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The Household Energy Transition in India and China

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Contents

Abstract

Both India and China are countries in energy transition. This paper compares the household energy transitions in these nations through the analysis of both aggregate statistics and nationally representative household surveys. The two countries differ sharply in several respects. Residential energy consumption in China is twice that in India, in aggregate terms. In addition, Chinese households have almost universal access to electricity, while in India almost half of rural households and 10% of urban households still lack access. On aggregate, urban households in China also derive a larger share of their total energy from liquid fuels and grids (77%) as compared to urban Indian households (65%). Yet, at every income level, Indians derive a slightly larger fraction of their total household energy needs from liquid and grid sources of energy than Chinese with comparable incomes. Despite these differences, trends in energy use and the factors influencing a transition to modern energy in both nations are similar. Compared with rural households, urban households in both nations consume a disproportionately large share of commercial energy and are much further along in the transition to modern energy. However, total energy consumption in rural households exceeds that in urban households, because of a continued dependence on inefficient solid fuels, which contribute to over 85% of rural household energy needs in both countries. In addition to urbanisation, key drivers of the transition in both nations include income, energy prices, energy access and local fuel availability.

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The Household Energy Transition in India and China

Shonali Pachauri
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Introduction

India and China, the two Asian giants, account for almost two-fifths of the world's population, but less than one-fifth of the world's primary energy use. Their recent impressive economic growth has intensified their demands for energy. Both countries have experienced annual growth rates of energy consumption in excess of 4% in recent years. Global primary energy demand is projected to increase by 50% between 2005 and 2030. Almost 45% of this increase will be in China and India alone (IEA, 2007). Yet, despite their formidable growth, poverty and a lack of access to sufficient amounts of clean and efficient energy sources to meet demand in full remain serious concerns and a challenge in both countries. Of the world's estimated 1.6 billion people without access to electricity (IEA, 2004), over a billion reside in these two countries, most of them in India. In addition, in rural areas almost 90% of Indians and over 60% of Chinese still use traditional biomass fuels for their cooking and heating needs. Without access to clean and efficient modern energy, these households remain entrenched in an energy poverty cycle that limits prospects to improve their quality of life and hampers sustainable development (WEC, 1999).

Following the framing of the Millennium Development Goals (MDG) there has been renewed interest in analysing the links between energy and sustainable development and this is now high on the political agenda. Meeting these goals without major improvements in the quality and quantity of energy services, especially for the poor, is not viable. A growing body of evidence now points to the significant benefits of greater access to cleaner and more efficient energy supplies in terms of improved welfare and well-being resulting from reduced drudgery, improved health, higher literacy, enhanced productive opportunities and reduced environmental consequences[1]. This has also spurred efforts to identify strategies for bringing about swifter household energy transitions to cleaner and more efficient energy types in the world's developing nations.

Purpose in this paper is to carry out a comparative and descriptive analysis of the household energy transitions in India and China, to identify key stages in the transition process, and some of the key factors driving the household energy transition. We assess the changes in terms of three indicators. First, we look at transitions in terms of changes

[1] For recent literature on the benefits of household access to modern energy see Meadows (1998); World Bank (2001); DFID (2002); UNDP (2005); Spalding-Fecher (2005); IAC (2007).

in the quantities of energy used by households. Second, we assess changes in the percentage of persons using different types of energy and third, we examine the shifting patterns and structure of household energy consumption.

In general, energy transitions and inter-fuel substitutions, at an aggregate national or sectoral level, have been the subject of focus of several studies (for e.g. Uri, 1979; Jones, 1995; Bjorner and Jensen, 2002). However, an analysis of energy choices, fuel switching patterns and factors affecting household energy transitions at a micro household level, and the implications of such micro-level changes for aggregate national energy use, have received relatively less attention. Previous studies that analyse household energy transitions in developing countries have largely looked at small villages or cities (Hosier and Dowd, 1987; Sathaye and Tyler, 1991; Leach, 1992; Smith et al., 1994; Reddy and Reddy, 1994; Davis, 1998; Masera et al., 2000; Barnett, 2000). More recent research has made use of large nationally representative household surveys. These more recent studies, such as one on the urban household energy transition by Barnes et al. (2005) and work by Heltberg (2004) on household fuel switching in eight developing nations, have provided a more comprehensive assessment of both the diversity underlying the energy transition process as well as the fundamental principles applicable across countries. A similar comparative analysis for India and China has, however, not been carried out so far.

This paper aims at filling this gap by analysing both aggregate trends and micro-data from large nationally representative household surveys from the two countries. The main energy services demanded directly by households, which we cover in our analysis, are cooking, lighting and appliances, and heating. Space heating is not a large component of demand in India and is required only seasonally in a few parts of the country. In China, household energy needs for heating are more significant, and particularly in some northern regions of the country can be as high as 40% of total household energy needs (UNDESA, 1999). The data sources we use do not allow us to distinguish the amount of energy used for specific end-uses. However, as certain types of energy are more likely to be used for certain purposes rather than others, we can get a sense of the amounts used for cooking and heating as opposed to lighting and appliances by analysing the patterns of household energy use in the two countries. Our work builds on recent analysis of household energy use patterns in rural China (Jiang and O’Neill, 2004) and in India (Pachauri, 2007; Farsi et al., 2007).

