

Energy Poverty in Rural and Urban India

Are the Energy Poor Also Income Poor?

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Abstract

Energy poverty is a frequently used term among energy specialists, but unfortunately the concept is rather loosely defined. Several existing approaches measure energy poverty by defining an energy poverty line as the minimum quantity of physical energy needed to perform such basic tasks as cooking and lighting. This paper proposes an alternative measure that is based on energy demand. The energy poverty line is defined as the threshold point at which energy consumption begins to rise with increases in household income. This approach was applied to cross-sectional data from a comprehensive

2005 household survey representative of both urban and rural India. The findings suggest that in rural areas some 57 percent of households are energy poor, versus 22 percent that are income poor. For urban areas the energy poverty rate is 28 percent compared with 20 percent that are income poor. Policies to reduce energy poverty would include support for rural electrification, the promotion of more modern cooking fuels, and encouraging greater adoption of improved biomass stoves. A combination of these programs would play a significant role in reducing energy poverty in rural India.

This paper—a product of the Agriculture and Rural Development Team, Development Research Group—is part of a larger effort in the department to understand the determinants of rural energy poverty and its influence in rural income and poverty. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at skhandker@worldbank.org.

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Energy Poverty in Rural and Urban India: Are the Energy Poor Also Income Poor?¹

By

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Introduction

The relationship between energy and poverty has preoccupied development specialists for decades. Running modern economies without energy is impossible; thus, it has been argued that energy use, particularly such modern energy² as electricity, is related in some way to economic development (Besant-Jones 2006; UNDP 2005). However, the concern is whether the provision of energy services leads to economic development or whether economic development leads to expanding demand for energy. The conventional wisdom is that energy is a necessary but not a sufficient condition for development. But this begs the policy question as to whether the lack of energy, especially modern energy, is a cause of poverty.

The linkage between modern energy access and welfare is well documented. For example, the burning of biomass energy (e.g., fuelwood, dung, or crop residue) in conventional ways often contributes to indoor air pollution and is thus a health hazard (World Bank 2002a, 2002b).³ The use of more modern fuels, such as LPG, can alleviate this problem. In rural areas, the collection of fuelwood, often performed by women and school-going children, takes time away from other productive pursuits (Saghir 2004; Barnes and Toman 2006). Thus, replacing traditional ways of consuming biomass with more efficient energy-consumption methods or consumption of modern energy can lead to time savings and better opportunities. Use of electricity in the evenings can

² The term modern energy connotes those types of energy used in more developed societies, compared to traditional energy types still prevalent in developing countries that have probably been used for thousands of years. In general, liquid fuels, such as kerosene and LPG, along with electricity, are considered modern forms of energy; while traditional fuels generally consist of biomass fuels (wood, agricultural residue, and dung), which are used in traditional stoves.

³ The inefficient burning of biomass fuels also adds carbon to the atmosphere, contributing to the heat-trapping effect of greenhouse gases (GHGs) and thus to climate change.

extend household members' work and study hours and contribute to productivity and educational achievements (Cabraal and Barnes 2006; Roddis 2000; Wasserman and Davenport 1983; World Bank 2002c).

This paper aims to deepen our understanding of energy as one factor that underpins both economic development and poverty reduction by analyzing the relationship between energy and poverty in India. Its objectives are two-fold. First, we examine whether it is possible to establish a level of energy consumption at which people can be perceived as “energy poor.” Second, we investigate the relationship between income and energy poverty to determine whether reducing income poverty can help reduce energy poverty. The basic premise is that there is a level of energy consumption that is absolutely needed to sustain welfare, and this is called the energy poverty line. This minimum requirement of energy services may not necessarily coincide with the energy services consumed by those who are deemed “income poor.” The paper also postulates that, beyond this point, energy contributes to increased welfare. That is, energy is essential not only for supporting a decent quality of life but also for continued growth and productivity.

Electricity Consumption and Economic Growth

At the international level it is well established that there is a high correlation between energy consumption and economic growth, although the direction of causality is unclear. Countries with high levels of income also used high levels of energy. For instance, for each person in the United States energy consumption is 10 times the amount that is used in India. Energy consumption also increases with economic growth as well. For India, economic growth has been quite high in recent years. This trend has been mirrored within the energy sector, and this is especially true for electricity consumption. Between 2000 and 2007 India's economy grew nearly 77 percent and this was matched by a 60 percent increase in electricity consumption (Figure 1).

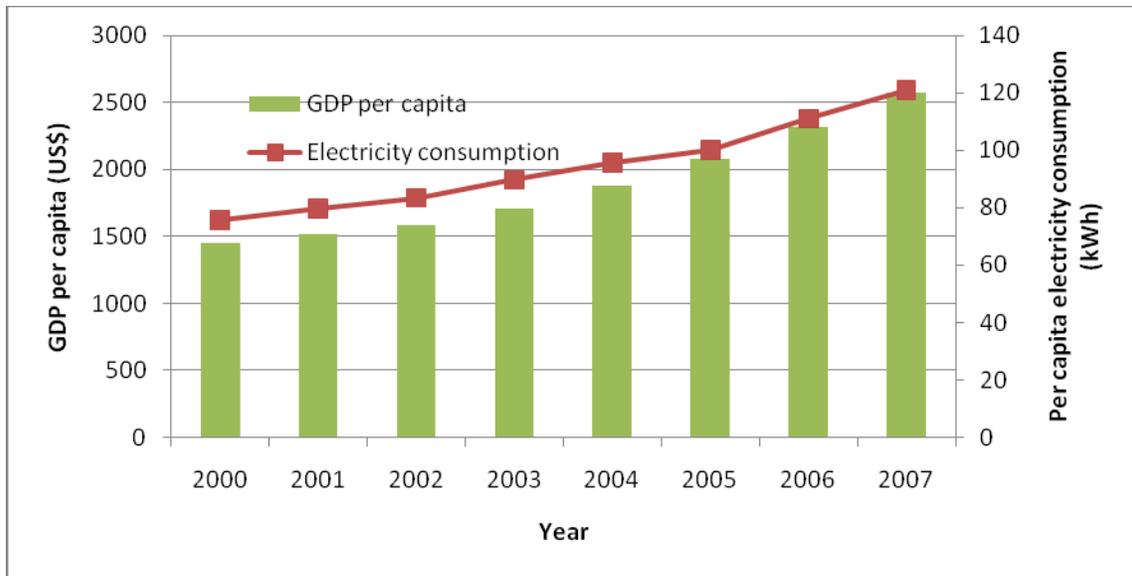


Figure 1: Trends in economic growth and electricity consumption in India

Energy is important both for economic development, but it also plays a major role in improving conditions at the household level. The benefits of modern energy both for improved economic growth and for improving the quality of life in developing countries were recognized as necessary conditions for achieving the Millennium Development Goals (MDGs) (World Bank 1996). Although energy is not one of the MDGs, the MDG Summit considers it essential for achieving most of the goals. It is generally recognized that energy issues must be dealt with in order to alleviate poverty in the developing world (DFID 2002; Sachs 2005).

Generally rural areas lag behind urban areas in access to modern energy. The electricity grids tend to expand outward from urban areas first to well off rural areas and finally to the more remote parts of countries. Likewise, the distribution of LPG is dictated by a network of retailers. Such retailers generally prefer to expand from the most densely population and higher income markets found in urban areas and once these markets are saturated only then will they continue to expand to rural areas. As of 2005 the percentage of households with electricity in urban India was 94 percent and in rural areas it was lower at around 57%. For LPG, 71% of urban households use LPG

compared to just 17% in rural areas. The factors contributing to these differences involved both income and physical access to the energy providers. As a consequence, we would expect that the energy poverty rate in rural areas should be higher than in urban areas where even very poor people have access to modern energy services. It is true that they may not be able to afford purchase large quantities of energy, but at least it is available to them. Thus it is likely that energy poverty will be more similar to income poverty in urban compared to rural areas. In order to investigate this issue, we first review the different approaches that have been used to measure energy poverty in developing countries.

The Concept of Energy Poverty

The notion of an energy poverty line is well-accepted around the world. There is a large body of literature on how to measure poverty and the reliability of alternate measures (Ravallion, 1998; Ravallion and Bidani, 1994; Pradhan and Ravallion, 1998). The idea of measuring an energy poverty line is similar, but there is no consensus on the methodological and conceptual issues that define it. Also, there has been very little opportunity to the level of energy poverty between urban and rural areas. In this section we review the existing measures of energy poverty and describe the method that will be employed in this paper.

