# Providing Clean Cooking Fuel in India: Challenges and solutions


IISD International Institute for Sustainable Development

Global Subsidies Initiative

IRADe Integrated Research and Action for Development

Jyoti K. Parikh
Ashutosh Sharma
Chandrashekhar Singh
Shruti Neelakantan



April 2016

Published by the International Institute for Sustainable Development.

## International Institute for Sustainable Development

The International Institute for Sustainable Development (IISD) is one of the world's leading centres of research and innovation. The Institute provides practical solutions to the growing challenges and opportunities of integrating environmental and social priorities with economic development. We report on international negotiations and share knowledge gained through collaborative projects, resulting in more rigorous research, stronger global networks, and better engagement among researchers, citizens, businesses and policy-makers.

IISD is registered as a charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Government of Canada, provided through the International Development Research Centre (IDRC) and from the Province of Manitoba. The Institute receives project funding from numerous governments inside and outside Canada, United Nations agencies, foundations, the private sector, and individuals.

## GSI

GSI is an initiative of the International Institute for Sustainable Development (IISD). GSI is headquartered in Geneva, Switzerland and works with partners located around the world. Its principal funders have included the governments of Denmark, the Netherlands, New Zealand, Norway, Sweden and the United Kingdom.

## IRADE

IRADe is a fully autonomous advanced Research Institute based out of New Delhi India, which aims to conduct research and policy analysis and connect various stakeholders in South Asia, including government, non-governmental organizations (NGOs), corporations, and academic and financial institutions. Its research covers many areas, including energy and power systems, urban development, climate change and environment, poverty alleviation and gender, food security and agriculture, as well as the policies that affect these areas.

---

### Providing Clean Cooking Fuel in India: Challenges and solutions

April 2016

Written by Jyoti K. Parikh, Ashutosh Sharma, Chandrashekhar Singh and Shruti Neelakantan

**IISD Head Office**

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

**Tel:** +1 (204) 958-7700
**Fax:** +1 (204) 958-7710
**Website:** www.iisd.org
**Twitter:** @IISD_news

**Global Subsidies Initiative**

International Environment House 2,
9 chemin de Balexert
1219 Châtelaine
Geneva, Switzerland
Canada R3B 0T4

**Tel:** +1 (204) 958-7700
**Fax:** +1 (204) 958-7710
**Website:** www.iisd.org/gsi
**Twitter:** @globalsubsidies

**IRADe**

C-80, Shivalik Shivalik
Malviya Nagar
New Delhi 110017
India

**Tel:** +91 (11) 2667 6181
**Fax:** +91 (11) 2667 6180
**Website:** www.irade.org

# Preface

Integrated Research and Action for Development (IRADe) has consistently pursued gender issues in general and gender and energy issues in particular since its inception. Our activities span policy analysis, research and several projects involving surveys and stakeholder analysis for the purpose of enhancing energy access in India.

This research report discusses access to energy in the context of the Ghaziabad district, which is a predominantly urban district adjacent to New Delhi. Recently, the Government of India has introduced multiple schemes and programs addressing energy access where a majority of the population continue to struggle to gain energy access. The Kerosene Free Delhi (KFD) scheme launched by the Delhi government largely focused on facilitating households to gradually eliminate the use of kerosene by providing liquid petroleum gas (LPG) as a clean fuel alternative.

In this study, we conducted a series of surveys and studies in Ghaziabad district, which is essentially a city with associated infrastructure and higher income levels. The report illuminates some unique findings that assist in creating linkages among energy, gender and socioeconomics. Switching to cleaner energy sources not only improves the economic and social livelihood status of the households, but has a direct impact on health, environment and women's immediate environment.

The recommendations largely focus on laying a path to eliminate unequal distribution of cooking fuels among the economically challenged and to further strengthen the availability and distribution to all, including those in the remote areas. We hope that the Government of India, oil companies, the state government and other related authorities will find the results and recommendations helpful in enhancing the access to clean energy for cooking, especially to poor households. The government can use this study to design a nationwide LPG distribution plan.

*Jyoti K Parikh, Executive Director, Integrated Research and Action for Development*

# Acknowledgement

Integrated Research and Action for Development (IRADe) is grateful for financial support by the Danish Government and facilitated by the Global Subsidy Initiative (GSI) of the International Institute for Sustainable Development (IISD), Geneva.

We express our sincere thanks to Mr. Mohit Kumar Gupta, Mr. Rajat Puri, Mr. Sugandh Choudhary, Ms. Sonali Vyas of IRADe for their help in conducting primary survey from the household in GMC and data entry.

We acknowledge and express heartfelt gratitude to all the respondents and other stakeholders who took time off to respond to our primary surveys: officials from Uttar Pradesh (U.P.) government various departments, LPG distributors and Public Distribution System kerosene dealers from Ghaziabad for sharing their experiences and insights.

We would also like to extend our sincere thanks to Dr. Kirit Parikh (Chairman, IRADe) for having given his valuable comments and suggestions throughout the course of this study. Last but not the least, we would like to thank all the staff of IRADe, who provided additional support throughout this research effort.

*Project Team*
*Dr. Jyoti Parikh, Dr. Ashutosh Sharma, Mr. Chandrashekhar Singh and Ms. Shruti Neelakantan*

# About the Authors

**Professor Jyoti K Parikh**, Executive Director of IRADe was a member of the Prime Minister's Council on Climate Change – India and is a recipient of the Nobel Peace Prize awarded to IPCC authors in 2007. She served as the senior professor and Acting Director of IGIDR, Mumbai 1986–2003, International Institute for Applied Systems Analysis (IIASA), Austria for eight years (1980–86, 76–78) and Planning Commission, as senior energy consultant at New Delhi (1978–80). She has served as energy consultant to the World Bank; the U.S. Department of Energy; EEC; Brussels and UN agencies such as UNIDO, FAO, UNU and UNESCO; Environment Consultant to UNDP, and so on. She worked as an advisor to various ministries for the Government of India.

She obtained her M.Sc. from University of California, Berkeley, in 1964 and Ph.D. in Theoretical Physics from University of Maryland, College Park in 1967. She has guided 12 Ph.D. theses in energy, environment and climate change and given lectures in more than 40 countries around the world.

Her publications include nearly 200 project research papers and 25 books and monographs and span many areas ranging from policy analysis of energy and environment, climate change policies, modelling, technology assessment, power sector, natural resource management, agriculture, health, poverty and gender.

**Dr. Ashutosh Sharma** is Senior Researcher in IRADe. He has done a Ph.D. in macroeconomics from University of Mumbai, India in 2013. His research area of interest includes the economics of growth, sustainable development, climate change impacts, gender, and energy and applied econometrics. He handles large datasets such as census, consumption surveys, and employment and unemployment surveys. He is an expert in preparing primary survey questionnaire and conducting primary research. He has worked extensively in the area of rural energy and household energy

**Mr. Chandrashekhar Singh** is a senior researcher in IRADe. His has an M.A. in Economics from Gokhale Institute of Politics and Economics, Pune, India (2006). He has worked on a number of national and international projects spanning areas such as agriculture, environment, gender and energy, and energy demand modelling. His research areas of interest include econometric modelling and macro economic analysis.

**Miss Shruti Neelakantan** is a research associate in IRADe. She has recently completed her Erasmus Mundus Masters of Science (M.Sc.) in the Environmental Sciences Policy and Management program with semesters at the Central European University (Budapest), University of the Aegean (Greece), Lund University (Sweden) and University of Manchester (London). During her Masters, she had an internship with the United Nations Development Programme, where she produced a thesis titled *A Coupling Challenge: Exploring the Compatibility of Socio-Ecological Resilience with a Sustainable Development Framework*. Her core interest areas are sustainable development; policy, governance and environmental management systems; rural energy; and gender.

# Executive Summary

India has the largest concentration of population using biomass with inefficient stoves. About 840 million in India fully or partially rely on traditional biomass for cooking. In India, cooking is mainly carried out by women, and they play an important role in managing domestic energy needs. When modern fuels such as LPG are unavailable, women and children not only face health hazards due to smoke but also "time poverty." Freedom from smoke and the drudgery associated with biomass is the need of the hour to empower women and allow families to live purposeful lives. This report explores the issues and challenges of clean cooking in urban India through a case study of the Ghaziabad Municipal Corporation, Uttar Pradesh.

## Approach

We conducted surveys of 250 households in Ghaziabad district using a structured household questionnaire that was delivered between August 5 and October 10, 2015. The detailed questionnaires included information on family structure, socioeconomic conditions, energy-use patterns, housing characteristics, cooking behaviour, access to crucial infrastructure for subsidy transfer (JAM[1]) and willingness to pay for liquid petroleum gas (LPG). The energy-use pattern included information on the consumption of solid fuels and commercial fuels for cooking, where cooking fuel is procured, the time and effort involved in procurement, the price at which it is procured, etc. Characteristics of housing and other assets included information on type of house and location of the kitchen. Further information was collected on cooking behaviour, including the number of meals cooked using different fuels in a day, hours of cooking, cooking involvement by male or female members of the household and type of involvement. Reasons for not using clean fuels, willingness to pay for an additional amount of clean fuel and desire to forego the subsidized kerosene quota were also captured. The data were analyzed using tabular and regression analysis.

In a sincere effort to present an overall analysis, the sections have been broken down into smaller categories that contribute to the final results and recommendations. Following some literature on existing energy access and distribution situations, the report delves into the details of Ghaziabad, including the amount of energy used, sources utilized, comparison of prices, cooking duration, number of individuals in a household, and their roles in shaping the demand and supply curve of the various energy sources.

## Summary of Observations

### *Clean Cooking Energy Coverage and Accessibility*

- Our survey in Ghaziabad reveals that nearly 90 per cent of the households have access to JAM requirements, but merely 65 per cent households can be reached through the JAM scheme. It may happen that the household does not have all three mandatory requirements in one particular member to qualify under the JAM scheme.
- Official LPG connections are available in only 43 per cent of the households. Moreover, nearly, 22 per cent households possess 14.2 kg LPG cylinders without formal LPG connections and 33 per cent use small cylinders (available in 2 to 5 kg gas cylinders) with burners. Therefore, 55 per cent (22 per cent + 33 per cent) do not purchase LPG in a "regular" manner (where a 14.2 kg cylinder is delivered by the LPG distributor for noncommercial uses to households).
- Nearly 70 per cent of households with formal LPG connections possess a single LPG bottle, which prevents them from storing backup LPG at home. There is a lag of 3–4 days in between order and delivery of gas cylinder from the LPG distributor to the household. Therefore,

[1] The infrastructure, Jandhan-Aadhaar-Mobile (JAM), refers to three numbers: *Jandhan yojana*, a bank account for all schemes, *Aadhaar*, a unique identification number issued by the government and a mobile phone number.

households may be compelled to use an alternate fuel such as kerosene or biomass during the period between order and delivery.

- The percentage of households with formal LPG connections increases with the per capita income in our sample.

### Energy Usage and Prices

- As the household demand for total cooking energy increases, the probability of using modern fuel declines and the probability of using mixed fuel increases. The higher monthly cooking energy demand also lowers the probability of using traditional fuels.
- The average price per MJ of the purchased cooking fuels are as follows in the Ghaziabad Municipal Corporation: (i) dung cake is INR 1.76; (ii) fuel wood is INR 3.1; kerosene PDS is INR 0.83, (iii) other sources of kerosene is INR 1.78; (iv) subsidized LPG is INR 1.12; (v) LPG from the black market in a 14.2 kg cylinder is INR 2.66; and (vi) LPG in a smaller cylinder is INR 3.03.
- On average, households with LPG connections consume more energy for cooking (341 MJ per month) compared to households without LPG connections (292 MJ per month). However, the average monthly expenditure on cooking for households with LPG connections is INR 393, whereas households without official LPG connections pay INR 657 per month.
- Based on the household's average monthly cooking energy requirement in MJ, the study finds that an average of 137.67 kg of LPG is required per household per annum to meet their cooking energy needs, which means 9–10 LPG cylinders of 14.2 kg each in a year.
- A major obstacle for poor households not using the formal/regular channel for LPG connection is the hefty "startup" cost and lack of documents required for an official LPG connection.

### Clean Cooking and Gender

- Female literacy is an important determinant for the use of cleaner cooking fuels.
- As the female percentage in the family increases, the probability of using modern fuel declines and the probability of using mixed fuel increases.
- Female-headed households are less likely to use modern fuel (LPG) compared to male-headed households.

# Table of Contents

# List of Figures



# List of Tables

# 1.0 Introduction

Energy access has been widely recognized as a critical input for sustainable development. Access to clean and affordable sources of energy is an important requirement for the multiple challenges the world is facing in the form of rapid urbanization, globalization, technological innovation, rising inequalities and the impact of global environmental change (i.e., climate change). Rather than a need or a means, energy has become a goal in its own right due to its role in concerns related to food and water security, climate change, education, health care and employment, among others. Access to energy is a key determinant of how food is cooked and the associated health implications, the ways in which living spaces are heated and lit, as well as the time required to procure household energy. A huge chunk of poor people's income is spent on obtaining energy access for basic needs.