The paper is organised as follows. The next section describes the sources of data used in our analysis. Section 3 provides some background on recent trends in national energy consumption. Section 4 presents information on trends in residential energy consumption at the aggregate level and compares energy consumption patterns across rural and urban households in India and China. Analysis based on micro survey data of factors affecting the quantity and quality energy transitions across different groups of households is presented in section 5. Finally, a discussion of the results, their implications and broad conclusions are given in section 6.

Sources of national and household energy data

India

We source national aggregate energy data from various Indian official and ministerial publications such as Coal Statistics (GoI, various), Petroleum and Natural Gas Statistics (GoI, various), Electricity Statistics published by the Central Electricity Authority (CEA, various), various issues on “Energy” brought out by the Centre for Monitoring of the Indian Economy (CMIE, 1996; 2000; 2002; 2005), and The Energy and Resources Institute’s energy databases (TERI, 1999; 2001; 2003). For traditional biomass energy flows, we rely on data from the Regional Wood Energy Development Programme in Asia (RWEDP) of the FAO (FAO, 1997) primarily, but cross-check this with other published estimates, such as Ravindranath and Hall (1995) and the Planning Commission (PC, 1999, 2006).

At the disaggregate level, data from the household consumer expenditure surveys conducted by India’s National Sample Survey Organisation (NSSO) are used to determine detailed energy requirements of households and their socio-economic and demographic characteristics. For each NSS round the household consumer expenditure survey data is collected from a nation-wide sample of households, involving separate and comprehensive coverage of rural and urban areas, with the exception of some very remote and interior areas. Data from the 55th round of the survey is used for most of the cross-sectional analysis presented in section 5 of the paper. For its 55th round, the survey was administered between July 1999 and June 2000 to 120,310 households. For details regarding the sampling design and methodology of the surveys, refer to NSSO (2001). Data from several rounds of the household surveys are used to analyse changes in patterns of energy consumption over time.

For the purposes of this paper, data on all quantities and expenditures on fuel and light energy sources from the surveys, which are collected for a 30-day recall period, have been used. As the survey is carried out over the period of an entire year, seasonal variations in consumption are taken into account. All household quantities have been converted to annual values, and divided by household size so that all the analysis is done in terms of annual values per capita. While quantity data pertaining to different energy sources included in the survey are recorded in different measurement units (e.g. kilograms of firewood, kilowatt-hours of electricity, etc.), all the values have been converted to the common energy units of mega joules using the caloric conversion factors presented in Table-A in the appendix.

Data pertaining to expenditures from the surveys are in current Indian Rupees. In order to make the data comparable, consumer price index data have been used to covert all values to 2000 Rupees. The year 2000 Indian currency values are then converted to 2000 international Dollars ($) using the Purchasing Power Parity (PPP) exchange rates published in the Penn World Tables 6.2 (Heston et al., 2006).

China

The primary source as well as the only authoritative source with complete coverage of all supply and demand statistics in China is the National Bureau of Statistics (NBS).

NBS has established a system of complete reporting from units producing, transforming, delivering and using commercial energy, with supplementing information from survey teams and sectoral government agencies[2]. Despite problems, such as misreporting, unclear definition and coverage of statistical categories, the publicly available material is vast and of generally good quality (Sinton and Fridley 2002). For the purposes of this paper, the national aggregate data on energy statistics mainly derive from the China Statistical Yearbook (NBS, various years), China Energy Statistical Yearbook (NBS, various), and the China Energy Databook v.6.0 (LBNL 2004).

To understand the patterns of energy demand at the household level, we use data from the China Rural and Urban Socioeconomic Surveys. These surveys, conducted by the NBS, aim at providing comprehensive information on income growth and living standard improvements of rural and urban residents, and collecting production data for compilation of the national accounts. Before the 1990s, the rural and urban household surveys contained little useful information on energy use. Although an increasing number of questions on energy have been added, information on biomass which is the most commonly used source of energy among rural households is only available in the survey of 1999. Since the surveys provide complete coverage of direct energy consumption among urban residents almost none of which use biomass, we use the 1999 rural household survey data set and the 1999 urban household survey data set for our analysis. In addition, we also use data from several rounds of the urban household survey in order to analyse changes in patterns of energy consumption among urban households over time. As in the case of the Indian data, all energy quantities are converted to per capita per year values in mega joules of energy (see Appendix Table-A) and monetary values are converted to PPP $ in 2000 prices.

There are differences in the accounting conventions for converting energy data from standard units to caloric values in the two countries. In particular, large differences arise in case of the electricity data. In Chinese statistics, electricity is accounted for in primary energy terms excluding transport, distribution and storage losses. Whereas in Indian statistics the conversion is carried out in terms of final energy units to reflect the energy bought by households to meet final demand. As a consequence, conversion factors differ by a factor of three for electricity in the two countries. To correct for this, all Chinese household electricity data was divided by three to make it comparable to the Indian data.

Aggregate energy trends: National energy consumption in India and China

Examination of national primary energy consumption statistics shows clearly that both India and China are countries in energy transition. While the two countries are at different stages of the transition, the nature of the change is similar. In general, there is a shift away from low efficiency solid fuels to higher efficiency liquid and gaseous fuels and electric power in both nations. In addition, both countries are in the process of change from low motorisation to rapid growth of the transport sector. The rising

[2] The statistical summaries published by NBS are often slightly higher than those published by the sectoral government agencies, since the latter cover only state-owned and state-invested enterprises.

demand for oil and oil products to fuel the transportation sector is being met through increasing imports.

