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Rural energy access and inequalities: *An analysis of NSS data from 1999-00 to 2009-10*

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Table of Contents

Abstract

Energy access for all must go beyond electricity to ensure that people have access to clean fuels for meeting their heating and cooking requirements, and also help in livelihood enhancement and diversification.

Energy access is not only essential at the household level, but is also very critical to the provision of basic minimum infrastructure such as hospitals, schools and industries among others. For a country like India, developmental goals and energy access are very closely linked and "Universal Energy Access" as a goal is necessary not just for each household but also for the associated sectors in the economy that will play an important role in economic development.

In India, the energy consumption patterns in rural areas have been largely towards using firewood and other traditional biomass fuels such as chips, charcoal and dung cake. The demand for energy particularly in rural India consists mainly of energy for cooking and energy for lighting. Improving and extending access to energy services is one of the most urgent tasks that lies ahead since majority of the rural population in the country still has no access to electricity, and more than one-half rely on traditional biomass as their principal household fuel.

The objective of this paper is to analyse the trend of the uses of sources of energy for cooking and lighting among rural households in India. For this analysis, the data collected under the 55th, 61st and 66th rounds of the NSS has been considered. The purpose of this analysis is to provide key insights into household energy consumption patterns and indicative insights into the determinants of energy access and transitions among rural households in India. This report also intends to set the background for key data gaps that need to be addressed in order to facilitate a better understanding of household fuel choices which can better inform policy in a manner which would improve the situation of energy access and enhance further development to ensure a better and secure future.

Introduction

Access to modern energy services is fundamental to fulfilling basic social needs, driving economic growth and fuelling human development. This is because energy services have an effect on productivity, health, education, availability of safe water and communication services. Modern energy sources such as electricity, natural gas, modern cooking fuels and mechanical power are necessary for improved health and education, better access to information and agricultural productivity.

Furthermore, the way in which energy is generated, distributed and consumed affects the local, regional and global environment with serious implications on livelihoods, income and human development prospects.

Energy access for all must go beyond electricity to ensure that people have access to clean fuels for meeting their heating and cooking requirements, and also help in livelihood enhancement and diversification.

Energy access is not only essential at the household level, but is also very critical to the provision of basic minimum infrastructure such as hospitals, schools and industries among others. For a country like India, developmental goals and energy access are very closely linked and "Universal Energy Access" as a goal is necessary not just for each household but also for the associated sectors in the economy that will play an important role in economic development.

Some of the benefits people enjoy with access to modern energy sources are outlined below. *(Pachauri, et.al, 2011)*

a) ***Private Benefits:*** Household Lighting, Communications& Entertainment, Thermal Comfort, Other Appliances

b) ***Enhanced Income Generation Options:*** Mechanical Power, Microenterprises

c) ***Community Services:*** Public Lighting, Health(refrigeration for vaccines), Education

d) ***Economic/ Livelihood Impacts of Lacking Access to Modern Energy:***

- Limited productive hours in the day for those un-electrified and who spend time in own fuel collection
- Lack of access to electricity and mechanical power also limits work and business possibilities

e) ***Environmental Impacts of Solid Fuels Dependence:***

- If unsustainably harvested, can lead to local deforestation and land and soil degradation and are no longer CO2 neutral
- Products of incomplete combustion (PIC) have a higher global warming potential (GWP) than carbon dioxide

- Growing evidence of strong climate impacts of black carbon (soot) emissions, particularly for arctic and glacial ice

While the benefits of energy access and security are no doubt immense, it is a considerable challenge especially for a diverse country like India. Some of the key barriers to enhancing access are:

- ***Information and Data:*** For nations with the least access, no data on what people currently use and how much they can afford

- ***Political commitment and Policy:***

    - Much of existing funding still goes to large infrastructure projects that bypass the poor
    - Often liberalization of energy markets undertaken without consideration of those lacking access

    - Institutions and Markets: Responsive and accountable institutions with local involvement are key to successful implementation

- ***Financing:***

    - Governments need to raise finances for programs
    - Innovative financing needed at the user end too

It is very critical to understand what 'energy security' entails and the associated dimensions. India has defined its energy security as "…when we can supply lifeline energy to all our citizens as well as meet their effective demand for safe and convenient energy to satisfy various needs at affordable costs at all times with a prescribed confidence level considering shocks and disruptions that can be reasonably expected"(IEP, 2010).

It is not just sufficient that a fuel type is available but it is equally important that there exists a minimum level of physical infrastructure such that the fuel source is available easily to a household or individual when the requirement arises. In the context of green economy, this aspect takes an additional dimension of "clean fuel", i.e. the fuel type while being accessible and available should also be a cleaner fuel such that the overall benefits of energy access are greater in terms of additional health and livelihood benefits.

Provision of modern energy sources at a price that is affordable to the user is critical to achieving the goal of universal energy access. Affordability has two key aspects – the ability and the willingness of the individual to pay. The ability to pay is most often driven by constraints of income whereas the willingness to pay is driven by the availability of the resource and the opportunity cost of investing in a particular fuel type. It is crucial to understand that when a household makes a decision on the share of expenditure on energy, both the ability as well as the willingness to pay plays an important role.

The issues of access, availability and affordability are quite tangible and thus very often quoted as the barriers to energy access. But something that is not as tangible, and on further probing becomes an important factor when it comes to achieving energy access for all, is the attitudes and perceptions of people. The way of living of people, especially of those residing in rural areas in India, is governed

by a mix of socio-cultural customs and their own experiences with various contraptions designed with the aim of improving their livelihoods.

Thus, fuel choice, is governed by a mix of factors that include whether the fuel is available easily or not (availability); whether any alternative being provided is easily substitutable to the traditional fuel choice (substitutability); whether the appliance design in which the fuel would be used is easy to operate (ease of usage), for example, the case of traditional versus improved cook-stoves; which among the fuel choices available fits best in the household consumption basket, i.e. within the income or budget constraint; and finally, whether the choice of fuel and appliance designs are user friendly and fit within the socio-cultural structure of the society.

The lack of access to clean and efficient fuels or energy sources is a primary indicator of energy poverty in a country. Clean fuels essentially include electricity, LPG and kerosene in comparison to using firewood and charcoal for household activities. In India, the energy consumption patterns in rural areas have been largely towards using firewood and other traditional biomass fuels such as chips, charcoal and dung cake. *(Husain, 2005)*

When we look at energy consumption with particular reference to rural India, the demand for energy in India consists mainly of energy for cooking and energy for lighting. Improving and extending access to energy services is one of the most urgent tasks that lies ahead since majority of the rural population in the country still has no access to electricity, and more than one-half rely on traditional biomass as their principal household fuel.

The objective of this paper is to analyse the trend of the uses of sources of energy for cooking and lighting among rural households in India. For this analysis, the data collected under the 55th, 61st and 66th rounds of the NSS has been considered. The purpose of this analysis is to provide key insights into household energy consumption patterns and indicative insights into the determinants of energy access and transitions among rural households in India. This report also intends to set the background for key data gaps that need to be addressed in order to facilitate a better understanding of household fuel choices which can better inform policy in a manner which would improve the situation of energy access and enhance further development to ensure a better and secure future.

1. National Sample Survey (NSS) Data: An Overview

The National Sample Survey Organisation (NSSO) in its surveys includes questions on household income, fuel consumption, access to fuels and ownership of various appliances. These together provide a description of consumption and lifestyle patterns of people in rural and urban areas across different states of India.

1.1 Energy Access and Transitions

As per the latest round (NSSO 2010; 66th Round), assuming that all the firewood reported is used for cooking, about 29.50 kg of firewood and chips (per capita per month) are consumed in rural households as compared to about 2.31 kg of LPG per capita for cooking purposes. Access to clean energy fuels is a challenge among households particularly in the rural areas. The graph below indicates the proportion of households having access to different fuel types in both rural and urban areas. As can be noted, access to cleaner fuels is limited and the use of traditional biomass fuels is

predominant among rural households. The primary need for energy at the domestic level can broadly be categorized under cooking and lighting needs.

The graph below *(Figure 1)* gives a picture of the distribution of fuel use across rural and urban India. Among rural households, almost 76% households are still dependent on the most polluting traditional biomass fuels to meet their cooking fuel requirements. The cleaner cooking fuels such as LPG have very little coverage (about 12%) among rural households. In comparison, almost 65% urban households indicate use of LPG as a cooking fuel.

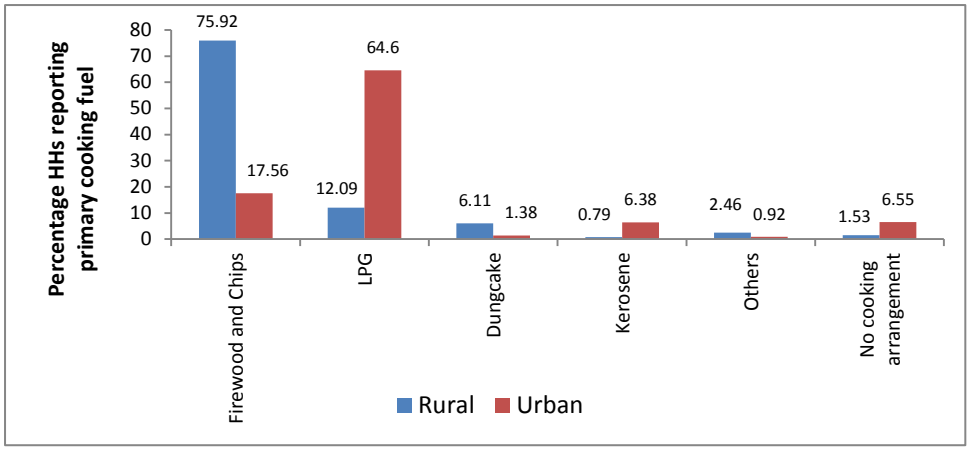

Figure 1 : Graph of Penetration rates of cooking fuel for 66th round
Source: NSSO 66th Round, 2009-2010

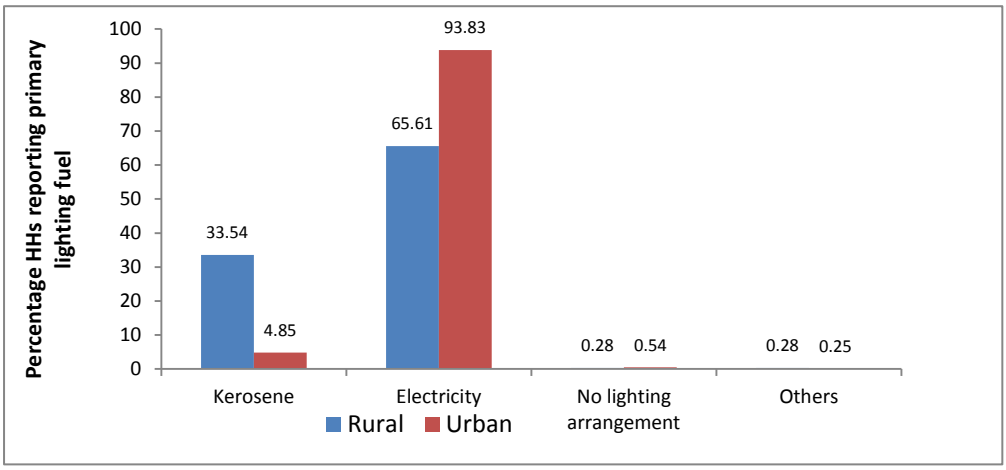

Figure 2 : Graph of penetration rates of lighting fuel for 66th round (2009-10)
Source: NSSO 66th Round, 2009-2010

The disparity in case of lighting is shown in Figure 2. There is considerable difference among rural and urban households in terms of access to cleaner energy sources, i.e. electricity. Only 65% of rural households indicate electricity as their primary source of lighting. However, even this figure may not be a true reflection of access to electricity as other factors such as regularity of supply also need to be considered while drawing conclusions. In urban areas, in comparison, more than 90% households have access to electricity as a primary source of lighting.