Developing countries like India are confronting the vulnerabilities associated with the looming climate crisis on one hand and the challenges of development and poverty alleviation on the other, which are closely associated with providing energy access to the energy poor in the country. As per the National Sample Survey 68th round, the dominant fuel mix in rural India still consists of firewood and chips, with around two thirds of the households still dependent on them. However, the transition to cleaner cooking fuels has largely materialized in urban India, with 68.4 per cent of the households using LPG (Government of India, 2015). The dependence on firewood and chips for cooking in urban areas has fallen from about 22.3 per cent to 14.0 per cent between 1999/2000 and 2011/12, a drop of 8.3 percentage points, while the dependence on kerosene has dropped from 21.7 per cent to 5.7 per cent during the same period (Government of India, 2015). On the other hand, the percentage of urban households using LPG has increased from 44.2 in 1999/2000 to 68.4 in 2011/2012 (Government of India, 2015). The growth in LPG use in urban areas has been almost balanced by a decline in the use of kerosene as well as firewood and chips. The choice of fuel is also contingent upon socioeconomic conditions. The factors that determine the selection of energy carriers include affordability, physical access, physical availability and socio-cultural factors like conventional cooking fuels, etc. Energy access also has severe gender implications, including the use of women's time and their health. Hence, the strategy of climbing the energy ladder means addressing energy development, poverty, social justice, equity and gender issues as parts of the same political process of development.

This study focuses on the issues and challenges in switching to clean cooking fuel in Ghaziabad Municipal Corporation (GMC), which has an urban population. This report focuses on cooking fuel only because the electricity supply for lighting exists. Though power cuts create a need for kerosene usage, kerosene usage for lighting is usually only limited to the period of power cuts and can be replaced by solar lamps. Distribution, supply and servicing of solar lamps is easier in cities. Cooking fuel switching is a low-hanging fruit and has direct health, environment and financial benefits. The study investigates the factors affecting the households' decision of using LPG[2] for cooking, the constraints of LPG connections and measures to improve accessibility to LPG connections in poor households.

## 1.1 BACKGROUND OF GMC

Ghaziabad is a suburban district located in western Uttar Pradesh and shares boundaries with Delhi in the west. As per the Census 2011, the district comprises 0.85 million households with a population of 4.68 million. Nearly 71 per cent (3.16 million) of the population has been categorized as urban (Table 1). GMC, which is a part of Ghaziabad district, has 3,36,069 urban households with a population of 16,48,643 (Table 1). Moreover, GMC comprises 56 per cent of Ghaziabad district's urban households and 52 per cent of the urban population. GMC has a total area of 210 square

[2] LPG is considered a prevalent and widely accepted clean cooking energy sources in India.

kilometres and has been divided into five administrative zones: (1) City Zone, (2) Kavi Nagar Zone, (3) Vijay Nagar Zone, (4) Mohan Nagar Zone and (5) Vasundhara Zone.

**Table 1: Ghaziabad district households and population**

| | Households (in '000') | | | Population (in '000') | | |
|---|---|---|---|---|---|---|
| District / Tehsils | Rural | Urban | Total | Rural | Urban | Total |
| GMC | - | 336.07 | 336.07 | - | 1648.64 | 1648.64 |
| Ghaziabad District | 248.05 | 602.63 | 850.68 | 1519.10 | 3162.55 | 4681.65 |

*Source: Government of India (2011)*

Figure 1 provides the cooking and lighting energy profile of GMC. Electricity is a major source of lighting (96.6 per cent), followed by kerosene (2.2 per cent) and other sources, which are used by merely 1 per cent of the households. LPG is a major source of cooking energy used in nearly 86 per cent of households, followed by biomass (12 per cent), kerosene (0.8 per cent) and others (0.5 per cent).

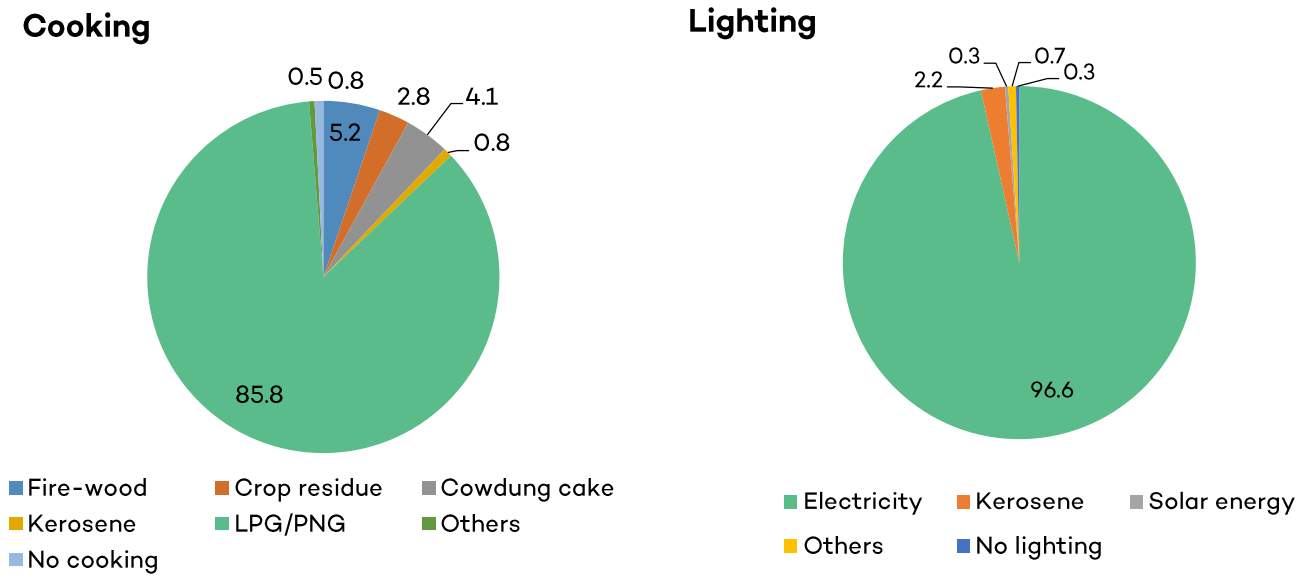


**Figure 1: Main source of cooking and lighting in GMC**

*Data Source: Government of India (2011)*

## 2.0 Literature Review

Researchers in the past have tried to understand the dynamics of energy use in families of varying incomes, with reference to the "energy ladder" as a model of household decisions to substitute or to switch between available fuels (Baldwin, 1986; Hosier & Dowd, 1988; Leach, 1992; Leach & Mearns, 1988; Smith, 1987). The energy ladder model envisions a three-stage fuel-switching process. The first stage is marked by universal reliance on biomass. In the second stage, households move to "transition" fuels such as kerosene, coal and charcoal in response to higher incomes and factors such as deforestation and urbanization. In the third stage, households switch to LPG, natural gas or electricity. The main driver affecting the movement up the energy ladder is hypothesized to be income and relative fuel prices (Barnes & Floor, 1999; Leach, 1992). The "traditional energy ladder," proposes that, as families gain socioeconomic status, they abandon technologies that are inefficient, less costly and more polluting, that is to say, "lower" on the energy ladder, such as dung, fuel wood and charcoal (Barnes & Floor, 1996; Smith, 1987).

The "energy ladder" model, however, is highly criticized, as evidence from a growing number of countries suggested that multiple fuel use was common. An important finding shared by studies (Barnes & Qian, 1992; Davis, 1998; Heltberg, 2004; Hiemstra-van der Horst, 2008; Hosier & Kipondya, 1993; Masera, Saatkamp & Kammen, 2000; Mekonnen & Kolhin, 2008) is that household cooking patterns are far more complex than those depicted in the energy ladder model, which shows a linear transition from traditional to modern fuels in relation to increased income. Households consume a portfolio of energy sources, a phenomenon known as "energy stacking" (Masera et al., 2000).

Studies conducted in the past have highlighted that household fuel choices are a complex process and depend upon a variety of factors. Studies tend to agree that income is a key determinant of both the switch to new energy sources and total energy demand. Household income, reflecting the household economic situation, is considered to be an important determinant for household fuel switching, as it determines the affordability of the fuel for households (Brouwer & Falcao, 2004; Heltberg, 2004; Hiemstra-van der Horst, 2008; Mekonnen & Kolhin, 2008; Ouedraogo, 2006). The relationship between household social characteristics, like level of education, household size and fuel switching, has been investigated in the past (Heltberg, 2004; Hosier & Dowd, 1987; Knight & Rosa, 2012; Kowsari & Zerriffi, 2011; Mekonnen & Kolhin, 2008; Peng, Hisham & Pan, 2010; Rao & Reddy, 2007; Reddy, 1995; Van der Kroon, Brouwer & van Beukering, 2013). Household size affects fuel choices, but does not trigger switching: larger households are more likely to use multiple cooking fuels (Energy Sector Management Assistance Programme, 2003b).

In patriarchal societies, men are mostly heads of the household and therefore responsible for making financial decisions, positioning them at a higher social stance. The patriarchal society structure may hamper the energy transition (El Tayeb Muneer & Mukhtar Mohamed, 2003; Schlag & Zuzarte, 2008). The gender composition of the family is another important aspect that has been rarely discussed in past studies. Women bear the major burden of indoor air pollution and, assuming that a high female ratio entails enhanced female bargaining power, it could be hypothesized that the high female ratio in the family would positively affect the cooking choices of modern cooking fuel. Alternatively, a high female ratio also means more availability of female collection and cooking labour time, and therefore they continue using firewood and mixed fuel (Energy Sector Management Assistance Programme, 2003a). Energy policies that refer to both government and market interventions related to prices, subsidies and taxes affect the energy-use patterns. The price of traditional fuels compared to modern fuels is considered an important driving force for fuel switching (Mekonnen & Kolhin, 2008; Schlag & Zuzarte, 2008). Beyond these, some researchers have also emphasized the importance of the available infrastructure for modern fuel distribution (Leach, 1992).

Fuel switching to modern fuels also necessitates a fixed investment. Whereas fuelwood costs are evenly spread out, expenditure on LPG tends to come in spikes with particularly severe startup costs. The uptake costs of LPG and natural gas are often thought to deter potential users. A better understanding of the obstacles for greater spread of clean cooking fuels would clearly be of policy interest. The poor household may find it difficult to make the initial investment, and it may restrict their switching to cleaner cooking fuel such as LPG. The Government of Delhi in 2012 launched the Kerosene Free Delhi (KFD) scheme in collaboration with three oil marketing companies (OMCs) and the Ministry of Petroleum and Natural Gas (MoPNG). Under the scheme, free gas connections, along with LPG-filled cylinders, a two-burner gas stove, a regulator and suraksha pipes were issued to the Jhuggi Ration Card, Below Poverty Line and Antodaya Ann Yojana card holders who were using kerosene oil for cooking. The KFD scheme enabled Delhi in becoming the first kerosene-free city in India. The KFD scheme launched in Delhi has set the tone among policy-makers and researchers that the coverage and benefits of clean cooking fuels can be extended to poor households. Recently, in an attempt to improve the LPG reach in poor households, MoPNG has extended the scheme for free LPG "startup" kits for below poverty line households in urban areas, which had previously been restricted to rural areas. Under this scheme, the security deposit for a 14.2 kg LPG connection and the cost of the pressure regulator amounting to INR 1,600 is borne by the OMCs from their corporate social responsibility (CSR) funds.

# 3.0 Design Frame and Methods

Given the paucity of detailed data for cooking fuel at the urban household level, this study collected primary data on urban household fuel consumption in GMC, which had not been studied before. The goal was to understand the current fuel consumption patterns and factors affecting the household's decision of switching to clean cooking fuel. In order to capture the complexities of household energy-use patterns, whether LPG subsidies are received by those who deserve them and whether the subsidy system works or not, household surveys and a focus group discussion with household groups in selected locations were conducted.

## 3.1 HOUSEHOLD SURVEY

The diversity that exists within GMC in the level of economic development and resource accessibility makes it a suitable geographic region for analyzing the question of fuel switching, as it provides a variation on the key independent variables of interest. The households of interest in this study were less well-off, living in either slums or economically weaker section housing societies.

The quantitative section of the research was conducted through a structured household questionnaire used in GMC between August 5 and October 10, 2015. A five-step approach (Figure 2) was used to carry out the household survey in GMC. The detailed questionnaires included information on family structure, socioeconomic conditions, energy-use pattern, housing characteristics, cooking behaviours and willingness to pay for LPG. The energy-use pattern included information on the consumption of solid fuels and commercial fuels for cooking, where cooking fuel was procured, time and effort involved in procurement, price at which procured, etc. Housing characteristics included information on type of house and location of the kitchen. Further information was collected on cooking behaviour, including number of meals cooked using different fuels in a day, hours of cooking, cooking involvement by male or female members of the household and type of involvement. Reasons for not using clean fuels, willingness to pay for an additional amount of clean fuel and desire to forego the subsidized kerosene quota were also captured.


**Figure 2: Steps involved in the household survey**

Household-level data were collected from nearly 250 households in four selected locations of GMC. The response rate was very high and only four people (representing one household each) throughout the entire survey period refused to answer.

## 3.2 HOUSEHOLD SAMPLING

Household sampling was done using a three-step process. In the first step, four out of five zones of GMC (i.e., Kavi Nagar, Vijay Nagar, Vasundhara and Mohan Nagar) were selected randomly to capture the geographical coverage. In the second step, housing societies/colonies with more concentration of middle- and low-income families were identified, and then one housing society from each zone was selected randomly. The housing society with a larger concentration of middle- and low-income families was selected mainly to (i) understand the fuel switching behaviour in less well-off households, (ii) to understand the policy issues at the middle and bottom of the income pyramid and (iii) to capture the diversity it displays with respect to migrants and long-term residence status of the families. The last step was to randomly select sample households for conducting the survey.