Currently, China is the world's second largest energy consumer, whereas India ranks fifth. In absolute terms, China's aggregate primary energy consumption is about three times that of India's. However, in per capita terms energy consumption remains low in both countries, particularly in India. Average energy use is low compared to developed OECD nations and even the world average (Table 1). Both countries have experienced a tripling of primary energy consumption over the last twenty-five years. The accelerating growth of the two economies has been fuelled by energy and is in turn fuelling demand for even more energy. Given current trends of rapid urbanisation, industrialisation, and rising incomes in both countries, a further increase in energy consumption in both countries is expected.

Table 1. International comparisons of key indicators

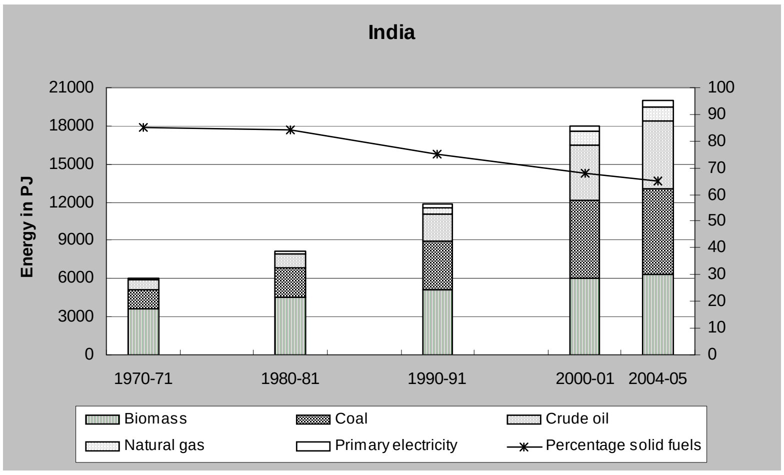
	China	India	OECD	World
Primary energy consumption (in EJ=10^18J)	68	20	231	470
Per capita energy consumption (in GJ)	52	22	198	74
Per capita fossil based energy use (in GJ)	44	15	147	44
Per capita income (in 2000 PPP $)	5419	2885	25340	8231
Population (in million)	1308	1090	1164	6352
Urbanization (in %)	43	30	73	48

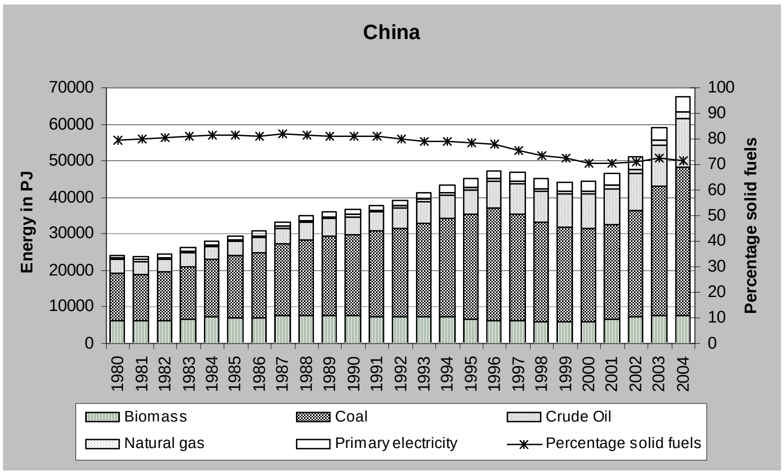
Source: IEA Energy Balances of Non-OECD countries for the year 2004 and national sources for China and India

An analysis of trends in primary energy consumption over the last quarter century in both countries reveals a changing structure in the importance of different types of energy, in addition to a tremendous growth in the quantity of energy used. Both nations have been experiencing a decline in the proportion of biomass energy consumption over the last few decades. However, even today, biomass comprises about 15% of China's primary energy consumption, and about 32% of India's. In terms of absolute consumption, aggregate biomass use increased in India from about 4500 PJ to 6300 PJ between 1980-81 and 2004-05. During the same period, biomass consumption in China fluctuated between 6000 PJ and 8500 PJ (Figure 1).

The consumption of commercial (non-biomass) forms of energy increased much faster over the same time period. Among commercial energy sources, both nations are heavily dependent on coal. While the actual amount of coal consumption continues to grow in both nations, the proportion of coal in total commercial energy consumption has declined. The share declined only marginally in China from 72% in 1980 to 68% in 2004. In India, the decline was more significant from 64% in 1980-81 to 50% in 2004-05. This decrease in the proportion of coal in total commercial energy consumption for both nations has been accompanied by a rise in the share of oil and natural gas, but more so for India than China. Oil comprises the second largest part of the commercial energy mix in both countries and accounted for over 20% of China's total commercial primary energy use in 2005 and 39% of India's in 2004-05. Given the low domestic reserves of oil and gas in both countries, China currently meets more than 40% of its oil demand from imports, and India is dependent on imports for 70% of its domestic oil demand. The share of natural gas in the total primary energy consumption of both nations, is currently quite low, but has experienced very rapid growth in the last decade.