If we look at the story so far in India, the access situation while showing clear signs of improvement in urban areas; is still a challenge in rural India. In order to be able to appreciate the challenge of providing energy access in rural India, it is important to understand how energy transition has occurred in rural India over the past decade. The figures below give a snapshot view of the number of

households reporting a particular fuel as the primary lighting or cooking fuel. In the case of cooking, the fuels considered are firewood and LPG, whereas for lighting, kerosene and electricity have been considered as they are the most common fuels used.

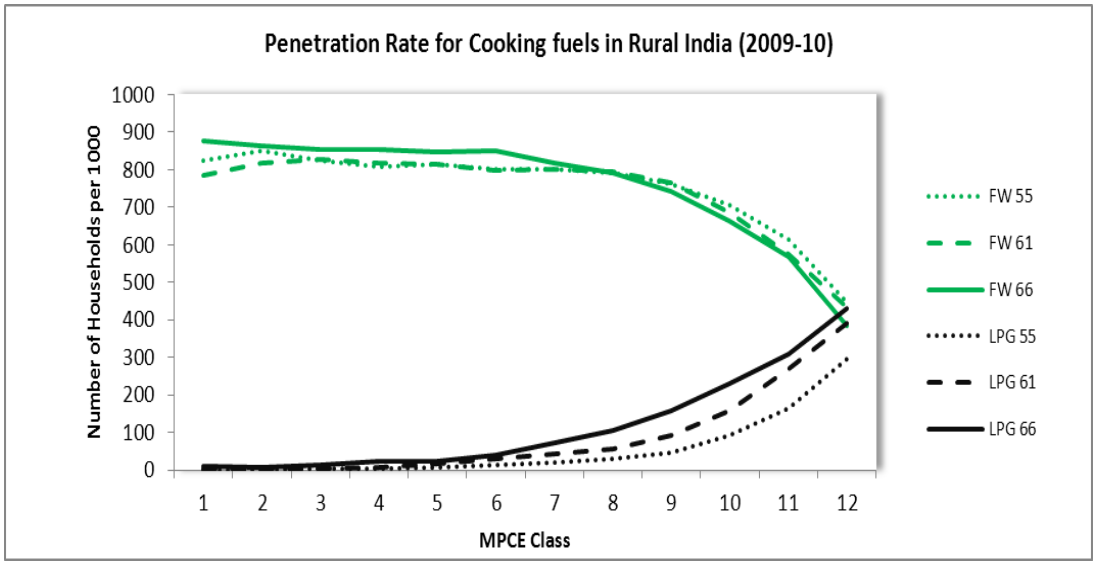

Figure 3 : Penetration rates of cooking fuels over time and across income classes
Source: 55th, 61st & 66th Rounds of NSSO (1999-2000, 2004-2005, 2009-2010)

Both Figures 3 and 4 indicate the percentage of households in rural India reporting a particular fuel as the primary cooking fuel (firewood and LPG) and primary lighting fuel (Electricity and Kerosene) respectively. The graphs plot the trends over time and across income classes[1]. If we see the case for cooking *(Figure 3)*, we find that the intersection point between the graph for firewood and LPG occurs only at the higher MPCE classes. This indicates that the switch from firewood to LPG is occurring only among the higher income classes. Thus, in the case of cooking fuels, we find that there is no real transition to in terms of access to modern cooking fuels.

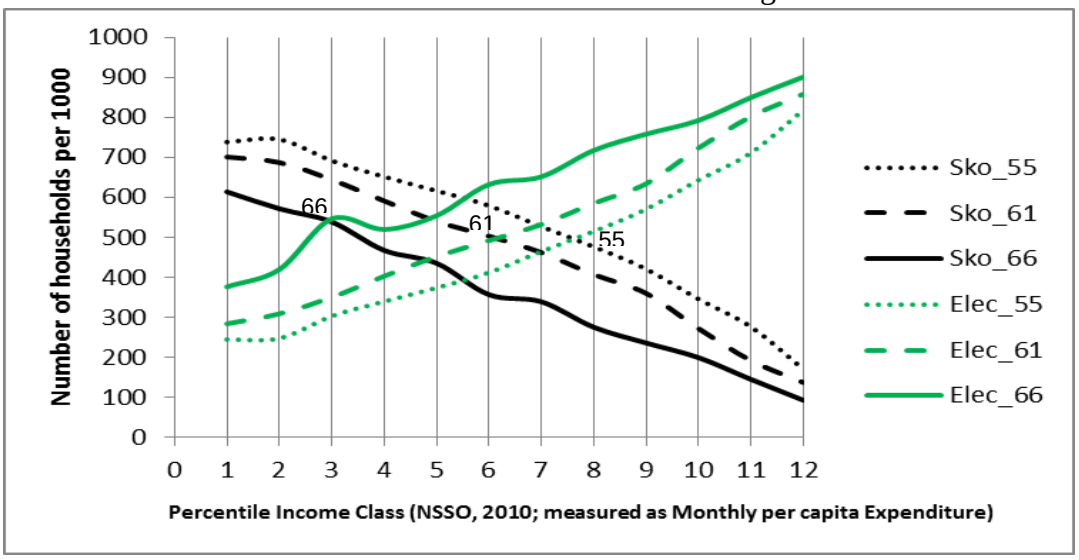

Figure 4 : Penetration rates of lighting fuels over time and across income classes
Source: 55th, 61st & 66th Rounds of NSSO

[1] Monthly Per Capita Expenditure (MPCE) classes have been taken as proxy for income by the NSSO survey for each household and these are used to categorize the income classes with 1 being the lowest and 12 the highest. The data has been used from three NSSO rounds: 55th Round (1999-2000); 61st Round (2004-05); and, 66th Round (2009-10).

Figure 4 indicates the penetration rates or the number of households per 1,000 households reporting a particular fuel as the primary lighting fuel, in this case, kerosene and electricity. it can be noted that while in the 55th round (1999-2000) the intersection point between the graph of kerosene and electricity occurred around the 8th MPCE class; in the 61st round (2004-05) the intersection point occurred around the 6th MPCE class; and, in the 66th round (2009-10) the intersection point occurred around the 3rd MPCE class. This means that the switch (denoted by the intersection point of the graph of kerosene and electricity) to modern lighting fuels is occurring at lower income classes over time, indicating improved access to modern lighting fuels and a clear transition path. The success in the case of lighting can be attributed to the national level Rural Electrification Program *(Rajiv Gandhi Grameen Vidyutikaran Yojana or RGGVY)* that aims to provide electricity to all villages in India. As of May 2012, Government of India had spent about Rs. 28, 265 Crores on rural electrification under the RGGVY Program, covering over 3 lakh villages.

Clearly, the transition witnessed in lighting fuel usage is not replicated in the case of cooking fuels. Providing access to modern cooking fuels and more importantly, effecting a transition towards modern cooking fuels will remain a challenge in terms of energy access at the household level. With respect to use of cooking fuels, the factors governing a household's decision to use a particular fuel are very different from the case of lighting and these factors also differ from one region to another, making the goal of energy access more challenging.

1.2 Energy Consumption Patterns across rural households

Energy consumption patterns differ for households across regions and income groups as well as over time. To capture household energy transitions, it is very critical to understand the choices different households belonging to different income groups vary with changes in the environment.

In this section, energy consumption patterns across income groups and across agro-climatic zones would be analysed so as to get valuable insights into household energy choices which would help inform policy.

The table below provides a snapshot of changes in consumption patterns in rural India of three important fuels, namely, firewood, LPG, kerosene and electricity that are used predominantly for cooking and lighting among rural households. In the case of firewood, we find that there is an increase in household consumption from 1999-2000 to 2004-05 and then a slight decline in 2009-10. It should be noted that the actual quantity of reported consumption level in 2009-10 was still higher than that reported in 1999-2000. The overall consumption of firewood has in fact, increased in the past decade by about 7.5%. In the case of electricity, there has been an increase in electricity consumption by almost 25 – 30% overall. While for LPG, though there have been marginal changes in consumption over time, it has remained more or less constant. *(Refer Figure 5)*

We can categorize the households into three different income groups namely: Low Income, Medium Income, and High Income. The table *(Table 1)* below summarizes the changes in physical consumption of different fuels over time.

Table 1: Fuel consumption patterns over time in rural India

	Low Income	Medium Income	High Income
Firewood	Increase from 1999-00 to 2004-05 *(95kg – 113kg)*; Decline from 2004-05 to 2009-10 *(113kg – 102kg)* but overall increase in the decade	Significant increase from 1999-00 to 2004-05 *(107kg -125kg)*; lower mid-income remain same from 2004-05 to 2009-10 *(~120kg)*; high mid-income indicates decline from 2004-05 to 2009-10 *(124kg – 115kg)*	Drastic increase from 1999-00 to 2004-05 *(112kg – 124kg)* and marginal decline in 2009-10 *(~120kg)*; richer have higher consumption
Electricity	Increase from 1999-00 to 2004-05 *(33kWh – 37kWh)*; marginal increase from 2004-05 to 2009-10	Increase over time *(40kWh – 47kWh)*; low mid-income indicate greater increase in consumption *(~6kWh)* than high mid-income	Increase over time *(54kWh – 80kWh)*; significant increase from 2004-05 to 2009-10 *(61kWh – 80kWh)*; for highest income group, 2004-05 and 2009-10 consumption values converge *(~80kWh)*
LPG	Increase from 1999-00 to 2004-05 *(6kg to 8kg)*; marginal change from 2004-05 to 2009-10	Increase in consumption by lower mid-income *(7kg to 10kg)*; high mid-income constant from 2004-05 to 2009-10 *(~11kg)*	No change from 2004-05 to 2009-10 *(~10-11kg)*
Kerosene	Marginal decrease from 1999-00 to 2004-05 *(3.17lts to 2.83lts)*; constant (~2.82lts) from 2004-05 to 2009-10 ; Similar trends for market purchased kerosene	Significant decline in PDS kerosene consumption from 1999-00 to 2004-05 *(3.62lts to 3.20lts)*; further decline in PDS kerosene consumption from 2004-05 to 2009-10 *(3.20lts to 2.98 lts)*; Similar trends for market purchased kerosene	Drastic decline in PDS kerosene consumption from 1999-00 to 2004-05 *(4.29lts to 3.35lts)* and further decline from 2004-05 to 2009-10 *(3.35lts to 3lts)*; Similar trends for market purchased kerosene

