collapsed to 102 codes in the final version. Codes were grouped together into principal ideas. A total of 14 code groups were generated which were then arranged into five broad themes.
4. The coders regularly communicated with field staff that carried out the interviews for clarifications on the data, agency structure, dissemination cycle, and role of various personnel.

3. Results

3.1. Study Site and Participants

The study is spread across Chittoor district of rural Andhra Pradesh in southern India. The average literacy rate in rural Chittoor stands at 67%, with a lower literacy rate for women compared to men as per the 2011 Census. There are about 996 women per 1000 males in rural Chittoor. LPG dissemination on ground is managed by private distributorships set up under public or private gas companies in India. Both agencies in the study are classified as “Rurban Vitrak” (Rural–Urban Distributor), and this study focused on supplier interface with rural areas. For the purpose of this manuscript and to maintain confidentiality, the distribution agencies in the study are termed agency A and B hereon. The two agencies bear a similar organizational structure and are located in the administrative block headquarters serving rural areas nearby.

The 13 interviewees occupied various roles across the dissemination spectrum within two major LPG distribution agencies operating in the study site (see Figure 1). Distributors are the owners of the LPG agency and sometimes a manager is appointed by the distributor to oversee everyday operations of the agency. Computer operators are employed by the agency to work on data management related to bookings and cancellations. Delivery personnel employed by LPG agencies are responsible for transporting LPG directly to consumers. Mediators fill the need in villages that are distant from the agency. Typically, the LPG agency uses mediators as “stock points,” where they supply a select number of LPG cylinders to mediators and the consumers then buy LPG directly from them.

3.2. Themes

Based on a review of the literature and initial discussions, the research team pre-identified a few themes. The original themes identified were social norms and socio-cultural differences, proximity, perceptions, information barriers, last mile connectivity, privatization, and fear of the unfamiliar. After analysis of the interviews, five broad themes were identified incorporating factors that influence dissemination of LPG in rural Southern India. There was some convergence between pre-identified themes and the themes that emerged from the interview data, explicated in Section 4. The five themes are outlined below.

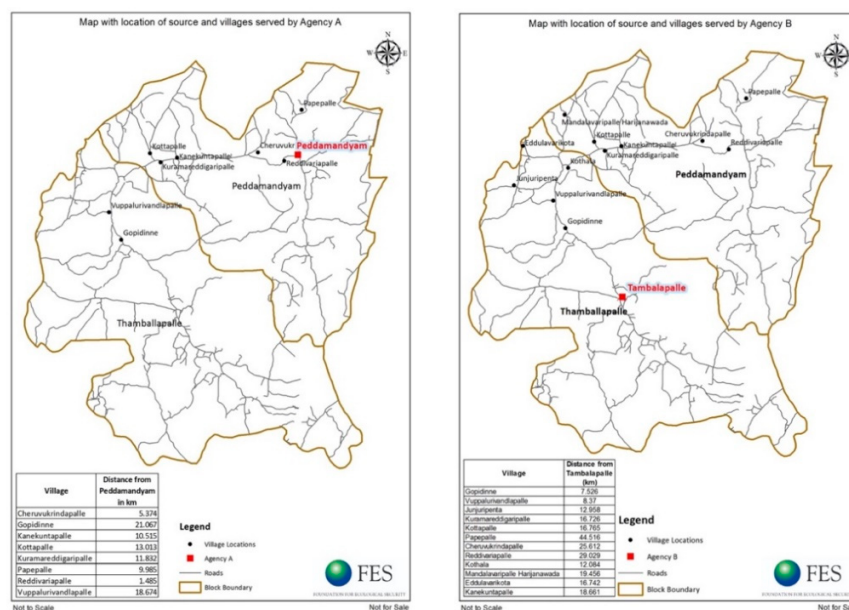


Figure 1. Map of villages served and liquefied petroleum gas (LPG) source location for agency A and B.