Figure 1. Primary energy consumption in India and China





Trends in total and average residential energy consumption in China and India

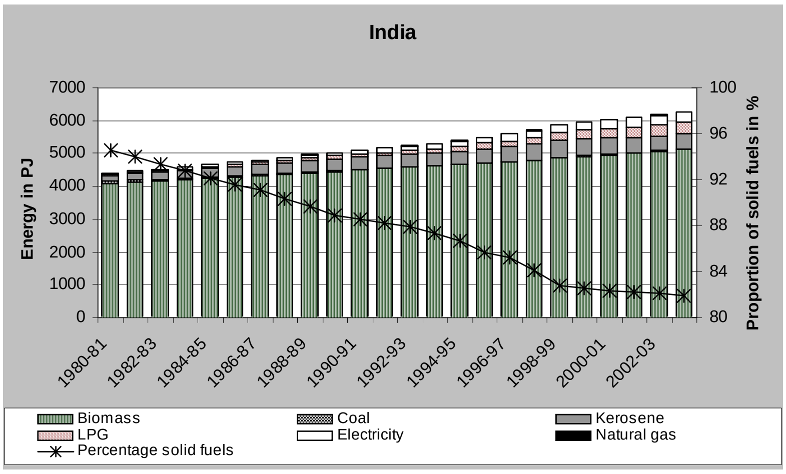
Shifts in the structure of aggregate residential energy consumption

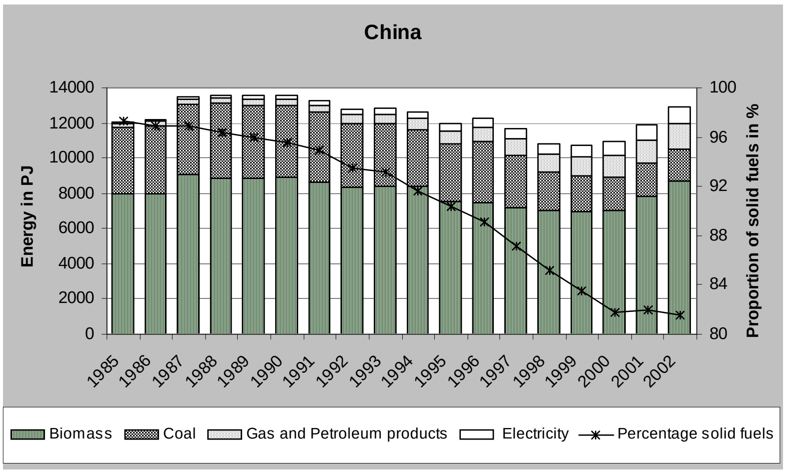
At the aggregate level, patterns of residential energy consumption are not dissimilar in the two countries with most household energy needs still being met from solid fuels (biomass and coal). Currently, the proportion of total solid fuels in aggregate residential energy use stands at about 80% in both countries.

In China, the share of residential energy met from grid sources, i.e. electricity and piped natural gas, is close to 10%. In India too, about 8% of residential energy needs are currently met from grids. The remaining share of residential energy demand is being supplied by liquid fuels (petroleum products) in both countries. Changes in the patterns of household energy use in both countries are evident with a transition towards a higher proportion of more efficient fossil based liquid and grid energies over the last couple of decades. However, the still relatively high proportion of household energy needs being supplied by solid fuels suggests that the two countries are yet at a relatively early stage of the household energy transition, as compared to most OECD countries.

Some differences in patterns of energy use are also evident across the two countries. In aggregate terms, residential energy consumption in China is twice that of India's. In 1980-81 over 90% of energy consumed by households in India was from biomass sources. While this share declined to just over 80% in 2000-01, the actual quantity of biomass consumed increased continuously over the entire period. In China, there was a decrease in firewood consumption, while the use of crop stalks changed little over the last two decades. The reduction in the share of solid fuels in China experienced two stages: (1) in the 1980s and early 1990s, biomass was replaced by coal; (2) after the mid 1990s, both the share of biomass and coal declined and was replaced by liquid and grid sources. The absolute amount of residential energy use also decreased in the late 1990s (Figure 2). This decrease was entirely due to declining firewood and coal use among rural households, and decreasing coal use among urban households. In more recent years, residential energy consumption has been rising due to the rapid increase in the use of commercial fossil based energies.

Figure 2. Residential energy consumption in India and China





The largest difference in the quantity of residential energy resource in the two nations is for coal, whose use is almost a hundred fold higher in households of China as compared to those in India. Although its use has declined in absolute amounts in both countries and became insignificant in India (it remains significant only in certain coal mining regions), coal continues to remain an important source of heating energy for many Chinese.