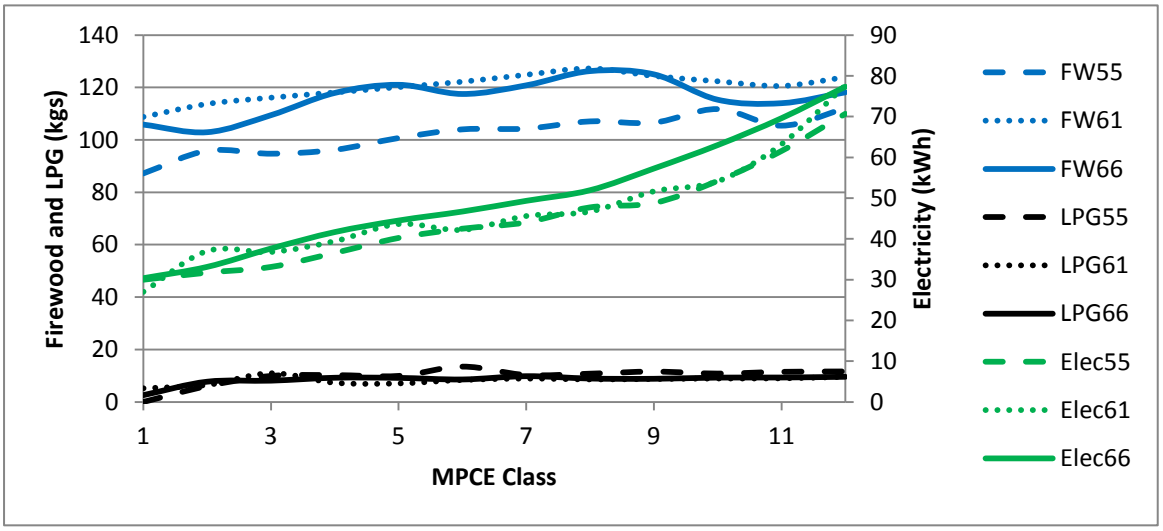

Figure 5 : Consumption of Firewood, LPG and Electricity over time across income classes
Source: 55th, 61st and 66th Rounds of NSSO

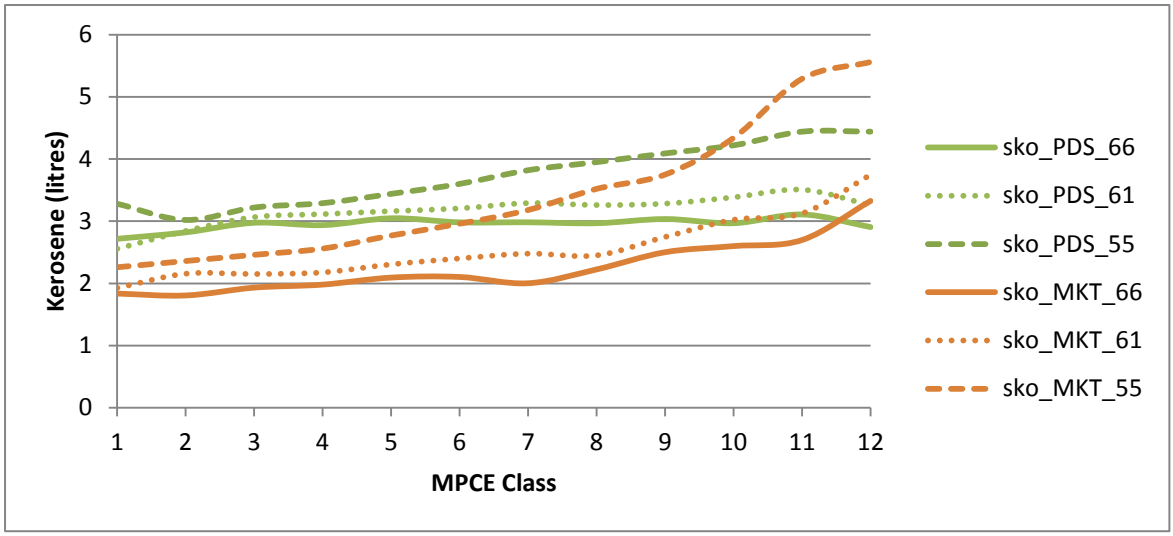

Figure 6 : Consumption of Kerosene over time and across income classes
Source: 55th, 61st and 66th Rounds of NSSO

1.2.1 Firewood consumption

Among the Low Income groups we find that per household consumption has gone up from 95 kg per month (55th Round, NSSO) to about 102 kg per month (66th Round, NSSO). Among the medium income households, we find that there is a significant increase from 107 kg per month (55th Round, NSSO) to about 125 kg per month (61st Round, NSSO) and then a decline to about 115 kg per month by the 66th Round of NSSO. Among the Medium Income category, those in the lower income bracket indicate a more or less constant consumption level of firewood per month over the three rounds whereas for those in the upper income brackets in this category, there has been a decrease from about 124 kg per month (61st Round, NSSO) to about 115 kg per month (66th Round, NSSO). In the High Income group, there has been an increase in consumption over time from about 112 kg per month (55th Round, NSSO) to about 120 kg per month (66th Round, NSSO). The households in the higher end of the spectrum of this category indicate higher levels of consumption.

1.2.2 Electricity Consumption

There has been an increase in consumption of electricity across all income groups over the three rounds analysed. Households belonging to the Low Income category saw a 12% increase in electricity consumption, i.e. from 33 KWh (55th Round NSSO) to 37KWh (66th Round, NSSO) per household per month. Among the Medium Income households, there was a significant increase in electricity consumption over time. Households in the lower spectrum of this category saw a 15% increase while households in the higher income spectrum of the Medium Income category saw a 21% increase in electricity consumption. As for the High Income category, there has been a considerable jump in electricity consumption with households in this category indicating an increase by almost 48%. Though, from the 55th to the 61st Round, there was only a marginal change in electricity consumption; the last 5 years (from the 61st to the 66th Round) have seen a significant increase of almost 28%. Also, for the highest income households, they seem to be already consuming an optimum of 80KWh per month as the trend lines of the all the three rounds converge at that point. Though there has been an increase in consumption of electricity across all income classes, the measure has not been much for the low income households. The impact of improved electricity access is seen more among the high income and middle income households.

1.2.3 LPG Consumption

Consumption of LPG has some interesting observations if we look at the NSSO rounds over time. All the income groups indicate no increase in LPG consumption from the 55th to the 61st while from the 61st to the 66th round there is a decline in LPG consumption. Assuming sampling bias, it still means that there is no increase in consumption over time or rather, household consumption of LPG has more or less remained constant over the past decade. Unlike the other fuels, penetration of LPG has also not increased significantly, thus bringing up the issues of access and service delivery. If we see the Lower Income households, their LPG consumption is constant at about 6 – 8kg per month; the medium income households consume about 10kg per month; and, the high income households consume about 10kg per month. There has been no significant change in LPG consumption which is a cleaner fuel. Unlike electricity, which shows considerable improvement over the years, the transition to LPG has not occurred as expected.

1.2.4 Kerosene Consumption

Consumption of kerosene is seen to significantly fall over time across all income groups. This could be attributed to the increasing access to electricity and LPG; more so with the access to electricity. Consumption of kerosene falls drastically among the higher income groups. Kerosene is available to consumers through the Public Distribution System (PDS) which provides a fixed amount at a subsidized rate every month as well as the market where the rates are higher. There is more than a 50% subsidy on kerosene supplied through the PDS mechanism.

Since kerosene is mainly used to meet lighting needs at the household level in rural areas, improved electricity access will lead to lower kerosene consumption by virtue of it being a close substitute to electricity. There is a significant decrease in kerosene consumption of about 30% and 41% among higher income households over time (1999-00 to 2009-10) for both PDS and Non-PDS kerosene respectively. The low income households report a decrease in PDS kerosene consumption of about 10% while in contrast the Non-PDS kerosene consumption indicates a decline of about 30% in the period 1999-00 to 2009-10. Among the medium income households, the reported decline in PDS kerosene is about 17% while the reported decline in Non-PDS kerosene consumption is about 20% during the same period.

2. Energy Poverty

The definition of poverty has evolved over the years from being a measure of income poverty to a much more comprehensive measure of deprivations of any kind such as health, education, income, energy and so on. The concept of energy poverty has been increasingly debated in recent years (IEA, 2002). Energy poverty is often defined in terms of expenditure on energy as a proportion of household expenditure.

Various definitions and estimates of energy poverty and the energy poverty line are available. Pachauri et al. (2004) have examined different approaches to measuring energy poverty such as developing a fuel poverty line in monetary terms as well in energy terms. The authors also prepare a two-dimensional indicator to measure energy poverty as well as distribution. However, not many studies have calculated the extent of energy inequality for India or between different states in India.

2.1 Energy Consumption patterns across income classes in rural India

Income is considered as the prime determinant of energy consumption patterns *(Khanker, et. al, 2010; Rao, 2007; Massera, et. al, 2000)*. As per Keynes' Theory of Consumption, with increasing income levels, the percentage of expenditure for food increases at a decreasing rate, but we find that for the lowest income group there is no alternative other than spending the maximum possible for food items. In the rural sector, 68.45% of the expenditure is towards food items and the remaining for non-food items. For the highest income class, expenditure on food items constitutes about 33.69% for the rural sectors. Consumption of second hand items is slowly becoming a practice in the society. This further adds to the problem of energy efficiency, especially among rural households, which as mentioned earlier, constitutes a problem for actually measuring useful energy at the household level due to considerable variations in the efficiency of appliances being used.

Major item of expenditure under non-food items in both rural and urban sector is 'fuel and light'; the expenditure comes to around 43.3% of the non-food items in rural sector. The primary source of energy used for lighting for the lowest income class in the rural sector is kerosene (about 70.1% of households) and about 28.4% have electricity as a source of lighting. Primary source of energy for cooking for the lowest income class in the rural sector is firewood & chips (about 78.4% of households) and dung cake as the next major source for 7.2%[2].

Rural people largely depend upon fuel-wood, crop residues, and cattle dung for meeting the basic energy needs for cooking and heating purposes. With increasing population pressure, the consumption of fuel-wood has far exceeded its supply, thereby causing considerable pressure on existing natural resources.