3.2.1. Workforce Factors

Multiplicity of Roles

Interviewees reported performing roles that went beyond their job descriptions. For instance, one respondent reported resolving technical issues pertaining to LPG leakages in addition to their role as mediator (2.RK). Two respondents had been working as delivery personnel before becoming mediators. The reported earnings for mediators were about INR 30 per cylinder (0.42 USD), with INR 200 (2.81 USD) paid as installation costs for new connections. A few respondents saw their role as a “service to society,” with one reporting that the job satisfaction was high despite lower remuneration. A third-party technician is sometimes appointed by the agency to provide technical assistance at the consumer end (13.MS). However one respondent, mechanic-cum-delivery personnel (10.PB), stated that most customer problems were solved by delivery personnel. Another delivery personnel who also doubled as a mechanic, reported that the instructions to new LPG customers were usually provided by them at the time of installation in addition to conducting safety clinics for consumers. This illustrates the range of roles performed by disseminators, especially delivery personnel. The lack of clarity in some roles can be a potential dissemination challenge.

Quality of Personnel and Training Issues

All respondents were asked about trainings they were able to access. A computer operator (5.GS) reported not receiving any training on the aspect of the LPG dealership, but understandably underwent data management and computer skills training before starting their job. Four respondents reported receiving training on customer relations—a crucial aspect of their job, especially those that directly interface with consumers, such as the delivery personnel. At least two respondents reported having received no trainings whatsoever. The three mediators received no training except in the case of one mediator, who had previously worked as a delivery personnel (4.SS).

Most trainings according to the respondents, focused on conducting safety campaigns with consumers. A safety clinic helps demonstrate “the safety measures around LPG use” to consumers (13.MS). According to interviewees, LPG agencies in the area were typically mandated to organize four safety clinics per month; these safety clinics provided information to consumers about stove usage, such as, “always keeping the stove three feet above the floor to maximize gas use and avoiding chances of the cylinder blasting (*sic*) and keeping cylinders away from lamps and incense sticks” (11.MS).

Respondent 11.MS, a delivery personnel with agency A, reported attending one training per year which included safety training, as well as training on “consumer-interaction.” 9.RS, a distributor, reported that the safety training was provided by the sales officer. There is some discrepancy in training norms, expectations, and delivery, and it was not uniform across and within the agencies.

Customer Relations and Challenges

Challenges reported by respondents primarily had to do with their interactions with consumers and their unavailability for LPG delivery. Seven interviewees spoke of challenges in dealing with consumers in the field suggesting that this issue remains central to their experience as LPG disseminators.

“Sometimes, at the time of LPG delivery, people are not available at home. The delivery personnel wait for some time and then come back. Though the delivery personnel give prior intimation to the household, they [consumers] are not available at home. This is one of the biggest issues.” (12.KR)

“If delivery personnel were unable to get in touch with the consumers, they cancel the booking. If there is a problem with phone numbers or the mobile network, it becomes the consumer’s responsibility to get back to the delivery personnel. Before going to the village, the delivery personnel inform consumers at least an hour in advance.” (8.AS)

An urban-rural divide in available resources was also apparent—a distributor (9.RS) observed that while customers in towns attended to deliveries more often and could be contacted through phone messaging (SMS), consumers in villages were less likely to attend to deliveries owing to their work schedules and were not accessible by phone messaging. He articulated a common refrain among those interviewed, that there was no dissemination issue, except lack of coordination between the delivery personnel and customers, suggesting further, that the only gap was that the customers did not feel a sense of responsibility.

3.2.2. Institutional Factors

Logistics and Scale of Operations

In general, LPG dissemination follows the path from manufacturing plants to the agency. From the agency, LPG is either supplied to the consumer by delivery personnel or collected by consumers directly from mediators. These mediators are critical in villages that are difficult to access by the local LPG agency; consumers contact mediators for new connections as well as refills.

“They have stock points on long routes. There are four stock points along different routes. Delivery personnel dump the cylinders in the stock points and hand over the stock to mediators. Consumers then purchase full cylinders from mediators.” (13.MS)

The mediators therefore effectively bridge the dissemination gap by servicing the underserved, remote locations. Additionally, customers contact mediators when they want to pick up LPG cylinders, thus addressing one of the chief delivery concerns raised in the interviews—that of customer unavailability in rural areas.

Supply Chain Management

Problems related to stock availability were not among the chief concerns raised by respondents. Typically, the stock reaches the agencies once every 2–3 days (13.MS) and reaches the mediators once a week (2.RK). One delivery personnel (6.RS) alluded to challenges with inadequate availability of vehicles and insufficiency of stock which delay delivery schedules. The same delivery personnel later reported that they had sufficient vehicles and human resources for stock delivery, diverging from what they had asserted earlier. Others (10.PB, 12.KR, 14.PS) affirm that agency staff, vehicle availability, and

stock were ample and that there were no issues in delivery owing to those factors. This contradiction, primarily in one respondent's report points to either an unrealistic assessment of the infrastructure and supply chain systems in place, or potential participant bias.