Changes in rural and urban residential energy consumption

In addition to looking at trends in national residential energy use, it is useful to compare patterns of energy use and the pace of energy transitions between rural and urban households in both nations. In India, national energy statistics do not provide differentiated information on consumption by rural and urban households. The only source of such data is the NSSO household consumption surveys. However, data from national energy statistics are not always consistent with the aggregate estimates derived from the household surveys. In particular, aggregate biomass consumption is underestimated by one-third by the household surveys compared to that from the national energy statistics. This may be, in part, because the surveys only report on firewood consumption and fail to collect data on the amount of dung[3] and crop residues used. In addition, however, the discrepancy is likely to be a result of the fact that national aggregate estimates include all final consumption of populations in private non-profit and charitable institutions and other institutional households such as orphanages, prisons, hospitals, etc. The household surveys, however, only cover private households. Another factor contributing to the discrepancy is that survey-based estimates of total population are about 10% below the census numbers, as some remote areas are not covered by the surveys. Data on kerosene consumption from the surveys are also lower than from the national statistics. This discrepancy is because part of the kerosene supplies intended for distribution through the subsidised public distribution system is illegally diverted to the black market for dilution with diesel stocks.

For China, both the China Statistical Yearbook and the household surveys provide information on household energy consumption for rural and urban sectors separately. Differences are evident in the estimates for some fuels from these separate data sources. For urban households, the aggregate national statistics show a very strong tendency of substitution of solid fuels (coal) by natural gas and electricity, and also a decline in per capita energy use during the 1990s. However, results derived from the household surveys suggest that per capita energy consumption of urban households consistently and significantly increased during the 1990s. The reasons for this difference between the two data sources may be twofold: (1) the aggregate statistics of urban/rural population is affected by the definition of urban areas and changes in this definition over time; (2) biases in the sampling procedure of the survey. The former may have resulted in too high per capita energy use in the early years and too low figures in the

[3] Data from the NSSO surveys does not include any information on the quantity of dung used. Information is collected only on whether the household uses dung or not. To overcome this gap in the data, modifications to the survey data were made to estimate the amount of dung used. See Pachauri (2007) for a detailed description of the corrections applied.

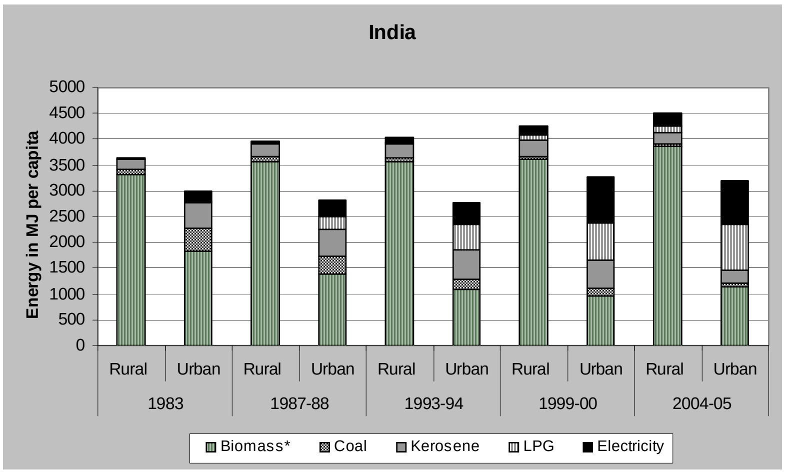
later years since the criterion for defining urban areas has been relaxed recently. However, the second factor might have resulted in the estimates being somewhat higher than in reality, since city households, that use more energy per capita, were selected disproportionately more than town households in the urban household survey (Bramall 2001).

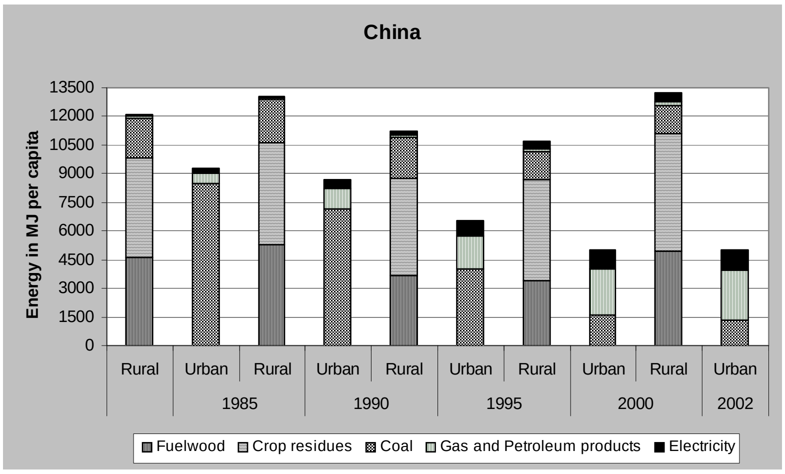
Despite the data inconsistencies for solid fuel use across different sources in both countries, a clear distinction in the pattern of energy consumption among households in urban and rural areas is evident. In India, rural residential energy consumption is still met largely from biomass sources. In China, biomass and coal continue to be the main sources of energy in rural households. Although gas, oil and electricity consumption in rural areas has increased over the last 25 years, it still remains very low and much lower than in urban households in aggregate and per capita terms. Urban households in both nations consume a larger share of electricity and fossil based energy sources. Even so, total residential energy consumption in rural households exceeds that in urban households, as a consequence of their continued dependence on inefficient solid fuels (Figure 3). Fossil based energy sources now increasingly dominate the energy mix of urban households in both countries. However, biomass, while significantly declining in importance, continues to remain a source of household energy in urban India and the same is true of coal in urban China.