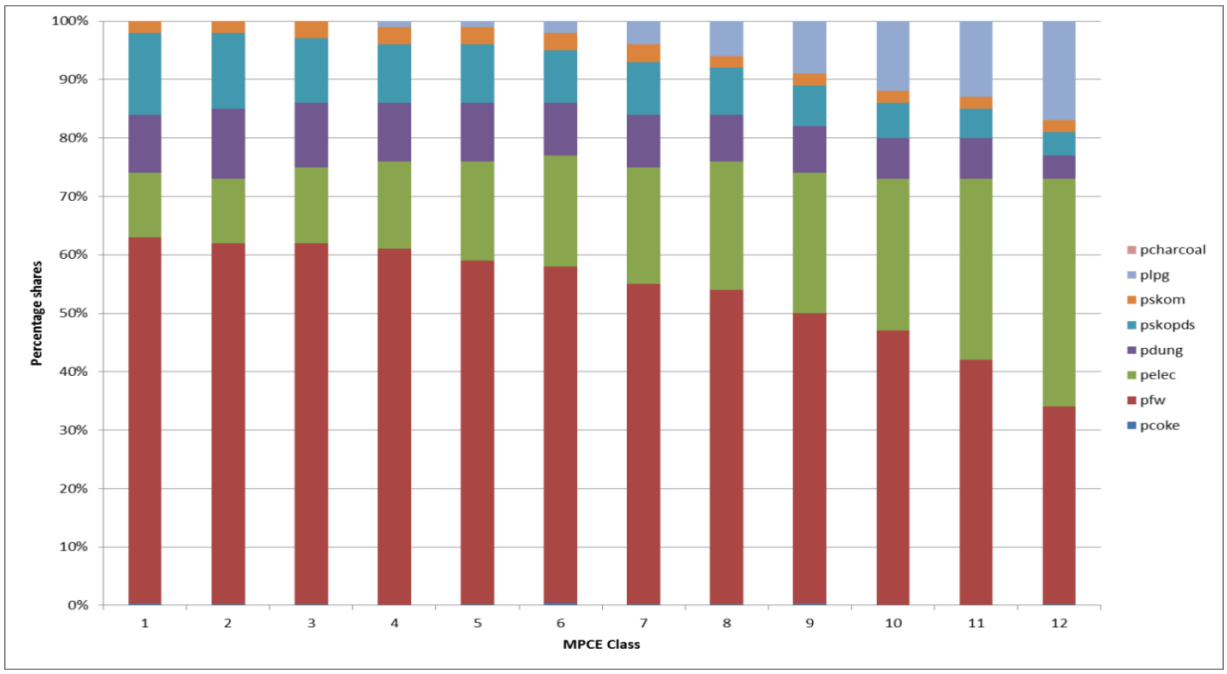

Figure 7 : Expenditure on fuels for cooking and lighting across income classes
Source: NSS 66th Round, 2009-2010

[2] Its all about the lowest mpce class, K Thomas, Seminar on 61st Round of NSSO Survey, Ministry of Statistics and Program Implementation

Among rural households, there is a clear decrease in the share of expenditure on firewood in richer households, which is complemented by a trend in increasing expenditure shares on LPG. While this is an encouraging trend, it is important to understand that a significant amount of biomass fuels are collected freely from the local environment and hence do not reflect in terms of expenditure shares. Thus while the share of income being spent on biomass fuels may be decreasing it does not necessarily entail a decrease in the actual quantity of fuel consumed. Nevertheless, there is a decrease in the share of income being spent on charcoal, kerosene (both PDS and market), firewood and dung-cake. While in the case of firewood and dung-cake, the reported expenditures need to be carefully examined, the decreasing expenditure on kerosene is an encouraging sign. In the case of electricity, there is a clear increase in the expenditure as we move up the income ladder which indicates that electricity consumption increases with income.

The energy expenditure of households differs not just due to income but on various factors such as availability of fuel which impacts prices; the purpose for which the fuel is to be used which is defined by certain social and cultural customs that people follow and so on. These factors play a significant role in household energy choices and differ from region to region. Given India's diversity, it is critical to understand the role of factors other than income in household fuel choices so as to better inform policy and practice aimed at transitioning towards modern and cleaner fuels for domestic energy needs, especially, cooking and lighting.

For this purpose, regional energy consumption patterns can be examined across agro-climatic zones in India. The country has been divided into 15 agro-climatic zones by the Planning Commission, Government of India *(Refer Annex B)*. The division of agro-climatic zones was chosen as most rural households depend on biomass for their energy needs and these are to a large extent apart from socio-economic factors, governed by natural resources which in turn are a function of the climate type which affect the agricultural practices prevailing in the region and thus the availability and use of crop residue.

2.2 Regional Energy Consumption patterns in India

Geographical location of households also determines energy use patterns. Households located near farms or forest or with easy access to these are more likely to use biomass like wood or crop residue.

The geography of India comprises of a multitude of ecosystems varying from mountainous to coastal ecosystems. Going back to the history of mankind and evolution, cultures have evolved to a large extent based on the natural and local ecosystems in which people have lived and they have adapted over time with changes in the environment. Thus, with lifestyles of people being shaped by a host of socio-cultural factors, it is imperative to understand regional variations and the plausible reasons for such differences.

The graphs below *(Figures 8, 9, 10 & 11)* indicate the percentage of households reporting a particular fuel as the primary cooking fuel. The graphs have been plotted for rural households in each agro-climatic zone (Z1 to Z15). The last graph indicates the percentage users of different cooking fuels at the national level for all rural households. While the percentage of population dependent on different fuels for meeting their cooking needs may at first seem directly related to income and poverty, but on probing deeper into the actual physical quantities of each fuel consumed and its consumption across different income groups within each region, we will find that the relationship of energy consumption

with income is not as significant as it has been considered to be, i.e. there are certain consumption patterns that are not explained by income patterns and thus, indicate the presence of other factors such as social and cultural differences that may account for these variations in energy consumption patterns.

The dependence on biomass fuels is significantly high across all regions with the lowest being 52% in Zone 15 *(Figure 11)* which consists of the islands of Andaman and Nicobar and Lakshadweep. It is only in this region where there is highest dependence on kerosene for cooking while the percentage households using LPG as a primary cooking fuel is well above the national average. The fairly lower dependence on biomass among the islands can also be attributed to the fact that the resource endowment is limited and given the fragile nature of island ecosystems, even though the dependence on biomass is lower than the national average, particular attention needs to be given to protect these ecosystems and the communities living there.

If we look at the mountainous regions of India (Zone 1 and 2), we find that there is a significant share of the population (lower than the national average) depending on biomass for cooking, but we also see that there is higher coverage of LPG in these regions (higher than the national average). In Zone 1 *(Figure 8)*, which includes the states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand, we can expect that the high coverage of LPG is a reflection of the performance of fairly developed states like Himachal Pradesh and Uttarakhand.

Also, given that there is significant forest cover in the mountain zone, biomass is easily available, thus indicating a high percentage of population dependent on it. But, if we look at the physical consumption of firewood per household per month, as per the 66th NSS round, an average household consumes about 191kgs of firewood per month and about 203kgs of firewood per month in Zone 1 and 2 respectively. This figure is almost 1.7 times the average national figure of about 117kgs per household per month in rural areas. While there is no major difference in household sizes as compared to other regions and neither is there a high proportion of population in the low income groups, there must be other factors apart from income determining the high consumption of firewood per household.

If we look at Zone 3 *(Figure 8)*, which includes the state of Paschimbanga (West Bengal), we find that more than 75% of the rural population is dependent biomass fuels while the coverage of LPG is very low. This is the only region other than Zone 4 that indicates the use of other locally available materials as fuels for cooking, thus indicating that local ecosystem characteristics seem to affect energy consumption patterns across households. In Zone 3, the consumption of firewood per household per month is about 101kgs which is below the national average.

In Zone 4 (Western Uttar Pradesh) and Zone 5 (Eastern Uttar Pradesh and Bihar), we find that the dependence on biomass is very high, among the highest across regions in India. Also, the coverage of LPG is very low *(Figure 8 & 9)*. This could be due to the fact that a significant percentage of the population lives below the poverty line in these states (~ 25%). In these regions, the consumption of firewood (about 88kgs per household per month in Zone 5 and 6) is the lowest among all regions even though a large proportion of population is dependent on biomass. This could also be due to the density of population being high in these regions as compared to others leading to lower per capita availability of resources.

Zone 6 *(Figure 9)* which consists of the states of Delhi, Punjab and Haryana presents an interesting case. Here, the proportion of population dependent on biomass is one of lowest and it also has the highest coverage of LPG across all regions in India. There is a very high possibility that this observation is being affected by the presence of a state like Delhi in the sample which is significantly developed and has a very high rate of urbanization and lesser availability of forest land. The primary consumers of firewood and other biomass fuels would be from the rural areas of Punjab and Haryana which are mainly agricultural states. When we look at the per household per month consumption of firewood, it is about 138kgs which is a little over the national average and this is possibly due to the large number of farmers in Punjab and Haryana and the fairly high density of population.

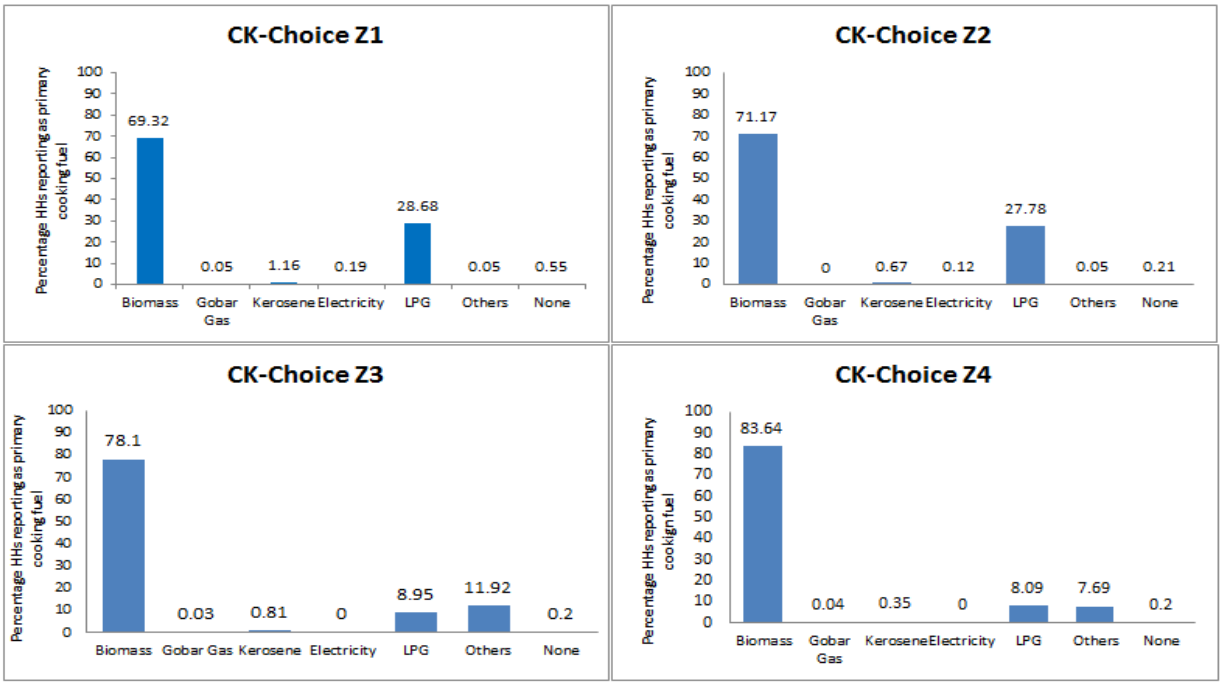

Figure 8 : Choice of primary cooking fuel in Zones 1, 2, 3 and 4
Source: NSS 66th Round, 2009-2010