In one case the capacity of the warehouse where LPG were housed was 8000 kg, with the stock flow—number of cylinders—being 560 to 570; the agency had three vehicles and “adequate human resources for timely delivery of cylinders” (9.RS). The respondent further noted that an agency had to sell 5000 cylinders per month, but sometimes managed only 3000. Another respondent from the same agency reported that the agency had four vehicles for supplying cylinders with the warehouse being able to house 700 cylinders at a time (13.MS). The respondent also shared that the agency had 11,000 connections in all. This divergence in number of connections and the warehouse capacity illuminates a potential inefficiency of the supply chain management. This could imply an inadequacy of cylinders available to service all connections, or in the first case, a lower demand than projected supply estimates.

Responses on the scale of delivery varied vastly between respondents. According to one delivery personnel, they covered 100 “habitations” in all (8.AS); a mediator reported selling 20 cylinders per week (2.RS); while another mediator (4.SS) sold around 10 LPG cylinders per day. According to computer operator (13.MS), the optimal number of daily bookings was 146, which sometimes extended to 200 refill requests a day. Dissemination personnel also employed certain strategies to manage the supply-chain, taking field realities into consideration. For instance, one delivery personnel noted planning ahead for non-availability of customers by carrying 8 LPG cylinders when they had a delivery request for 10 (10.PB).

Gaps in Infrastructure

The interviews overwhelmingly suggest a positive perception of the dissemination infrastructure. According to one respondent, “The agency has sufficient staff” (3.NN) while other respondents suggested a marked improvement leading to sufficient infrastructure and human resources for delivery (4.SS, 7.PK, 9.RS). Respondents pointed to poor road conditions as a significant barrier to LPG delivery: “If roads are good then the problems with consumers will also reduce” (6.RS). When it came to inter-agency communication, the distributor and manager reported maintaining effective communication with other agencies, while most other personnel reported no coordination or interaction with other agencies.

3.2.3. Policy Factors

Perceptions of Policy

This theme looks at the perception of dissemination personnel toward LPG policies and their suggestions for improvements. A repeated observation among those interviewed was the high cost of LPG refills, viewed as a barrier to LPG uptake. At the time of the study the refill cost per cylinder was INR 717 (10.07 USD). The uneven price fluctuation of LPG tends to further exacerbate the situation: “If there is reduction in refill cost it is only by INR 10–20 (0.14–0.28 USD). But if it is increased, it is almost by INR 40–50 (0.56–0.70 USD)” (4.SS). Another respondent noted, “Many people are not booking refill because of high costs” (5.GS), lending further evidence to affordability of refills being a significant barrier to sustained LPG use.

A delivery person noted that the high refill costs were a “burden for white-card holders and for those who have taken LPG connections under the Deepam scheme” (6RS). Under the Andhra Pradesh Public Distribution system, the white ration card is given to households below the poverty line [39]. Another respondent noted: “If the refill cost is around INR 500–550 (7.02–7.73 USD) then it is affordable for almost everyone” (14.PS).

Subsidies and Fraud

An additional facet that emerged was the muddled information around the policy pertaining to refills and subsidies: “People are of the opinion that if they pay certain amount for LPG refill, they will get back some amount” (14.PS).

Other respondents shared that people were generally aware of subsidies and it had been a great aid for BPL households (8.AS) but the same respondent also advocated for subsidy removal as a policy measure going forward. BPL households can access 12 subsidized cylinders per year with additional cylinders available at full price. The major problem for households obtaining a subsidy for refills, as stated by the respondents, was non-linkage of Aadhar (Universal ID) cards with their bank accounts (8.AS, 12.KR). The dissemination personnel sometimes take responsibility of resolving subsidy issues (3.NN), adding yet another dimension to their work profile, as noted in the first theme.

