The Status of Rural Energy Access in India: A Synthesis

HARVARD Kennedy School
BELFER CENTER for Science and International Affairs

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THE STATUS OF RURAL ENERGY ACCESS IN INDIA: A SYNTHESIS

ABSTRACT

India is facing a formidable challenge as it works to ensure the availability of a reliable source of modern energy carriers to the majority of its rural population. In 2005, in a rural population of about 809 million, approximately 364 million were without access to electricity and approximately 726 million were using biomass for cooking. These figures reflect the failure of various policies and programs implemented by the government over a period of time. The data also suggests that it is time for India to adopt a more radical approach if it is to bridge this energy access gap. However, before the government can address this challenge, it is essential that it gain a deeper insight into the prevailing status of energy access in India. This knowledge will enable the design of targeted policies, programs, and institutional mechanisms. As a contribution to this knowledge, we present a detailed analysis of the temporal and regional dynamics of the rural energy access situation in India. The results indicate that the energy deprivations are highest for the households belonging to the poorest strata with 93% of them depending on biomass for cooking and 62% living without access to electricity. For the high income rural households, these levels were 54% and 18% for cooking and electricity access respectively. The past trends suggest that the annual rate of expansion is gradually declining over the years. Growth rates in cooking access levels came down from a very high rate of 16.4% during pre-1991 period to just 3.8% in the post-2001 period and that for household electrification, declined from 9.7% to 4.3% during the same period. Regional variations indicate that the differences in achievements of the top five and the bottom five states are starkly contrasting. The five states with highest cooking energy access level have been categorized as “successful states” and the remaining five states with low access level as “failure states.” On an average, the cooking access levels were 5.3 times higher in successful states compared to failure states whereas this ratio was 3.4 for electricity access.

INTRODUCTION

India's energy crisis is defined by the fact that the major share of its rural population is energy poor. Energy poverty, indicated by the lack of access to modern energy services, is a direct outcome of income poverty. The poor cannot afford to pay for the services of the modern energy carriers and they live in sub-standard buildings/houses, which are unfit to be connected to the modern energy systems. Similarly, any poor nation will be constrained by inadequate access to both energy and financial resources, and therefore will be unable to build an adequate infrastructure that would facilitate connectivity to modern energy carriers. Thus, "un-affordability" due to poverty and "inaccessibility" due to inadequate infrastructure are the root causes of the lack of access to modern energy. This lack of energy access has major implications for economic development, livelihoods, social dignity, and environmental sustainability, while access to energy has strong links with poverty reduction through income, health, education, gender, and the environment (Saghir, 2005). It is a vicious cycle of linked events, one leading to another and finally getting back to the original positions of "poor individual" and "poor country." The United Nations Development Programme's (UNDP) millennium development goals (MDGs) reflect the desires of the suffering humanity. Thus, it would not be an exaggeration to state that expanding energy access is at the core of achieving MDGs. Many of the stakeholders, including national governments, international organizations, and non-governmental organizations (NGOs), have recognized these linkages as well as the need for expanding energy access. However, both experience and research suggest that the gap between the recognition of the need for expanding energy access and the action toward achieving energy access for all is very wide and ever expanding. The issues of energy access are only treated superficially in national and international development plans (UNDP, 2007). Partially, this is because energy governance is always biased towards "supply-side" and suggested solutions always revolve around "hardware" aspects. The "demand-side" aspects of energy have always been neglected. Energy service for sustainable development has never been the focus of energy planning. The focus of the energy sector is usually on expanding electricity generation and oil refinery capacities, on transmission and distribution lines, and on maintaining a steady supply of fossil fuels.

India is facing a formidable challenge as it works to ensure the availability of a reliable source of modern energy carriers to the large majority of its predominantly rural, population. The findings of the National Sample Survey (NSSO, 2007) indicate that although 74% of the Indian villages were electrified as of 2005; only 54.9% of the households had access to electricity and the remaining depended on kerosene lamps for lighting. With respect to access to modern fuels for cooking, in 2005, only 9% of the rural households had access to liquefied petroleum gas (LPG) and about 84% were still depending on biomass for their cooking energy needs, with only 1.3% having access to kerosene. Thus, bridging the access gap in modern energy services for cooking and lighting is a major challenge for India. However, before the government can address this challenge, it is essential that it gain a deeper insight into the prevailing status of energy access in India. This knowledge will enable the design of targeted policies, programs, and institutional mechanisms. Keeping this in mind, in the present paper, we have presented a detailed analysis of the temporal and regional dynamics of rural energy access situation in India.

ENERGY ACCESS: THE CONCEPT AND DEFINITION

Energy access is a term mostly used in the context of describing the energy use pattern of poor people in the world. It basically means the extent of access these poor people have to the energy end-use services delivered by the modern energy carriers like electricity, petroleum products, and modern biofuel. The typical energy end-uses considered for determining access levels are household cooking and lighting, which are treated as basic energy needs. In some cases, end-uses contributing to productive livelihoods like mechanical power are also included. In the present context, only two end-uses, cooking and lighting are included for assessing the energy access levels. In the present study, the modern energy carriers considered for cooking are: liquefied petroleum gas (LPG); kerosene; cattle dung or soft biomass based biogas; and electricity and for lighting: electricity. In general, energy access does not mean just a physical access to the energy carrier, but rather it includes a broader concept of all the issues that impede accomplishing energy access for all.

Conceptually **energy access** means that modern energy services should be physically **accessible** and **available** to the people, should be of **acceptable** quality, reliability and preference, should be **affordable** both in terms of low capital and operating cost and in the context of income levels, and finally it should be **adequate** in terms of abundance.

In the case of electricity access for lighting and other end-uses, for example, merely extending the electricity grid to the village and connecting the household to the grid will not ensure "energy access" as defined above. Opening a LPG agency in the village, installing biogas plants, and having a PDS kerosene shop alone will not ensure access to modern cooking fuels. Only when it conforms to the above conditions and provides modern energy-based end-use services for meeting the basic and livelihood needs for all, one could say that the goal of energy access is achieved. Thus, lack of energy access could be due to any of the following reasons:

- ***Lack of physical access*** because the villages remain un-electrified, or the building/house is not connected to the grid in an electrified village or the building/house is unfit for electricity connection. In the case of cooking energy, lack of access could be due to absence of LPG or PDS kerosene outlets in the vicinity or lack of biogas plants or other decentralized energy systems in the village. Lack of motorable roads for transporting cooking fuels would be another reason for not having physical access.
- ***Lack of physical availability*** because of no locally available energy resources to produce required energy carriers, lack of adequate generation and supply capacity resulting in power blackouts, power cuts, and load shedding, diversion of energy carriers to other sectors or un-intended end-uses, stock-outs, non-availability of skilled human resources for operation and maintenance and repairs,
- ***Lack of acceptability*** due to low quality of electricity supply with frequent interruptions and voltage fluctuations. Lack of convenience in use of fuel and inability to perform activities in a desired way, need for changes in conventional cooking habits, technological complexities and extra effort to procure the energy carrier, reluctance due to the influence of behavioral/social/information factors like ignorance, indifference, and lack of information. Unwillingness to shift from free to priced energy carriers. Expecting other benefits like livelihood opportunities.

- ***Lack of affordability*** due to high initial cost of connectivity and income poverty resulting in inability to pay for the energy carriers and to invest for connectivity.
- ***Lack of adequacy*** due to energy resource constraints and inadequate production capacity resulting in energy shortages, financial resource constraints preventing construction of new production facilities, transmission and distribution systems, and transport infrastructure.

APPROACH FOR SYNTHESIZING THE STATUS OF RURAL ENERGY ACCESS

The current status of rural household access to modern energy carriers is analyzed from multiple perspectives. First, the relationships between the energy access and income levels are analyzed. The monthly per capita expenditure (MPCE) classes adopted by the National sample survey organization (NSSO) to group households have been used as a proxy for income classes. Second, the changes in rural energy access levels are studied. The objective is to capture both the temporal as well as the regional dynamics of the process of expansion in energy access. The temporal dynamics are being captured through tracking the changes in access levels over a period of time and the regional dynamics through analyzing the status for the selected major states across India. The states have been chosen based on their performance in terms of rural household energy access levels achieved in the year 2004-2005. A total of 10 major states, five each with highest and lowest rural household energy access levels have been chosen for the analysis. Two indicators, access to modern fuels for cooking energy and access to electricity for lighting, are used for ascertaining the access levels. These two instances of energy end-use, are traditionally considered as the basic needs and typically, it is only after satisfying these basic needs there is a hope for graduating into other end-uses of energy. The modern cooking fuels include LPG, kerosene, biogas and electricity. Another important assumption used is with respect to the extent of use of an energy carrier for a given end-use. Households using a particular energy carrier as a primary fuel for cooking or lighting are considered as having access to that energy carrier. Households using a particular energy carrier as a secondary or tertiary fuel (occasional use) are not considered for determining the access levels to that energy carrier. In the case of electricity for lighting this is obvious; a household having electricity connection is expected use electricity as primary energy carrier for lighting. However, this is not so obvious for cooking fuels. There are significant number of households in rural India, which use biomass as a primary cooking fuel and kerosene as secondary or tertiary cooking fuel. There are even rural households using LPG as secondary or tertiary fuel. As explained above, the reasons could be lack affordability or availability even though physical accessibility is not an issue. In other words, these households still lack access to LPG or kerosene as primary cooking fuels.

Data obtained from various secondary sources is used for assessing the status of rural energy access. Most important data sources used for this analysis are reports of the 2001 Census and the sample surveys of National Sample Survey Organization (NSSO). The data collection method adopted for the 2001 Census was a complete enumeration whereas it was a sample survey by NSSO and in 2004-2005 survey (61st round survey), the data was collected from a sample of randomly selected 79,298 rural and 45,346 urban households spread over 7,999 villages and 4,602 urban blocks. A stratified multi-stage sampling design was adopted and the survey covered all the states and the union territories in the country

(NSSO, 2007). This is the largest and the best effort in household related data collection in India excepting the census.