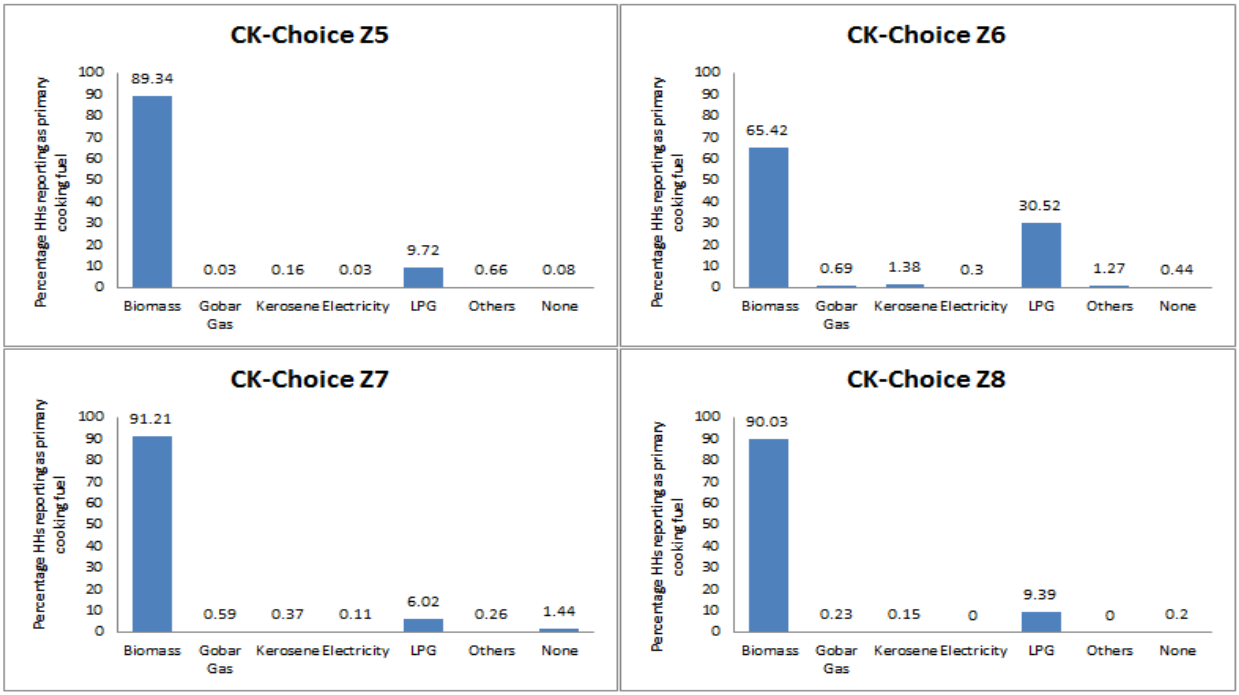

Figure 9 : Choice of primary cooking fuel in Zones 1, 2, 3 and 4
Source: NSS 66th Round, 2009-2010

Zone 7 (Figure 9) includes the states of Orissa (except coastal districts), Jharkhand and Chhattisgarh. The dependence on biomass is the highest among all regions while the coverage of LPG is the lowest. It also has the highest proportion of the population among the lowest income groups (~31%). While firewood consumption on an average is around 120kgs per household per month, it should be noted that the not all households maybe consuming the same amounts and thus it is important to look into inequality measures as well (which are detailed in the next section). Further to the need for looking into energy inequality, we find that while the coverage of LPG is the lowest, the average LPG consumption among the households that report LPG use is about 11.8kgs which is near to a full cylinder which weighs about 14kgs. This is also above the national average of 9.26kgs.

In Zone 8, we find a similar pattern to that of Zone 7, i.e. high dependence on biomass and low coverage of LPG. This region includes the state of Madhya Pradesh and eastern Rajasthan. This region too has a significant proportion of population living among the lower income groups (~16%). The average firewood consumption per household per month is fairly high at about 112kgs, which could be explained by the fact that Madhya Pradesh is considerably forested. With low LPG coverage, the average consumption is also around 8.96kgs per household per month.

It should be noted that both Zone 7 and 8 have considerable tribal populations and thus, energy consumption patterns are not just driven by income but by socio-cultural factors as the lives of these communities are deeply intertwined with the natural environment and their use depends on the social and cultural construct that they live in.

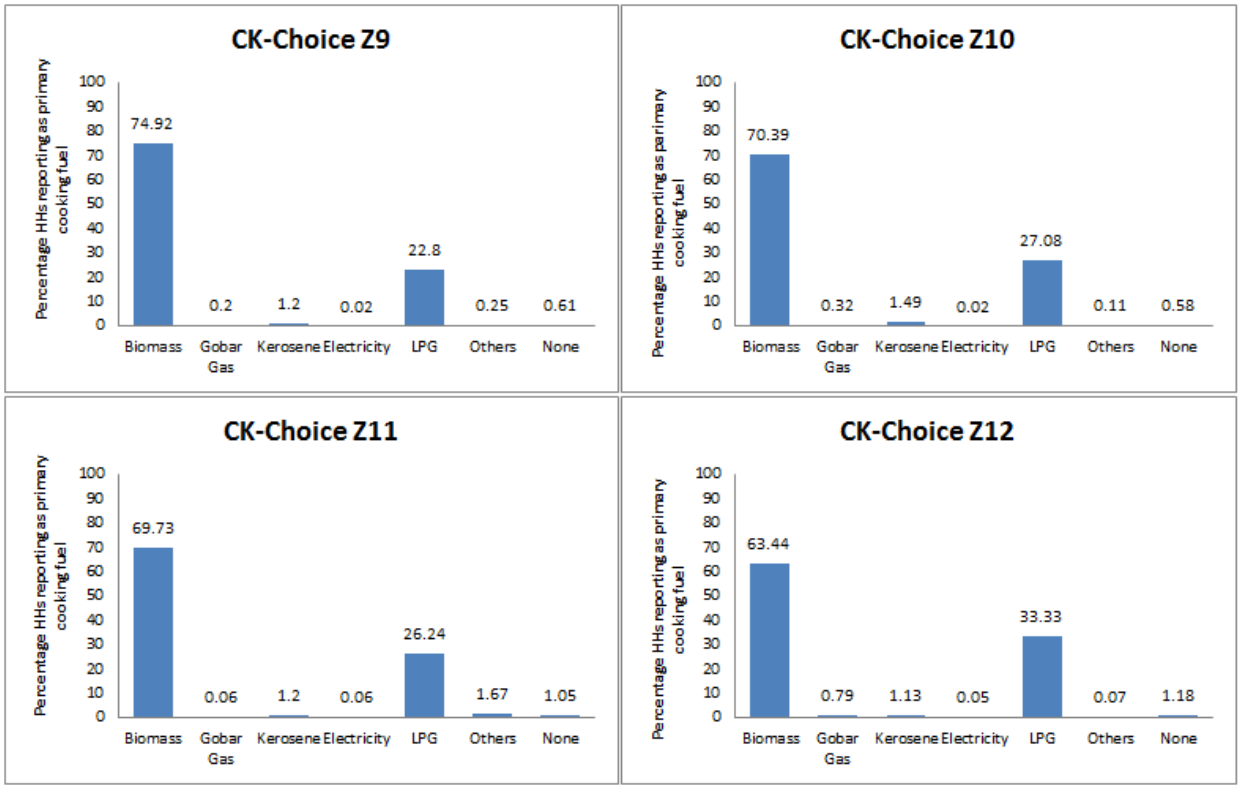

Figure 10 : Choice of primary cooking fuel in Zones 1, 2, 3 and 4
Source: NSS 66th Round, 2009-2010

Zone 9 (Figure 10) which includes most of the state of Maharashtra (except coastal areas), south-western Madhya Pradesh and northern Karnataka, indicates better access than most other regions, which can be attributed to the good performances in the region especially in Maharashtra. The LPG

coverage is also fairly high with about 23% households reporting it as a primary cooking fuel. The average fuel consumption in this region is about 103kgs per household per month (lower than the national average) whereas the LPG consumption per household per month is about 10.5kgs which is well above the national average.

If we see Zone 10 (Figure 10) which includes the states of Karnataka (except coastal and extreme northern districts), Andhra Pradesh (except coastal districts) and Tamil Nadu (except coastal districts), we find that the coverage of LPG is fairly high with about 27% households reporting using it as a primary cooking fuel. Also, the dependence on biomass is fairly high with about 70% households dependent on biomass fuels for cooking needs. Though, it should be noted that while among the three states in this region, Karnataka and Tamil Nadu are performing fairly well across many economic indicators, Andhra Pradesh has its challenges particularly due to a considerable prevalence of famines in the region which considerably affects the incomes of the households. We find that the average per household per month consumption is about 120kgs and 8.9kgs for firewood and LPG respectively. The higher firewood consumption in Karnataka and Tamil Nadu can be due to the fact that these regions are agriculturally intensive and well-forested, but in Andhra Pradesh, the consumption of firewood can also be driven by the presence of certain indigenous communities that live among villages located within the forests.

In Zone 11 and 12 (Figure 10), we find that the dependence on biomass is much lower at about 69% and 63% respectively. Both these zones include the east coast and west coast of India respectively. While Zone 11 includes the coastal districts of Odisha (Orissa), Andhra Pradesh and Tamil Nadu; Zone 12 includes the coastal districts of Karnataka, Maharashtra and the entire state of Kerala. While the proportion of population dependent on biomass is marginally lower in Zone 12, the corresponding coverage of LPG is also higher in Zone 12 by roughly the same proportion. The LPG coverage in Zone 11 is about 26.2% whereas in Zone 12 it is about 33.3%. Though, interestingly, while Zone 11 has a greater proportion of population living among the lower income groups (~10%) as compared to Zone 12 (~3%), we find that the consumption of firewood in Zone 12 is much higher than the national average and is about 174kgs per household per month as compared to 98.5kgs per household per month in Zone 11. In the case of LPG, while coverage is significantly higher in Zone 12, the average per household per month consumption of LPG is about 7.46kgs and 8.92kgs in Zone 12 and 11 respectively.

Zone 13 (Figure 11) includes the entire state of Gujarat. We would expect that given the rapid pace of development in Gujarat, particularly in the last decade, the proportion of population dependent on biomass would be considerably lower than national average (~75%). On the contrary, we find that almost 77% of the rural population is dependent on biomass fuels for their cooking needs. The LPG coverage would also be expected to be higher than the indicative 18%. The average biomass and LPG consumption per household per month are about 117kgs and 9.4kgs respectively. It is also the region indicating highest dependence on kerosene for their cooking needs among rural households. Thus, Gujarat does pose an interesting case for further looking into energy access issues and household transitions towards cleaner energy forms.