Anecdotal evidence from the respondents also points to the incidence of fraud and deception among consumers. Five respondents stated that consumers were booking LPG cylinders merely to get the subsidy benefit of INR 260 (3.65 USD). For instance, two respondents noted that some customers would buy the cylinder at the subsidized amount and sell it at full price to third parties (8.AS, 13.MS). Another respondent, a mediator, noted that if everyone received the subsidy, this would become a non-issue (4.SS). While they recognized that subsidies made sense for BPL households, respondents believed it was also the cause of much friction and that illiteracy and lack of awareness contributed to disputes on subsidy. Lowering the refill costs and removal of the subsidies was an emphatic policy suggestion from the interviewees to encourage LPG usage and continued uptake. Six of the 13 respondents (5.GS, 6.RS, 7. PK, 8.AS, 11.MS, 12.KR) were in favor of removing subsidies. As a respondent summed it up, “If there is no subsidy... only those who have a real need will book for a refill” (7.PK).

3.2.4. The Last Mile

Proximity and Distance

The distance from LPG warehouse to consumers is crucial to dissemination. The warehouses with LPG stock are typically located close to the agency, in one case about two kilometers and in another six kilometers from the agency (7.PK, 12.KR, 13.MS). The LPG is then distributed to consumers by delivery personnel. While the role of mediators warrants them to be located further away from the LPG warehouse, one mediator reported being about 13 km (around eight miles) from the furthest village they supplied to (4.SS). This is not a large distance to cover given that agencies reported having adequate vehicles at their disposal. This might, therefore, be an indicator of inefficient organization or point to poor road infrastructure that could play a defining role in last mile connections to interior rural locations. Delivery personnel affirm that access to some villages is challenging; for example, roads are often in poor condition, making door-to-door delivery difficult (6.RS, 7.PK, 9.RS).

As seen in Figure 1, Agency A delivers LPG to villages at distances ranging from under two kilometers to over 20 km. Agency B in turn delivers to villages as far as 45 km away, indicating a broader range of villages serviced.

Figure 2 demonstrates the location of villages at a distance of 6–8 km supported by a mediator for agency B.

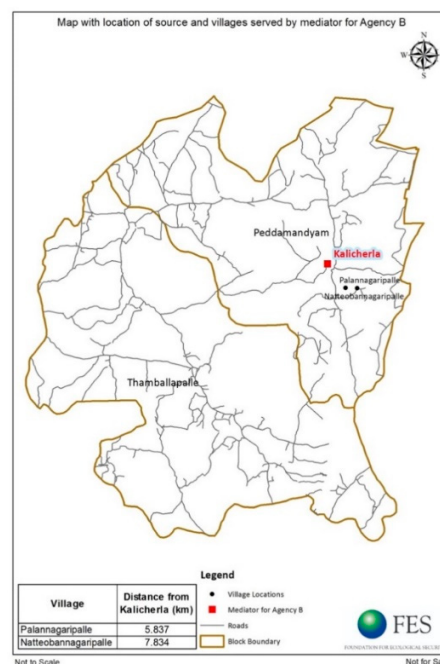


Figure 2. Map of villages served by mediator for agency B.

Access to Information

Respondents (5.G.S and 11.M.S.) identified lack of awareness around LPG use as a factor affecting uptake: “In case of single cylinder, people exactly don’t know when it will get over Sometimes people return cylinders when there is still 1–2 kgs left” (5.GS). The suppliers felt there was a need to create awareness of more efficient LPG usage (7.PK). One respondent suggested the involvement of government departments like *Velugu*, within the Department of Women and Children, in organizing information campaigns and meetings:

“Instead of private actors, if the Government creates awareness in the form of advertisements through TV channels, like in the case of tobacco; if monthly once in SHG meetings, women discuss about the usage of LPG and the health benefits of it, then many people will use LPG. It would also be very effective if the LPG agency invites SHG leaders to the safety clinics.” (9.RS)

As an example of the lack of complete information affecting customers’ access to subsidies and LPG use, another respondent stated,

“The present refill cost is INR 717 (10.07 USD) and people are getting INR 216 (3.03 USD) as the subsidy amount. Due to a lack of awareness many people haven’t linked their bank accounts with their Aadhaar number. This is one of the major issues. Consumers don’t do the bookings in a proper manner. But after two months consumers approach the agency and ask for the subsidy amount. After booking also if people don’t take the cylinder, it gets cancelled after 3 days. After that they won’t be able to make a booking. Without knowing this, the consumers feel that they actually book refills. Consumers won’t get subsidy in such cases.” (12.KR)

This demonstrates that access to information continues to be a challenge for customers suggesting a lack of clarity around procedural and technical aspects of LPG booking and usage. The combination of computerized systems with lower literacy levels, especially in rural areas, could be a factor in the information-perception divergence. This gap in information, according to respondents, further contributes to disputes between customers and disseminators.