RURAL COOKING ENERGY ACCESS

About 70% of the population in India lives in rural areas. The rural cooking energy scenario is characterized by inadequate, poor, and unreliable supply of energy carriers and large dependence on traditional biomass fuels. Non-commercial biomass energy sources, predominantly firewood, agricultural waste, and cattle dung cakes, contribute over 27% of the total primary energy consumed in the country (Planning Commission, 2008). Biomass is primarily used for meeting the cooking requirements through traditional stoves having very low efficiencies, of the order of 10%. The analysis based on data from the latest National Sample Survey (NSSO, 2007) indicates that about 84% of the rural households were using biomass (firewood and agro-waste) and cattle dung as primary cooking fuel in 2005 (Table 1). Only 10.3% of the rural households use modern carriers like LPG, kerosene, biogas, and electricity as primary cooking fuels. This low share is mainly because of the issues related to access, affordability, and acceptability as explained earlier. The situation gets worse for the households belonging to low income class where the share of non-commercial fuels for cooking rises to nearly 93%. The three income classes are derived from the expenditure classes (MPCE or monthly per capita expenditure class) used by the National sample survey organization (NSSO) in its surveys. The total number of rural households of 152.7 million in 2005 is estimated using the rural population estimate of United Nations Population Division (UNPD, 2008) and the projected family size of 5.03. This has been calculated using the family sizes obtained from the census results of 1991 and 2001. The use of LPG as a primary cooking fuel is limited to only about 33% of the high income rural households. Surprisingly, though kerosene is subsidized heavily and supplied through government controlled public distribution system (PDS), it is only used by 1.3% of the rural households as primary cooking fuel (Table 1). In the rural areas, kerosene is mainly used as lighting fuel whereas it is used as cooking fuel by the urban poor. However, there are households, which use these fuels as secondary and tertiary cooking fuels and the share will go up if these households are included.

Table 1: Number of rural households using a particular energy carrier as a primary fuel for cooking in 2005 (in millions)

	Biomass	LPG	Dung	Kerosene	Coal	Biogas	Electricity	Others	TOTAL
Low income	44.3 (83.4)	0.4 (0.7)	5.0 (9.5)	0.2 (0.3)	0.5 (0.9)	0.0 (0.0)	0.0 (0.0)	2.7 (5.1)	53.1 (100)
Middle income	59.7 (77.2)	5.2 (6.7)	7.3 (9.5)	1.0 (1.3)	0.6 (0.7)	0.2 (0.2)	0.03 (0.05)	3.3 (4.3)	77.3 (100)
High income	10.5 (47.2)	7.5 (33.8)	1.5 (6.9)	0.8 (3.7)	0.2 (0.8)	0.2 (0.9)	0.04 (0.2)	1.5 (6.5)	22.3 (100)
TOTAL	114.5 (75.0)	13.1 (8.6)	13.9 (9.1)	2.0 (1.3)	1.2 (0.8)	0.4 (0.3)	0.1 (0.1)	7.5 (4.9)	152.7 (100)

Note: Figures in brackets give the percentage of households
Source: Author's estimate based on NSSO (2007)

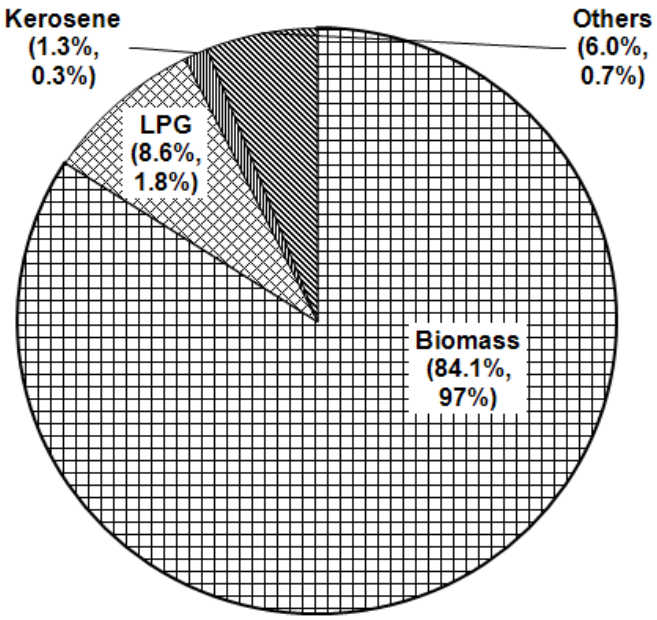
It is estimated that about 84% of the total rural household cooking energy consumption, including primary, secondary, and tertiary cooking fuels, is derived from biomass with firewood having a dominating share. However, in terms of primary cooking fuel, biomass (including cattle dung) accounts for about 97% of the rural household cooking energy consumption (Table 2). As primary cooking fuels, modern fuels like LPG, kerosene, electricity, and biogas account for only 2.2% share. Figure 1 shows the rural household dependency on cooking fuels, which indicates the dominance of biomass. Even the forecast shows that this domination of biomass as main cooking fuel is expected to remain significant at 52% in 2031-2032 with the remainder share contributed mainly by fossil fuel based energy carriers (Planning Commission, 2006). The estimates for 2031-2032 show that most of 285 million tonne of biomass and 139 million tonne of cattle dung would be consumed by the rural households. Out of the expected household LPG consumption of about 49 million tonne, the share of rural households would be approximately 11 million tonne. The rural households are also estimated to use about 15.7 million KL of kerosene, again mostly for cooking.

Table 2: Consumption of primary cooking fuels by rural households in 2005

	Biomass (million tonne)	LPG (million tonne)	Dung (million tonne)	Kerosene (million litres)	Coal (million tonne)	Biogas (million M3)	Electricity (GWh)	TOTAL (PJ)
Low income	88.6	0.0	20.2	31.8	0.5	3.8	2.6	1518.9 (37.6)
Middle income	119.3	0.7	29.3	177.9	0.6	51.5	27.9	2095.4 (51.9)
High income	21.1	1.0	6.2	147.6	0.2	56.2	30.7	424.3 (10.5)
TOTAL	229.0	1.7	55.6	357.3	1.2	111.5	61.1	4205.9
TOTAL (PJ)	3435.6 (81.7)	76.5 (1.82)	653.6 (15.5)	13.1 (0.31)	24.4 (0.58)	2.6 (0.06)	0.2 (0.01)	

Note: Figures in brackets give the percentage shares
Source: Author's estimate based on NSSO (2007), CMIE (2006), Reddy, et al (2009) and Planning Commission (2006)

Figure 1: Rural cooking fuel dependency (2005)

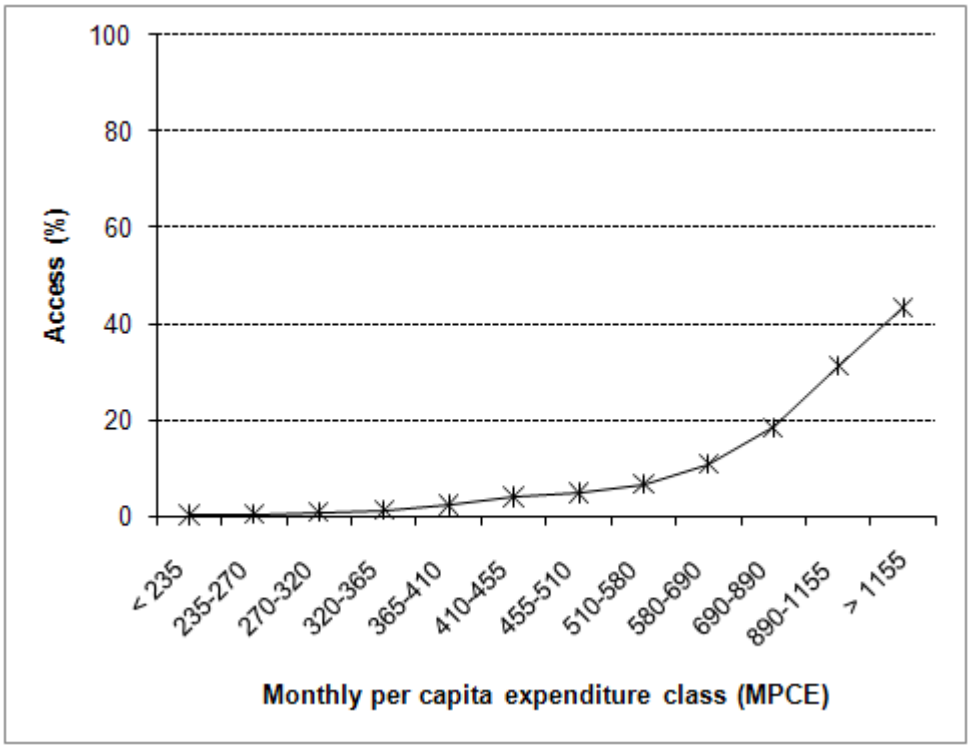


Note: First number within the brackets is the share of households using a particular fuel for cooking and the second number is that share of that fuel in total energy consumption.

The estimated household cooking energy consumption in 2005 was about 4,206 PJ indicating per household consumption of about 27.5 GJ per year (Table 2). On an average, the low income households consume about 29.7 GJ of cooking energy per year per household where as they are 28.3 GJ and 19.9 GJ annually for households belonging to middle and high income classes respectively. This indicates the increase in efficiency levels of modern cooking fuels used by higher income households.