# 4.0 Summary Statistics of Households

## 4.1 ECONOMIC STATUS

Among the survey respondents 68 (28 per cent) were men and 178 (72 per cent) were women. Table 2 presents the demographic structure of surveyed households. Out of the 246 households, 48 per cent (117) belong to the second income class (i.e., INR 5,000–9,999) and 30 per cent (74) to the third income class. Nearly 76 per cent (187) of the surveyed households were headed by a male, reflecting the male dominance in society, but this survey stated a preference for interviewing female members of the household. However, in the lowest income class 11 out of 13 households were found to be headed by a female. This should be read with the fact that eight out of these 11 female headed households lacked any male member more than 15 years of age. The average family size of the surveyed households was 5.4. The per capita income (PCI), considered a better measure of well-being compared to income level, increased with the income class in this sample. The average PCI of the sample was INR 1,997, which presents the percentage distribution of surveyed households according to PCI.

> "My mother asked me to drop out of school though I was very much interested in study. She told me what will you do after study any way you have to cook and up to fifth std study is sufficient for that. My sisters were also dropped out of schools after completing 2-3 std. My brother had also left his study after completing 5th std and started helping my father."
>
> *- Kausar Begum from Kanshiramhousing society, Ghaziabad*

**Table 2: Economic status and household type of sample households**

| Income Class (INR) | No. of households | No. of male headed households | No. of female headed households | No. of family members | Average family size | Per capita income (INR) |
|---|---|---|---|---|---|---|
| 0-4,999 | 13 | 2 | 11 | 45 | 3.5 | 1,118 |
| 5,000–9,999 | 117 | 93 | 24 | 561 | 4.8 | 1,555 |
| 10,000–14,999 | 74 | 59 | 15 | 445 | 6.0 | 1,971 |
| 15000–19,999 | 18 | 12 | 6 | 104 | 5.8 | 2,817 |
| 20,000–24,999 | 17 | 15 | 2 | 122 | 7.2 | 2,919 |
| ≥25,000 | 7 | 6 | 1 | 58 | 8.3 | 3,750 |
| **All** | **246** | **187** | **59** | **1335** | **5.4** | **1,997** |

*Source: IRADe household survey for LPG Ghaziabad, 2015*

## 4.2 LITERACY LEVELS

Literacy levels and educational attainment are vital developmental indicators to understand the level of male and female education. The survey captured the highest level of education for each male and female member of the sample households. It was observed that 3.7 per cent of sample households did not have any male family member and 0.4 per cent did not have any female family member. The households were grouped into four categories based on the highest level of education attained by male and female members in

> "My LPG connection is on the name of my husband and he does not have a bank account. My son has a bank account. My agency has stopped giving me LPG cylinder and asking my husband to provide his bank account details only then they will give me cylinder.
>
> *Meena from Arthala, Mohan Nagar, Ghaziabad*

the households: (i) illiterate (ii) 1–5 years of schooling (iii) 6–10 years of schooling and (iv) above 10 years of schooling. It was found that female household members were at a disadvantage in education levels when compared to their male counterparts. Seventeen per cent of the households had no literate male member, whereas this statistic for females was much higher, at 32 per cent. In primary education (1–5 years), females outnumbered males in contrast with secondary (6–10 years) and senior secondary levels (above 10 years), where males were seen to be doing better (Figure 3).

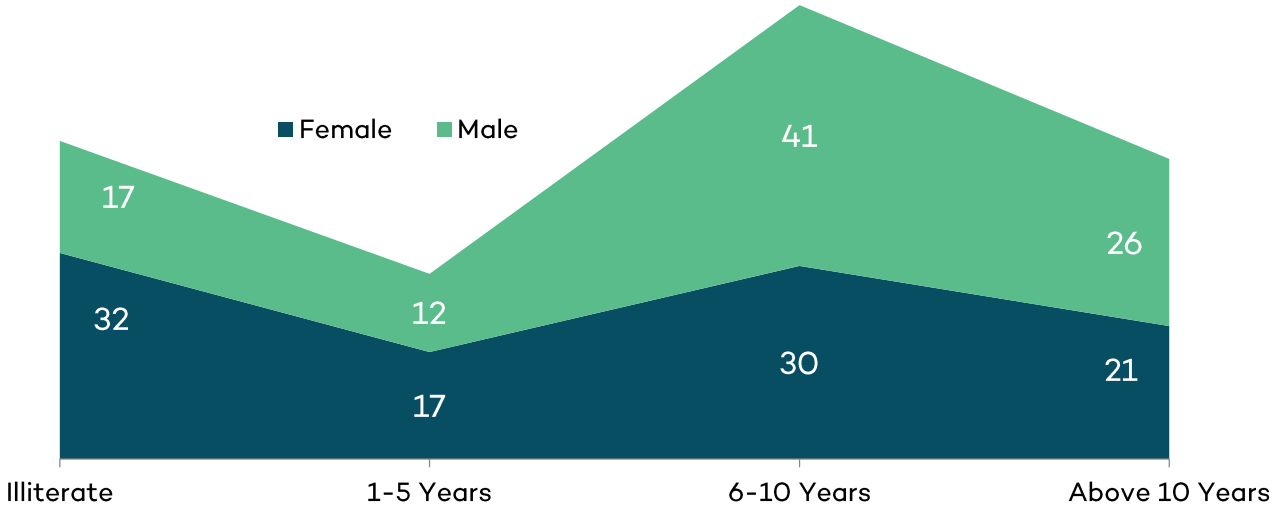


**Figure 3: Household distribution (%) by male and female education level**

*Source: IRADe household survey for LPG Ghaziabad, 2015*

## 4.3 ACCESS TO JAM

The Government of India is promoting three modes of identification, the Jandhan-Aadhaar-Mobile (JAM trinity), to deliver cash transfers directly to the beneficiary accounts in order to augment the effectiveness of existing programs. The JAM trinity is seen as an effective measure to reduce leakages: it helps in the direct biometric identification of disadvantaged citizens through Jan Dhan bank accounts, Aadhaar (Unique Identification Number) and mobile phones, allowing the direct transfer of funds into their accounts. MoPNG has launched the Direct Benefits Transfer for LPG (DBTL) scheme for transferring LPG subsidies. Figure 5 presents JAM's coverage in the surveyed households.

*A 5 Kg LPG cylinder with burner*

**Figure 4: A 5-kg LPG cylinder with burner**

To receive benefits from the government under JAM, an individual member of the household has to have all three identities synced (bank account, mobile number and Aadhaar card). The survey in Ghaziabad revealed that, though nearly 90 per cent of the households had access to these three basic requirements, barely 65 per cent households had at least one member with all three requirements in place that could access the JAM scheme. In some cases, it was possible that different members of the household had acces to these three basic requirements,[3] and any individual member of the household did not have these three mandatory things simultaneously in his/her name to qualify for benefits under JAM scheme.

[3] For illustration, let's assume a household has three members (A, B and C). In this household, A has an Aadhaar number, B has a mobile number and C has a bank account. Despite this household possessing all the three basic requirements for being eligible to receive benefits under the JAM scheme, they will not be able to do so because no individual member in the household possesses all three mandatory requirements in his/her name. Alternatively, let us assume another household has three members (X, Y and Z). In this household, becasue X has all three—Aadhar number, mobile number and bank account number—this household would be eligible to receive benefits under the JAM scheme.

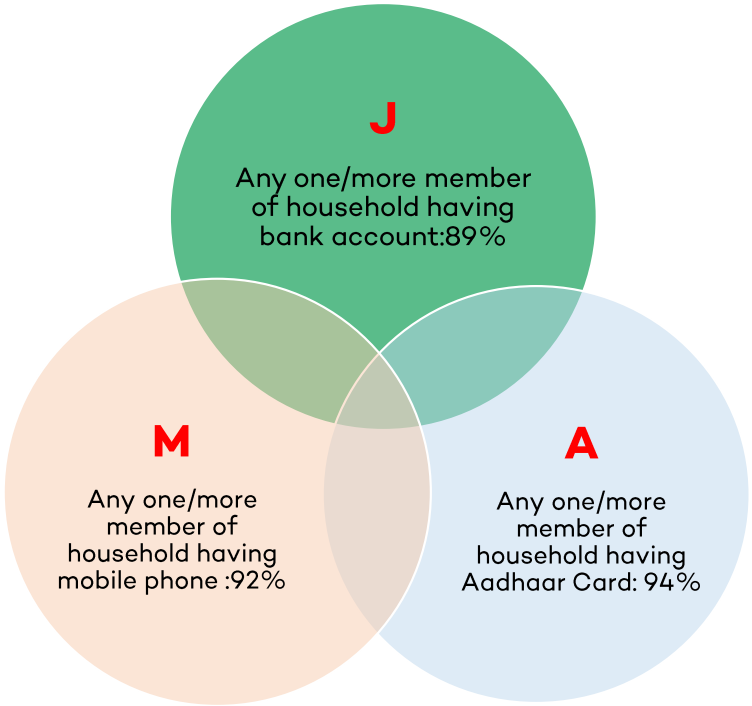


**Figure 5: Households can be reached through JAM**

*Source: IRADe household survey for LPG Ghaziabad,2015*

## 4.4 HOUSEHOLD ACCESS AND USES OF LPG FOR COOKING

### 4.4.1 Public Sector Oil Marketing Companies' Official LPG Connections

Figure 6 presents the availability of LPG connection types in the surveyed households. Subsidized LPG connections provided by public sector OMCs were available in only 43 per cent of the households. Twenty two per cent of households possessed LPG cylinders without official LPG connections; that is, they purchased the cylinders from the black market and also got them refilled on the black market. Therefore, LPG cylinders (14.2 kg cylinders) were available with 65 per cent (43 per cent + 22 per cent) of households. But, 88 per cent of the households were fully or partially cooking using LPG and they possessed small cylinders (available in 2 to 5 kg gas cylinders) with burners. **This leaves only 12 per cent of households that exclusively use solid fuel (fire wood, dung cake and coal) and kerosene for cooking**. The households that possess small LPG cylinders with burners also get them refilled on the black market. Though the subsidized LPG connections were limited to only 43 per cent of the sampled households, LPG was being used by nearly 88 per cent of the sample households. This means that a flourishing LPG black market exists, where customers who do not have subsidized connections are sold LPG at higher prices. Poor households that do not have official LPG connections resort to buying LPG for their needs at substantially higher prices than the relatively well-off households that have subsidized LPG connections.

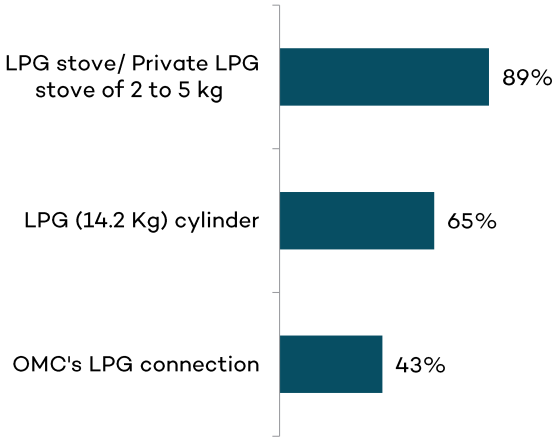


**Figure 6: LPG connection/usage status**

*Source: IRADe household survey for LPG Ghaziabad, 2015*

Figure 7 presents the PCI and class-wise formal LPG connections. It shows that there is a positive correlation between per capita income class and percentage of households with official LPG connections. Although meant for the poor, families with low PCI are less likely to have an LPG connection as compared to high-PCI families. Therefore, this supports the finding of earlier studies that the current LPG subsidy regime is regressive in nature and the poor receive less benefits then rich families. This is contrary to the concept of social justice that more benefits should flow towards the poor and vulnerable. Figure 8 presents the cooking energy fuel types used by households and further compares the monthly use of cooking fuel types for households with official OMCs' LPG connections and those without OMCs' LPG connections. Overall, nearly 8 per cent of the households use only biomass and 20 per cent of the households use both biomass and LPG (refer to Figure 8 below). As Ghaziabad is a predominantly urban district close to Delhi, the majority of surveyed households (50 per cent) used only LPG for cooking. Twenty per cent of the households used both LPG and kerosene for cooking and only 2 per cent used kerosene exclusively for cooking. This suggests that many households used a portfolio of cooking energy sources reflecting "energy ramping" before completely shifting to the cleanest sources of energy, in this case LPG.