Given the large population growth and urbanisation in China and India over the last 25 years, it is useful to examine patterns of energy use of rural and urban households over time measured in per capita terms as these may differ from the aggregate trends. For India, trends at the per capita level mirror those at the aggregate level and suggest that in terms of shares of different energy types in total residential energy use, rural households did not witness any striking changes in their patterns of energy use. Biomass use per capita increased in absolute terms, but only slightly, over the entire period. By contrast, a significant increase in the quantity of electricity use per capita (ten fold), occurred. However, the total amounts and the proportions of commercial energy consumed in rural households continue to remain very low. In urban households, a much more rapid substitution of biomass by commercial fuels and electricity is evident. Biomass consumption per capita declined and this decline resulted in a decrease in total per capita household energy consumption in urban households between 1983 and 1993-94 and 1999-00 and 2004-05. However, during the mid 1990s, rise in LPG and electricity consumption among urban households drove up per capita energy use (Figure3).

Similar trends can be found in China. Among rural households, although per capita biomass use gradually declined during most of the 1990s and coal use was moderately substituted by modern and cleaner energy, no significant transition in energy use patterns is apparent (Figure 3). Among urban households much more significant and distinct changes in the patterns of energy use occurred with the transition involving both a substitution and addition as a result of increased demand. These data show that for urban residents a significant switch from coal to gas and electricity occurred in the 1990s. As a consequence of this change, the gap between urban-rural consumption also widened significantly during this period.

Figure 3. Per capita energy consumption patterns in urban and rural households.





Changes in the percentage of users of different household fuels and electricity

Shifting trends in the patterns of residential energy mix can also be assessed by examining the changes in the percentage of population using different fuels and electricity over time. Table 2 shows these changes over the last quarter century for India. The fact that the columns don't sum to 100% provides evidence of the fact that most households use multiple fuels. Major changes are evident in the percentage of persons using different energy types across rural and urban households over this period. The percentage of population using LPG increased from 9% to 61% in urban areas. However, in rural households the uptake of LPG was much slower and even in 2004-05 only 12% of the rural population used this fuel. Electricity access also changed dramatically over this period. Whereas 15% of the rural population and 58% of the urban population were using electricity in 1983, by 2004-05, 54% of the rural and 91% of the urban population were doing so. Kerosene is used very widely by all households. While the percentage of rural population using this fuel has not changed much over this period, the percentage of urban population using kerosene declined from 92% to 55%.

The share of traditional biomass energy users (both firewood and dung) in rural areas also did not change during this period. However, in urban areas, the percentage of the population using traditional biomass energy halved.

Table 2: Percentage of population using different sources of household energy in India

	1983		1987-88		1993-94		1999-00		2004-05	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
LPG	0	9	1	20	2	33	6	47	12	61
Coal/coke	3	21	3	14	2	8	2	5	2	5
Electricity	15	58	24	67	36	77	47	84	54	91
Kerosene	95	92	96	88	95	83	96	75	91	55
Fuelwood	86	61	89	50	88	42	88	35	88	35
Dung	53	27	56	24	53	18	52	12	46	10

Source: NSSO Household Consumer Expenditure Surveys

Chinese urban household survey data from the years 1992, 1996, 1999 and 2001 are also analysed to further understand trends in residential energy use for urban areas, as complete residential energy use data in the rural household survey is not available in all the years except 1999. As in the case of India, for China too the survey data show that among urban households, the percentage of population using coal significantly dropped from 48% in 1992 to 29% in 2001. During the same period, the percentage using LPG increased from 45% to 56% and there was a significant rise in those using piped natural gas as well (Table 3). While time series data from the rural surveys is not available, data from the 1999 survey shows that less than half the percentage of rural population used LPG as compared to in urban areas. However, there was near universal access to electricity in both rural and urban households.

Table 3: Per capita energy use and percentage users by energy sources for China

		Urban 1992	Urban 1996	Urban 1999	Urban 2001	Rural 1999
Coal	MJ	3245	2313	2085	2356	1843
	%	47.5	32.3	27	28.8	38
LPG	MJ	541	734	845	805	40
	%	45.1	53.6	56.7	56	28
Piped natural gas (urban only)/ Biomass (rural only)	MJ	892	1400	1421	1464	6214*
	%	21.3	30.8	33	34.7	62
Electricity	MJ	1445	2357	3182	3774	84
	%	93.8	92.5	94.8	96.2	97
Total	MJ	6122	6805	7544	8398	8181

Source: NBS Urban Socioeconomic Surveys

Note: * In rural areas this represents Biomass use as no Piped natural gas is used in rural households

Factors affecting household energy transitions in India and China

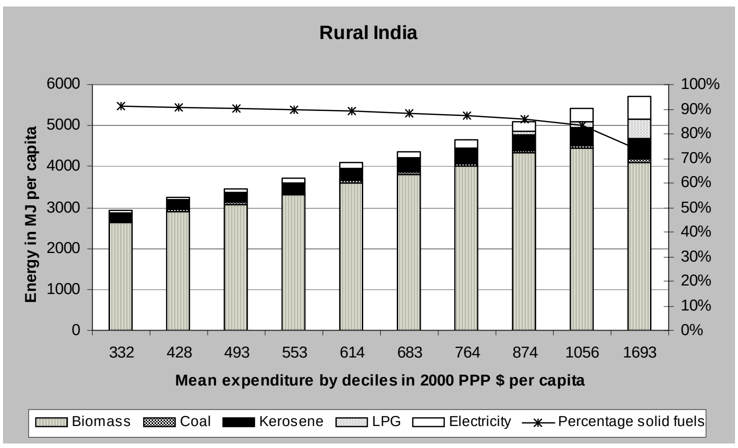
The aggregate and per capita trends presented in the previous sections provide an overview of some of the changes in the pattern of energy consumption in households of India and China over time. However, they are less useful in identifying the key drivers of changing household choices and residential energy consumption patterns in these two nations. In order to gain a greater understanding of such factors, we undertake a cross-sectional analysis using household survey data from 1999/2000 for the two countries.