The relationship between access to modern cooking fuels like LPG, kerosene, biogas and electricity and rural household income levels is revealing. It is basically the relationship between rural energy poverty and income poverty in the context of cooking fuels. Figure 2 shows the relationship between access to modern cooking fuels and monthly per capita expenditure (MPCE) levels, where expenditure class is treated as a proxy for income levels. It is obvious from the figure that with the increase in income levels, the access to modern energy carriers has increased from 0% for lowest expenditure class to about 43% in the case of highest expenditure class.

Figure 2: Access to modern energy carriers for cooking and rural poverty in 2005

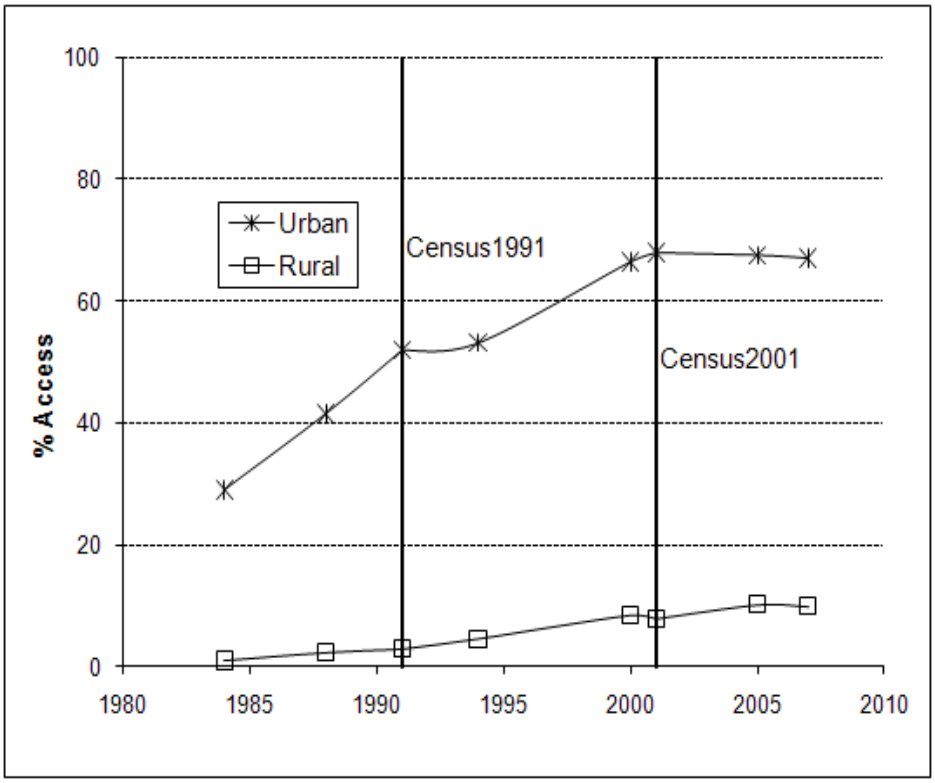


Cooking Energy Access: Trends and Disparities across Urban and Rural Regions

Figure 3 shows the historical trends in the expansion of household access to modern cooking fuels. The trends are presented for the last 23 years during 1984-2007 for both the urban and rural regions (NSSO, 1997, NSSO, 2001, Census, 2005, NSSO, 2007, Rajarathnam, 2008). The trends are disheartening. The post-2001 growth trends are flat or

show a slight declining trend indicating negligible expansion in household access to modern fuels (Figure 3). In the case of urban regions, the average annual rate of expansion in access levels was 8.7% during pre-1991 period, 2.7% during the period 1991-2001 and –0.2% during the post-2001 period. The negative annual growth rates in the post-2001 period are a serious issue. As per the results of NSS, the major reason appears to be higher rate of decline in the share of households using kerosene as a primary cooking fuel without any corresponding rates of shift to other modern fuels like LPG and electricity. Most of the shifts have happened to categories of other fuels and no cooking arrangements. The trend is not much different for the rural region either, the household access levels were growing at a very healthy rate of 16.4% annually during pre-1991 period came down to 10.5% during 1991-2001 and drastically reduced to 3.8% in the post-2001 period. From the trends one could easily postulate that this is an outcome of the lack of effective policies and programs on expanding cooking energy access. In the urban region, in recent years, practically no major shift is happening from conventional to modern cooking fuels. The share of LPG is growing but it is mostly due to a shift from kerosene to LPG as a primary cooking fuel. In the case of rural region, the share of households using modern fuels is rising but at a declining annual rate. The households using kerosene, biogas, and electricity are shifting to LPG as a primary fuel. There is some shift to LPG happening even from biomass using households may be because of better accessibility. However, this is very small. Most importantly, it is disheartening to note that the rate of expansion is declining very sharply. It is very clear from these trends that the kerosene sales through public distribution systems (PDS) at highly subsidized rates has failed to make it as a primary cooking fuel in the rural areas. Another aspect, which emerges from this analysis, is that the cash starved rural households cannot be expected to move away from “free cooking fuels” to “paid cooking fuels” even if they are available at very low prices. The urgent need is for a comprehensive policy and a focused program on expanding household access to modern cooking fuels, especially targeted at the poor.

Figure 3: Trends in household access to modern cooking fuels



The historical trends show that the gap between the levels of urban and rural household access to modern cooking fuels is widening (Figure 3). The difference in access levels between urban and rural areas was 28% in 1984, reached a peak of 60% in 2001, subsequently declining to about 57% in 2005 and remaining at same level in 2007. Unless some initiatives are taken, the gap is not likely to decline sharply in the future. The current need is to promote expansions in both urban and rural household access levels, and definitely at a higher rate in the case of rural households. This would enable gradual decrease in the gap.

Cooking Energy Access: Regional Disparities across States

The regional dynamics are captured by analyzing the household cooking energy access status for the selected major states in India. A total of 10 major states, five each with highest and lowest rural cooking access levels in 2004-2005 have been chosen for the analysis (NSSO, 2007). The five states with highest cooking energy access level have been categorized as "successful states" and the remaining five states with low access level as "failure states." The successful states had achieved rural cooking access in the range of 16.8-28.1% in 2005 whereas the range for failure states was 1.9-5.4%. The five successful states are Punjab, Haryana, Gujarat, Kerala, and Tamil Nadu in the order of success. The five failure states are Bihar, Orissa, Madhya Pradesh, West Bengal, and Rajasthan in the order of failure. These percentages suggest that even the so called successful states have failed miserably in providing access to modern cooking fuel for rural households. The failure states have hardly made any attempt to expand the cooking energy access. This is unfortunate considering the serious health impacts due to indoor pollution caused by the

inefficient use of conventional fuels and the gender discrimination involved in using and procuring these fuels.

Figure 4 shows how these five successful states have performed over a period of 11 years in expanding rural cooking energy access levels. The performance of these best states in India does not appear promising both from the perspective of the status of access levels as well as the growth in access levels. The gap between 100% access and current access levels is enormous. From the figure, it may be noted that Punjab and Gujarat had almost similar access levels in 1994. In 11 years, Punjab expanded the household access levels at an annual growth rate of 6.8% whereas Gujarat could achieve only a rate of 4.4%. Most credible achievement is that of Haryana, which increased access levels from 5.5% in 1994 to 23.5% in 2005, an increase at an annual growth rate of about 14.1%. Even in Kerala, the access levels have more than doubled at a growth rate of 11.6%. Since the base access levels are low even double digit growth rates are not helping these states to achieve the desired access levels. One disturbing trend is that between 1994 and 2000, the access levels in these five states were growing at an average rate of 12.5% per annum and then this came down sharply to 4.8% during 2000-2005. All the states experienced such a decline in the growth rates from the first to second period. This too reflects lack of any policy or scheme for expanding access levels both at the state or national level.