Over the past 20 years, many involved in energy issues have grappled with the concept of energy poverty (Bravo et al., 1979; Krugman and Goldemberg, 1983; Goldemberg, 1990; Pachauri and Spreng, 2004; Foster et al., 2000; Saghir, 2004), and several approaches have been used to define and measure it. *Methods* have often been based on the physical energy or expenditure for specifying a minimum level at which households can be considered non-poor. Such methods define the minimum amount of energy needed based on a basket of goods and services to meet direct energy needs (e.g., cooking, lighting, and heating someone's home) and the energy embodied in additional

goods and services that households use. One drawback, however, is the difficulty in pinning down the exact minimum level of energy required for basic needs, owing to the significant country and regional differences in cooking practices and heating requirements. Energy consumption is often location-specific due to the vast differences in climatic conditions worldwide. Furthermore, the minimum needs for physical quantities of energy are chosen somewhat arbitrarily.

Among the methods based on physical energy requirements, an important one was proposed by Bravo et al. (1979). The Bravo measure quantifies a household's direct energy needs in considerable detail including those for cooking and lighting. The average household in a tropical country such as Bangladesh requires about 27.4 kilograms of oil equivalent (KgOE) per capita per month to meet its essential direct energy needs. A second interpretation of physical energy requirements, proposed by Goldemberg (1990), includes a wider range of energy-using activities, placing that estimate at 32.1 KgOE per capita per month. A third, more universal interpretation, which examines the physical needs of daily cooking and lighting based on various surveys from around the world, results in a much lower minimum household energy requirement (50 KgOE per year) (Modi et al., 2005). Thus, varying assumptions yield vastly different results.

A second approach defines energy poverty as the level of energy used by households below the known expenditure or income poverty line (Foster et al., 2000).⁴ Because the expenditure-based poverty line is well-defined in most countries, this approach is fairly attractive since it is unnecessary to measure how much energy people are actually using. One can simply assess the average fuel used by the households at the expenditure poverty line based on a household energy survey. But the drawback of defining energy poverty based on such general criteria, as opposed to an energy basket

⁴ The terms *expenditure poverty* and *income poverty* are used interchangeably throughout this paper, although the measurement of such poverty involves expenditure only.

of goods and services, is that the expenditure poverty line is based on general economic and social policies rather than the energy policies of the country studied; thus, tracking energy poverty equates to tracking income poverty trends. The underlying assumption of this approach is that expenditure-poor households are necessarily energy poor; while in reality, some non-poor households, based on the expenditure poverty measure, may still be energy poor.

A third approach is based on energy expenditures as a proportion of total income, as mentioned in various studies (e.g., Pachauri and Spreng, 2004). It is well-established that poor households spend a higher percentage of their incomes on energy than do wealthier ones. Recent empirical studies indicate that such percentages can range from about 5 percent up to 20 percent of cash income or expenditure (e.g., Barnes et al., 2005). As poor households spend increasingly greater shares of their income on energy, they reach a point where they begin to cut back on their energy use to minimum levels. A cutoff point of 10 percent of total income is frequently mentioned in the literature as a common level of expenditures for poor households. The idea is that households forced to spend as much as 10 percent of cash income on energy are being deprived of other basic goods and services needed to sustain life. The drawback is that 10 percent is a rather arbitrary figure. Thus, to a certain extent, this approach suffers from the same problems as those methods based on physical measures of energy.

This paper explores a fourth way of measuring energy poverty that is similar to expenditure poverty in concept and applicable to a wide variety of climatic and socioeconomic conditions. This approach is based on the level of energy demand as it relates to household income. This paper uses a demand-based approach to define energy poverty line as the threshold point at which energy consumption begins to rise with increases in income. At or below this threshold point households consume a bare minimum level of energy and should be considered as energy poor. For the poorest

people well below the energy poverty line, this means that, even if their incomes increase, their use of energy does not because they are at the bare minimum amount necessary to sustain daily life. This also means higher shares of energy expenditure because, below a certain threshold, energy use does not change but people have less and less income; higher shares of energy expenditure, in turn, mean lower levels of household welfare because people have less to spend on other goods and services, including food and non-food items. This approach is data-intensive, requiring the analysis of household surveys that cover details of energy consumptions. But its attractiveness is that the definition of energy poverty is based on how people actually consume energy, based on local resource conditions, energy prices, and policies.

A Demand-based Approach for Defining Energy Poverty

The assumption underlying the measure of energy poverty is that household consumption of energy and other non-energy goods and services is related to overall well-being. The relative shares of energy and other expenditures reflect the underlying price and availability of energy of different types and their impacts on overall welfare. However, higher shares of energy expenditure mean lower levels of household welfare because a lower percentage of spending is available for other goods and services, such as food and non-food items. At the same time, a higher monetary expenditure on energy does not necessarily imply a higher quantity of energy use as this depends on energy price, efficiency, type of use, and other factors. It may make a household worse off by lowering the observed level of its welfare. This suggests that the role of energy use in household welfare should be examined from the demand for energy services and not from expenditure on energy alone.

Assessing the role of energy use in household income and non-energy consumption involves some tricky issues, such as determining the direction of causality between energy use and income or

other measures of welfare (for a more thorough discussion of this issue, see Barnes, Khandker and Samad, 2010). A household's well-being certainly influences its energy demand; at the same time, its energy use affects its income and welfare. A rise in household income is accompanied by more choices for expenditure. Households spend more on energy by expanding existing energy use (e.g., buying more kerosene lanterns or extending the duration of electricity use), and purchasing modern energy appliances (e.g., electric irons, lamps, or fans), and energy-consuming entertainment and luxury items (e.g., TVs, refrigerators, VCRs, and air conditioners), which they previously could not have afforded. On the other hand, energy use, particularly modern energy, can bring about tangible changes in household welfare, both directly and indirectly. This leads us to conclude that household well-being, income, and energy use are jointly determined.

The use of lighting serves to illustrate the joint relationship between income and energy. High-quality lighting services can extend activities beyond daylight hours. This is particularly true for an electric lamp, which provides 100 times more lighting than a kerosene wick lamp (*kupi*). Higher levels of lighting can improve income-generation activities, such as keeping a store open for longer hours or making a home business more productive. Both contribute to increased income and employment. Access to lighting services may also increase study hours for school-going children, which, in turn, can increase their educational achievements.

To determine that basic minimum energy requirement, the approach followed in this paper examines how a household's demand for energy varies with the change in other major welfare indicators, such as income. One way to observe that change is to examine the energy demand function. A household's energy demand is influenced by a range of factors at the level of the household (education, income, land and non-land assets, hygiene, and so on) and community (energy price, village infrastructure, prevailing wage structure, and commodity prices). These factors

are likely to be quite different in urban compared to rural levels. However, for energy-poor households that are only meeting their basic energy needs, the relationship between energy uses and income should be weak. This is the central premise for defining an energy poverty line. This method is applied to both urban and rural India using a nationally representative household survey of energy use in both rural and urban areas, containing a rich data set on energy consumption, income, and other factors necessary for assessing an energy poverty line.

Data Description

The India Human Development Survey (IHDS) is a multi-sector survey with a nationally representative sample of 41,554 urban and rural households. It covers all major states and union territories of India, with the exception of Andaman/Nicobar and Lakshadweep. In all, these households were sampled from 33 states and union territories, 383 districts, 1,503 villages, and 971 urban blocks.

Different designs were used to select the urban and rural samples. The urban sample was drawn from all urban areas in a state. These areas were listed in order of their size with the number of blocks drawn from each area based on probability proportional to the block's population. Once the number of blocks for each urban area had been determined, the enumeration blocks were selected randomly with help from the Registrar General of India. From these Census Enumeration Blocks of about 150 households, a complete household listing was conducted and a sample of 15 households was selected per block. For sampling purposes, some smaller states were combined with nearby larger ones. The rural sample took advantage of an earlier survey to draw a random sample

that is statistically valid for rural areas in India. After data cleaning, a total sample of 22,538 rural households and 12,325 urban households were included in this paper's analysis.⁵

The energy questions that were asked in the IHDS survey are more extensive than those of comparable surveys such as the Demographic and Health Surveys and the Living Standards Measurement Studies. The energy questions in the IHDS survey cover use of fuels, cash expenditures on fuels, the collection time for obtaining biomass fuels, and the types of stoves and electric appliances in the household. For electricity, there are also questions on the reliability of the power supply and the source of electricity for the household such as whether they are serviced by the local state electricity board or from a neighbor. These detailed energy questions allow for a much more detailed analysis of the welfare impact of the use of different types of energy. In fact, we next turn to the demand for energy in India.

Patterns of Household Energy Use

Of the many factors that have constrained India's development, energy usage figures prominently. Energy use per capita in India lags far behind that of other countries around the world (World Bank 2006). Moreover, there are wide disparities in energy use between urban and rural areas (where three-fourths of the country's people live). This section highlights India's existing patterns of household energy use, and estimates energy demand functions.