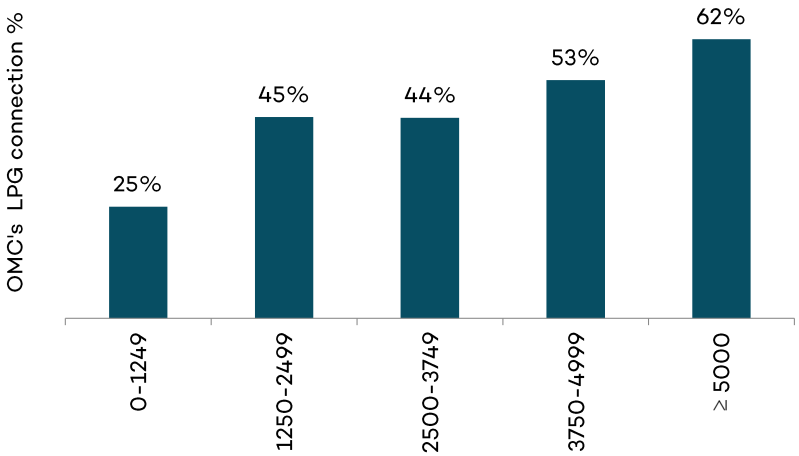


**Figure 7: Per capita income (PCI) class-wise LPG connection**

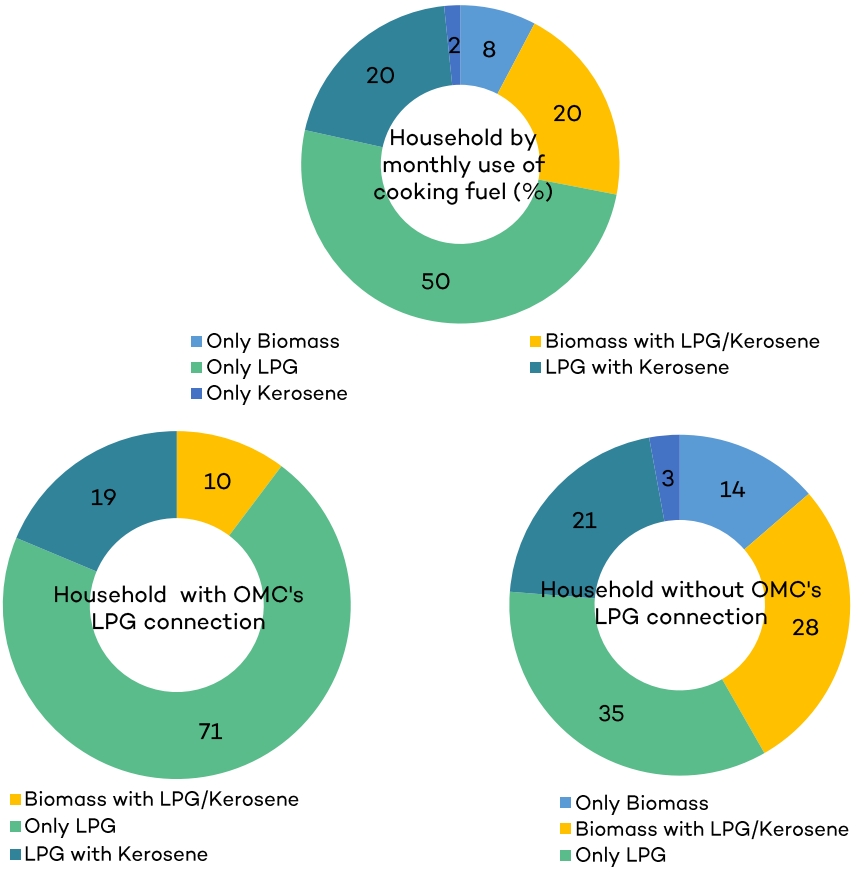


**Figure 8: Household classification of cooking fuel and LPG connection status**

*Source: IRADe household survey for LPG Ghaziabad, 2015*

LPG distributors deliver filled cylinders at the registered address to customers residing in their normal areas of operation and collect the empty cylinders. The majority of households did not report any issue with regard to cylinder delivery at their doorstep; however, it was found that 70 per cent of the households with official LPG connections had a single bottle connection, which prevented them from storing backup LPG at home. There is a lag of three to four days in between ordering the cylinder and delivery from the LPG distributor to the household. Therefore, households may be forced to use an alternate fuel such as kerosene or biomass during this period (order and delivery). Under DBTL, consumers receive subsidies in their bank account as per their entitlement of subsidized cylinders. Approximately 15 per cent of households with official LPG connections stated that they had not been receiving subsidies in their account for various reasons. A few reasons mentioned were: (1) their bank accounts are not linked by the agency, (2) household members do not hold a bank account and (3) mismatch in the spelling of the name of the bank and LPG registration.

The "energy ramping" model is also applicable to families with LPG connections. Nearly 29 per cent of households with official LPG connections use either biomass or kerosene along with LPG for cooking. It is interesting to note that 35 per cent of households without LPG connections were cooking solely on LPG; only 14 per cent of these households cook on biomass and nearly three per cent on kerosene. Figure 8 shows that nearly 84 per cent of the households without official LPG connections were using only LPG or LPG with biomass/kerosene for cooking. This is a huge percentage and suggests that there is a willingness to use LPG for cooking, but since it is not formally accessible to them, they have to get it through informal/illegal channels.

## 4.5 STATUS OF AVAILABILITY OF KEROSENE THROUGH THE PUBLIC DISTRIBUTION SYSTEM

The survey also tries to evaluate the efficiency of the Public Distribution System (PDS) for kerosene. Almost 100 per cent of the respondents entitled[4] to get kerosene from the PDS system said that they were able to get kerosene as per their entitlement from the PDS shop without paying extra, but some households also complained that they had to spend their productive working hours (which ranges from 30 minutes to 4 hours) collecting kerosene from the PDS. Kerosene is available from the ration shop only on designated dates and household members who fail to access the resources on the particular day lose their kerosene quota. It was also observed that many households, though not using kerosene, still purchased their entitled kerosene from the PDS shop and sold it at a higher price on the black market (illegal market). In Ghaziabad, subsidized kerosene is sold to the customers through the PDS shop at approximately INR 16/litre, and can then be sold on the black market in Ghaziabad at an average of INR 40/litre. This price difference provides an incentive for households to buy kerosene from the PDS shop and sell it on the black market. Thirty-eight per cent of households with official LPG connections are also entitled to PDS kerosene. The high difference in the price of diesel (diesel price in Ghaziabad: INR 51.48 on December 16, 2015) and black market kerosene is the principal reason that kerosene is sold on the black market, as it can easily be used to run diesel-fuelled engines.

> *"I don't have LPG connection. I have borrowed a cylinder from a relative therefore always get it filled in black market. My relative had double bottle connection and offered me his second LPG bottle. He does not have to get it filled frequently as they have only 2 member in their house and manage with the single LPG cylinder".*
>
> - Rajaram from Vijay Nagar, Ghaziabad

[4] As per the PDS system, households with PDS cards are eligible to get kerosene at a subsidized price from the government designated ration shops.

## 4.6 COOKING ENERGY PRICE, AVERAGE CONSUMPTION AND SOURCES

The survey calculates expenditure associated with cooking fuels in rupees in the last 30 days. Based on the monthly fuel consumption (in respective units) from various sources, monthly useful energy at the final consumption stage of cooking in megajoules (MJs) is calculated for each household using Table 3.[5] More details are available in the annex at the end of the report.

**Table 3: Efficiencies at the final consumption stage of cooking**

| Fuel source | Energy content (MJ per KG) | Conversion efficiency (%) | Useful energy at final consumption stage of cooking (MJ per KG) |
|---|---|---|---|
| LPG | 45.5 | 60 | 27.3 |
| Kerosene (pressure) | 43.0 | 55 | 23.6 |
| Fuel wood (traditional), 15% moisture | 16 | 15 | 2.4 |
| Dung, 15% moisture | 14.5 | 12 | 1.7 |

*Source: Adapted from O'Sullivan & Barnes (2006)*

Based on the sample household cooking energy expenditure and final cooking energy consumption, the study derives the prices of various sources of energy per MJ, as presented in Figure 9. Dung cake is relatively cheaper than other sources, including LPG from the black market. Given the prices of fuel wood in Ghaziabad, it is one of the most expensive sources of energy for cooking. The price of a non-subsidized LPG cylinder, available through the public sector OMCs' distributor, is currently sold at INR 610 for the 14.2 kg cylinder. This means that the price per MJ for non-subsidized LPG is only INR 1.58, making it cheaper than all energy sources except PDS kerosene and subsidized LPG. Households without LPG connections, mostly the poor, are paying more than twice the price of subsidized LPG; a premium for using LPG for cooking.

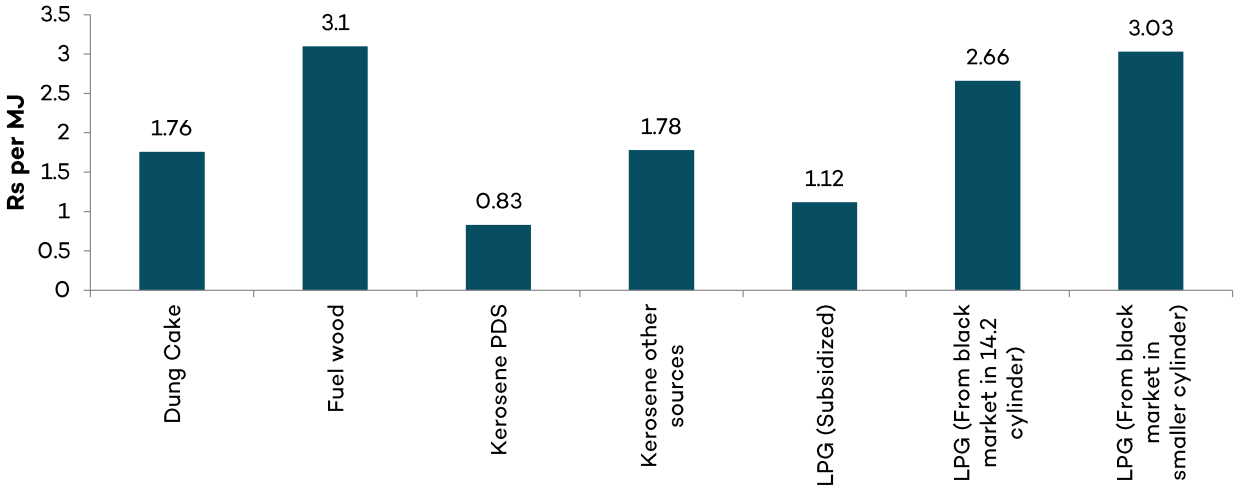


**Figure 9: Price of cooking energy from different sources**

*Source: IRADe household survey for LPG Ghaziabad, 2015*

The average monthly cooking energy per capita declines with the family size (Figure 10). Results show that large households tend to consume less energy per capita than smaller households, because the use of energy in household cooking activities are not directly proportional to the household size and remain constant or change insignificantly with the change in household size. The average monthly cooking energy consumption per capita for the entire sample is 58 MJ. Given the average family size

[5] Density of kerosene has been taken as 0.83 kg per litre (Sarkar & Kadekodi, 1988).

of the sample is 5.4 (Table 2), the average monthly cooking energy requirement per family is 313.2 MJ, and annual cooking energy requirement per family is 3758.4 MJ. To generate 3758.4 MJ of useful cooking energy, 137.67 kg of LPG will be required at the final stage of consumption. This means 9–10 LPG cylinders of 14.2 kg per year would be sufficient to meet the cooking energy requirements for an average family in GMC.

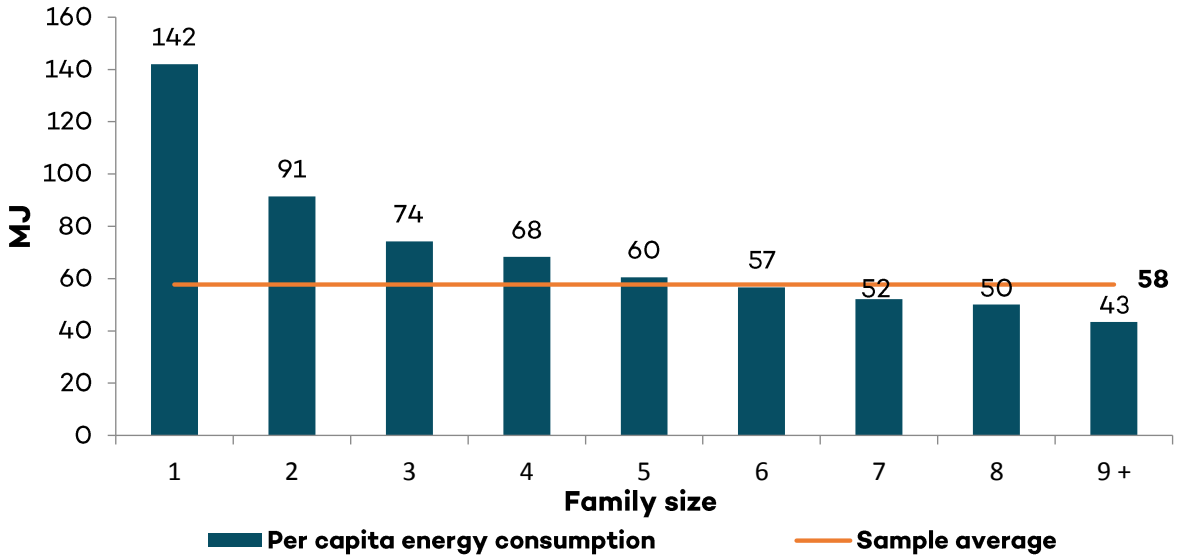


**Figure 10: Average monthly per capita cooking energy consumption**

*Source: IRADe household survey for LPG Ghaziabad, 2015*

Figure 11 presents the income class-wise household average monthly consumption of cooking energy in MJ. The total consumption of cooking fuel increases with the income level, as the higher income class uses more cooking energy than the lower income class. The energy mix of cooking fuel also changes with the household income level; households with higher income derive a major portion of their cooking energy needs from cleaner energy sources; here it is LPG.