Figure 4: Household access to modern cooking fuels; the successful states

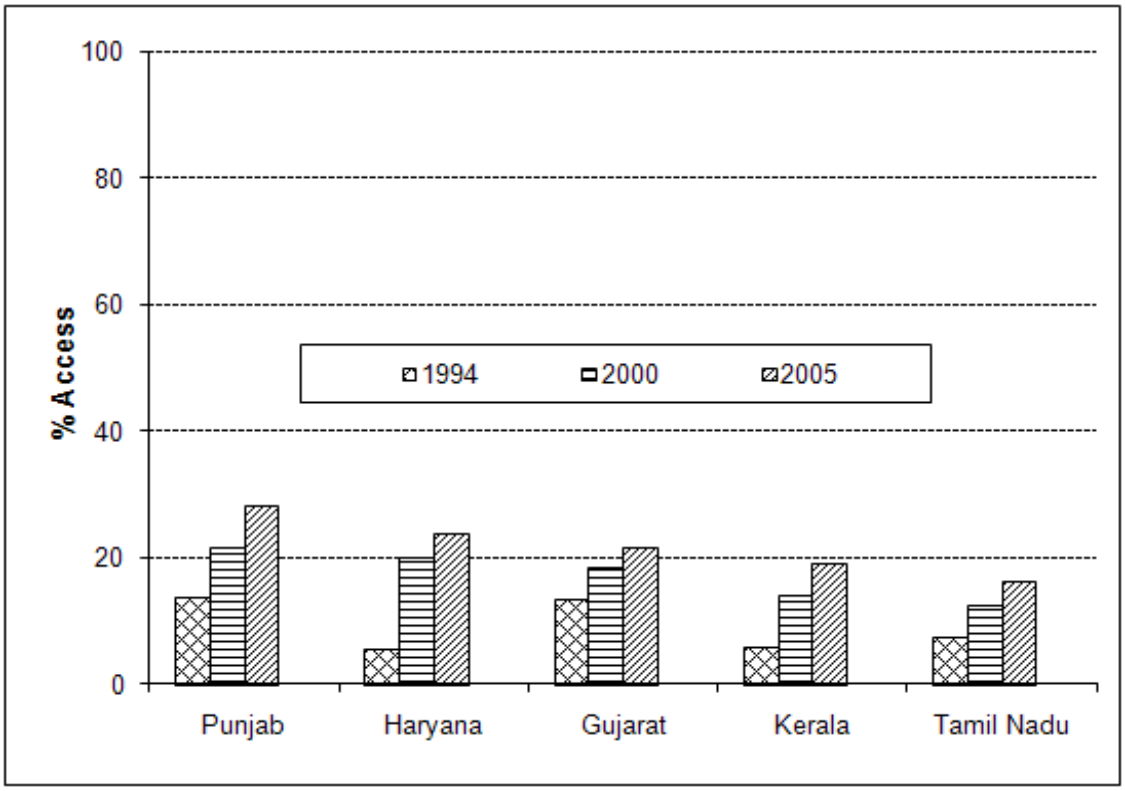
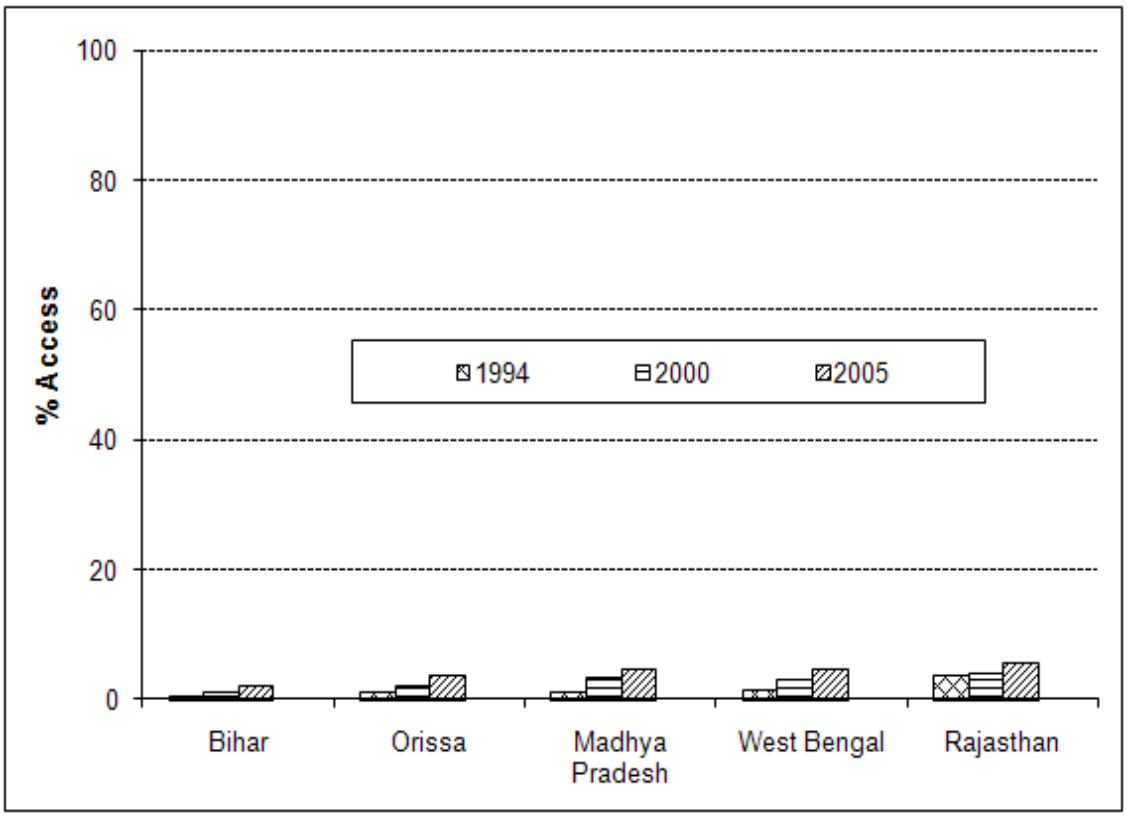


Figure 5 shows similar trends for the failure states. The access levels are extremely low and the gap to be bridged to reach 100% access is extremely large. The successful states have achieved, on an average, more than five times the access levels of the failure states. The average annual rate of expansion was 12.8% during 1994-2000 and this reduced marginally to 9.8% during the period 2000-2005. This is an unacceptable trend considering their current access levels. At least in terms of rate of expansion, the failure states are performing better than the successful states. Among the failure states, Bihar, Orissa, and West Bengal are showing consistent double digit annual growth rates in access levels during both the periods. Partially, the high growth rates are due to extremely low base access levels. Madhya Pradesh had a very healthy growth rate of 22.6% during 1994-2000, which came down drastically to 6.2% during 2000-2005. On the other hand, Rajasthan is faring badly with consistently low growth rates. The declining trend in expanding access is alarming more so in the case of these failure states. The situation is begging for appropriate policies and radical programs for expanding rural cooking energy access.

Figure 5: Household access to modern cooking fuels; the failure states

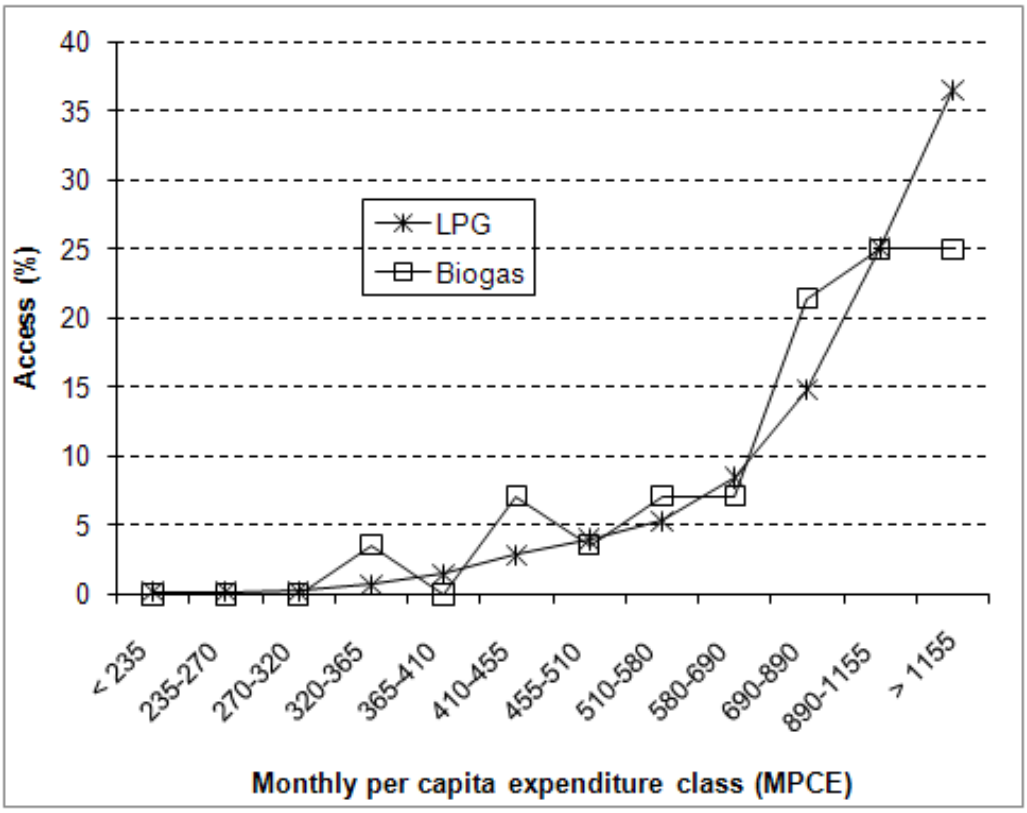


Biogas and LPG Reached only High-income Rural Households

Biogas derived from cattle dung is also an equally convenient gaseous fuel for cooking particularly in the rural context. To promote its use and with an implicit objective to reduce the consumption of non-renewable fuels and fuel wood, the government of India launched

the National Project on Biogas Development (NPBD) in 1981-1982 to disseminate family type biogas plants (Neudoerffer, et al, 2001), a technological solution to expanding cooking energy access. The program is being implemented by the Ministry of New and Renewable Energy (MNRE) and it was renamed as the National Biogas and Manure Management Project (NBMMP) in 2002-2003 retaining the same objectives. Since the objective is technology dissemination rather than expanding energy access, the NPBD scheme never targeted any section of the rural population. Rural poor being the major sufferers of lack of access to modern cooking fuel were hardly the beneficiaries of this program. With cattle ownership and the availability of adequate dung being the criteria for the installation of biogas plants, the poor got excluded from the program. Thus, the government subsidy for installing biogas plants was targeted at the high income rural families. The evidence based on the analysis performed on NSS data for 2005 (NSSO, 2007) also proves the same (Figure 6). It may be observed from the figure that the biogas and LPG using households belong to the same expenditure classes or middle and high income groups. It may not be entirely wrong to conclude that the subsidized NPBD scheme facilitated access to modern cooking fuels for the high income rural households who could not avail themselves of the LPG connections due to the lack of physical access. In other words, these households could easily afford LPG if it is accessible and could have even afforded the complete cost of biogas plants.