3.2.5. Socio-Economic Factors

Social Norms

Social and behavioral norms in the area presented unique challenges to dissemination of LPG. Use of traditional fuels like firewood and kerosene is routine. Easy access to firewood without additional costs significantly contributes to continued use of firewood for cooking. Further, according to one delivery personnel, villagers typically go to work early in the morning and the delivery personnel try to plan their deliveries earlier in the day instead of later (8.AS). This is a strategy used by dissemination personnel to work within local norms and contexts. An insight into the minimization of fuel related costs was that families that had access to both LPG and traditional fuelwood stove “use LPG for cooking purpose and traditional stove for water heating.” (9.RS).

According to one mediator (14.PS), religion too played a role in LPG dissemination efficiency. The mediator recounted that 30–40 households in an area following a particular religion had availed Company B’s LPG connection, despite easier and proximal availability of Company A’s services. This according to the interviewee was because they did not want to use services provided by a mediator belonging to a different religion. The preference of a provider belonging to the same religion, was not corroborated or brought up by other respondents, but highlights the possible importance of prevailing social norms on LPG dissemination.

Economics

The high cost of LPG refills was unanimously panned by respondents who suggested that lowering refill costs of LPG would result in increased use. Nine out of 13 the respondents suggested that INR 500 (7.02 USD) for refill would make it affordable and result in a significant increase of LPG use. Seasonal migration was another determinant of usage and user profile in rural areas. According to respondents (7.P.K., 10.PB, 12.K.R.), household members often migrate to nearby cities and towns for work, leaving older adults and children at home: “The older adults do not use LPG for fear of explosion” (7.PK).

Fear of the Unknown

The need for increasing awareness around the benefits of LPG and the misconceptions relating to its use was reiterated by many respondents. The fear of exploding LPG cylinders was a major obstacle in adoption of LPG (3.NN, 7.PK, 9.RS, 10.PB, 12KR). These responses highlight the importance of increased engagement with customers (both existing and potential) in addressing their reservations around LPG safety. This suggests an important area of intervention for dissemination workers to aid increased uptake and sustained use of LPG. The agency owner reported a rise in LPG usage over the years and that fewer people feared cylinder explosions (9.RS), and this could be attributed to the various safety campaigns organized by LPG agencies

Role of Women

Under the Deepam scheme, the LPG connection is provided in the name of the women of BPL families. Almost all respondents (11 out of 13) held the view that women played a key role in adoption and use of LPG. According to one respondent, “Women are the key people in entire process of LPG adoption and usage” (13.MS). Another respondent expressed,

“Women are playing critical role in this entire process. They are the ones responsible for getting connections and to use the cylinder as the kitchen is their domain. Nowadays women are also seeking for easy and faster cooking (*sic*)”. (11.MS)

The role of women was vital because they usually made the bookings and were the primary users of the technology (2.RK, 3.NN). Since the entire burden of cooking is almost unfailingly placed upon women, the respondents postulated that LPG usage reduced the time women spent gathering firewood and that they could cook more easily and faster (3. NN, 4.SS, 8.AS, 11.MS). The role of women in

uptake and sustained use of LPG should be considered closely by disseminators in order to increase their influence and agency. Women were seen as the primary influencers encouraging other women to use LPG, instrumental in adoption of the technology: “They have a feeling that they can use LPG if other women are able to use it” (10.PB).

4. Discussion

This paper adds to energy dissemination literature by exploring challenges in propagation of clean energy in rural, resource-poor communities and weaving in the perspectives of LPG suppliers. The discussion focuses on the five factors articulated in the results.