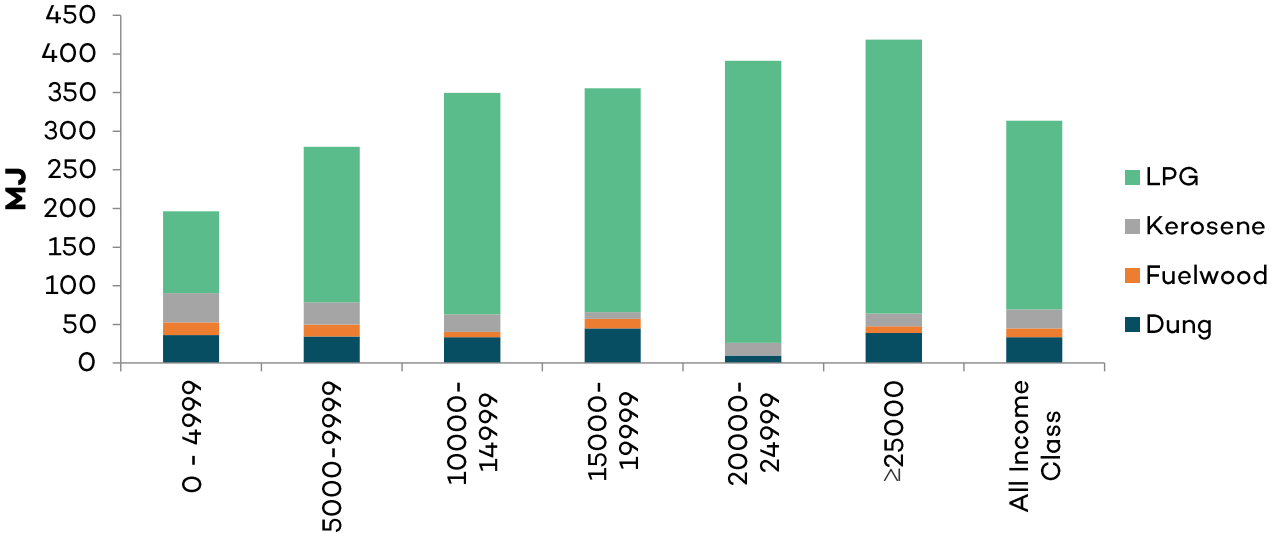


**Figure 11: Average monthly cooking energy consumption of household (in MJ)**

*Source: IRADe household survey for LPG Ghaziabad, 2015*

### 4.6.1 Costs of Cooking Fuels

Figure 12 reflects that, on an average, households with LPG connections consume more energy for cooking (341 MJ per month) compared to households without LPG connections (292 MJ per month). Households with LPG connections derive 96 per cent of their monthly cooking energy from LPG against merely 61 per cent of households without LPG connections. Although the energy consumption by households without LPG connections is less compared to households with LPG connections, the expenditure pattern provides a very different picture. The average monthly expenditure on cooking for households with LPG connections is INR 393, whereas for households without LPG connections, it is INR 657. *Though LPG is a cheaper source of cooking fuel, households are still not readily switching to it. This can be attributed to several factors, including intital capital cost of an LPG connection, arranging INR 600–700 each time for purchasing a 14.2 kg cylinder, etc.* This reveals that households without LPG connections are using dearer sources of cooking energy, adversely affecting their household budget. The high startup cost needed for an LPG connection and, in some cases, arranging the money to pay for a 14.2 kg cylinder are preventing the household from switching to LPG. This highlights the plight of non-LPG households; in energy terms, they use less but pay more.

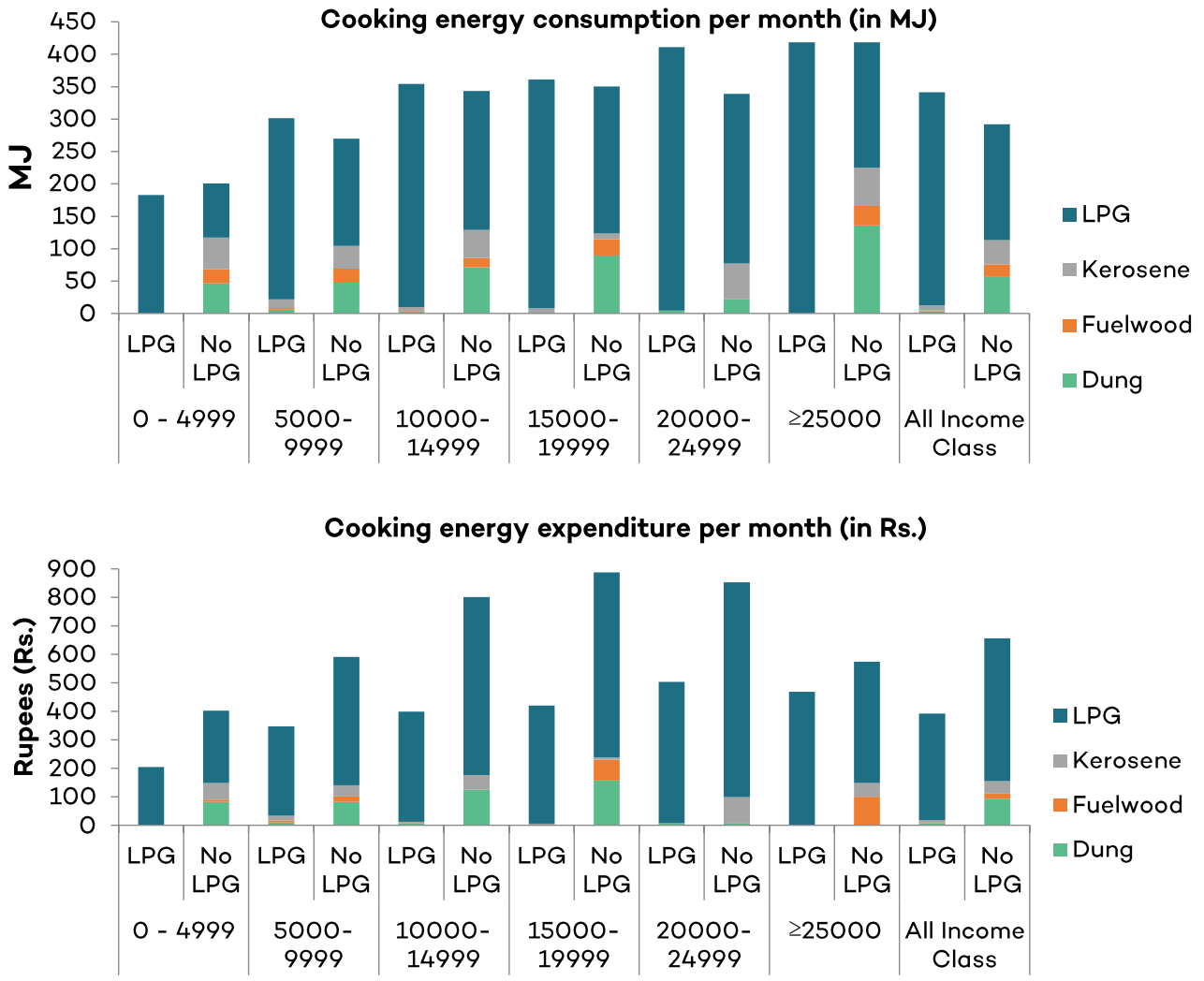


**Figure 12: Average monthly cooking energy consumption (in MJ) expenditure (in INR) of households with and without LPG connection[6]**

*Source: IRADe household survey for LPG Ghaziabad, 2015*

[6] Note: "LPG" reflects households with an LPG connection and "No LPG" reflects households without an LPG connection. Expenditure is only for purchased cooking fuel and not for home produced/collected cow dung and fuel wood.

## 4.7 TIME SPENT COOKING AND CLEANING

The study collected household cooking details for the preceding day of the survey. Information related to fuel used for cooking, and time spent cooking and cleaning vessels was gathered. Compared to LPG, vessels used for kerosene stoves require 3.82 minutes more and vessels used for biomass stoves require 7.46 minutes more for cleaning per cooking session. Compared to LPG, cooking with a kerosene stove requires 6.18 minutes more and cooking on a biomass stove requires 22.20 minutes more per cooking session (Table.4).

**Table 4: Cooking fuels and average cleaning and cooking time (in minutes)**

| Energy source | Average family size | Cleaning | | | Cooking | | |
|---|---|---|---|---|---|---|---|
| | | Average cleaning time per session per capita | Excess cleaning time per session per capita compared to LPG | Average excess cleaning time per session compared to LPG | Average cooking time per session per capita | Excess cooking time per session per capita compared to LPG | Average excess cooking time per session compared to LPG |
| Biomass | 5.8 | 6.44 | 1.28 | 7.46 | 13.36 | 3.82 | 22.20 |
| Kerosene | 4.8 | 5.96 | 0.80 | 3.82 | 10.83 | 1.30 | 6.18 |
| LPG | 5.4 | 5.15 | 0 | 0.00 | 9.54 | 0.00 | 0.00 |

*Source: IRADe household survey for LPG Ghaziabad, 2015*

## 4.8 HEALTH ISSUES RELATED TO BIOMASS USES

Fuel wood, crop residue and animal dung are the three important types of biomass used in Ghaziabad. This survey captured the health implications of biomass used for cooking on three indicators (eye irritation, respiratory problems and incidents of burns, if any) from the women respondents of the households using biomass. We asked these questions to women respondents only because women and children suffer most from indoor air pollution, because they are traditionally responsible for cooking and other household chores, which involve spending hours by the cooking fire and being exposed to smoke. Eye irritation because of using biomass for cooking was most prevalent, reported by 97 per cent of the respondents, followed by respiratory problems and burns (Fig. 11).

> *"I was cooking on biomass earlier but has regular pain in my eye. I had become almost blind when I went to doctor he advised me not to use biomass hence shifted to LPG.*
>
> - Sunita from Kanshiram madhuban, Ghaziabad

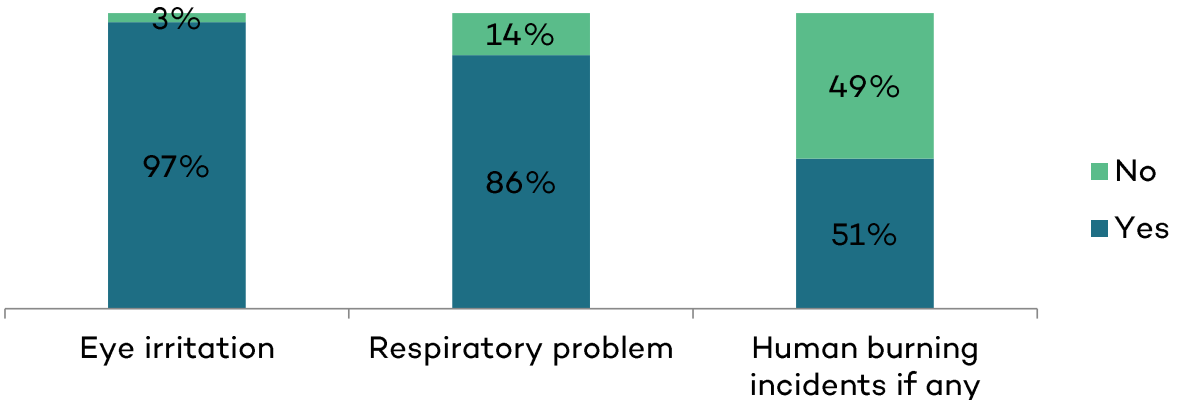


**Figure 13: Health issues related to cooking with biomass**

*Source: IRADe household survey for LPG Ghaziabad, 2015*

## 4.9 STATUS OF NON-LPG[7] HOUSEHOLDS

To understand the reasons for not having an official LPG connection (till the date of survey) the survey asked a mix of qualitative and quantitative questions from these household sets. The majority of these households stated that they had visited the LPG distributor to get an official connection, but the hefty startup cost needed for a formal connection was a deterrent for availing the connection. The distributors (that participated in the survey) do not sell standalone LPG connections, clubbing, burner and several other accessories with the LPG cylinder, such as the regulator and suraksha pipe, which makes the startup cost of a new official connection more expensive. Nearly, 90 per cent of the respondents who already had a formal LPG connection said that they were compelled to buy an LPG hot plate and other accessories (these are available at cheaper prices in markets) from the LPG distributor, which increased the initial sum required for a formal LPG connection. Moreover, they said that the purchase of accessories was a precondition by the LPG distributor to aquire a LPG connection. The lack of required documents is another obstacle in obtaining a formal connection. In response to their willingness to buy a formal connection, almost 100 per cent households responded affirmatively that they were willing to buy a formal LPG connection. Willingness to pay the startup cost varied with the level of household income; their willingness to pay for the connection varied from INR 1,000 to INR 4,000. Households were also willing to pay the startup cost in installments, as this option makes it easier for the household to pay the startup cost. In response to the question "Will you be able to afford to pay for LPG each month?" a surprising 100 per cent of the households said that they could comfortably pay the monthly running cost of LPG.

## 4.10 HOUSEHOLD DECISION MAKING

The roles played by the different family members in various household decisions gives an overview of the relative bargaining power within the family and how power is shared or concentrated within any family or household setting. In this study, an effort has been made to understand the relative roles of males and females in decisions made on six important issues in each intra-household setting in Ghaziabad: (i) decision about sending children to school, (ii) purchase of stove and fuel, (iii) food for the family, (iv) health check-ups and other family medical-related needs, (v) purchase of household appliances and (vi) taking out loans and other major financial decisions. As shown in Figure 14, females play a major role in day-to-day household decision making, such as sending children to school, purchase of kitchen utensils and other small day-to-day requirements; whereas males dominate the long-term or financial decisions of the family, such as purchase of land or taking out loans.