Figure 6: Biogas and LPG reached only high-income rural households



The following analysis using the NSS data for 2005 (NSSO, 2007) establishes beyond a doubt the fact that the biogas technology dissemination program of the government of India has not been successful in expanding energy access to the rural poor. The rural poverty line for 2004-2005, based on monthly per capita expenditure (MPCE) level of Rs. 446.68, is used as a reference point for estimating the number of rural poor households in India (Planning Commission, 2009). However, NSSO survey-based data for 2004-2005 contains information only in terms of MPCE ranges, and the range containing the above rural poverty line is Rs. 410-455. Therefore, in this study, as a next best approximation, we have assumed the MPCE of Rs. 455 as a rural poverty line. Based on this, it is estimated that about 44.9% of the rural households in India belong to below poverty level (BPL) or just above that category (i.e., MPCE of Rs. 455 and below). Instead of calling this 44.9% of the rural households as BPL households, we call this category as poor households. The underlying assumption is that even the rural households marginally above the poverty line will also be poor households. According to the planning commission report, about 41.8% of the rural population in India falls under the BPL category with the rural poverty line of Rs. 446.68.

The analysis suggests that in 2005 only about 5.8% of the rural households using LPG as primary cooking fuel belonged to the poor category of rural households. The above result translates into only 1.1% of the rural poor households using LPG as a primary fuel and this is equal to about 740,000 out of a total of about 67 million rural poor households. Biogas has also failed to reach the rural poor households. The results suggest that only about 10.7% of the primary biogas using rural households belong to the poor category. In other words, only about 0.1% of the rural poor households use biogas as a primary cooking fuel and this is equal to about 88,000 poor households. In total, about 828,000 households out of a total of 67 million rural poor households, or approximately 1.24%, use gaseous fuel as a primary cooking fuel. With kerosene, another modern fuel for cooking, this percentage climbs up to 1.89%. Thus it is quite clear from this analysis that the access levels of modern cooking fuel to rural poor households are pathetic.

RURAL LIGHTING ENERGY ACCESS

Lighting is an important household energy end-use service as it is directly related to quality of life. Lighting is the energy end-use that is exclusively associated with electricity as it can provide high quality of light at high efficiency compared to a fuel-based light source (Dutt, 1994). Nearly 0.4 billion people in India mostly from rural regions, still have no access to electricity. The extent of rural electrification in India varies widely from one state to another and from one region to the other, e.g., more than 90 percent of the villages of the states of southern and western part of India are electrified, whereas in states like Uttar Pradesh, Bihar, Jharkhand, Orissa, and in some north eastern states, less than 60 percent villages are electrified. Even in electrified villages many households are not connected to the electricity grid (CEA, 2006).

The analysis based on National Sample Survey data (NSSO, 2007) shows the current status of rural electricity access to lighting in India (Table 3). Only 55% of the rural households use electricity for lighting and 44% of the households have access to only low quality kerosene lighting. The situation is worse for the low income households where about 61%

of the households were using kerosene for lighting in 2005. The status improves with the rise in income levels. Both physical access and affordability are the main factors influencing these low access levels. However, compared to cooking energy access, the lighting access situation appears far better. Unlike cooking energy access, the governments both at the national and state levels have initiated many programs for expanding electricity access for rural households.

Table 3: Number of rural households using a particular energy carrier as a primary fuel for lighting in 2005 (in millions)

	Electricity	Kerosene	Others	TOTAL
Low income	19.6 (37.8)	31.8 (61.4)	0.4 (0.8)	51.8 (100)
Middle income	46.8 (59.2)	31.5 (39.9)	0.7 (0.9)	79.0 (100)
High income	17.6 (80.5)	3.8 (17.6)	0.4 (2.0)	21.9 (100)
TOTAL	84.0 (55.0)	67.2 (44.0)	1.5 (1.0)	152.7 (100)

Note: Figures in brackets give the percentage of households
Source: Author's estimate based on NSSO (2007)

The estimates based on NSS data (NSSO, 2007 and MOSPI, 2007) and Indian energy statistics (MOSPI, 2006) show that the electrified rural households in India were consuming about 39,579 kWh in 2005 and this was equal to a per household consumption of about 470 kWh per year. It has been assumed that on an average 35% of the electricity consumption is used for lighting and this comes to about 165 kWh per year. There are no readily available sources giving the share of lighting in total rural household electricity consumption. Various literature as well as household surveys have reported different shares for rural household lighting ranging from 20 to 50% out of total electricity consumption (Dutt, 1994; Murthy et al, 2001). The rural household electrification programs of the government of India and various other state governments have predominantly focused on the electrification of rural BPL household. All of these households have been given single lighting point connections. A combination of these two sources of information has been used to arrive at the above estimate of 35% lighting share in total electricity consumption. The underlying assumptions used to arrive at this estimate of 165 kWh (in addition to the above two) are that on an average, each rural household requires lighting for five hours per day, with the low income households using one incandescent bulb (IB) of 40 watt capacity, the middle income households using one IB (40 watt) and one fluorescent tube (FT) of 50 watt including choke, and the high income households using one IB (40 watt) and two FTs (100 watt). It is possible that the households belonging to the middle and the high income categories have more than the above number of lighting devices and use different wattages, however they would not be working continuously for five hours during the day.

It is interesting to note that though 55% of the rural households were using electricity for lighting in 2005, their energy share is just around 30% compared to about 70% in the case of kerosene using households (Table 4). This indicates the very low efficiency levels of

kerosene lighting. The total lighting energy use in 2005 was nearly 168 PJ indicating per household annual usage of 1.1 GJ. The poor households consume about 1.2 GJ whereas high income households use 1.0 GJ per household for lighting in a year. It is important to note that the estimated electricity consumption of about 13,850 GWh reported here is exclusively for lighting and the fact is that electricity is used for many other types of end-uses even by the rural households. In 2005, the rural households consumed an estimated 25,700 GWh of electricity for other end-uses.

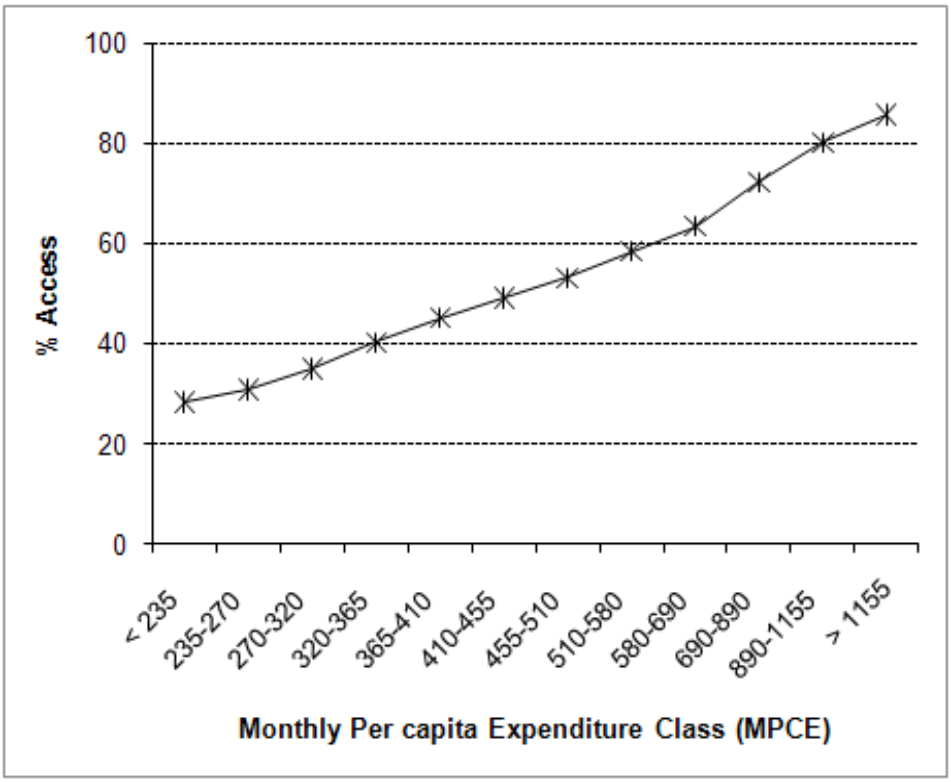
Table 4: Consumption of primary lighting energy carriers by rural households in 2005

	Electricity (GWh)	Kerosene (million litres)	TOTAL (PJ)
Low income	1,637	1,529	61.8 (36.8)
Middle income	7,811	1,512	83.5 (49.7)
High income	4,405	184	22.6 (13.5)
TOTAL	13,853	3,225	167.9
TOTAL (PJ)	49.9 (29.7)	118.0 (70.3)	

Note: Figures in brackets give the percentage shares
Source: Author's estimate based on NSSO (2007), MOSPI (2006), MOSPI (2007), Reddy, et al (2009) and Planning Commission (2006)

There is a significant increase in the percentage of access to electricity with the rise in income levels (Figure 7). As explained earlier, the expenditure classes have been used to represent income levels. Rural household electricity access is just 28% at the lowest expenditure class whereas it increases substantially with the rise in expenditure levels to reach 86% of the households with a MPCE level of Rs, 1,155 and above. Thus, affordability is an important factor in determining access levels. Possibly, this trend also indicates that the villages with relatively rich households tend to locate closer to the grid. The converse is also true; grid connectivity provides better economic opportunities for the villagers. For example, irrigation for farming and mechanical power for rural industries, are some of better outcomes of village electrification.