4.1. Workforce Factors

Interviews in this study revealed that most dissemination personnel received training on safety and customer relations and some of these trainings were performance-based. Since delivery personnel interface regularly with consumers, customer relations training is crucial for fulfilling their objectives. However, mediators reported receiving no such training, unless they had previously worked as part of the formal dissemination system. Mediators are critical to reaching remote areas and act as the source of LPG and information to consumers in these villages and their training should be prioritized. A training program that includes aspects of customer relationship, management and repair, and safety programs at different levels of the dissemination cycle including at the mediator level, could enhance the quality of services to accelerate the adoption of clean cooking technology [40]. The multiplicity of roles performed by some personnel could be a double-edged sword. On the one hand, it is more efficient if delivery personnel are able to deal with localized consumer issues, however, it is not clear if all personnel that interface with consumers have been trained to respond to these challenges and it could lead to differential results. Additionally, it is unclear if the added responsibility of conducting the safety campaigns carries compensation for delivery personnel and it could be perceived as burdensome in the absence of corresponding recompense. Most respondents placed the onus of remaining at home to receive LPG on the consumer. Responses also alluded to systemic issues of migration, poverty, and livelihood insecurity forcing younger villagers to move out for work, leaving behind older adults and children who are unable to attend to LPG delivery.

4.2. Institutional Factors

In terms of inter-agency communication, there was no communication at the sub-agency level between delivery personnel and mediators. While this would not be surprising with private sector companies, both agency A and B are private distributorships for public sector companies and can in essence work together to advance government policy. The majority of dissemination personnel interviewed were of the view that there were no shortcomings in implementation or infrastructure, however individual responses suggested otherwise, as seen in the Section 3.2.2. This points to a less than realistic assessment of extant resources as indicated in Bansal, Saini, and Khatod [8]. In terms of supply and demand of cylinders, there is a vast difference in what is deemed optimal by the LPG agency and the actual demand on ground. While infrastructure and supply chains continue improving, this divergence provides evidence of LPG uptake being lower than projected needs.

4.3. Policy Factors

The relatively high costs of LPG compared to traditional fuels remains an important factor with almost all respondents recognizing it as a challenge impacting dissemination goals. The removal of subsidies, according to respondents, would clarify the extent of LPG usage and uptake and help check instances of fraud where cylinders are ostensibly taken for the subsidy but not used. The recommendation from suppliers to remove subsidies as a whole, needs to be viewed in perspective. Removal of subsidies without building commensurate support systems might prematurely and permanently deter the poorest from accessing a clean energy alternative [41]. Respondents also pointed

to lack of information among consumers around access to subsidies and instances of fraud that add to their workload. The challenges faced by customers in receiving subsidies was associated with disputes between customers and disseminators and merits attention.

Technical interventions necessitate corresponding infrastructure development, such as better roadways that can service remote areas and facilitate clean cooking technology dissemination [42]. Conditions of roads as well as distance of customers from the suppliers emerged as potential challenges to dissemination. Mediators along the dissemination spectrum act as conduits for villages that are difficult to reach and are critical to last mile connectivity. Another significant challenge identified was inadequate information among customers on the handling of LPG. Information about the policies and technology, therefore, continues to be critical for increased and sustained uptake of LPG. Despite multiple efforts, LPG adoption has remained a challenge. While policy measures in the last half decade have increased the uptake of LPG, sustained use has emerged as a challenge and the results of this study offer some insights into why dissemination bottlenecks factor into barriers to adoption and sustained use of LPG.

4.4. Socio-Economic Factors

While behavior-related barriers such as lack of awareness around the technology have been observed in previous studies [12,43], technical interventions that do not take into account the socio-cultural norms often come up against hurdles to adoption. Higher forms of technology coupled with lower formal education and awareness can lead to additional barriers to access and dissemination. According to the Socio Economic and Caste Census undertaken in 2011 [44], the poverty line in India stands at about INR 32 (0.45 USD) per day per person for rural areas with monthly household incomes among the poorest ranging between INR 1000–5000 (14–70 USD) a month. A refill cost of INR 717 (10.07 USD) remains unaffordable for many as other family needs take precedence. The perceived high cost of LPG combined with easy availability of biomass hinders increased uptake of LPG. Fuel stacking particularly with biomass becomes a common household strategy to minimize LPG costs [24]. Technological interventions interact with socio-cultural norms; prejudices and belief systems often impinge upon decision-making and adoption of technology. At the same time, these transitions can be seen as means to achieve broader socio-economic and behavioral change.

The multi-dimensional positive impacts of engaging women can be tapped toward more effective dissemination. Women's self-help groups (SHGs), among other community-based organizations, are important institutions to work with on dissemination strategies. All dissemination personnel in our study site were men which could be a potential barrier in sustained engagement between disseminators and targeted customers who were primarily women. Existing societal imbalances such as gender differentials could be a challenge and women's needs cannot adequately be articulated or gleaned by the primarily all-male distribution network. Employing women at different points along the dissemination spectrum can therefore significantly contribute to increased engagement. Instead of being seen simply as beneficiaries, if women are encouraged to be primary actors and drivers, it will not only advance their agency within policy governance and in their households, but will also be a crucial step in improving dissemination of clean cooking fuels in areas it is needed most to present a model of a more gender-aware energy planning that takes gender equity into account [45–47].