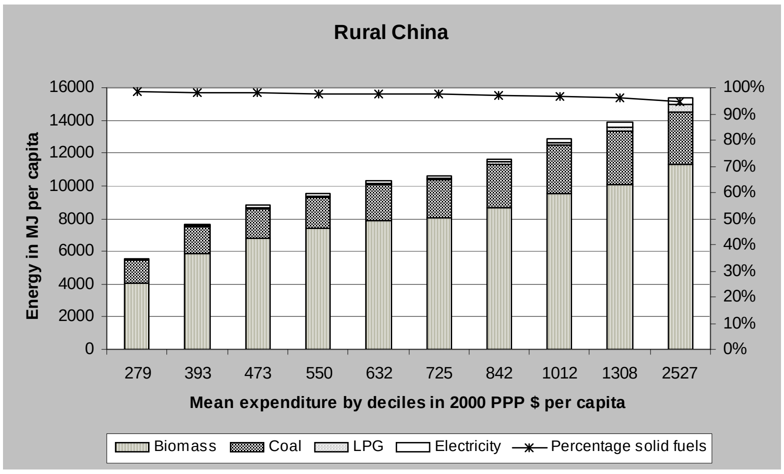
Previous research on energy transitions suggest the importance of factors such as household income, energy prices, costs and quality of supply, and urbanisation in determining household energy choices and the nature and pace of transition to modern fuels and electricity. In what follows we discuss each of these factors in turn, along with others such as demographic differences and geographic variations in influencing the amounts and patterns of household energy consumption across China and India.

Income and expenditure

In analysing the relationship between economic affluence and residential energy use, it is informative to analyse variations by household income. However, as the Indian household survey data does not collect any information on income, total household expenditures are used as a proxy. We find that energy choices, energy shares and consumption levels vary significantly by affluence level across rural and urban households. Among rural households in both countries, as expenditure levels rise, the quantities of all types of energies consumed increase. Only in India, for the top rural decile, does the quantity of solid fuels decline slightly as non-solid energy forms substitute. In other words, the transition to cleaner commercial energy is rather limited in rural Indian and Chinese households and it is only among the top decile groups that the share of energy from biomass and coal decreases with a proportional rise in share of non-solid fuels and electricity (Figure 4).

Figure 4. Per capita energy consumption patterns across rural deciles.