Figure 7: Electricity access for lighting and rural poverty in 2005



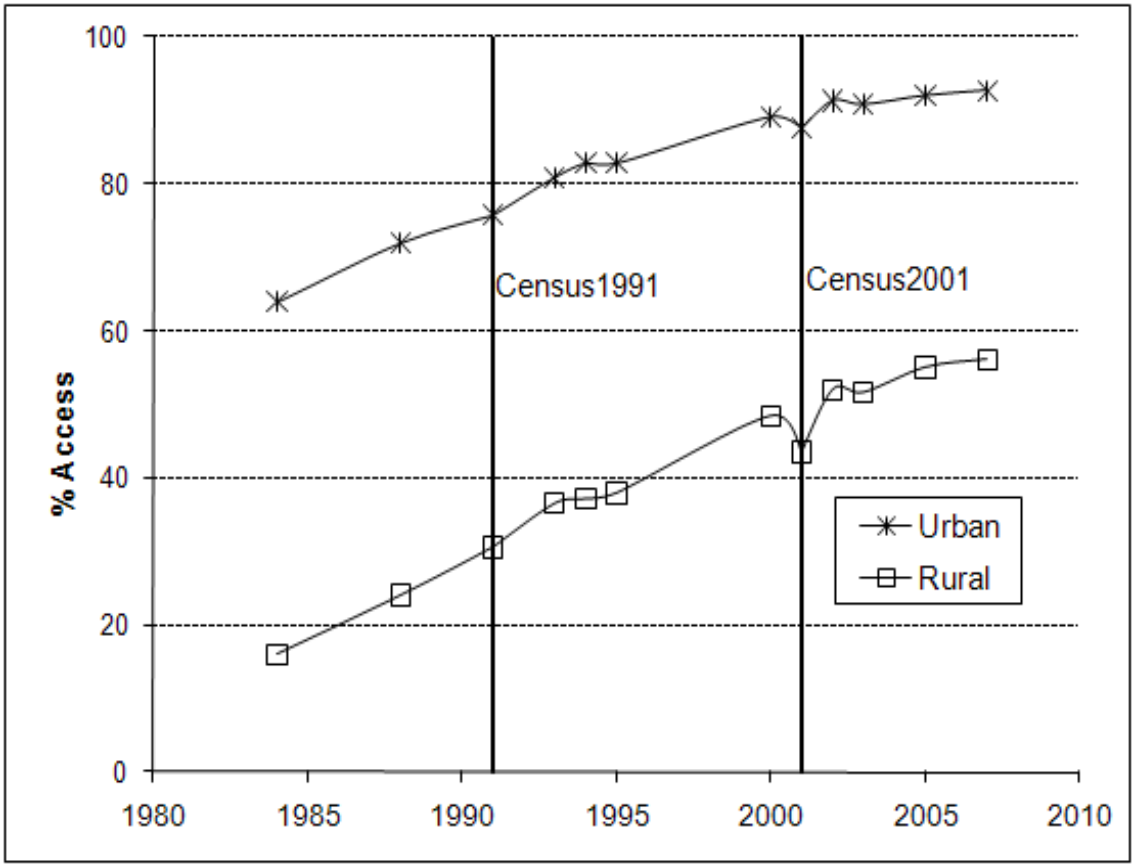
Lighting Energy Access: Trends and Disparities across Urban and Rural Regions

The results of the 2001 census in India was revealing in terms of rural electricity access. It was revealed that only 43.5% of the rural households were connected to the grid. In contrast, about 87.6% of the urban households had grid connectivity. This means, nearly 78 million rural households, or about 420 million out of about 742 million rural people, were without electricity in 2001. The update on rural electricity access levels was provided by the National Sample Survey data (NSSO, 2007) for the year 2004-2005 and it does not present any welcome information as it indicated an increase in electricity access levels to 55%. However, it is very important to keep in mind that the access levels determined using NSS data is on an average 5% higher than that estimated based on census data. This could be easily observed from the "kink" appearing in the graphs in 2001 (Figure 8). This difference was noted when the graphs showing trends obtained using the census data (1991 and 2001) and NSS data (1993 and 2003) on rural electricity access was compared. The estimates based on census data are more accurate than NSS data. Because one is based on enumeration of all households and the other one is a sample survey. If we accept this over estimation by NSS, then the actual rural household electricity access level in 2005 would be 51% instead of 55%. However, subsequent discussion on the historical trend ignores this error since there is no source other than NSSO for obtaining the information for recent years.

The historical trends for the last 23 years spanning between 1984-2007, in expanding household access to electricity shows a wide gap between urban and rural access levels (Figure 8). Though the gap is reducing, it is occurring at very slow rates. From the figure it appears that the household electrification rates are declining in the recent years. The trends on access to electricity for lighting have been estimated using data on shares of households using various energy carriers as primary fuel for lighting (NSSO, 1997, NSSO, 2001, Census, 2005, NSSO, 2007). The detailed analysis of the trend reveals some interesting insights. The urban household electrification level was relatively high at 64%, even in 1984, compared to just 16% for rural households. This was the reason for low annual electrification rate of 2.4% observed for urban households during the pre-1991 period whereas this was a high 9.7% for the rural households. The household electrification rates for urban households were 1.5% during 1991-2001 and just 1.0% during post-2001 period. Even with these low electrification rates, the urban household access reached a healthy figure of nearly 93% by 2007. On the other hand, rural household electrification which began with a high annual growth rate of 9.7% during 1984-1991 enabling access levels to nearly double in seven years, could not keep up this pace. The annual household electrification rate fell sharply to 3.6% during 1991-2001 resulting in just a 43% jump in access levels in 10 years. This is a lackluster performance compared to almost 100% increase in just seven previous years. However, the rate of rural household electrification picked up during post-2001 years and the expansion is happening at 4.3% annually. At this rate, it will take another 12 years to reach the current urban electricity access levels. The government of India has implemented an ongoing massive program on rural electrification called Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) to expand electricity access for the rural households. This program is expected to speed up the process of electrification.

The historical trends show that the gap between the levels of urban and rural household access to electricity for lighting is declining but at a very slow rate (Figure 8). The difference in access levels between urban and rural was 48% in 1984 and then gradually declined to nearly 37% in 2006. The RGGVY program for rural electrification is expected to bridge this gap significantly.

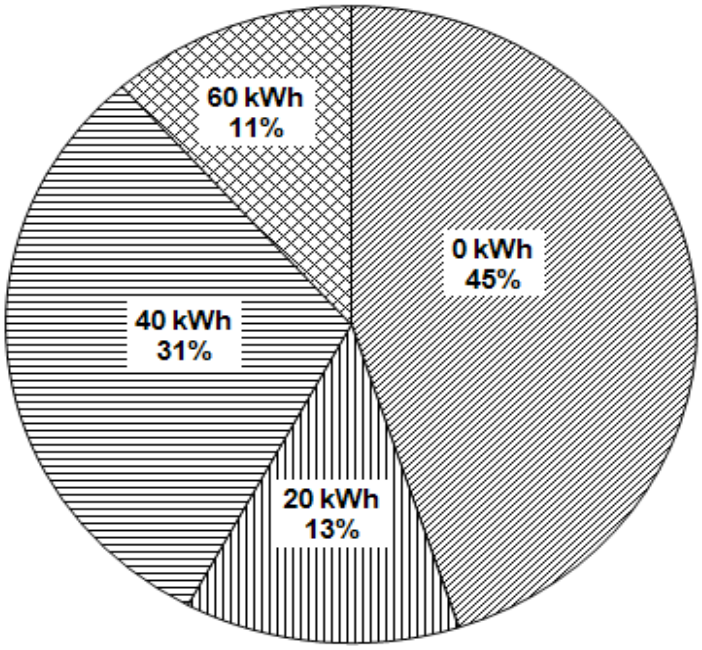
Figure 8: Trends in household access to electricity for lighting



It is important to keep in mind that household connection is not equal to household access. In other words, grid connectivity alone does not ensure complete access to electricity. It is also equally important to ensure a reliable and high quality supply of electricity without disruptions. Only then can the rural population perform various electricity-based (most importantly lighting) end-uses and derive the benefits of electricity access. The electrified households in the rural areas consume a very low quantity of electricity mainly because of an unreliable and low quality electricity supply. Rural regions in India have to live with long-duration power cuts and load-shedding. The analysis based on NSS data (NSSO, 2007 and MOSPI, 2007) and India energy statistics (MOSPI, 2006) show that the electrified rural households in India were consuming about 470 kWh per household per year in 2005. Even the distribution of this consumption across all the rural households is skewed (Figure 9). Among the 55% electrified households, 13% were consuming 20 kWh per month, about 31% 40 kWh per month, and 11% about 60 kWh per month. To this, we can add about 45% of the un-electrified households with a monthly consumption of ZERO kWh, and the rural electricity access picture is completed. Comparing these with the world average monthly household consumption of 665 kWh (UNESCAP, 2009) shows the pathetic situation of rural electricity access in India. Even now the situation would not be much different from that observed 2005. This clearly indicates that the problem of rural household electricity access in India is five-pronged:

- Lack of electricity infrastructure in villages (low capacity)
- Lack of household electrification (low connectivity)
- Lack of adequate generation and supply of reliable electricity (low availability)
- Lack of financial access (un-affordability)
- Lack of information (ignorance)

Figure 9: Share of rural households and their monthly average electricity consumption (2005)



India must address all these inadequacies in addition to the issue of un-affordability discussed previously. The RGGVY program which is being implemented now has primarily focused on addressing the issues of low capacity, low connectivity, and un-affordability and has largely ignored the issue of low availability.