4.5. Limitations

A few limitations in this study ought to be noted.

1. The number of interviews is small at 13, with two LPG agencies represented. However, in qualitative research among homogenous groups, scholars have considered this to be an acceptable number to draw out meta-themes [33,37]. The field-team interviewed an array of dissemination roles—LPG delivery personnel, computer operators, mediators, and distributors. Those interviewed belonged to the same geographical region within relatively homogenous

agency structures, and this number was deemed sufficient once all roles were reflected in the study. While data-saturation was not the chief aim, the 13 interviews helped gather perspectives on dissemination challenges across the delivery spectrum and were found to be adequate to generate the themes. The agencies represented in the study are illustrative of the main players and disseminators of LPG on ground.

2. Results from this study cannot be generalized but can be used to characterize some lesser known experiences of those at the other end of the dissemination cycle. Future studies can improve on findings offered in this paper by using a larger number of cases across different states to understand differences in state policy infrastructure.
3. All interviews were conducted by field staff in the local language (Telugu) and translated into English by the field-team. Some of these transcribed interviews were paraphrased instead of being translated verbatim introducing potential bias and loss of contextual information. To address this through member checking and to validate the data, the field team took the transcribed interviews back to respondents to ensure their answers were accurately reflected.
4. A social desirability bias cannot be ruled out in the interviews between the respondents and the representatives of the partner organization [48].
5. Further, all respondents were men, conceivably a result of the job description and the social structures present in small-town India. Their views on ascribed women's roles are presented as such and provide insight into the way suppliers perceive traditional gender roles. Future studies should look at self-help group members and other women in the dissemination cycle to get a broader, more comprehensive and gender-balanced representation of views.

5. Conclusions

Previous studies on adoption and sustained use of LPG among other clean cooking technologies point to techno-economic, social, behavioral, and commercial challenges that must be surmounted for efficient dissemination [5,27,49]. These barriers are often conflated, with good reason, with barriers to adoption since many of these challenges cannot be siloed. While earlier studies have focused on policy governance or end-users to understand these challenges, this study looks at existing LPG infrastructure and policy from the standpoint of disseminators and brings in their perspectives to inform the discussion on improving implementation of clean cooking interventions in resource poor communities in Southern India. A human centered approach to understanding perspectives from the field presents insights into policy implementation and the social construction of energy systems [45].

Our study suggests infrastructural and information gaps, and a need to tailor and structure training of personnel. Interviewees in this study supported a reduction of LPG refill costs and subsidy removal to better benefit those most in need of support. These aspects of energy transition require contextualized solutions and strategies [42]. Subsidies to incentivize technology adoption do not always improve uptake or quality of services because of the emphasis on cost reduction and as such, they remain a contentious policy mechanism [5,32] that gives rise to disputes between consumers and distributors. Further, awareness campaigns on negative health impacts of fuelwood usage are beneficial but must go hand in hand with the removal of economic barriers to clean technology.

While not generalizable owing to the research methodology, our study offers insights for similar energy infrastructure and governance structures across India and other low-and middle-income countries. Our focus on clean energy transitions in rural communities, presents a study in how current energy policies play out and has implications for countries in a similar stage of a shift in energy systems. As a low-carbon source, LPG has numerous contributions to environmental health, poverty, and sustainability, with a distinct equity focus, to improve the well-being among the poorest. Calculations show that LPG is associated with a drop of nearly 50–66% of carbon emissions from traditional biomass fuels in India, underscoring the need to transition to this clean fuel to improve millions of lives [26]. Moreover, some of the barriers noted in LPG distribution provide insights into design and implementation of renewable energy dissemination as well. Interviews with those on

the frontiers of implementation of national energy policies bring on-the-ground perspectives into high-points of policy as well as operational setbacks. Their perspective sheds light on the role of institutions in energy governance and infrastructure to highlight gaps and features of rural India's energy transition trajectory [45].