The patterns of urban and rural energy demand in India differ markedly (Table 1). In rural areas, patterns of energy use typically involve high reliance on traditional fuels, including wood, dung, and straw burned in inefficient stoves. In urban areas, only one-third of households use fuelwood, compared to nine-tenths of rural households. In terms of quantity of energy use, rural households consume about 132 kg of fuelwood per month, more than four times the amount

⁵ Because samples were drawn as a fixed number of 15 households from each block, the analysis throughout the paper uses weights for making the analysis representative of the population.

consumed by urban households (32 kg). In terms of total energy use, biomass accounts for 89 percent of household energy consumption in rural areas and 35 percent in urban areas. In India, like many other developing countries, most rural households use biomass fuels for cooking as it is the cheapest form of energy and can be collected from the local environment. Moreover, the opportunity cost for biomass collection is low, as it is usually collected by women and young children who, in most cases, are not employed outside the household. Fuelwood, in fact, is considered a superior cooking fuel because it is much preferred over other biomass fuels, such as crop residues or dung.

However, the transition to modern fuels has been increasing. For cooking, urban households frequently use kerosene, along with LPG. Use of LPG among urban households is 71 percent, with monthly consumption averaging 9 kg (with an average consumption of 13 kg per household that actually uses the fuel). This compares to only 17 percent among rural households, whose monthly LPG consumption averages just 1.7 kg (with an average LPG consumption of 10.7 kg per user household).⁶ In rural areas, 91 percent of households use kerosene, particularly for household lighting (used mostly in wick lanterns or hurricane lamps). In households with electricity, kerosene is often used as a backup lighting source when brownouts or blackouts occur.

The household electrification rate in urban areas is 94 percent, compared to 57 percent in rural areas. In rural households, lighting is the major use of electricity. But in urban households, electricity use extends well beyond lighting to encompass a wide array of appliances (e.g., television sets, radios, irons, and electric fans). Indeed, electricity constitutes about 26 percent of total energy consumption among urban households, while its share among rural households is less than 5 percent.

⁶ Figures are averaged for all households (not just users).

For rural households, fuel wood constitutes the highest share of total energy expenditure, at 40 percent (Table 1). This expenditure may not represent what households actually paid. Since biomass is mostly collected without direct cost, the local market price has been used to impute the value of biomass use in rural areas. For urban households, electricity is the highest energy expenditure, followed by LPG. Overall, urban households pay about Rs. 557 per month on energy, compared to Rs. 477 spent by rural households. Because of the higher use of biomass energy in rural areas, rural households actually consume more energy in total compared to urban ones. However, this pattern is reversed when the efficiency of energy use is taken into consideration. After adjusting for efficiency of use, people in urban areas actually consume more *end-use energy* compared to rural households. The reason is because they use more modern forms of energy that offer a wider range of energy services.

Since the energy-poverty estimation outlined in this paper is based on household energy demand, it is important to investigate the determinants of that demand. This is particularly helpful from a policy-making perspective, which promotes modern energy sources over traditional ones. A household's demand for a particular energy sources depends on a host of factors following the analytical framework outlined above. Apart from the characteristics of the household, those of the alternate energy sources (e.g., availability and price) and community can influence a household's energy demand. A reduced-form model for household energy demand of any type can be of the following log-linear form:

$$\ln E_{sij} = \alpha^e + \beta^e X_{ij} + \gamma^e V_j + \lambda^e P_{sj} + \varepsilon^e_{sij} \quad (1)$$

where,

E_{sij} = s -th type energy demand of i -th household of j -th village,

X_{ij} = vector of household characteristics (e.g., household head age, gender, landholding, and so

on),

V_j = vector of village characteristics (e.g., prices of consumer goods, infrastructure variables including village electricity),⁷

P_{sj} = village-level energy price of s -th type,

$\beta^e, \gamma^e, \lambda^e$ = parameters to be determined, and

ε_{sij}^e = unobserved random error.

Since there are households that do not consume a particular energy source, zero consumption is observed for those households and so a censored regression technique such as Tobit is used instead of ordinary least squares to estimate the energy-consumption demand equation for alternative sources of energy.⁸ A reduced-form, log-linear demand equation is used to reflect the influence of exogenous factors, such as prices and land assets. Since household income can be influenced by energy use itself, household income is not included as a covariate.⁹

Table 2 presents summary statistics for both dependent and independent variables drawn for both rural and urban India. The average years of schooling of household heads are 4 years in rural areas compared to nearly 8 years in urban areas. Urban households own much less agricultural land (0.34 acres on average) than their rural counterparts (2 acres on average). Fuelwood is slightly cheaper in rural India, while kerosene and LPG are cheaper in urban India.¹⁰ Virtually all urban communities have an electricity connection, compared with about 87 percent of rural villages. The price of electricity in urban areas is slightly higher (Rs. 3.62) than in rural areas (Rs. 3.06).

⁷ These variables are not available for the urban sample as no community questionnaire was fielded for the urban area.

⁸ Zero consumption may reflect the substitution of lower priced or otherwise more attractive fuels for the fuel in question.

⁹ We will shortly show a structural model of energy demand where energy consumption depends on income, where income can be partly influenced by energy consumption, yielding a well-known simultaneity bias in estimation.

¹⁰ Prices of energy sources and that of other consumer goods (used in the regression model for rural households) are adjusted by state-wide and rural-urban consumer price index.

Table 3 presents the Tobit estimates of demand function for alternative energy sources for both rural and urban households. Education of the household head increases the demand for more modern energy in both rural and urban India. In terms of biomass consumption, education of males matters little; however, education of females has a highly negative correlation in both rural and urban areas.

As expected, prices play a major role in energy demand; the own price effect is negative for all energy sources except electricity in rural and urban areas. For example, a 10-percent increase in the price of fuelwood lowers a household's monthly fuelwood demand by about 7 percent in rural areas and 10 percent in urban areas. With regard to modern energy, a 10-percent increase in the price of LPG lowers a household's monthly LPG consumption by about 2 percent in rural areas and nearly 23 percent in urban areas (Table 3). Thus, as expected, urban households are more sensitive to the price of LPG than are rural households, possibly because they have the option of switching to kerosene as an alternate cooking fuel in case of an LPG price hike.¹¹ Apart from these impacts, there are also substitution effects. For example, a 10-percent increase in the price of kerosene raises monthly LPG consumption by 0.4 percent in rural areas and about 3 percent in urban areas.

Other important variables that have a significant effect on energy demand are household land assets and status of village electrification. Household land assets have a positive effect on biomass demand in both rural and urban areas, while village electrification results in greater household consumption of electricity and decreased use of kerosene in rural areas (since these function as substitutes for each other).

These findings suggest that energy policies have a significant impact on energy demand. Thus, it might be possible to bring households out of energy poverty if policies are geared toward

¹¹ Rural households can also switch to kerosene or fuelwood in case of a price increase in LPG; however, LPG use in rural areas is limited to better-off households, who are relatively insensitive to price hikes.

promoting rural electrification. Having examined the determinants of household energy demand, we are well positioned to estimate energy poverty.

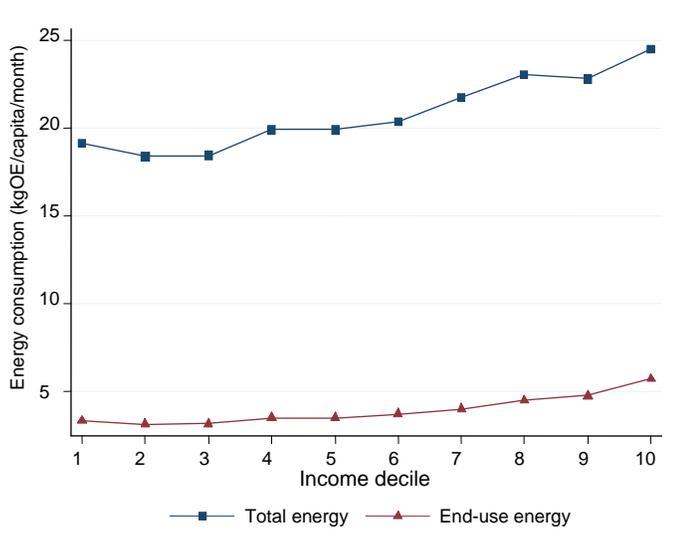
Defining an Energy Poverty Line Using Total versus End-use Energy Services

Without adjusting for energy efficiency, rural households actually consume more total energy than urban households. This is because people in rural areas use mostly traditional energy burned in inefficient ways. The more interesting questions are how much end-use or useful energy do such households consume and what is the implication for the estimation of energy poverty? These are the questions explored in this section.