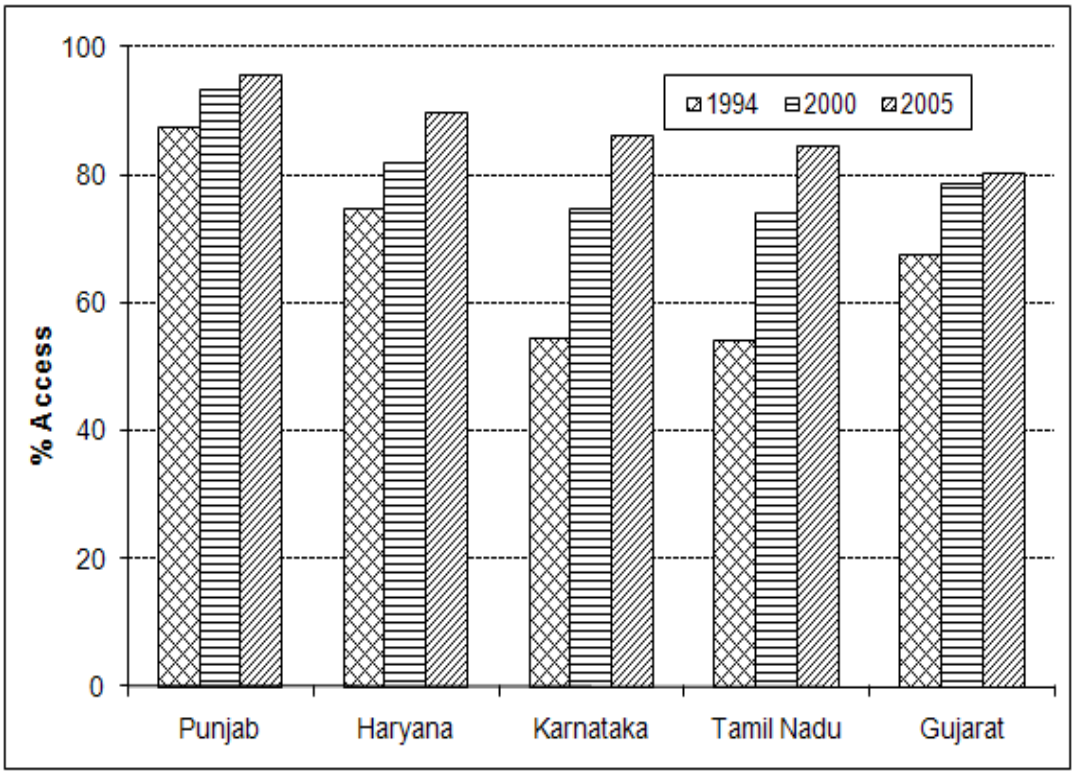
Lighting Energy Access: Regional Disparities across States

The regional dynamics of electricity access are being captured by analyzing the NSS data for the selected major states in India. As explained earlier, the states have been selected based on their performance in terms of level of rural household electricity access achieved in 2004-2005. A total of 10 major states, five each with the highest and the lowest rural household electricity access levels, have been chosen for the analysis. The best performing, or successful states, had achieved rural household electrification rates in the range of 80-96% whereas the range for the worst performing, or failure states was 10-34%. The five successful states are Punjab, Haryana, Karnataka, Tamil Nadu, and Gujarat in the order of success. The five failure states are Bihar, Uttar Pradesh, Assam, Orissa, and West Bengal in

the order of failure. The successful states were able to achieve higher levels of electricity access to rural households, which were substantially higher compared to access to modern cooking fuels. On the other hand, although better than cooking energy access, the failure states have been unable to achieve significant expansion in providing lighting energy access. This is surprising to have two sets of states in the same country exhibiting such contrastingly different performances. The electricity sector, especially rural electrification, is predominantly controlled by the state governments although with support from the central government. Therefore the success of the programs on rural electrification was entirely dependent on the efforts of the government institutions in terms of effectiveness of programs, efficiency of implementation, and availability of financial support and these varied across states. These appear to be the reasons for such contrasting results. The recent involvement of the central government, through RGGVY, in funding as well as implementing the rural electrification is expected to change the whole scenario.

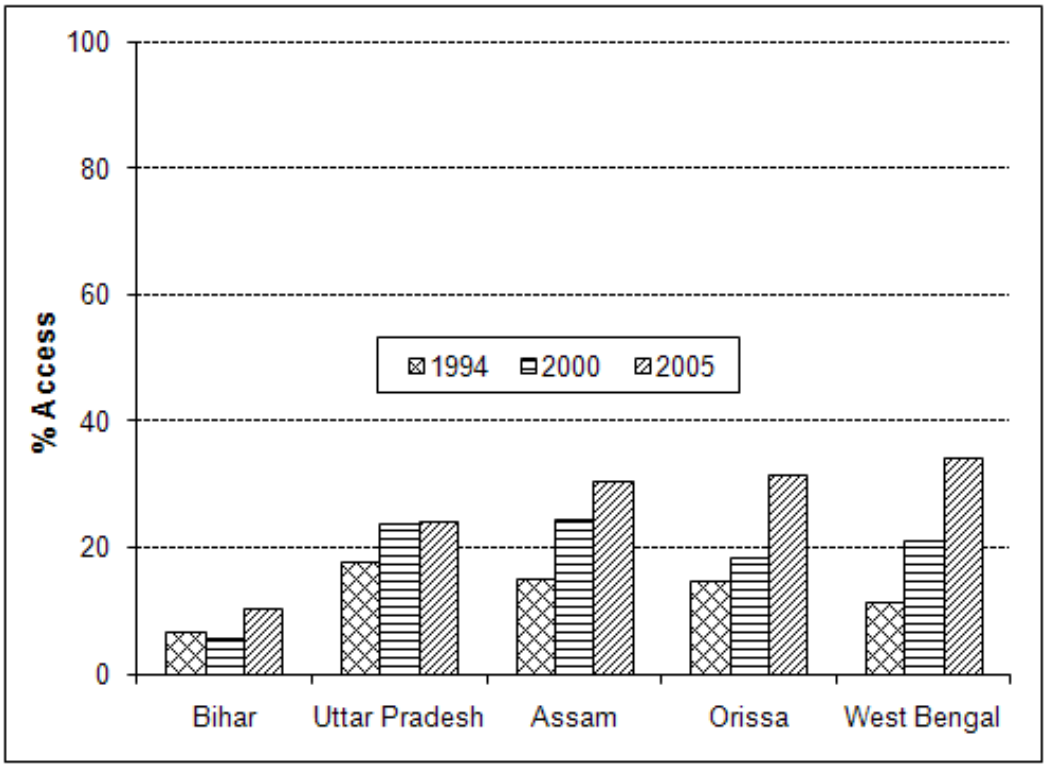
The extent of rural electrification in India varies widely from one state to another and from one region to the other, e.g., more than 90% of the villages of southern and western India are electrified, whereas in states like Uttar Pradesh, Bihar, Jharkhand, Orissa, and in some north-eastern states, less than 60% of the villages are electrified. Figure 10 shows how these five successful states have expanded rural household electricity access over a period of 11 years by giving the status for three distinct years. The performance of the five best states in India shows that all of them have provided electricity access to above 80% of the rural households by 2005. The star among these five states is Punjab having provided the highest electricity access level of about 87% in 1994 and reaching nearly 95% in 2005. In 11 years, Punjab expanded the household access levels at an annual growth rate of just 0.8%. The low growth rate is mainly because of the higher base and the remaining households to be electrified may be in the remote regions or may not be suitable for electrification. The best performance in expanding rural electricity access levels was shown by two southern states, Karnataka and Tamil Nadu, with annual growth rates of 4.3% and 4.2% respectively during these 11 years. The annual rates of growth in expanding electricity access are declining in all the states. Since all these states have crossed, or are on the verge of crossing, a 90% rural access level, reaching the remaining 10% of the households will be a difficult task. Most of these households may be in the remote regions inaccessible to the grid or may be staying in houses which are unfit to be electrified. On an average, the expansion rate was 3.2% during 1994-2000 which declined to 1.7% during 2000-2005.

Figure 10: Household access to electricity for lighting; the successful states



The failure states, however, had provided access to less than 35% of the households in 2005 with Bihar leading the pack in terms of worst performance at about 10% rural households having access to electricity. Figure 11 shows similar trends for the failure states. Overall, the access levels are extremely low and the gap to be bridged to reach 100% access is extremely large. The successful states had achieved, on an average, more than 3.4 times the access levels of the failure states in 2005. Bihar, in fact experienced a decline in rural household electricity access levels during 1994-2000, from about 6.4% in 1994 to 5.7% in 2000, an annual rate of decline of –1.9%. The main cause of this decline was the de-electrification of villages due to natural calamities, to local political interference, and to the theft of infrastructure. Fortunately for Bihar, the rate of expansion picked up and it was about 12% during 2000-2005. The annual rate of expansion for the failure states as a whole was 5.3% during 1994-2000 and this increased significantly to 7.7% during the period 2000-2005. This was a satisfactory trend considering their current access levels and the prospects for future years appear to be good. At least in terms of rate of expansion the failure states were performing significantly better than the successful states. Among the failure states, Bihar, Orissa, and West Bengal were showing consistent double digit growth rates in access levels during 2000-2005. The unfortunate state is Uttar Pradesh, which had a reasonable growth rate of 4.8% during 1994-2000, but which came down drastically to 0.4% during 2000-2005. Unless there is significant reversal, Uttar Pradesh is expected to lag behind other states. The factors like high poverty levels, administrative inefficiency and apathy, lack of targeted state-level programs, political interference, and resource constraints have contributed to such a low performance among the failure states.

Figure 11: Household access to electricity for lighting; the failure states



RURAL ENERGY ACCESS: INDIA AND THE WORLD

Access to modern energy carriers for lighting and cooking is a major issue in the world. The World Energy Outlook 2009 of the International Energy Agency reports that in 2008 there were about 1.5 billion people without access to electricity and about 2.5 billion people were still relying on biomass for cooking (IEA, 2009). In other words about 22% of the world's population did not have access to electricity and nearly 85% of them live in rural areas. In the case of cooking it was about 37% of the population relying on biomass and again most of them in rural areas. The situation has not changed much since 2005, when about 1.6 billion people were without electricity and about 2.6 billion were using biomass for cooking. Unfortunately, the analysis based on NSSO (2007) and IEA (2006) suggests that India accounts for a significant share of this deprived population. In 2005, India accounted for 28.4% of the rural and 8.6% of the urban world population without access to electricity with an overall share of 24.6%. Again, India accounted for nearly 33.8% of the rural and 23% of the urban world population without access to modern cooking fuels with an overall share of 31.9%. This is to be assessed in the backdrop of India's population shares in the world. India accounted for 24.1% of the rural and 10.3% of the urban population in 2005 and with an overall share of 17.4% (based on UNPD, 2008). In relation to the population shares, India's position in terms of energy access in the world is inferior except in the case of urban access to electricity.