[7] "Non-LPG" means that the household does not have legal LPG connection.

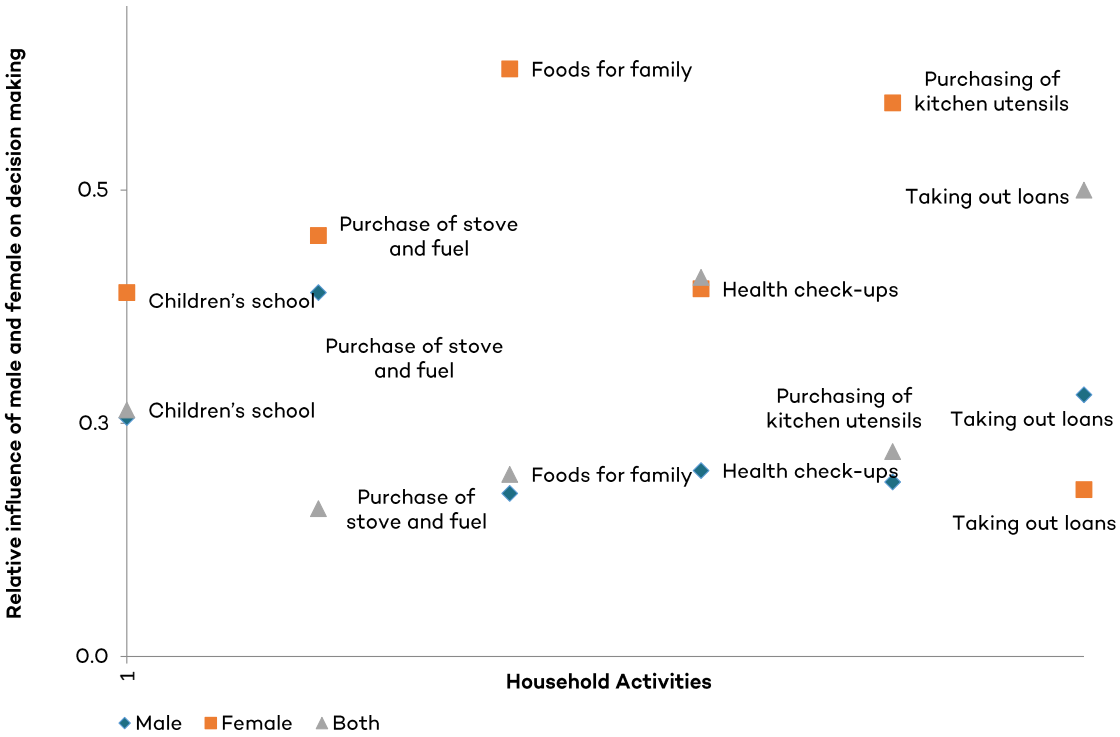


**Figure 14: Household decision making and role of male and female**

*Source: IRADe household survey for LPG Ghaziabad, 2015*

# 5.0 Model Estimation

This section assesses the choice between LPG and alternative cooking fuel by households. The user ramps up gradually towards cleaner fuel rather than leapfrogging (Heltberg, 2004; Kowsari & Zerriffi, 2011). In other words, households use traditional fuels in the early stage, mixed fuel in the next step and finally modern fuels. Therefore, this study classifies the households into three categories: (1) households using only traditional fuel, (2) households using mixed fuel and (3) households using only LPG for cooking. The households were classified based on their monthly cooking energy consumption presented in Table 5.

**Table 5: Surveyed household classification according to monthly cooking fuel consumption**

| Household Classification | Sample household (N) | Average monthly income | Average monthly per capita income | Average highest year of schooling (male) | Average highest year of schooling (female) | Average household energy consumption (MJ) |
|---|---|---|---|---|---|---|
| Traditional | 19 | 1513.1 | 8334.2 | 4.2 | 3.1 | 265.3 |
| Mixed | 102 | 1851.6 | 10148.0 | 7.6 | 5.7 | 327.6 |
| Modern fuel (LPG) | 125 | 2488.7 | 11780.8 | 8.8 | 6.8 | 308.4 |

The households with traditional fuels are those households that use only solid fuel like dung cakes and/or firewood for cooking. Households that derive their monthly cooking energy from solid fuel and kerosene/LPG are classified in the mixed category. Households that only use LPG for cooking are categorized in modern fuel. A multinomial logit model (MNLM) is used to assess the determinants of the choice of cooking fuel combination. This is a standard technique for assessing how exogenous variables affect the choice between different discretionary outcomes. The response variable includes three distinct unordered alternatives: traditional, mixed and modern cooking fuel. The goal of this model is to find the best fitting model to describe the relationship between outcome variables. MNLM is an extension of logistic regression where dependent variable has "J" nominal outcomes (in our case J=3). In MNLM "J-1" equations need to be estimated, one for each category with the reference category (1=traditional fuel). The "J" equation solutions predict the probabilities as shown in equation 1.

$$\Pr(y_i = j) = \frac{\exp(\beta_j' X_i)}{\sum_{j=1}^{J} \exp(\beta_j' X_i)} \qquad (1)$$

Here, $\Pr(y_i = j)$ is the is the probability of choosing either mixed or modern with traditional as the reference cooking fuel category

$J$ is the number of fuel in the choice set.

$j = 1$ is the traditional fuel.

$X_i$ is the vector of predictors.

$\beta_j$ is the vector of estimated parameters.

Here the predictor variable is family size, highest year of female education in the family, gender composition (percentage of females in the family), monthly PCI, LPG price per MJ, household monthly energy demand and head of household. We have calculated the LPG price paid by each household based on their LPG consumption and expenditure. For those households that do not use LPG at all in the entire month (31 such households) we have used the proxy price of INR 3.03 per MJ which is the sample average price of LPG per MJ a household pays if it does not have a connection or possess an LPG cylinder informally. We have not taken the price of dung cakes and fuel

wood, as they are nearly the same in the sample. The kerosene price is also excluded from the model as the government provides a fixed amount of PDS kerosene at a fixed price. Given that, barring PDS kerosene, subsidized LPG followed by non-subsidized LPG are the cheapest sources of cooking energy at the final consumption stage, the model only has considered LPG prices.

Table 6 presents the model-fitting information, which indicates the parameters of the model for which the model fit is calculated. "Intercept Only" describes a model that does not control for any predictor variables and simply fits an intercept to predict the outcome variable. "Final" describes a model that includes the specified predictor variables and is arrived at through an iterative process that maximizes the log likelihood of the outcomes seen in the outcome variable. "Chi-square" is the likelihood ratio (LR) chi-square test in which at least one of the predictor regression coefficients is not equal to zero in the model. Degree of freedom (df) of the chi-square distribution is used to test the LR chi-square statistic and is defined by the number of predictors in the model (seven predictors in two models). The null hypothesis is that all the regression coefficients in the model are equal to zero. The small value of significance (.000) suggests that we can reject the null hypothesis at even one per cent level.

**Table 6: Model fitting information**

| | Model Fitting Criteria | Likelihood Ratio Tests | | |
|---|---|---|---|---|
| **Model** | **-2 Log Likelihood** | **Chi-Square** | **df** | **Significance** |
| Intercept Only | 446.162 | | | |
| Final | 350.803 | 95.358 | 14 | .000 |

**Table 7: Multinomial model result fuel switching in urban Ghaziabad**

| | **Energy Classification** [a] | **β Coefficients** | **Std. Error** | **Exponential(β)** |
|---|---|---|---|---|
| Households using mixed fuel for cooking | Intercept | -11.266 | 7.995 | |
| | Log of family size | -2.582 | 1.323 | 0.076 |
| | Highest year of female education in family | 0.123 | 0.075 | 1.131 |
| | Percentage female in family | -0.006 | 0.026 | 0.994 |
| | Log of monthly per capita income | 0.700 | 0.806 | 2.014 |
| | LPG price per MJ | -2.179 | 1.271 | 0.113 |
| | Log monthly household energy consumption (MJ) | 3.232 | 1.284 | 25.318 |
| | [Household head=Male] | 0b | | |
| | [Household head=Female] | -0.339 | 0.614 | 0.712 |
| Households using only LPG (clean fuel) for cooking | Intercept | -14.058 | 8.395 | |
| | Log of family size | -2.670 | 1.363 | 0.069 |
| | Highest year of female education in family | 0.141 | 0.078 | 1.152 |
| | Percentage female in family | -0.028 | 0.027 | 0.973 |
| | Log of monthly per capita income | 2.299 | 0.850 | 9.962 |
| | LPG price per MJ | -2.926 | 1.274 | 0.054 |
| | Log monthly household energy consumption (MJ) | 2.063 | 1.331 | 7.872 |
| | [Household head=Male] | 0b | | |
| | [Household head=Female] | -0.673 | 0.658 | 0.510 |

[a] *The reference category is 1= biomass. b this parameter is set to zero because it is redundant.*

**Household Size:** The results in Table 7 suggest that increasing household size has a negative effect on household fuel choice, suggesting that increasing family size can result in the use of inferior quality fuel for cooking. A one-unit increase in log of family size is associated with a 2.58 decrease in the relative log odds of using mixed fuel versus traditional fuel. Similarly, a one-unit increase in log of family size is associated with a 2.67 decrease in the relative log odds of using modern fuel versus traditional fuel. In terms of gender composition, a high share of females in the family reduces the likelihood of using modern fuel.

**Literacy:** Households with more years of female education are less likely to cook with traditional fuel. A one-year increase in female education is associated with a 0.12 increase in the relative log odds of using mixed fuel versus traditional fuel. Similarly, a one-unit increase in female education is associated with a 0.14 increase in the relative log odds of using modern fuel versus traditional fuel. Education, in itself, therefore helps trigger fuel switching in urban areas.

**Income:** Several past studies have noted income as an important determinant for fuel switching. In this study, the household monthly per capita income also turns out to be an important determinant for fuel switching. A one-unit increase in log monthly per capita income is associated with a 0.70 increase in the relative log odds of using mixed fuel versus traditional fuel. However, a one-unit increase in log monthly per capita income is associated with a 2.29 increase in the relative log odds of using mixed fuel versus traditional fuel.

**LPG Price:** The LPG price paid by the households is an important determinant of fuel switching. The results in Table 10 suggest that a one-unit increase in LPG price per MJ is associated with a 2.18 decrease in relative log odds of using mixed fuel versus traditional fuel. Similarly, a one-unit increase in LPG price per MJ is associated with a 2.93 decrease in relative log odds of using modern fuel versus traditional fuel. The households procuring LPG from the black market have to pay a very high price compared to households procuring subsidized LPG from the OMC's distributors. The challenge for the policy-makers is to make LPG affordable for poor households who have the lowest paying capacity. Poor households without formal LPG connections end up paying a premium over the market price for using LPG as a cooking fuel. The poor are cut off from modern energy services largely because they cannot afford to buy the LPG "startup" kit.

**Cooking energy demand:** The household energy demand improved fuel switching in GMC. The results suggest that a unit increase in log monthly household energy consumption is associated with a 3.23 increase in relative log odds of using mixed fuel versus traditional fuel. Moreover, a unit increase in log monthly household energy consumption is associated with a 2.06 increase in relative log odds of using modern fuel versus traditional fuel.

**Household head (male-headed versus female-headed households):** The relative log odds of using mixed fuel versus traditional fuel will decrease by 0.34 if moving from male-headed households to female headed households. Similarly, the relative log odds of using modern fuel versus traditional fuel will decrease by 0.67 if moving from male-headed households to female-headed households. Therefore, female-headed households are less likely to use modern fuels.

Fox and Andersen (2006) developed the "effect display" for the multinomial logit model—to find fitted probabilities—under the model for selected combinations of values of the predictors. An "effect display" is a table or graph meant to represent a term in a statistical model. To create an effect display, predictors in a term are allowed to range over their combinations of values, while other predictors in the model are held to "typical" values (Fox & Hong, 2010). The effect display of our estimated model has been presented in Figures 15 to 20. Figure 15 shows that, as the household size increases, the probability of using modern fuel declines. Large households may prefer to maintain several options for their fuel security (Energy Sector Management Assistance Programme, 2003a).

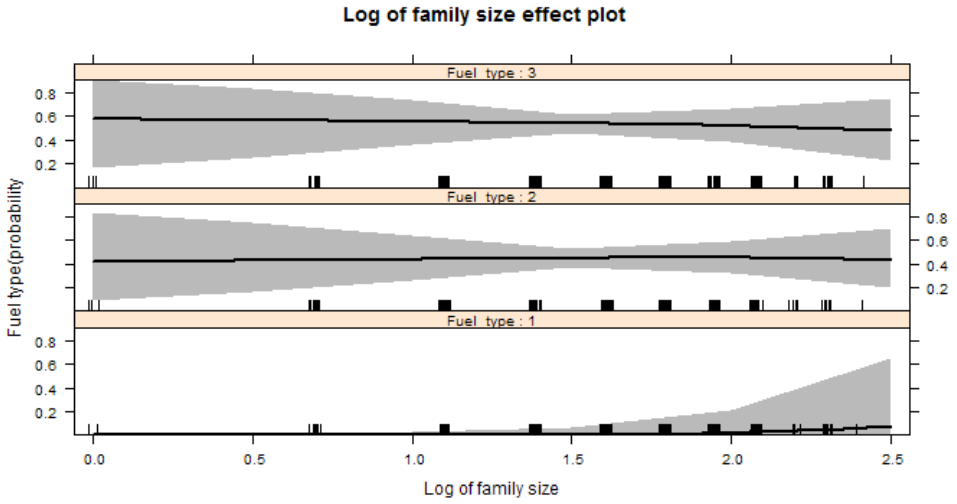


**Figure 15: Effect plot for the family size in the multinomial logit model**

Figure 16 shows that, as the highest year of female education in the family increases, the probability of using modern fuel increases, and the probability of using mixed fuel declines.