There are two quite commonly-used measures of energy use. Total energy use is the amount of total energy that people use regardless of the efficiency of the appliances that they use. End-use energy is the energy that is adjusted for the efficiency of the appliance, technology and mode of use by the household. There are traditional measures for converting total energy into end-use according to fuel type and efficiency of the energy appliance used (O’Sullivan and Barnes, 2006). For example, fuelwood used in a traditional open-fire mud stove has a 15-percent efficiency—3 percent higher than that of straw and leaves. Switching to an improved stove can increase that end-use efficiency up to 25 percent. The end-use efficiency of kerosene for cooking (burned in a wick stove) is about 35 percent. The use of a wick lamp for lighting has very low efficiency levels. The end-use efficiency of electricity is somewhat difficult to measure given new lighting technologies and other appliances that are becoming available, but we use a figure of 95 percent at the household level. A household’s end-use energy is the aggregate of all physical sources after their end-use efficiencies are taken into account.

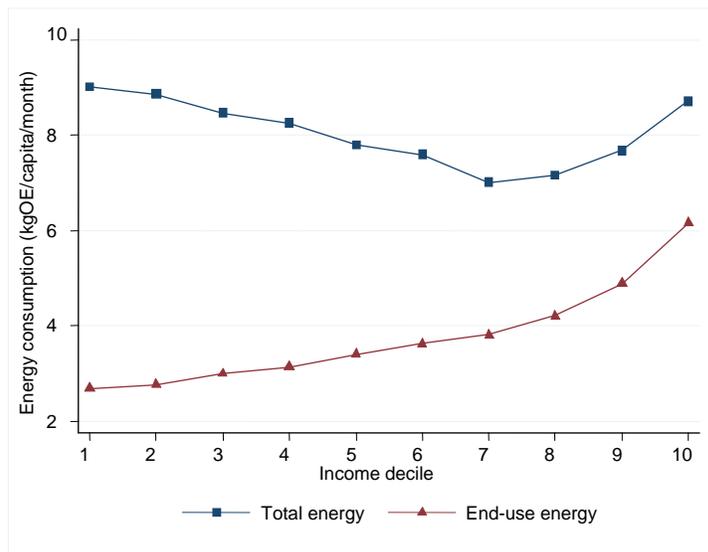
As might be expected, the end-use energy households consume from various sources differs significantly from total energy use (Table 4). In the conversion from total- to end-use

energy, rural households lose more than 80 percent of their total consumed energy (i.e., 76.65 kgOE out of 94.3 kgOE), while urban households lose about 55 percent (19.96 kgOE out of 36.2 kgOE). Three-quarters of the bulk of end-use energy consumed by rural households is derived from biomass, used mainly for cooking (and, in some cases, heating). By contrast, the 83 percent of urban households that use mainly modern energy sources benefit from a much wider array of end-use services.



Source: IHDS, 2005.

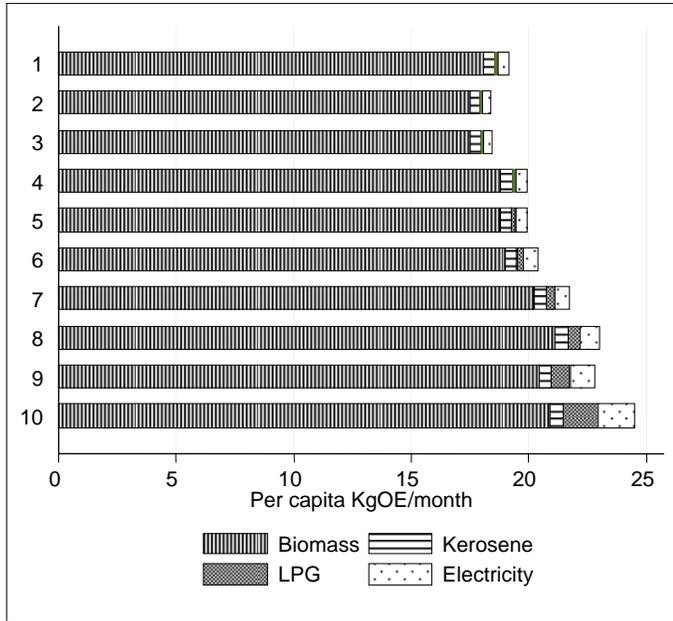
Figure 2a: Rural household energy-use pattern in India by income decile (per capita measures)



Source: IHDS, 2005.

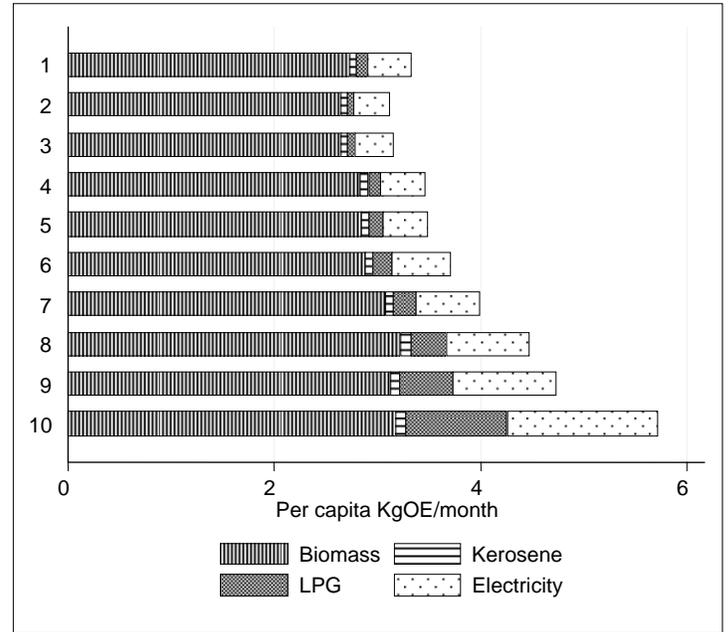
Figure 2b: Urban household energy-use pattern in India by income decile (per capita measures)

In rural and urban India, the relationship between energy use and income is positive for both total energy and end-use energy consumption (Figures 2a and 2b respectively). In rural areas, energy consumption rises almost monotonically with income. The gap between the two consumption measures remains roughly the same because energy use in rural areas is dominated by biomass. Although the shares of electricity and LPG increase in income deciles 9 and 10, biomass remains the predominant form of household energy use, even for the highest income groups (Figures 3a and 3b).



Source: IHDS, 2005.

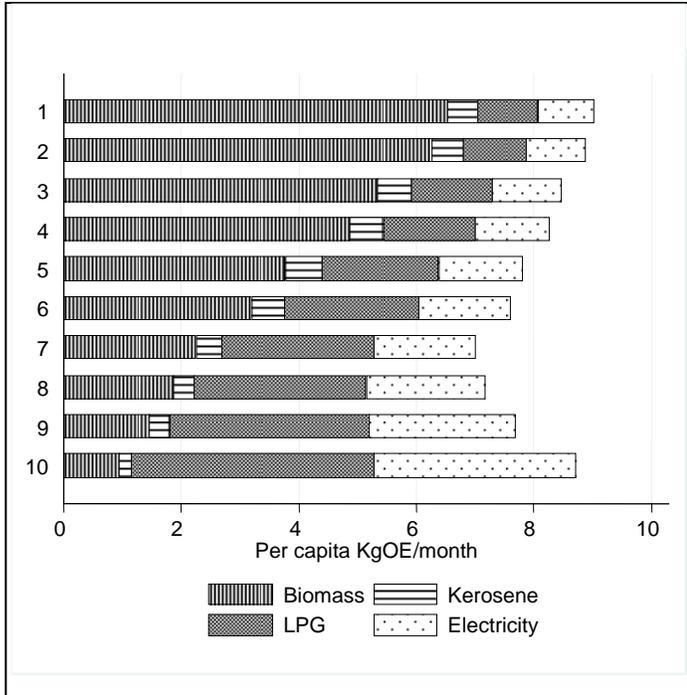
Figure 3a: Total rural energy consumption showing source share, by income decile



Source: IHDS, 2005.