Transitioning to LPG is a crucial step in the global shift to renewable and sustainable energy [24]. While renewable cooking energy sources like electricity and solar induction stoves can obviate aspects of last mile challenges such as the need for refills, other challenges such as socio-economic and cultural barriers, institutional factors affecting access to maintenance or upgrades as needed, and policy issues such as subsidies and affordability might continue to present themselves. India is an important player in the achievement of the SDG Goal 7 and ensuring a just, equitable transition to sustainable and clean energy policy in the global south particularly among those historically underserved by energy systems. This qualitative study adds to our knowledge base of the social dimensions of clean energy dissemination in low—and middle-income countries by focusing on experiences and strategies of LPG suppliers in rural southern India.

Author Contributions: Conceptualization, S.R. and P.K.; data curation, P.K.; formal analysis, S.R. and S.D.; funding acquisition, P.K.; methodology, S.R., S.D., and P.K.; software, S.R.; writing—original draft, S.R. and S.D.; writing—review and editing, S.H. All authors have read and agreed to the published version of the manuscript.

Funding: This study is funded under the Clean Cooking Implementation Science Network led by the Fogarty International Center with support from the National Institutes of Health (NIH) Common Fund. The content is solely the responsibility of the authors, and does not necessarily represent the official view of the funders.

Acknowledgments: We are most grateful to the community participants of this study and to the Foundation for Ecological Security for enabling access to these communities. In particular, we thank Kaushal, Raksha, Hemalatha, Noorjan, Shaheensha, Geetha, and Rahul.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Guide for Semi Structured Interviews

Thank you so much for taking the time to participate today. As you are aware, this research project focuses on exploring adoption and sustained use of LPG by rural poor in your area. We are interested in your experiences with implementation process of LPG. The majority of this discussion will focus on implementation strategies, or the deliberate processes you have used. Thus, a series of questions will be posed to give us a common reference by which to discuss your experiences and perceptions relative to specific implementation strategies. Your experience will inform future research focused on the development of implementation strategies that will hopefully make implementation and service delivery more effective. This will be a free-flowing discussion, so please feel free to share your thoughts, questions, and concerns throughout the process.

1. Describe your role in this organization and any previous experience with cleaner cooking schemes/projects?
2. How do you implement LPG supply/delivery [*probe on the following factors*]?
 - a. Infrastructure
 - b. Human resources: distributors, repair, etc.
 - c. Staff training
 - d. Supply chain
 - e. Advertising/campaigning
 - f. Interactions with other coordinating agencies
 - g. Finances
 - h. Data management
 - i. Overall project planning and management

3. What challenges do you face in sustainably disseminating LPG [*probe on the following factors*]?
 - a. Infrastructure
 - b. Human resources: distributors, repair, etc.
 - c. Staff training
 - d. Supply chain
 - e. Advertising/campaigning
 - f. Interactions with other coordinating agencies
 - g. Finances
 - h. Data management
 - i. Overall project planning and management
4. Could you provide specific examples of these challenges?
5. Of the challenges we just discussed, can you talk about those that are most critical to you?
6. What are the strategies you employ to cope with these challenges [*probe on the following factors*]?
 - a. Infrastructure
 - b. Human resources: distributors, repair, etc.
 - c. Staff training
 - d. Supply chain
 - e. Advertising/campaigning
 - f. Interactions with other coordinating agencies
 - g. Finances
 - h. Data management
 - i. Overall project planning and management
7. What strategies are the most successful?
8. Could you provide specific examples of these strategies?
9. One of the key and persistent challenges widely discussed has been lack of sustained use of LPG after a one-off adoption? Could you elaborate factors that contribute this behavior among consumers? (*Probe these factors within the dimensions of affordability, accessibility, and awareness*)
10. Have you undertaken strategies to address this? Probe specifically on dimensions of affordability, accessibility, and awareness.
11. Could you provide specific examples of these strategies?
12. Are some strategies more effective than others? Could you talk a little bit more about them?
13. Were some of these strategies more or less effective depending on the stage of implementation? [*adoption vs. sustainment*]
14. Why do you think they are so important?
15. Are some of the strategies you described simply more agreeable or satisfactory to you?
16. Did any of the strategies listed sound good in theory but prove to not be as helpful in practice?
17. What do you think are the benefits of LPG adoption for community members?
18. Are there other things that you would like to share with me related to your experience of implementation and implementation strategies on LPG in your area of operation?

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