In terms of absolute numbers, in 2005, India had 0.4 billion out of 1.6 billion people in the world without access to electricity. The worst is with respect to cooking energy access,

India had 0.83 billion out of 2.6 billion people in the world who were using biomass for cooking in 2005. Figures 12 and 13 show these differences in achievements distinctively. It may be observed from Figure 12 that about 89.8% of the rural population did not have access to modern cooking fuels in 2005 whereas this was just about 64.1% in the case of world as a whole. With respect to urban population these percentages were 32.5% and 14.6% respectively. As mentioned earlier, India's performance in providing access to electricity for urban households was better than the world average in 2005 (Figure 13). Lack of urban electricity access was 8% for India and that for world was 14.6%. The situation of rural electricity access in India, though better than cooking access, was worse than the world access levels. India could provide access to only 55% of the rural population by 2005 whereas it was 62% in the case of world as a whole.

Figure 12: Population without access to modern cooking energy in 2005

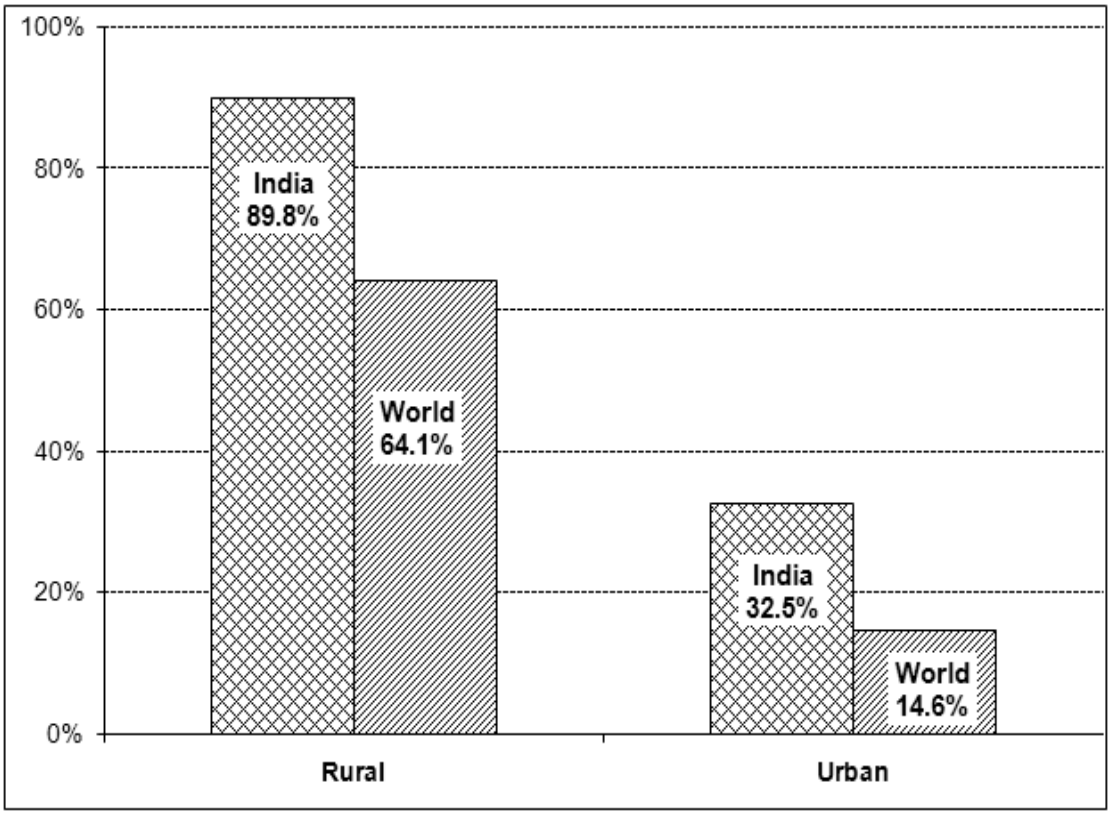
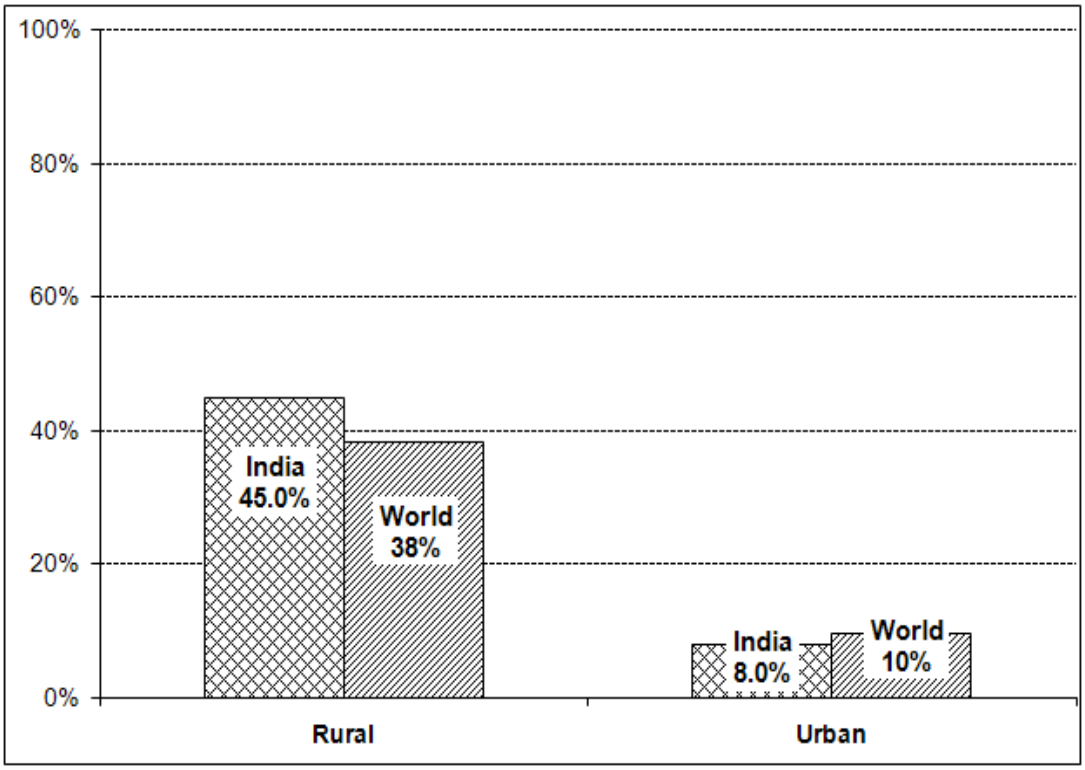


Figure 13: Population without access to electricity in 2005



SUMMARY AND CONCLUSION

In this paper the rural energy status in India was discussed from the perspectives of access to modern fuels for cooking and electricity for lighting for households belonging to different income classes and regions (states of India). The results indicate that the energy deprivations are highest for the households belonging to the poorest strata. For cooking, in 2005, about 84% of the households depended on biomass as a primary fuel and biomass consumption accounted for 97% of the energy used for cooking. In the case of low income rural households, the extent of dependency on biomass for cooking was even higher at 93%. In the case of electricity access for lighting, although overall access levels were 55%, only about 38% of the low income households had electricity access whereas it was about 80% for rural high income households. The rural-urban comparisons suggest that the gap between urban and rural energy access levels for cooking is not declining whereas that for lighting is declining albeit at a very slow rate. This indicates the lack of initiatives for expanding rural cooking energy access and the ineffectiveness of initiatives implemented for expanding rural electricity access. The differences in achievements in providing energy access to rural households by the top five and the bottom five states among the major states in India are starkly contrasting. This is true with respect to both cooking and lighting energy access. On an average, the cooking access levels were 5.3 times higher in successful states compared to the failure states. Similarly, the electricity access levels were 3.4 times higher in successful states compared to the failure states. This is surprising since two sets of states in same country exhibiting contrastingly different performance. The factors like high poverty levels, administrative inefficiency and apathy, lack of targeted state-level programs,

political interference, and resource constraints have contributed to such a low performance among the failure states. Lopsided policies, ineffective implementation programs, and lack of institutions had contributed to lack of energy access in rural India. These results suggest that India needs a radical approach to bridge the rural energy access gap which aims at overcoming these limitations.

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ABOUT THE ENERGY TECHNOLOGY INNOVATION POLICY (ETIP)

The overarching objective of the Energy Technology Innovation Policy (ETIP) research group is to determine and then seek to promote adoption of effective strategies for developing and deploying cleaner and more efficient energy technologies, primarily in three of the biggest energy-consuming nations in the world: the United States, China**,** and India. These three countries have enormous influence on local, regional, and global environmental conditions through their energy production and consumption.

ETIP researchers seek to identify and promote strategies that these countries can pursue, separately and collaboratively, for accelerating the development and deployment of advanced energy options that can reduce conventional air pollution, minimize future greenhouse-gas emissions, reduce dependence on oil, facilitate poverty alleviation, and promote economic development. ETIP's focus on three crucial countries rather than only one not only multiplies directly our leverage on the world scale and facilitates the pursuit of cooperative efforts, but also allows for the development of new insights from comparisons and contrasts among conditions and strategies in the three cases.