Lastly, in Zone 14, which includes western Rajasthan, we find very high dependence on biomass fuels for meeting household cooking needs. Almost, 91.5% of the rural population uses biomass fuels as their primary cooking fuel, while only 8% households indicate using LPG for cooking. We do

know that incomes in this region are considerably low and it also includes many remote villages as well where issues of access still exist. The average biomass consumption is very high at about 170kgs per household per month while the LPG consumption is about 8.2kgs per household per month.

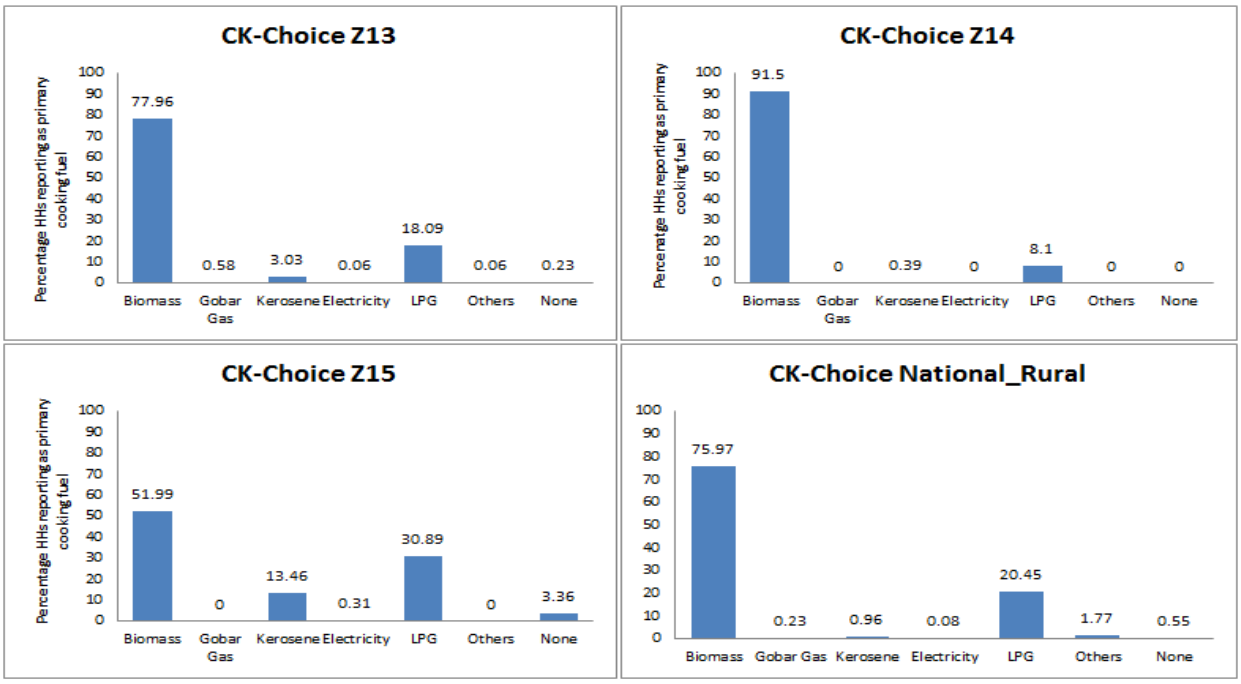

Figure 11 : Choice of primary cooking fuel in Zones 1, 2, 3 and 4
Source: NSS 66th Round, 2009-2010

The figures below (Figure 12 and Figure 13) indicate the consumption of fuels across regions in India. As discussed earlier, we have already detailed out the consumption patterns and variations across regions for firewood and LPG, which are primarily cooking fuels. It is also important to understand the consumption patterns in the case of lighting fuels, i.e. kerosene and electricity. Electricity consumption is highest in Zones 1, 6 and 15 with per household per month consumption of 74kWh, 75kWh and 79kWh respectively, which is more than twice the national average of 36kWh. Correspondingly we would expect the kerosene consumption to be lower in these regions. While the kerosene consumption per household per month is lower in Zones 1 and 6 – about 1.55litres and 1.35 litres respectively, this is not the case in Zone 15. We find that with high electricity consumption, the kerosene consumption is the one of the highest among all zones at about 3.71litres per household per month. This could be that kerosene is used for purposes other than lighting. It should also be noted that since Zone 15 consists the islands of Andaman and Nicobar and Lakshadweep, kerosene could be used for lighting on boats by fishermen or for running motor boats. Given this trend in the islands, we would expect higher kerosene consumption among the coastal zones of 11 and 12, but we find that the kerosene consumption is a little over 2 litres per household per month in both the regions while the electricity consumption is higher than the national average (~36kWh) at about 55.5kWh and 58kWh per household per month in Zones 11 and 12 respectively.

The lowest electricity consumption is among Zones 2, 3, 4 and 5 with about 22.6kWh, 20.4kWh, 11.5kWh and 18.7kWh per household per month respectively. Correspondingly, in these zones, the kerosene consumption is fairly higher or around the national average with 2.33litres, 2.64litres, 2.7litres, 2.23litres per household per month in Zones 2, 3, 4 and 5 respectively.

Zone 13 which includes the entire state of Gujarat presents an interesting case again in the case of lighting fuels as well. Here, we find that it has the highest kerosene consumption of about 4.64litres per household per month among rural households in spite of having fairly higher monthly per household electricity consumption of 55kWh.

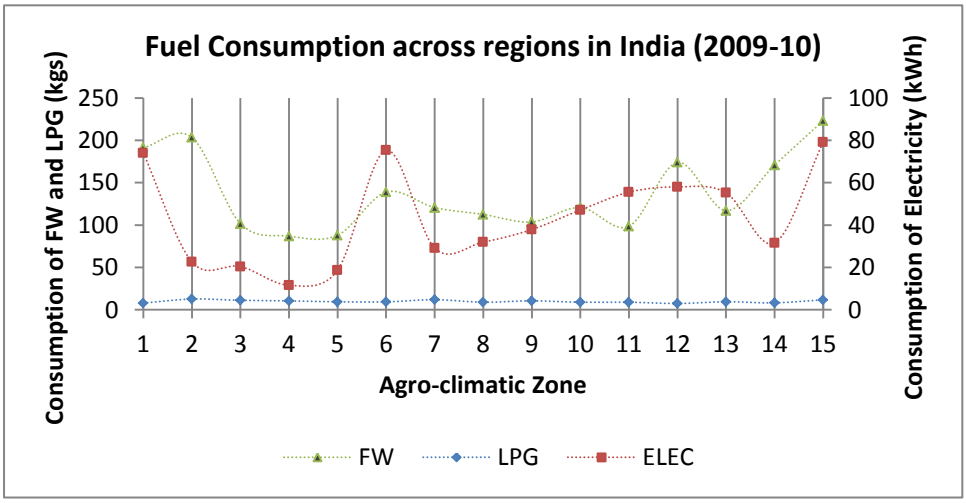

Figure 12 : Consumption of Firewood, LPG and Electricity across zones
Source: NSS 66th Round, 2009-2010

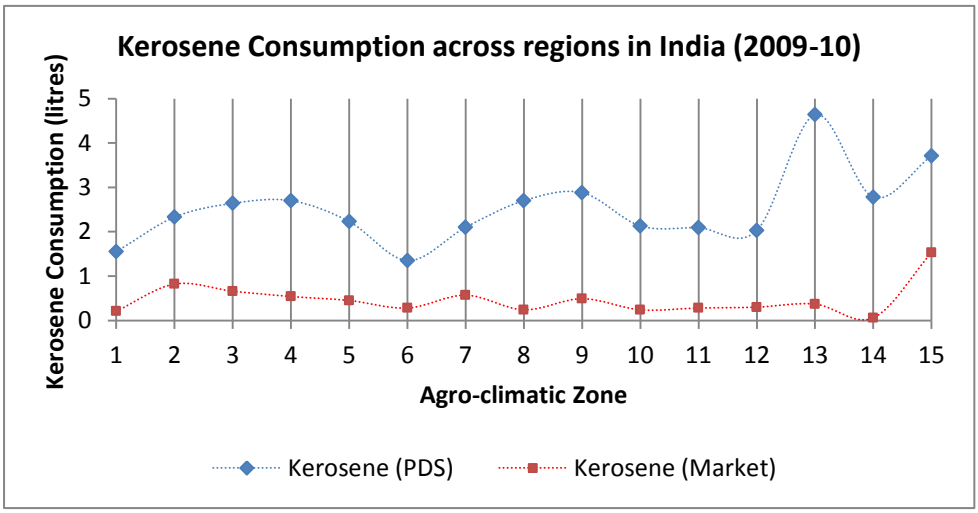

Figure 13 : Consumption of Kerosene (PDS and Non-PDS) across zones
Source: NSS 66th Round, 2009-2010

3. Energy Inequality

There is a strong correlation in general between the GNP or GDP of countries and their use of energy, however, such aggregates hide the fact that the more affluent groups within the developing countries use about as much energy as their counterparts in the industrialized countries, and about 5- 10 times the average energy consumption of the majority of the population (Siddiqui, 19953). Several authors have noted that in many developing countries the disparities between the affluent part of the population and the poorer sections of society are as large as those between the developing and the industrialized countries.

[3] **Variations in energy use by Indian households: An analysis of micro level data,** Energy 32(2). pp. 143-153, Siddiqui, T. 1995

Moreover, different dynamics operate at the household level - differences between financial and economic costs[4], issues of access and affordability etc. Household energy consumption also depends on appliance efficiency, which is highly variable across rural India, given that many appliances are either second-hand or third-hand, i.e. there exists a large secondary market for appliances among rural households in India. All these factors have implications for policies such as demand side management and other targeted interventions.

This study examines the household energy needs for cooking and lighting. In the case of cooking, the difference lies both in the amount of primary energy used as well as in the type of fuel used. While the poor rely heavily in most countries on fuel-wood and kerosene to meet their energy needs, gas and electricity are the preferred fuels for the more affluent households.

Energy inequality can be measured in terms of type of fuel used, quantity of energy used (useful energy or primary energy), prices of fuel and energy access. Thus, energy inequality is closely linked to concepts of energy access and energy poverty, and poverty itself.

Moreover, energy inequality can be studied at various levels - between rural and urban, between income classes and across regions. Differences in the pattern of energy consumption exist across regions. These have been highlighted in the previous section *(Refer Section 3.1)*.

For the purpose of this study, we examine the inequality in terms of biomass energy consumption, consumption of petroleum products (LPG and Kerosene) and in terms of electricity consumption (in kWh) both across income classes as well as across regions in India. We have distinguished between different energy forms to look into critical questions pertaining to energy consumption and household energy transitions. The inequality in this case has been measured using the Gini coefficient.

3.1 Inequality across Income classes

Figure 14 indicates the Gini coefficients for both income inequality and biomass energy consumption across income classes in rural India whereas Figure 15 indicates the Gini coefficient for both income inequality and petroleum energy consumption across income classes in rural India. For both biomass and petroleum products, inequality increases with an increase in income. This could be due to the fact that higher income households have a larger set of choices in terms of the fuel basket they can choose from whereas the lower income households depend on more or less the same kind fuel sources given their income constraints and lack of choice among different fuel types due to availability and affordability constraints. This indicates that while we would expect households to shift to cleaner fuels as incomes increase, it is not the case, as we find that for the richest households, the Gini coefficient is the highest, indicating considerable variations in energy consumption patterns among these households. Thus, this indicates that the energy consumption patterns are governed not just by income but a range of other factors such as social and cultural differences.