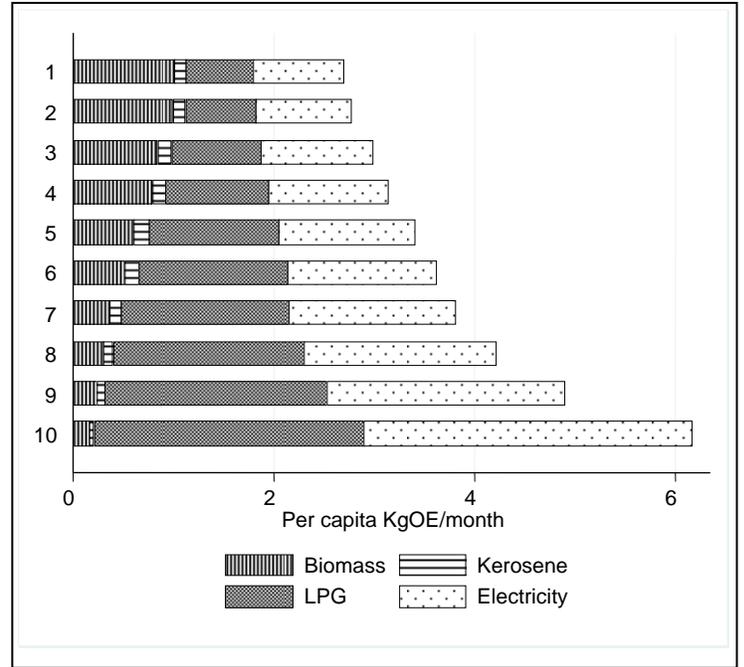
Figure 3b: End-use rural energy consumption showing source share, by income decile

The pattern of total and end-use energy consumption differs dramatically in urban areas (Figure 2b). While end-use energy trends upward as income levels rise, total household energy use declines until income decile 7, after which the trend reverses upward. The explanation for this apparent anomaly is that many of India’s poorer urban households consume more energy than their wealthier counterparts (income deciles 8–10); however, this energy is consumed in a less efficient way. Biomass consumption steadily declines as urban households move from lower to higher income levels, and this decreasing trend in biomass use lowers total household energy consumption for income deciles 1–7; however, as incomes rise, households replace biomass intake with LPG, which is about 4 times more efficient. As a result, they consume more end-use energy than their poorer counterparts, whose energy basket is dominated by biomass. Thus, when it comes to end-use household energy consumption in urban India, LPG makes the most difference, although for the highest income group, electricity consumption also peaks (Figures 4a and 4b).



Source: IHDS, 2005.

Figure 4a: Total urban energy consumption showing source share, by income decile



Source: IHDS, 2005.

Figure 4b: End-use urban energy consumption showing source share, by income decile

From this discussion it is obvious that total energy consumption is not a true measure of the benefit to households from energy consumption. Instead, it is the end-use energy that effectively represents the benefits to household from energy consumption, regardless of its total-energy consumption pattern. That is why energy poverty should be estimated based on end-use, rather than total, energy consumption, although for comparison purpose, we also report estimates based on total energy consumption. The share of energy-poor households is identified by estimating an energy demand equation in terms of alternative income deciles, plus other determining factors of energy demand. If there is some minimum level of energy necessary to maintain welfare, there should be a threshold income up to which energy is a basic need and income would not matter to this level of energy demand.¹²

¹² Since household income itself can be influenced by its energy demand, decile variables should in principle be based on an income stripped of the change due energy consumption, not on the reported income. We use a 2-stage instrumental variable regression to estimate such changes and find that results do not vary when such changes are incorporated in

Energy demand is insensitive to lower income dummies for rural households, after which energy demand responds positively and significantly with higher income (Table 5). More precisely, energy demand for end-use energy in rural India does not respond to income until after the 5th income decile or the 50th percentile. Energy consumption up to this income level can be considered the bare minimum necessary for basic needs such as cooking, heating or lighting. The poverty line can be calculated based on the average consumption of end-use energy for households that at the 5th income decile 5. This figure which can be characterized as the energy poverty line for rural India is 3.4 kgOE per person per month (Table 6). The situation is somewhat different for urban areas as the demand for energy increases significantly after the 2nd income in decile. This means that for urban areas the energy poverty line based on the average energy at the 2nd income decile is 2.4 kgOE per person per month.¹³ That the urban energy poverty line is slightly lower than the rural one is probably because of greater access to modern energy and a wider range of available energy services.

The energy poverty headcount is based on the number of people above and below the energy poverty line. Likewise the incidence of more general income poverty is based on the number of people below the expenditure poverty line as defined by the National Sample Survey Organization in India. The goal is to make a comparison between energy poverty and the more general income poverty index.¹⁴ One interesting finding is that for the end-use measure, energy poverty in rural areas at about 57 percent is more than double the rate for urban areas at 28 percent. Energy poverty is much worse than expenditure poverty in rural areas, while the values of the two measures are much closer in urban areas. Thus, the figures suggest that energy consumption by urban households is commensurate with economic status probably reflecting easy availability of

constructing the decile variables. The instruments used are the prices of alternative sources of energy, which were not then included in the energy consumption equation.

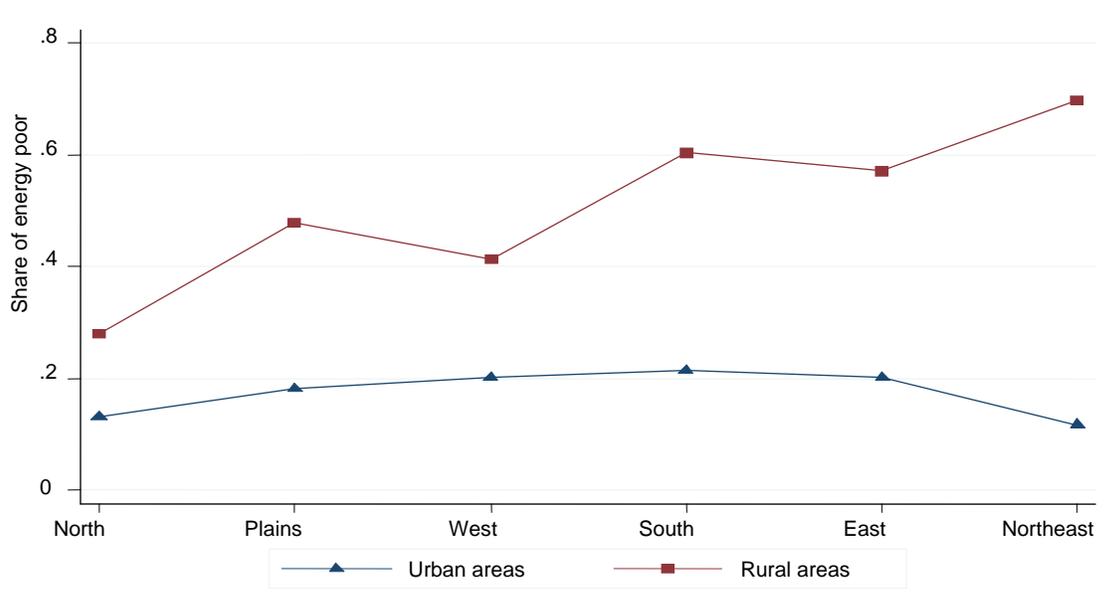
¹³ The energy poverty line calculated for rural Bangladesh using a similar method is 2.6 kgOE per capita per month (Barnes, Khandker, and Samad 2010).

¹⁴ Expenditure poverty, estimated using the consumption expenditure from our data, is based on state-level rural and urban poverty lines estimated by the National Sample Survey Organization (NSSO) of the Ministry of Statistics and Program Implementation for 1999–2000 (adjusted by the CPI to reflect 2004–05 figures) (GOI 2007).

modern energy. But in rural India, many otherwise expenditure non-poor households consume less than the required minimum energy services so there are apparent policy or service availability problems in rural areas.

As was the case in Bangladesh (Barnes, Khandker, and Samad 2010), the energy poverty measures in rural areas are quite similar. However, for urban areas it is clear that end use energy is clearly a better measure of energy poverty. The reason is that as indicated in Figures 4A and 4B total energy use actually declines with income because people are using more modern fuels in more energy efficient appliances. The estimation based on total energy gives, incorrectly, an energy poverty headcount of 69 percent, which is even higher than the corresponding rural measure. In contrast, the energy poverty headcount of 28 percent based on end-use energy is more realistic. This disparity between the two measures further justifies using end-use energy as opposed to total energy to estimate energy poverty.

The gap between income and energy poverty is further highlighted by the regional differences in the share of energy poor among income non-poor population in rural and urban areas. Ideally, we would expect such a share to be low; however, this is the case only in urban areas, where it remains within about 20 percent of the income non-poor, although there is some regional variation. In rural areas, by contrast, the share of energy poor is much higher, and there is significant regional variation (Figure 5). The gap is highest in the Northeast and lowest in the North (the states of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, and Punjab), where energy-poor households represent about one-quarter of non-poor households. Although the economy of North is predominantly agrarian, the region has prospered because of the Green Revolution, unlike states in the Northeast, which have lagged (Shariff 1999).



Source: IHDS, 2005.

Figure 5: Share of energy poverty among India's income non-poor by geographical region

Estimation of energy poverty depends only on the amount of energy consumed by the household but not on the energy sources. But understanding the constituent energy sources is important to analyzing the energy poverty. In particular, the extent of modern energy consumption can give us important insight into the formulation of policy directives aimed at reducing energy poverty. For this, it is necessary to understand the composition of energy used by both energy poor and non-poor households. Table 7 presents interesting contrasts in the energy use pattern of poor and non-poor between rural and urban households.