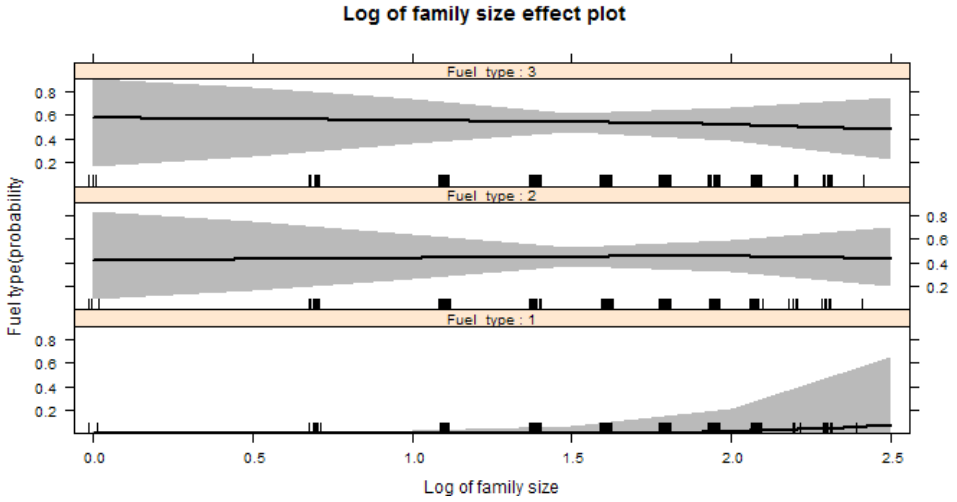


**Figure 16: Effect plot for the highest year of female education in the family in the multinomial logit model**

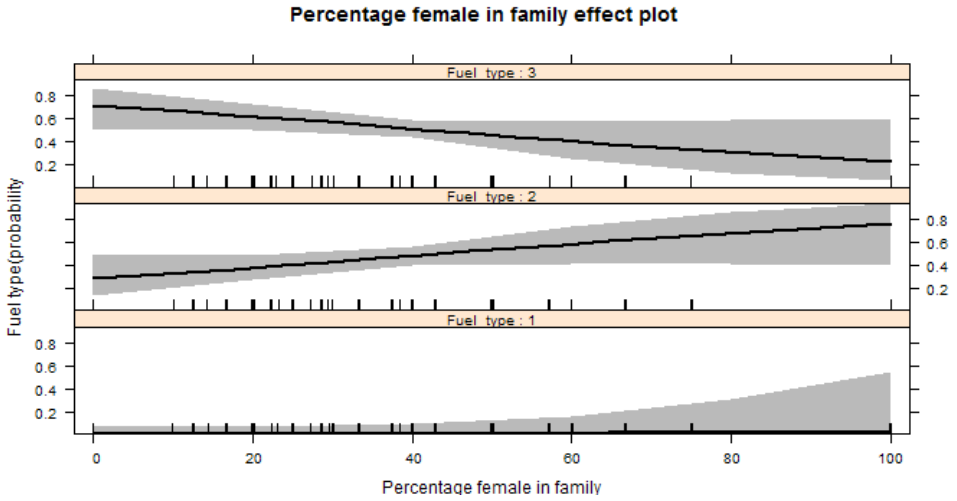


**Figure 17: Effect plot for the percentage female in the family in the multinomial logit model**

The gender composition effect suggests that if the female percentage is low in the family, then the probability of using modern fuel is high (Figure 17). However, as the female percentage in the family increases, the probability of using modern fuel declines and probability of using mixed fuel increases. Figure 18 shows that, at low levels of monthly per capita income (MPCI), the probability of using mixed fuel is high, whereas as the MPCI increases the probability of using mixed fuel declines. On the other hand, increasing MPCI is associated with higher probability of using modern fuels.

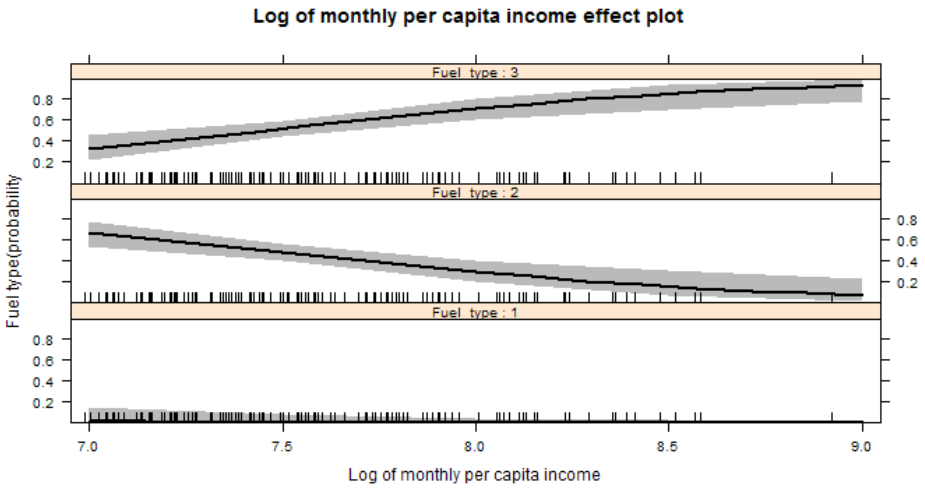


**Figure 18: Effect plot for the log of monthly per capita income in the multinomial logit model**

The LPG price-per-MJ effect is presented in Figure 19. At the lowest level of LPG price, the probability of using modern fuel (i.e., LPG) is very high, and, as the LPG price increases, the probability of a household using modern fuel declines. On the other hand, as the price of LPG increases, the probability of using mixed fuel also increases. It is important to note that the cheapest source of LPG is subsidized LPG sold through OMC distributors. The government needs to increase the coverage of LPG connections to encourage the urban population to use modern fuels.

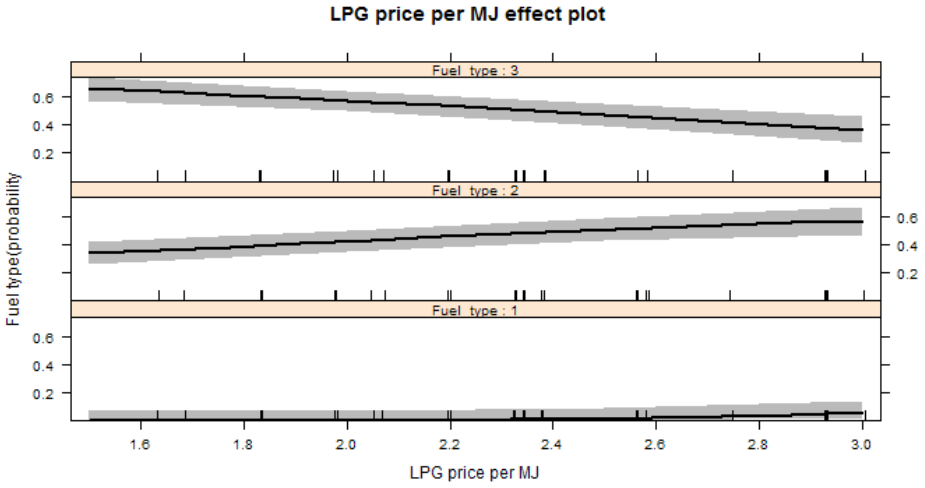


**Figure 19: Effect plot for the log of monthly per capita income in the multinomial logit model**

The monthly cooking energy consumption effect on household fuel type is presented in Figure 20. Interestingly, as the household demand for total cooking energy increases, the probability of using modern fuel declines and the probability of using mixed fuel increases. The higher monthly cooking energy demand also lowers the probability of using traditional fuels.

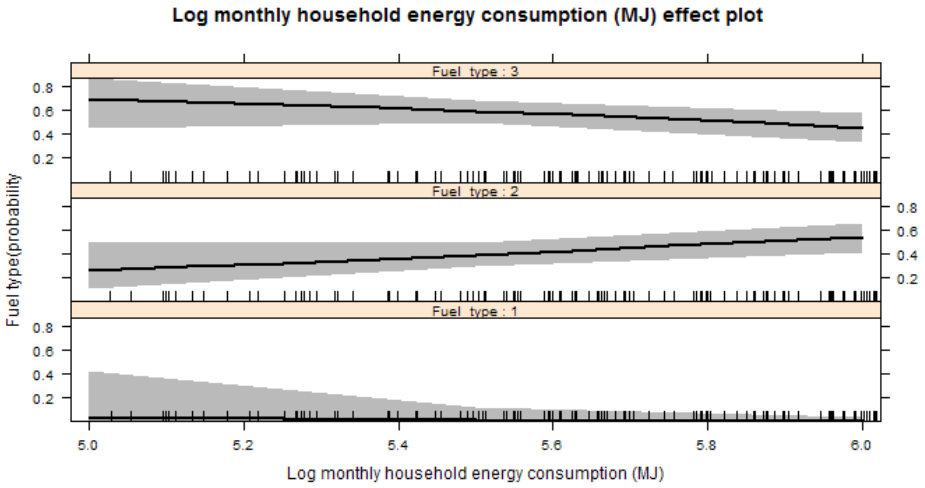


**Figure 20: Effect plot for the log of monthly household energy consumption in the multinomial logit model**

# 6.0 The Way Forward to Enhance Clean Cooking Energy Access in Urban Areas

This report proposes a way forward to enhance clean cooking energy access in urban areas, based on the findings from primary field work in GMC. Ghaziabad is a suburban district located in western Uttar Pradesh and shares boundaries with Delhi in the west. As per the Census 2011, the district comprises 0.85 million households with a population of 4.68 million (Government of India, 2011). Nearly 71 per cent (3.16 million) of the population has been categorized as urban. GMC which is a part of Ghaziabad District has 3,36,069 urban households with a population of 16,48,643. There are multiple factors that come into play for fuel switching, including level of income, education, family size and composition, fuel prices, accessibility, energy demand and awareness. This research study analyzes the cooking energy scenario and finds that accessibility to LPG is a pressing issue that requires a multipronged approach to improve the coverage of LPG. Policy recommendations and ways forward from this study are listed below.

## 6.1 OBSERVATIONS AND RECOMMENDATIONS

In GMC, kerosene is not the popular fuel of choice for cooking, as merely **two per cent households exclusively use kerosene for cooking**, and 20 per cent of the households use both LPG and kerosene for cooking. Further, it was observed that the kerosene quota allotted to the poor households was diverted to other uses, as it is rarely used for lighting. The majority of poor households surveyed use electricity or wax candles for lighting. **The study finds that the importance and use of kerosene in GMC has very limited relevance for poor households as a fuel used for cooking or lighting**.

The study proposes that GMC can be an ideal example to **implement a kerosene-free scheme** such as the one implemented in Delhi by the state government. The small fraction of households exclusively using kerosene or using kerosene along with other fuel for cooking can be assisted easily with LPG connections before the kerosene supply is removed, to prevent them switching to biomass. Keeping in mind the total expenditure difference on cooking fuel for households with LPG connections and without LPG connections, it does make economic sense for the households without LPG to acquire LPG for cooking. At the same time, electricity supply to the household also needs to be improved so that they should not have to resort to using wax candles for lighting.

Those without official LPG connections try to get them unofficially through LPG vendors or the black market. The reason they do not apply for a connection is the hefty "startup" cost (startup cost includes an expensive stove/burner and other accessories that LPG distributors insist new users must buy from them) or unavailability of required documents.

The availability of an official LPG connection benefits households in terms of lower monthly expenditures for cooking fuel. The average monthly expenditure on cooking for households with LPG connections is INR 393, whereas for households without LPG connections, it is INR 657 (IRADe survey, 2015). As an initiative by the Government of India, a dedicated CSR fund of public sector OMCs is focused on a scheme to distribute free LPG "startup" kits to poor households. This will enable households below the poverty line to obtain access to official LPG connections.

**Awareness and Coverage of LPG**

- Currently, governments are providing assistance to poor households through free LPG connections, which takes away the startup cost—but households are unaware of such schemes. There is an urgent need to devise **an awareness campaign for the consumers** focusing on how poor customers can benefit from of such schemes. The information can also be focused on: (i) documents required for aquiring a formal connection and (ii) the initial money that needs to be paid for the same.
- A set of guidelines should be given to the LPG distributors to ease new customer registration, especially for poor customers.
- A toll-free grievance number should be set up and advertised well.
- A considerable unmet demand with willingness to pay exists. More distributors to expand supply can help people as well as the oil companies in expanding their business. The supply of LPG can be increased by importing more LPG from abroad (or purchasing from private players who may currently be exporting LPG), as the price is considerably lower now.
- Equated monthly installment facilities should be made available for a household that has difficulties arranging for one-time lump sum payments towards "startup" cost.

The findings of the study suggest that, on average, a household's final cooking energy consumption per year can be met by 137.67 kg of LPG, which can be fulfilled by providing 9–10 of the 14.2 kg LPG cylinders per annum.