In Figure 14, the blue line is the national income Gini, i.e. the income inequality across all income classes among rural India, which stands at about 0.32. But, in terms of biomass energy consumption, the aggregate inequality measure for rural India is higher and stands at about 0.46.

In case of petroleum products, as indicated in Figure 15, we find that the Gini is about 0.44, which is also higher than the income inequality measure.

[4] Clean energy costs money (financial cost) but certain forms of energy (e.g. biomass) only have an opportunity cost that poorer households may not consider so there can be a break between affluence and energy consumption

Thus, we see that energy inequality is higher than income inequality. While an overall analysis of the pattern of energy consumption in the country has been done at both – the national as well as regional levels, as well as the quantification in terms of calculating the actual level of inequality, there is need for a more detailed analysis of the factors affecting the use of different types of fuels. Quantifying these effects will aid in developing a clear understanding the backward and forward linkages between determinants and measure of energy poverty and inequality. There have been studies that have shown that energy poverty measures indicate a much greater share of the population living in poverty as compared to income poverty measures. But this may not necessarily be true as energy consumption patterns are not linked only to income but are driven by a range of other factors as discussed in earlier sections, some of which will seem to play a role in explaining certain interesting observations in energy inequality measures presented further in this section.

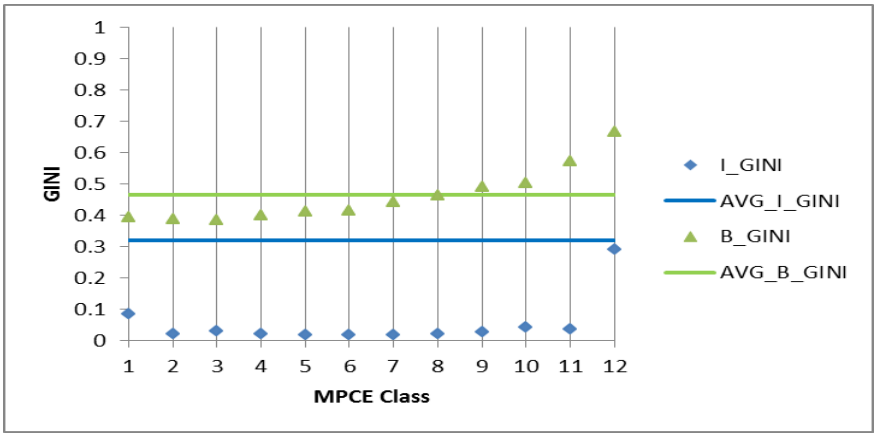

Figure 14 : Inequality in biomass energy consumption across income classes in rural India
Source: NSS 66th Round, 2009-2010

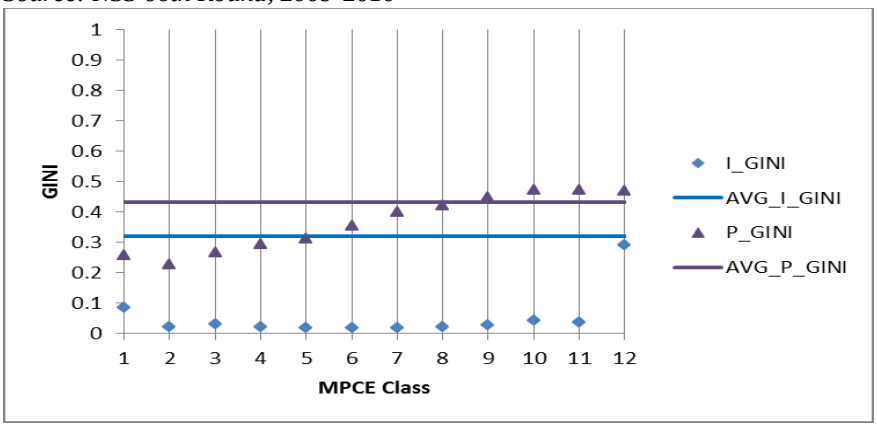

Figure 15 : Inequality in petroleum fuels consumption across income classes in rural India
Source: NSS 66th Round, 2009-2010

Thus, we find that there is a direct relation between income inequality and energy inequality in the case of biomass and petroleum fuels for rural India, i.e. higher income classes seem to indicate a higher level inequality. Though, we should take these figures with some caution as they are based on shares of expenditures and not as shares of income, thus, while these figures are certainly indicative of the differences in energy consumption and levels of inequality, there is a need for further research to look into fuel expenditure and consumption patterns.

In the case of electricity (Figure 16), we find that as incomes rise, the level of inequality decreases. This indicates that unlike biomass and petroleum fuels whose consumption is not just income driven, electricity consumption is more or less linked to income. We can safely assume this for electricity, as more often than not, the access to electricity to a household depends on availability of infrastructure

or on whether a household is influential (a function of income, which allows a household to obtain an electricity connection over other households). Also, in many cases, even if the household has been provided with an electricity connection, very often the supply is cut due to non-payment of electricity bills (i.e. affordability, which is also a function of income of the household).

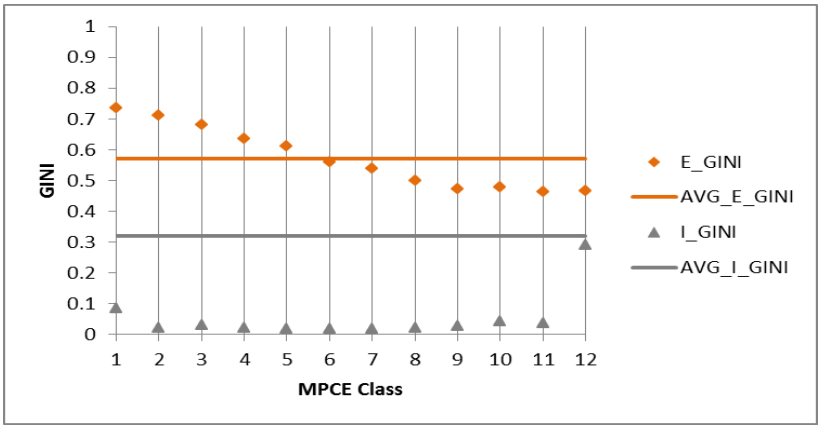

Figure 16 : Inequality in electricity consumption across income classes in rural India
Source: NSS 66th Round, 2009-2010

3.2 Inequality across regions in India

The fuel choices a household makes, especially in rural India, are significantly driven by the local environmental conditions, i.e. natural resource endowments such as forests. The scarcity or abundance of forest land - the access to natural resources defines to some extent the lifestyle of people. As mentioned earlier, we have divided India into different Agro-climatic zones and have looked into energy inequality across these regions as well.

The graph below (Figure 17) plots the Gini coefficient as well as the Atkinson Index, both measures of income inequality. We have plotted both measures to test the consistency of inequality results across regions in India. The Atkinson's Index is marginally higher than the Gini coefficient as it gives slightly greater weightage to households with lower income.

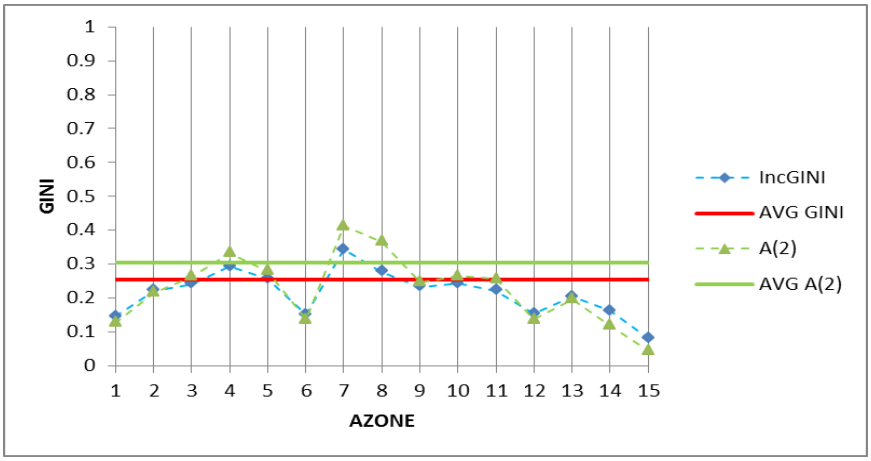

Figure 17 : Income inequality across regions in rural India
Source: NSS 66th Round, 2009-2010

The two graphs below (Figure 18 and Figure 19) plot the Gini coefficient for biomass energy consumption and petroleum energy consumption across regions in India. If we carefully observe the two graphs, we find that the pattern of distribution of the Gini coefficient for biomass (Bz_GINI) and petroleum (Pz_GINI) is a close mirror image of the income Gini (IncGINI). This brings out some interesting observations. We find that there is a partial inverse relation between energy inequality and

income inequality, which indicates the significant role factors other than income in determining household fuel choices.

While we would expect the income inequality to be high in Zone 6 which consists of the states of Haryana, Punjab and Delhi, we find that the income Gini is fairly low whereas the energy inequality is the highest. While this could arise from the fact that the energy consumption patterns are based on the expenditure approach to income, it is also indicative of the fact that energy choices are not a function of just income. It could also be that the given the presence of Delhi in the sample for Zone 6, the income inequality may not be a reflection of the true conditions as the incomes of the 'rural' population in Delhi (the rural population of Delhi has considerable access to an urbanised setting and has a different lifestyle than the rural population of states such as Punjab and Haryana) maybe offsetting the inequalities actually present in the sample of Haryana and Punjab.

If we look at Zone 1, which includes the mountain states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand, we again find that the energy inequality is fairly high, contrary to the income inequality measure. It is plausible that given the low density of population, the income inequalities may not be as evident in these states or it could be that the presence of samples from Himachal Pradesh and Uttarakhand may be offsetting the actual inequality present. It could also be that the consumption patterns are considerably different in these regions as these states also include some of the remotest parts of the country where access to energy is a challenge, thus, indicating significant inequalities in energy consumption.