First, in rural areas energy non-poor households consume more energy than energy poor households regardless of the source, whereas in urban areas non-poor households consume more energy than poor households only from modern sources (LPG and electricity). In urban areas, both types of households consume the same amount of biomass at per capita level. In fact, the non-poor households consume less kerosene than the poor households. There is a clear transition from traditional to modern sources as the energy poverty situation of the urban households improves.

Second, the difference in energy consumption between poor and non-poor households is the sharpest for electricity among all sources both in rural and urban areas. Electricity consumed by the households, besides meeting their energy needs and improving energy poverty situation in process, also provides a wider range of energy services than is possible with other sources. These energy services can play an important role in facilitating growth and development, which can in turn further improve the energy poverty situation of the households. Table 7 in that sense underscores the role of electrification in any policy formulation in the areas of energy poverty.

Energy Poverty: Issues of Access and Efficiency

The disparity between income and energy poverty, particularly in rural India, calls for an examination of two important issues. These issues include access to modern energy, particularly electricity, and the efficiency of current energy use. In this section, we discuss the roles of these issues in energy consumption and poverty and policy measures that can address these issues to alleviate India's rural energy poverty.

As mentioned previously, the household electrification rate in rural India is about 57 percent, versus 95 percent for urban households. In rural areas, lighting predominates as the primary use of electricity more than in urban areas. The large number of rural households still without electricity use inferior forms of lighting. The most common fuel used for lighting for households without electricity is kerosene. Kerosene, used mostly in wick lanterns and hurricane lamps, provides a lighting intensity about one-hundredth of what is possible with electricity, and is many times less efficient and more expensive. Switching from kerosene lamps to electric lights is a natural progression for households since they get more lighting energy at a lower cost after making the change. In urban areas the energy poor actually use more kerosene than those that are considered to be energy non poor. Also, making the switch to electricity offers many possibilities since

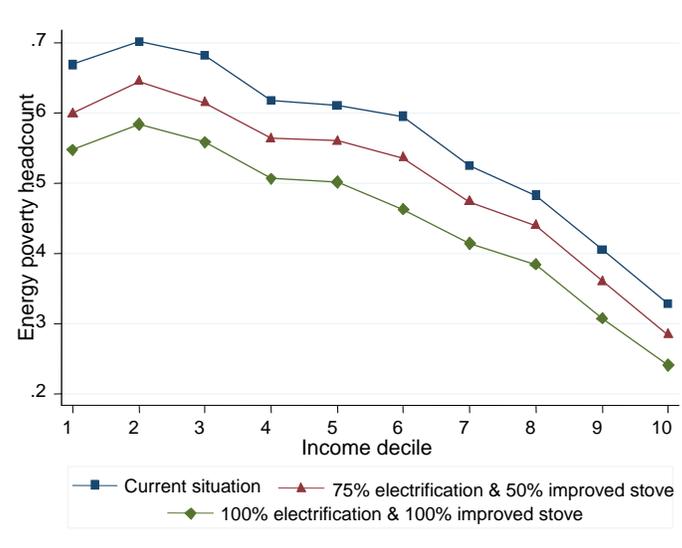
households gradually diversify their electricity use. As a result, their energy poverty situation can improve.

In addition to accessing modern energy sources such as electricity, rural households can reduce their energy poverty by using current energy sources more efficiently. In the context of rural India, such an improvement can be achieved in the area of energy for non-lighting uses (mostly cooking). As Table 1 suggests, India's urban households use mainly LPG (71 percent) and, to a lesser extent, kerosene (54 percent) to meet their cooking needs. By contrast, most rural households depend on biomass (95 percent). Since biomass used in traditional stoves has a much lower efficiency (15 percent) than either LPG (65 percent) or kerosene (35 percent), rural households actually consume more total energy but less end-use energy than those in urban areas. In addition, they suffer the health hazards associated with inefficient biomass burning. Thus, the question that can be asked is whether improving the efficiency of biomass could help to reduce the energy poverty status of India's rural households.

To explore how changes in the electrification rate and cooking efficiency of biomass energy can affect household energy-poverty status, we have created two scenarios. In the first scenario, households eliminate or reduce their kerosene consumption when they get electricity, and their electricity consumption more than compensates for the reduction in kerosene consumption. As a result, their energy poverty situation improves. In the second scenario, households can replace their low-efficiency traditional stoves (15-percent efficiency) with improved stoves (25-percent efficiency), which enables them to consume more end-use energy from less quantity of biomass. In the process, energy poverty can be reduced. The first scenario assumes an electrification rate of 75 percent for rural households (up from the current rate of 57 percent) and a 50-percent replacement of traditional biomass stoves with improved ones. The second scenario which would be a bit further off in the future assumes a 100-percent electrification rate and a 100-percent replacement of

traditional stoves. In both scenarios, we assume that households with improved stoves consume 25 percent less biomass than with traditional stoves.

The trends in energy poverty status resulting from the simulated changes clearly show that energy poverty declines rather significantly as people adopt more modern forms of energy (Figure 6). However, the decrease in energy poverty is higher among poor households compared to wealthier ones since electrification among rich households is already high and they have less energy poverty. Overall, energy poverty decreases from the current situation to 40 percent in scenario 1 and to 35 percent in scenario 2. Given these findings, policies that promote electrification of rural households have the potential of lowering energy poverty, as do policies that promote replacing traditional biomass stoves with more efficient stoves. Further reduction in India’s rural energy poverty is possible if rural households, like their urban counterparts, eventually switch to LPG as their cooking energy. Also, these predictions are based on constant changes in energy use, and we know that the results might actually be higher because of the multiplier impacts that energy has for development.



Source: IHDS, 2005.

Figure 6: Alternate energy poverty scenarios in rural India, by income decile

Conclusion

The findings of this study suggest that the provision of high quality energy services to rural areas has lagged behind urban areas. It is both financially and physically more difficult to service remote and poor populations compared to those living in urban areas. However, one would expect energy poverty would be commensurate with income poverty. This pattern is confirmed for urban India but it is not the case for rural areas. This means that despite national energy programs to help bring better energy services to people in rural areas, a significant gap in services still persists. There are many programs to deal with rural electrification under the Rajiv Gandhi Grameen Vidyutikaran Yojana rural electrification scheme. Although these programs made some progress in terms of access to the grid electricity system, there are still significant challenges in improving the reliability of power supply in the country. The challenges are basically two-fold: How to improve the access of rural households to electricity beyond the current rate of 56 percent and how to ensure reliable and adequate supply of electricity (Sargsyan et al, 2010).

Besides providing electricity, improving biomass use and its efficiency is essential for reducing energy poverty. According to our findings, some 90 percent of rural households in India still use fuel wood that explains some 56 percent of household total expenditure on energy. Yet only less than 4 percent of rural households (according to the survey used in this paper) had improved stoves for biomass use. Improving efficiency of fuel wood use for cooking is extremely important. An initiative has recently been launched to reach the majority of biomass energy users via a program that aims to both reduce CO₂ emissions and improve rural health (Indian Institute of Technology Delhi and The Energy and Resources Institute, New Delhi. 2010). It is expected that this initiative would improve the efficiency of biomass use in India.

On the other hand, improving access to modern fuels such as LPG for cooking and other purposes would help reduce energy poverty. However, the sale of LPG in India, for example, is

very widespread in urban areas and all LPG sold through the government has a large subsidy component in the price. Therefore, while urban households benefit from such programs, rural households do not. However, access to LPG is only beginning to spread to rural areas slowly.

Although rural energy activities receive significant support from the Government of India, our findings would tend to confirm that there is still a long way to go to ensure that the rural poor can take advantage of the many benefits of modern energy and the services that they provide to consumers.

References

- Barnes, Douglas, and Michael Toman. 2006. "Energy, Equity and Economic Development." In *Economic Development and Environmental Sustainability: New Policy Options*, eds. Ramon Lopez and Michael Toman. Oxford: Oxford University Press.
- Barnes, Douglas, Shahidur Khandker, and Hussain Samad. 2010. "Energy Access, Efficiency, and Poverty: How Many Are Energy Poor in Bangladesh?" Policy Research Working Papers No. 5332, World Bank, Washington, DC (mimeo).
- Besant-Jones, John. 2006. "Reforming Power Markets in Developing Countries: What Have We Learned?" Energy and Mining Sector Board Discussion Paper No. 19. Washington, DC: World Bank.
- Bravo, V., G. Gallo Mendoza, J. Legisa, C. E. Suarez, and I. Zyngierman. 1979. *Estudio Sobre Requerimientos Futuros No Convencionales de Energia en America Latina*, Project RLA/74/030, Fundacion Bariloche, Buenos Aires, Argentina, Report to the United Nations Development Program, 1979, Appendix 9, Primera Aproximación a una Definición de las Necesidades Basicas.
- Cabraal, Anil, and Douglas Barnes. 2006. "Productive Uses of Energy for Rural Development." *Annual Review of Environment and Resources* 30: 117–44.
- Department of International Development (DFID). 2002. *Energy for the Poor: Underpinning the Millennium Development Goals*. London: Department of International Development.
- Foster, V., Jean-Philippe Tre, and Quentin Wodon. 2000. "Energy Prices, Energy Efficiency, and Fuel Poverty." Latin America and Caribbean Regional Studies Programme. Washington, DC: World Bank.