**Rationalizing an LPG Subsidy**

- This study proposes **a cap of 9–10 subsidized cylinders** that could be procured by an LPG customer to prevent any misuse of the existing 12 subsidized cylinders. In turn, this would create an opportunity for the freed up subsidized cylinders for other needy poor customers without too much additional subsidy burden.
- Poor people are paying more than twice the price (per kg) of subsidized LPG, therefore the study recommends that the above-poverty-line population can comfortably afford the non-subsidized LPG cylinders, and the subsidy to them could be stopped.

There are numerous households that do not have a steady monthly income and may not be in a position to regularly pay the amount required to purchase the 14.2 kg cylinders.

**LPG Prices**

- It is suggested that smaller **subsidized cylinders with 5 kg of LPG** (currently introduced as a pilot scheme) **should be available for those who cannot pay the price of a 14.2 kg cylinder at one time**. These are also needed so that households are provided immediate relief until a broader policy improving access is introduced. This option, in addition to creating affordable, clean energy access to all households, would curb the black market for LPG.

The JAM trinity scheme, which is envisaged as an important tool to implement direct benefit schemes, requires bank accounts, identification cards and mobile numbers. Our survey in Ghaziabad reveals that, though nearly 90 per cent of the households have access to these three attributes, only 65 per cent of households have at least one member who fulfill all the three criteria.

Finally, our survey revealed that female literacy is an important determinant of the use of cleaner cooking fuels. Female education is a huge challenge and females have usually lower access to education facilities. Therefore, education among females should be strongly promoted.

## References

Baldwin, S. (1986). *Biomass stoves: Engineering design, development, and dissemination*. VITA and PU/CEES Report No. 224. Arlington, VA: VITA.

Barnes, D. F. & Qian, U. (1992). *Urban interfuel substitution, energy use and equity in developing countries*. World Bank Industry and Energy Department Working Paper, Energy Series Paper 53. Washington, D.C.: World Bank.

Barnes, D. & Floor, W. (1996). Rural energy in developing countries: A challenge for economic development. *Annual Review of Energy and the Environment, 21*, 497–530.

Barnes, D. & Floor, W. (1999, Fall). Biomass energy and the poor in the developing countries. *Journal of International Affairs, 53*(1), 237–259.

Brouwer, R. & Falcao, M.P. (2004). Wood fuel consumption in Maputo, Mozambique. *Biomass and Bioenergy, 27*, 233–245.

Davis, M. (1998). Rural household energy consumption: The effects of access to electricity-evidence from South Africa. *Energy Policy, 26*(3), 207–217.

El Tayeb Muneer, S. & Mukhtar Mohamed, E. W. (2003). Adoption of biomass improved cookstoves in a patriarchal society: An example of Sudan. *The Science of the Total Environment, 307*, 259–266.

Energy Sector Management Assistance Programme. (2003a). *Household fuel use and fuel switching in Guatemala*. Washington, D.C.: World Bank.

Energy Sector Management Assistance Programme. (2003b). *Household energy use in developing countries: A multicountry study*. Washington, D.C.: World Bank.

Fox, J. & Andersen, R. (2006). Effect displays for multinomial and proportional-odds logit models. *Sociology Methodology, 36*, 225–255.

Fox, J. & Hong, J. (2010). Effect displays in R for multinomial and proportional-odds logit models: Extensions to the effects package. *Journal of Statistical Software, 32*(1), 1–24.

Insert Government of India. (2011). Census of India 2011. Retrieved from http://censusindia.gov.in/

Government of India. (2015). *Energy sources of Indian households for cooking and lighting, 2011–12*. National Sample Survey Organistion Report No. 567. New Delhi: GoI.

Heltberg, R. (2004). Fuel switching: Evidence from eight developing countries. *Energy Economics, 26*, 869–887.

Hiemstra-van der Horst, G. & Hovorka, A. (2008). Reassessing the "energy ladder": Household energy use in Maun, Botswana. *Energy Policy, 36*, 3333–3344.

Hosier, R. & Dowd, J. (1987). Household fuel choice in Zimbabwe. *Resources and Energy, 9*, 347–361.

Hosier, R. H. & Dowd, J. (1988). Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis. *Resources Energy, 9*, 337–361.

Hosier, R. & Kipondya, W. (1993). Urban household energy use in Tanzania: Prices, substitutes and poverty. *Energy Policy, 21*, 453–73.

Knight, K.W. & Rosa, E. A. (2012). Household dynamics and fuelwood consumption in developing countries: A cross-national analysis. *Population and Environment, 33*(4), 365–378.

Kowsari, R. & Zerriffi, H. (2011). Three dimensional energy profile: A conceptual framework for assessing household energy use. *Energy Policy, 39*(12), 7505–7517.

Leach, G. (1992). The energy transition. *Energy policy, 20*(2), 116–123.

Leach, G. & Mearns, R. (1988). *Beyond the woodfuel crisis*. London: Earthscan.

Masera, O., Saatkamp, B. & Kammen, D. (2000). From linear fuel switching to multiple cooking strategies: A critique and alternative to the energy ladder model. *World Development, 28*(12), 2083–2103.

Mekonnen, A. & Kolhin, G. (2008). *Determinants of household fuel choice in major cities in Ethiopia*. Working Papers in Economics 399. Sweden: University of Gothenburg.

O'Sullivan, K. & Barnes, D. F. (2006). *Energy policies and multitopic household surveys: Guidelines for questionnaire design in living standards measurement studies*. Washington, D.C.: World Bank.

Ouedraogo, B. (2006). Household energy preferences for cooking in urban Ouagadougou, Burkina Faso. *Energy Policy, 34*, 3787–3795.

Peng, W., Hisham, Z. & Pan, J. (2010). Household level fuel switching in rural Hubei. *Energy for Sustainable Development, 14*(3), 238–244.

Rao, M. & Reddy, B. (2007). Variations in energy use by Indian households: An analysis of micro level data. *Energy, 32*, 143–153.

Reddy, B. S. (1995). A multilogit model for fuel shifts in the domestic sector. *Energy, 20*(9), 929–936.

Sarkar, H. & Kadekodi, G. K. (1988). *Energy pricing in India: Perspective, issues and options*. International Labour Organization, United Nation Development Programme and Economic Commission for Asia and Pacific.

Schlag, N. & Zuzarte, F. (2008). *Market barriers to clean cooking fuels in sub-Saharan Africa: A review of literature*. Working paper. Sweden: Stockholm Environment Institute.

Smith, K. (1987). The biofuel transition. *Pacific and Asian Journal of Energy, 1*(1), 13–32.

Van der Kroon, B., Brouwer, R. & van Beukering. P. J. H. (2013). The energy ladder: Theoretical myth or empirical truth? Results from a metaanalysis. *Renewable and Sustainable Energy Reviews, 20*, 504–513.

# Annex 1

## Table A1: Various cooking energy prices per MJ based on sample household

| Energy sources | Sample total expenditure (in INR) | Total energy (in MJ) | Prices per MJ (in INR) |
|---|---|---|---|
| Dung Cake | 13725 | 7777 | 1.76 |
| Fuel wood | 2774 | 895 | 3.10 |
| Kerosene PDS | 3274 | 3947 | 0.83 |
| Kerosene other sources | 3695 | 2080 | 1.78 |
| LPG (Subsidized) | 38996 | 34753 | 1.12 |
| LPG (From black market in 14.2 cylinder) | 37083 | 13967 | 2.66 |
| LPG (From black market in smaller cylinder) | 34285 | 11302 | 3.03 |

*Sources: IRADe household survey, 2015*

*Note: Expenditure and energy at final consumption has been calculated only for purchase cooking fuel.*

## Table A2: Cooking fuels and average cooking time

| Energy source | No. of households | Total cooking sessions (1) | Total cooking time (in minutes) (2) | Average family size (3) | Average cooking time per session per capita (in minutes) (4=(2÷1)/3) | Excess cooking time per session per capita compared to LPG (in minutes) (5) | Average excess cooking time per session compared to LPG (in minutes) (5×3) |
|---|---|---|---|---|---|---|---|
| Biomass | 47 | 100 | 7760 | 5.8 | 13.36 | 3.82 | 22.20 |
| Kerosene | 17 | 37 | 1910 | 4.8 | 10.83 | 1.30 | 6.18 |
| LPG | 182 | 429 | 22055 | 5.4 | 9.54 | 0.00 | 0.00 |

*Sources: IRADe household survey, 2015*

## Table A3: Cooking fuels and average cleaning time

| Energy source | No. of households | Total cleaning sessions (1) | Total cleaning time (in minutes) (2) | Average family size (3) | Average cleaning time per session per capita (4=(2÷1)/3) | Excess cleaning time per session per capita compared to LPG (in minutes) (5) | Average excess cleaning time per session compared to LPG (5×3) |
|---|---|---|---|---|---|---|---|
| Biomass | 47 | 100 | 3740 | 5.8 | 6.44 | 1.28 | 7.46 |
| Kerosene | 17 | 37 | 1050 | 4.8 | 5.96 | 0.80 | 3.82 |
| LPG | 182 | 429 | 11920 | 5.4 | 5.15 | 0 | 0.00 |

*Sources: IRADe household survey, 2015*

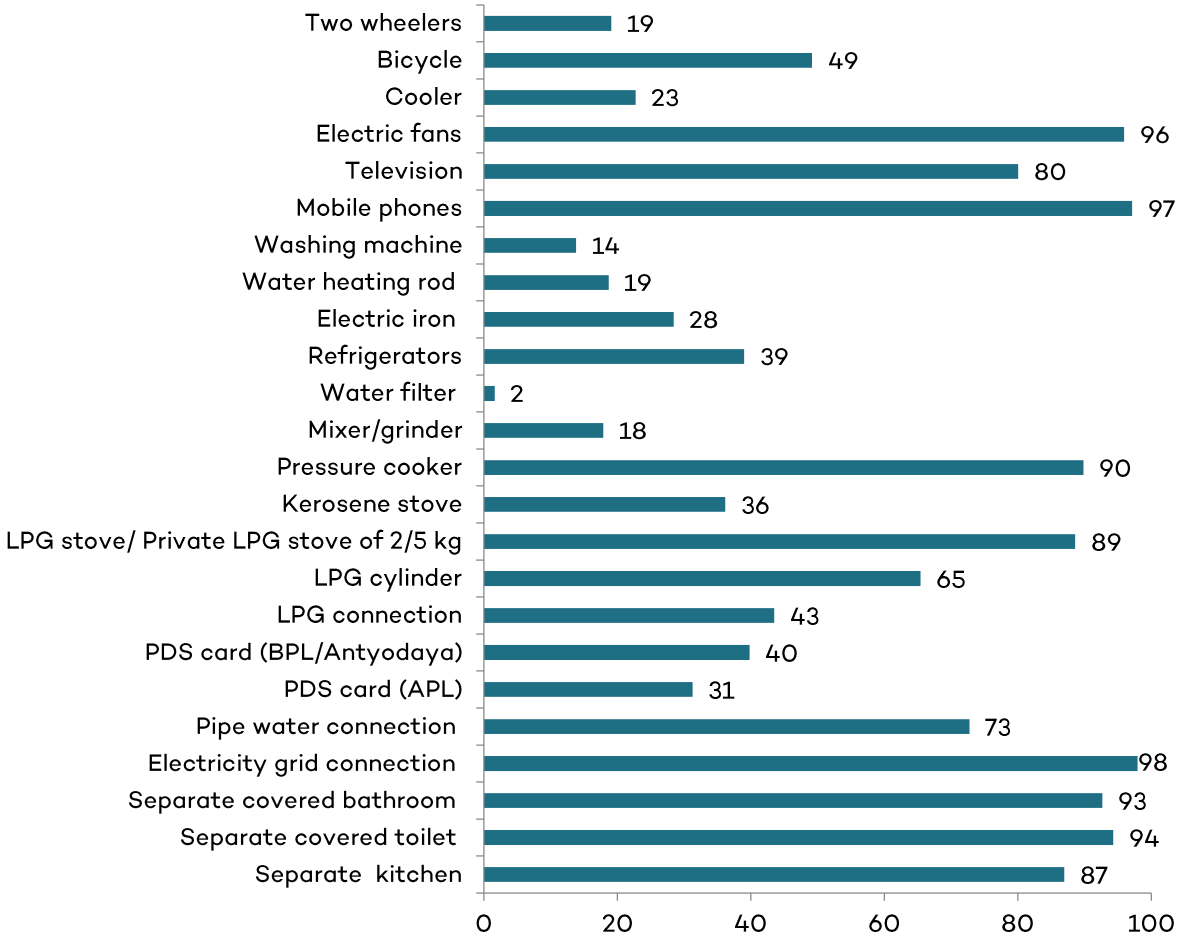


**Figure A1: Availability of facilities/amenities in surveyed households (%)**

*Sources: IRADe household survey, 2015*

Published by the International Institute for Sustainable Development.

**IISD Head Office**

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

**Tel:** +1 (204) 958-7700
**Fax:** +1 (204) 958-7710
**Website:** www.iisd.org
**Twitter:** @IISD_news

**GSI Office**

International Environment House 2
9 chemin de Balexert, 1219 Châtelaine
Geneva, Switzerland

**Tel:** +41 22 917-8683
**Fax:** +41 22 917-8054
**Website:** www.iisd.org/gsi
**Twitter:** @globalsubsidies

**IRADe**

C-80, Shivalik Shivalik
Malviya Nagar
New Delhi 110017
India

**Tel:** +91 (11) 2667 6181
**Fax:** +91 (11) 2667 6180
**Website:** www.irade.org

IISD Global Subsidies Initiative

Integrated Research and Action for Development
IRADe