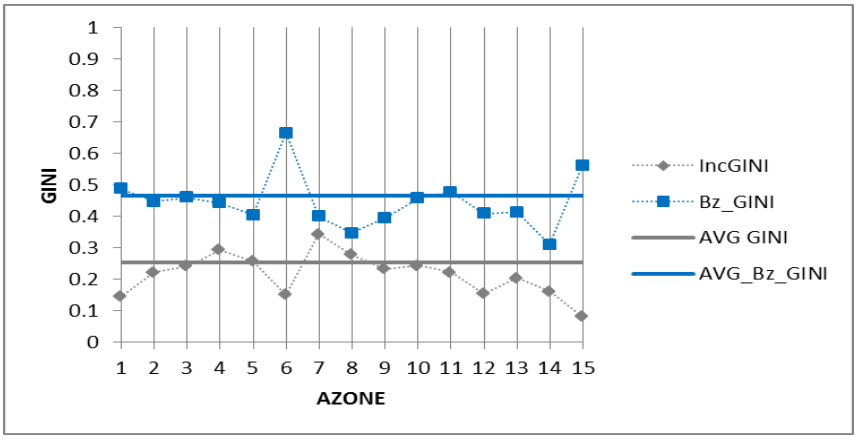

Figure 18 : Inequality in biomass energy consumption across regions in rural India
Source: NSS 66th Round, 2009-10

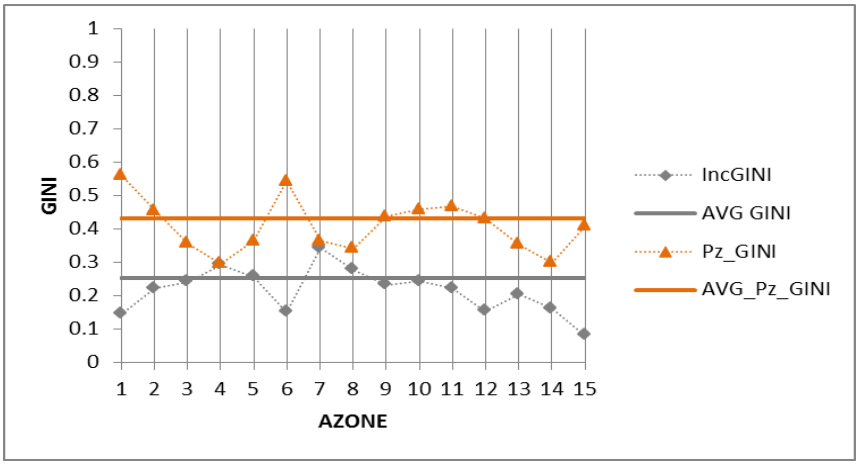

Figure 19 : Inequality in petroleum fuels consumption across regions in rural India
Source: NSS 66th Round, 2009-2010

In the case of electricity, we find that the inequality in electricity consumption follows a similar pattern to that of income inequality. Thus, reiterating that electricity and income have a direct relation unlike in the case of other fuels which are primarily used for cooking.

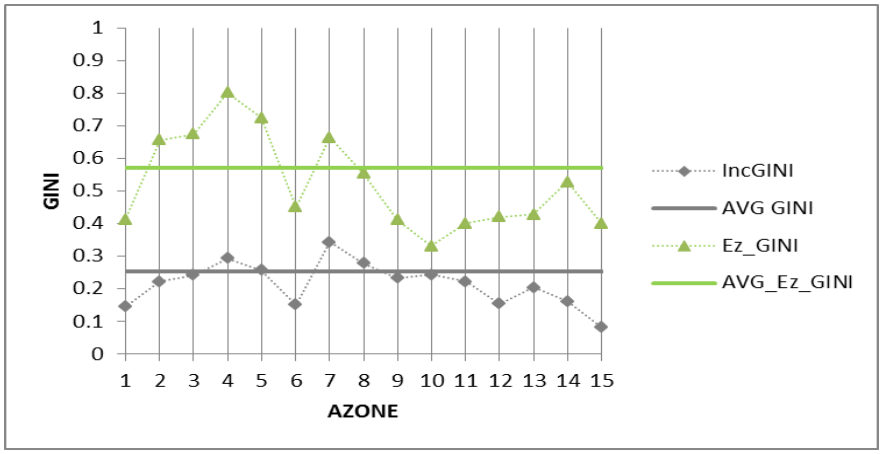

Figure 20 : Inequality in electricity consumption across regions in rural India
Source: NSS 66th Round, 2009-2010

Thus, we find that when we look at energy consumption patterns and inequalities in energy consumption of different sources across both income classes and regions based on secondary data available from NSS household consumption surveys, there is evidence contrary to the popular opinion that incomes drive energy transitions. We find that there are certain patterns that are nor explained just by income levels and thus indicate the presence of other factors defined by certain socio-cultural contexts that a society lives in and has evolved from.

4. Going beyond NSS data

Understanding household energy choices and transitions is a complex issue and needs to be dealt with in a very careful manner. It requires careful consideration in terms of data collection so as to ensure that key variables are captured to study their impact on household energy choices.
So far the National Sample Survey Organisation's annual consumption survey has been an important data source at the all-India level. The consumption survey asks questions on household expenditure across various heads and the quantity they consume, i.e. expenditure on health, education, durable goods, and food-items and so on. The survey also asks household's on their fuel expenditure and fuel consumption. This gives us key insights into household energy consumption patterns across regions and income groups.

But it should be noted that while the NSS data provides us such information, it is primarily a consumption survey and thus does not measure other social and gender related variables which may impact energy choices of a household. Thus, there is an urgent need to go beyond NSS data to understand household energy transitions, and in the Indian context, this poses a greater challenge as variations exist across all regions and income groups.

5. Conclusion

Household energy consumption levels and fuels used are closely related to variables such as availability, distance from the nearest source, prices of fuels, income, occupation, household size, education and religion that shape the preferences of households for certain fuels as well as and impose constraints binding them to use certain fuels. Therefore, while studying rural energy consumption patterns, particularly from the perspective of studying how a transition to clean energy

can be enabled, it is essential to understand the role of socio-economic parameters. This knowledge can then be used to determine what factors act as enablers or barriers in transitioning to clean forms of energy.

For analysing the patterns of consumption of energy in rural India, certain key issues emerge. The following set of questions, though not exhaustive is a representation of these issues and puts forward the need to go beyond the NSS survey.

A. How is energy poverty and energy inequality defined?

Although interlinked, energy poverty and energy inequality are two dimensions of the energy access linkage and can be looked at individually. Inequality can be in terms of fuel-use, quantity of energy used, useful energy, prices of fuel and also energy access. We have already seen in the earlier sections, that the relationship of income and energy choices is not so direct after all, but there are many patterns that are not completely explained by income, thus it brings forth the need to look into further dimensions of society and culture which impact people's lifestyles. Based on the literature available the existing concepts and measures of energy inequality (such as the DFID definition of energy poverty), need to be examined to determine if these suffice or whether any modifications are needed to align them especially in the context of rural India. Once the appropriate measures are identified, the quantification of energy poverty and inequality can be done to actually gauge the level energy poverty in rural India.

B. What is the relation between energy poverty and inequality and other social and macroeconomic variables such as level of income, education levels, and so on?

There exist strong linkages between access to energy/energy poverty and the other macroeconomic variables particularly income, occupation, household size, education and religion. These relations need to be kept in mind while analysing the evolution in the pattern of energy consumption across various regions. The pilot survey results bring out the relation between energy inequality and other socio-economic and macro variables.

C. What are the linkages between gender issues and energy consumption choices?

The choice of fuel has implications on the health and wellbeing of the women in rural households. More often than not, it is the women who are expected to collect biomass fuels for the household as cooking is a domestic chore that is expected to be carried out by them. Choice of cleaner fuels for cooking such as LPG reduces the time spent in collecting fuel and also has positive implications on the health of women and children in the household. Thus, it is very critical to consider the role of gender when it comes to household energy transitions. For this purpose, there is a need to go beyond the existing NSS data to capture key variables relating to gender and society.

D. What will be the transition path in the consumption of rural energy?

Several approaches can be used to understand the pathway of transition to cleaner and more efficient forms of fuel. Further, while analysing the transition in energy consumption, it is useful to map the change in energy sources to the change in other social and macroeconomic variables in order to understand not only the change in fuel-mix but also the factors that determine that change over time.

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ANNEXURES

Annexure 1: Penetration Rates of Cooking and Lighting fuels in Rural India

The table below (Table 2) provides an overview of access to different fuels for rural households belonging to different income groups in India over time.

Table 2: Penetration Rates of Cooking and Lighting Fuels across income groups and over time in Rural India

	Fuel	NSSO Round	Low Income (bottom 20%)	Med Income	High Income (top 20%)
Cooking	FW	55	*82-84%*	*79-81%*	*46-75%*
		61	*78-81%*	*79-81%*	*43-75%*
		66	*85-87%*	*81-85%*	*38-75%*
	LPG	55	0-1%	1-5%	5-29%
		61	0-1%	3-9%	9-39%
		66	0-2.5%	2.5-11%	12-42%
Lighting	Kerosene	55	*65-73%*	*47-61%*	*17-45%*
		61	*60-70%*	*40-59%*	*13-40%*
		66	*54-61%*	*23-50%*	*9-20%*
	Electricity	55	24-30%	33-50%	57-81%
		61	28-35%	40-58%	63-85%
		66	37-54%	51-71%	74-90%

Source: NSS 66th Round, 2009-2010

Annexure 2: Agro-climatic Zones

For resource development, the country has been broadly divided into fifteen agricultural regions based on agro climatic features, particularly soil type, climate including temperature and rainfall and its variation and water resources availability as under:

1) *Western Himalayan division*
2) *Eastern Himalayan division*
3) *Lower Gangetic plain region*
4) *Middle Gangetic plain region*
5) *Upper Gangetic plain region*
6) *Trans-Gangetic plain region*
7) *Eastern plateau and hill region*
8) *Central plateau and hill region*
9) *Western plateau and hill region*
10) *Southern plateau and hill region*
11) *East coast plain and hill region*
12) *West coast plain and hill region*
13) *Gujarat plain and hill region*
14) *Western plain and hill region*
15) *Island region*

Annexure 3: Key Hypothesis

Based on detailed literature review and analysis of available data, we feel that there is a need to go beyond the NSS data. While the NSS data does give us valuable information on consumption of different energy sources by households belonging to different income groups and across different states in India, it is primarily a household consumption survey and does not capture key variables related to energy access such as availability of fuels, role of gender, distance from fuel sources, household preferences based on socio-cultural contexts and so on. Thus, this study makes an attempt to beyond existing data to understand the drivers and barriers to household energy transitions in among rural households in India.

Based on the detailed analysis, we have formulated four key hypothesis to be tested as part of this study, which will enable us to capture many social and cultural variables that may impact household energy choices. The hypotheses are detailed below:

1. Significant changes in income flows impact energy use patterns
    - *Greater probability among households with regular salary flows to make a shift towards cleaner fuels such as LPG for cooking*
2. Higher the value of women's labour, lower the probability of collecting biomass fuels, and thus, lower the chance of using biomass fuels for cooking
    - *If the women contribute significant income shares to the household, there is greater chance of their involvement in household decision making and thus, in the case of energy choices as well*
3. Elasticity of fuel expenditure with respect to total expenditure of the household, i.e. priority of fuel as an expenditure for a household
    - *We would expect that as income increases, the expenditure share on energy would rise at a decreasing rate similar to the hypothesis set by Keynes in the case of household expenditure on food, also known as the psychological consumption hypothesis*
4. Impact of an intervention on energy use patterns aimed at directly improving energy access or indirectly through improved income security
    - *By looking at treatment and control groups, i.e. comparing samples that are similar in all aspects except the difference being that one set is exposed to an intervention while the other is not. This will help capture certain key socio-cultural factors that may play an important role in household energy choices, in some cases, a role greater than that of income*