Goldemberg, Jose. 1990. "One Kilowatt Per Capita." *Bulletin of the Atomic Scientists*, Vol. 46 (1).

Government of India (GOI). 2007. "Poverty Estimates for 2004–05." Government of India Press Information Bureau, New Delhi, March.

Indian Institute of Technology Delhi and The Energy and Resources Institute, New Delhi. 2010. New Initiative for Development and Deployment of Improved Cookstoves: Recommended Action Plan. Draft Report for the Ministry of New and Renewable Energy. Government of India.

International Energy Agency. 2009. *World Energy Outlook 2009*, International Energy Agency, Paris.

Krugmann, Hartmut, Goldemberg, Jose, 1983. "The energy cost of satisfying basic human needs," *Technological forecasting and social change* 24, 45–60.

Modi, Vijay, Susan McDade, Domini1que Lallement, and Jamal Saghir. 2005. *Energy Services for the Millennium Development Goals*, Joint publication of the World Bank, Washington DC and the United Nations Development Programme, New York.

O'Sullivan, Kyran, Barnes, Douglas F., 2006. *Energy Policies and Multitopic Household Surveys: Guideline for Questionnaire Design in Living Standard Measurement Surveys*, Energy and Mining Sector Board, Discussion Paper No. 17. World Bank, Washington, DC.

Pachauri, Shonali, and Daniel Spreng. 2004. "Energy Use and Energy Access in Relation to Poverty." *Economic and Political Weekly* 39(3): 271–8.

Pradhan, Menno, Ravallion, Martin, 1998. "Measuring Poverty Using Qualitative Perceptions of Welfare," *Policy Research Working Paper*, No. 2011. World Bank, Washington, DC.

- Ravallion, Martin, 1998. "Poverty Lines in Theory and Practice," *Living Standard Measurement Study Working Paper*, No.133. World Bank, Washington, DC.
- Ravallion, Martin, Bidani, Benu, 1994. "How robust is a poverty profile?" *The World Bank Economic Review* 8(1), 75–102.
- Roddis, Suzanne. 2000. *Poverty Reduction and Energy: The Links Between Electricity and Education*. World Bank, Washington, DC (mimeo).
- Sachs, Jeffrey. 2005. *The End of Poverty: Economic Possibilities for Our Times*. New York: Penguin Press.
- Saghir, Jamal. 2004. "Energy and Poverty: Myths, Links, and Policy Issues." Energy Sector Notes, No. 4, Energy and Mining Sector Board. Washington, DC: World Bank.
- Sargsyan, Gevorg, Mukul Bhatia, Anjali Garg, and Krishnan Raghunathan, 2010, "Improving Rural Electricity Services in India through Distributed Generation and Supply of Renewable Energy", Mimeo, World Bank.
- Shariff, A. 1999. *India-Human Development Report: A Profile of Indian States in the 1990s*. New Delhi: Oxford University Press.
- United Nations Development Programme (UNDP). 2005. *Energy Services for the Millennium Development Goals*. New York: United Nations Development Programme.
- Wasserman, G., and A. Davenport. 1983. *Power to the People: Rural Electrification Sector Summary Report*. USAID Program Evaluation Report No. 11. Washington, DC: U.S. Agency for International Development.
- World Bank. 1996. *Rural Energy and Development: Improving Energy Supplies for Two Billion People*. Development in Practice Series. Washington, DC: World Bank.

- . 2002a. *Energy Strategy for Rural India: Evidence from Six States*. Report of the Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), 258/02. Washington, DC: World Bank.
- . 2002b. *India: Household Energy, Indoor Air Pollution, and Health*. Report of the Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), 261/02. Washington, DC: World Bank.
- . 2002c. *Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits*. Energy Sector Management Assistance Programme (ESMAP), 255/02. Washington, DC: World Bank.
- . 2006. *World Development Report 2006: Equity and Development*. New York: Oxford University Press.

Table 1: Household energy-use patterns

Energy use	Traditional source				Modern source			All sources
	Fuelwood	Dung	Crop residue	Coal/charcoal	Kerosene	LPG	Electricity	
Rural areas (N = 22,538)								
Household users (%)	89.2	55.1	21.7	4.8	90.8	16.6	56.5	100.0
Quantity used*	131.6	73.8	28.8	3.9	2.7	1.7	36.0	-
Energy used (kgOE/month)	49.3	25.0	10.6	2.4	2.2	1.8	3.0	94.3
Energy expenditure (Rs/month)	191.8	77.1	43.2	7.9	39.6	36.8	80.3	476.7
Share in total household energy use (%)	56.3	22.6	6.8	2.5	3.5	3.6	4.7	100.0
Urban areas (N = 12,325)								
Household users (%)	34.6	13.4	1.8	6.6	54.2	71.4	94.0	100.0
Quantity used*	31.5	9.0	1.2	4.3	2.6	9.0	87.5	-
Energy used (kgOE/month)	11.6	3.0	0.4	2.6	2.1	9.3	7.3	36.2
Energy expenditure (Rs/month)	54.4	10.5	2.0	9.3	37.3	194.7	248.4	556.6
Share in total household energy use (%)	20.8	4.2	0.6	3.9	7.4	37.5	25.6	100.0

* kg for fuelwood, dung, crop residue, coal/charcoal, and LPG; liter for kerosene; and kWh for electricity.

Note: For many households, particularly in rural areas, expenditures on non-commercial fuels (fuelwood, crop residue and so on) are not reported and so were imputed using regression models.

Source: IHDS, 2005.

Table 2: Summary statistics of major explanatory variables used in household energy demand and outcome regressions

Variable	Rural areas (N = 22,538)	Urban areas (N = 12,325)
Age of household head (years)	47.22 (13.55)	46.16 (13.01)
Sex of household head (male = 1, female = 0)	0.91 (0.29)	0.90 (0.30)
Education of household head (years)	4.09 (4.39)	7.80 (4.99)
Highest education of household males (years)	5.96 (4.91)	9.26 (4.85)
Highest education of household females (years)	3.50 (4.39)	7.51 (5.24)
Household agricultural land (decimals)	200.0 (452.2)	343.68 (248.24)
Household has motor cycle (1 = Yes, 0 = No)	0.098 (0.300)	0.307 (0.461)
Household has color TV (1 = Yes, 0 = No)	0.116 (0.320)	0.547 (0.498)
Household has fan (1 = Yes, 0 = No)	0.443 (0.497)	0.902 (0.297)
Household has phone (1 = Yes, 0 = No)	0.075 (0.263)	0.282 (0.450)
Household has refrigerator (1 = Yes, 0 = No)	0.053 (0.225)	0.355 (0.479)
Household has car (1 = Yes, 0 = No)	0.006 (0.076)	0.034 (0.182)
Household has air conditioner (1 = Yes, 0 = No)	0.0005 (0.021)	0.013 (0.113)
Household has computer (1 = Yes, 0 = No)	0.002 (0.039)	0.025 (0.155)
Price of firewood (Rs/kg)	1.64 (0.79)	1.78 (0.30)
Price of kerosene (Rs/liter)	16.01 (5.72)	14.72 (3.47)
Price of LPG (Rs/kg)	22.43 (1.72)	21.81 (0.99)
Community has electricity (1 = Yes, 0 = No)	0.87 (0.33)	0.99 (0.04)
Price of electricity (Rs/kWh)	3.06 (0.93)	3.62 (0.63)
Distance to paved roads (km)	1.76 (4.46)	-
Distance to district headquarters (km)	44.72 (26.59)	-
Community has markets (1 = Yes, 0 = No)	0.97 (0.16)	-
Community has NGOs (1 = Yes, 0 = No)	0.17 (0.38)	-
Community has food-for-work program (1 = Yes, 0 = No)	0.56 (0.50)	-
Community has primary schools (1 = Yes, 0 = No)	0.94 (0.23)	-
Community has middle schools (1 = Yes, 0 = No)	0.62 (0.48)	-
Community has secondary schools (1 = Yes, 0 = No)	0.34 (0.47)	-
Community has medical facilities (1 = Yes, 0 = No)	0.55 (0.50)	-

Note: Figures in parentheses are standard deviations. Explanatory variables additionally include village wage and price of consumer goods.

Source: IHDS, 2005.

Table 3: Estimate of household energy demand by source

	Rural households (N = 22,538)				Urban households (N = 12,325)			
Explanatory variable	Log biomass (kgOE/ month)	Log kerosene (kgOE/ month)	Log LPG (kgOE/ month)	Log electricity (kWh/ month)	Log biomass (kgOE/ month)	Log kerosene (kgOE/ month)	Log LPG (kgOE/ month)	Log electricity (kWh/ month)
Age of household head (years)	0.001 (1.77)	0.001 (7.99)	0.010 (3.99)	0.003 (3.48)	-0.0004 (-0.75)	-0.0001 (-0.36)	0.001 (2.91)	0.003 (4.49)
Sex of household head (M = 1, F = 0)	-0.203 (-9.58)	-0.072 (-11.96)	-0.053 (-4.39)	-0.136 (-3.83)	0.012 (0.54)	-0.021 (-2.51)	-0.154 (-9.36)	-0.190 (-7.46)
Education of household head (years)	-0.005 (-2.07)	0.007 (13.39)	0.014 (10.65)	0.025 (7.66)	-0.023 (-8.84)	-0.002 (-2.01)	0.036 (21.96)	0.042 (16.50)
Highest education among household males (years)	-0.001 (-0.57)	-0.003 (-7.07)	-0.004 (-3.46)	-0.005 (-1.60)	0.004 (1.66)	-0.002 (-2.53)	-0.004 (-2.55)	-0.015 (-5.86)
Highest education among household females (years)	-0.018 (-9.20)	-0.003 (-6.15)	0.007 (5.53)	0.004 (1.36)	-0.017 (-9.27)	-0.004 (-6.07)	0.009 (7.05)	0.004 (2.33)
Log household agricultural land (decimals)	0.109 (8.46)	-0.011 (-4.47)	-0.022 (-3.51)	-0.018 (-1.20)	0.152 (9.02)	0.021 (3.86)	-0.036 (-3.07)	-0.053 (-2.91)
Community has electricity (Y = 1, N = 0)	0.299 (3.06)	-0.091 (-3.79)	0.399 (6.66)	1.402 (11.94)	-0.315 (-1.50)	0.130 (1.84)	0.412 (1.05)	2.316 (3.81)

Log price of fuelwood (Rs/kg)	-0.709 (-3.09)	0.046 (0.93)	-0.168 (-1.73)	0.766 (2.95)	-0.958 (-2.94)	0.116 (1.12)	0.251 (3.12)	-0.463 (-3.73)
Log price of dung (Rs/kg)	-0.335 (-6.11)	0.006 (0.67)	-0.050 (-2.67)	0.063 (1.02)	-1.022 (-2.83)	-0.113 (-0.95)	-0.225 (-1.77)	0.100 (0.51)
Log price of kerosene (Rs/liter)	0.101 (2.07)	-0.155 (-14.02)	0.042 (2.14)	-0.005 (-0.09)	-0.873 (-3.33)	-0.478 (-3.35)	0.273 (3.79)	0.100 (0.90)
Log price of LPG (Rs/kg)	-0.226 (-1.03)	0.052 (0.21)	-0.188 (-2.36)	0.010 (0.04)	3.263 (2.20)	-0.265 (-0.65)	-2.294 (-2.41)	-0.189 (-6.11)
Log price of electricity (Rs/kWh)	0.387 (3.32)	0.052 (1.31)	-0.034 (-1.12)	-0.090 (-0.95)	-0.370 (-7.88)	-0.109 (-5.70)	0.608 (0.94)	1.587 (1.59)
R ² (pseudo R ²)	0.121	0.316	0.403	0.533	0.205	0.188	0.425	0.427

Note: Figures in parentheses are t-statistics after controlling for cluster effects at the community level. Since the aggregate value of household non-land assets was not available, dummy variables for ownership of various goods (car, motorcycle, TV, air conditioner, computer, refrigerator, phone, and fan) have been used as its proxy. Explanatory variables also include state dummies, which for rural areas additionally include prices of consumer goods, village wages, and infrastructure variables (e.g., distance to paved roads and district headquarters and presence of markets, schools, NGOs, and medical facilities).

Source: IHDS, 2005.

Table 4: Monthly household consumption of end-use energy by source

Energy source	Rural India	Urban India
Biomass (kgOE)	13.26	2.81
Kerosene (kgOE)	0.35	0.49
LPG (kgOE)	1.16	6.05
Electricity (kWh)	34.16	81.73
Total energy (kgOE)	17.65	16.24

Source: IHDS, 2005. Note that unit of electricity (kWh) is converted to kgOE before it is added to the total end-use energy expressed in kgOE units.

Table 5: Estimates of household use of energy

Explanatory variable	Total energy		End-use energy	
	Rural India (N = 22,538)	Urban India (N = 12,325)	Rural India (N = 22,538)	Urban India (N = 12,325)
Age of household head (years)	0.123 (8.64)	0.016 (2.71)	0.023 (9.57)	0.011 (5.39)
Sex of household head (M = 1, F = 0)	-7.396 (-11.69)	-1.829 (-6.56)	-1.335 (-12.59)	-0.839 (-10.00)
Education of household head (years)	0.391 (8.12)	0.102 (4.68)	0.101 (11.27)	0.120 (14.55)
Highest education among household males (years)	-0.381 (-8.78)	-0.163 (-7.48)	-0.076 (-9.91)	-0.087 (-10.30)
Highest education among household females (years)	-0.494 (-10.89)	-0.162 (-9.97)	-0.077 (-8.71)	-0.028 (-5.33)
Log of household agricultural land (decimals)	0.361 (5.77)	0.290 (5.68)	0.038 (3.59)	-0.018 (-1.29)
Log price of fuelwood (Rs/kg)	-13.742 (-2.85)	-7.836 (-6.06)	-1.949 (-2.54)	-2.678 (-4.74)
Log price of dung (Rs/kg)	-7.976 (-8.27)	-5.206 (-2.03)	-1.242 (-7.72)	-0.222 (-0.28)
Log price of kerosene (Rs/liter)	2.674 (2.90)	-2.699 (-2.76)	0.430 (2.83)	-0.431 (-0.94)
Log price of LPG (Rs/kg)	-4.902 (-1.19)	54.730 (2.42)	-1.015 (-1.51)	3.817 (0.79)
If community has electricity	19.367 (5.73)	0.862 (0.49)	4.297 (6.88)	1.676 (4.80)
Log price of electricity (Rs/kWh)	9.045 (3.31)	-7.711 (-11.27)	1.179 (2.78)	-0.290 (-1.64)
Household income decile				
2 nd	-0.663 (-1.13)	0.464 (1.56)	-0.159 (-1.61)	0.156 (2.00)

3 rd	-0.507 (-0.87)	0.543 (2.10)	-0.157 (-1.57)	0.291 (4.19)
4 th	1.050 (1.77)	0.892 (2.83)	0.112 (1.15)	0.404 (5.23)
5 th	0.709 (1.64)	0.831 (2.99)	0.039 (0.41)	0.585 (7.30)
6 th	1.815 (3.04)	1.266 (4.28)	0.272 (2.69)	0.729 (8.49)
7 th	3.406 (5.30)	0.834 (3.16)	0.526 (4.95)	0.817 (9.67)
8 th	4.706 (7.34)	1.560 (5.26)	0.837 (7.24)	1.195 (11.69)
9 th	5.354 (7.98)	2.325 (7.23)	1.028 (8.98)	1.727 (14.98)
10 th	7.537 (9.30)	3.585 (10.48)	1.730 (10.60)	2.729 (21.14)
R ²	0.310	0.171	0.318	0.297
N	22,538	12,329	22,538	12,329

Note: Figures in parentheses are t-statistics. Explanatory variables additionally include village level prices of consumer goods, village wages, village infrastructure variables, and state dummy variables.

Source: IHDS, 2005.

Table 6: Incidence of energy-poor and expenditure-poor households

Poverty measure	Rural India		Urban India	
	Poverty line (per capita per month)	Poverty headcount	Poverty line (per capita per month)	Poverty headcount
Expenditure poverty (Rs)	358.3	22.3	548.8	19.5
Energy poverty				
Minimum total energy based measure (kgOE)	17.9	56.8	8.6	69.0
Minimum end-use energy based measure (kgOE)	3.4	57.2	2.4	28.0

Source: IHDS, 2005.

**Table 7: Energy-use patterns of energy-poor and non-poor households
(end-use energy per capita per month)**

Energy source	Rural households		Urban households	
	Energy poor	Energy non-poor	Energy poor	Energy non-poor
Biomass (kgOE)	1.69	4.40	0.59	0.59
Kerosene (kgOE)	0.06	0.10	0.14	0.11
LPG (kgOE)	0.09	0.46	0.44	1.83
Electricity (kWh)	3.40	12.43	6.51	23.97
Total energy (kgOE)	2.13	6.00	1.72	4.54

Source: IHDS, 2005. Note that unit of electricity (kWh) is converted to kgOE before it is added to the total end-use energy expressed in kgOE units.