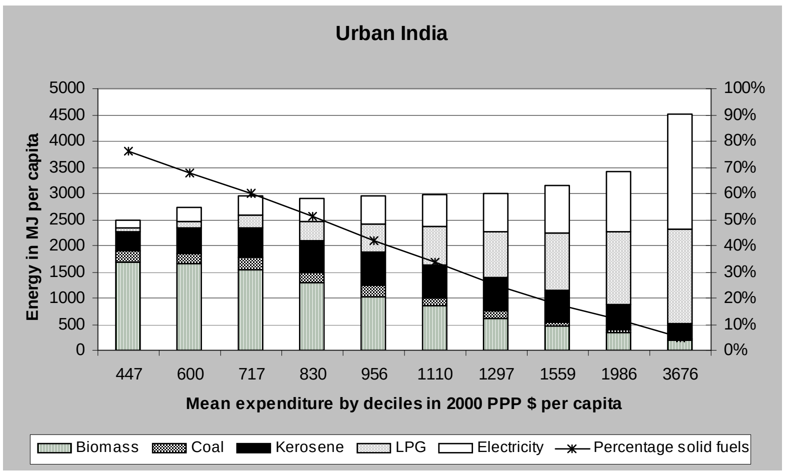


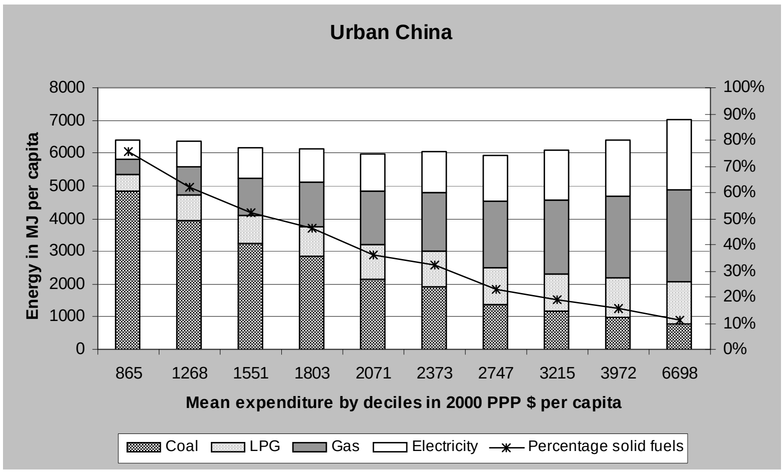


Among urban households, by contrast, the transition to modern energy types is more striking with increases in household expenditure levels in both nations. In urban Indian households, the quantity of biomass energy consumed decreases with rising affluence. Its share decreases from over 65% among the poorest to less than 5% for the richest decile. However, the quantity of kerosene and coal at first rises for the lower deciles, but then decreases for higher deciles, suggesting that these are used as transitional fuels. LPG and electricity consumption increase consistently across all urban deciles (Figure 5). The total quantity of energy used among middle income households does not vary much, because of the shift to modern fuels that are more efficient. That is, these households obtain more useful energy from their mix of energy types. A clear transition is evident with those in the top deciles clearly shifting away from biomass towards more electricity and LPG use.

A substitution effect is even more evident in urban China. As per capita expenditure increases, per capita total energy use steadily declines for the first six decile groups, before it starts to rise for the three top decile groups. This is mainly due to the shift from coal to more efficient modern fuels. The proportion of coal use quickly drops down from 65% for the poorest to less than 10% for the three top expenditure deciles, and the proportion and consumption of more efficient and convenient fuels (electricity, LPG and piped gas) increases (Figure 5). Moreover, while the share of LPG increases among lower deciles, the share then stays constant at around 20% for the higher deciles, while the share of piped gas continuously increases from less than 10% to about 40%. The proportion of electricity rises from about 20% for the poorest to about 55% for the richest decile.

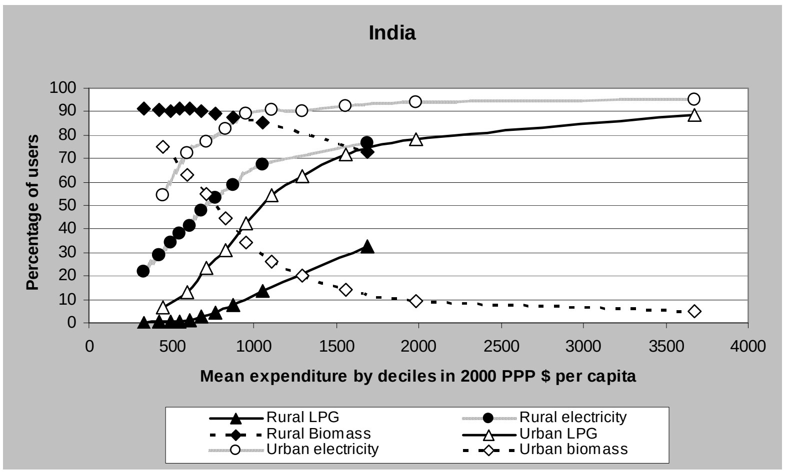
Figure 5. Per capita energy consumption patterns across urban deciles

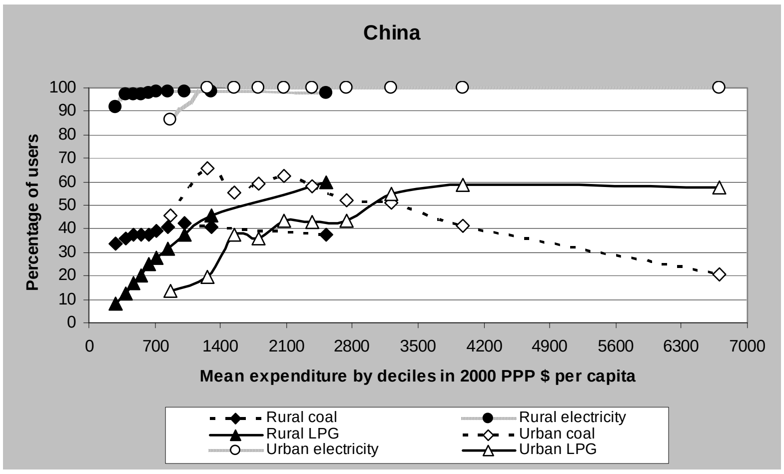




In addition to differences in the proportion of energy consumed from different sources across rural and urban expenditure deciles, the choice of different energy types as reflected by the percentage of population using different energy sources also differs significantly by level of affluence. A comparison of energy choices in households across rural and urban deciles within the individual countries provides further evidence that rural households in both nations still lack access to modern fuels, electricity and modern energy services. In the case of India, for each level of expenditure, a much larger percentage of the urban population uses modern fuel types as compared to the rural population. For instance, among the urban population with a per capita expenditure of about 1000 PPP$ in 2000 prices, over 90% use electricity and over 50% use LPG. However, in rural areas, at this per capita expenditure level, 67% of the population uses electricity and only about 15% use LPG (Figure 6). In China, while electricity access is almost universal across rural and urban households, differences in access to cooking and heating fuels are evident across rural and urban areas, with no rural Chinese using natural gas and no urban Chinese using biomass. At a per capita expenditure of around 1000 PPP$ in 2000 prices, about 60% of rural Chinese continue to rely on biomass and over 40% use coal. However, in urban areas, at this expenditure level, none use biomass, about 65% use coal and 13% use natural gas.

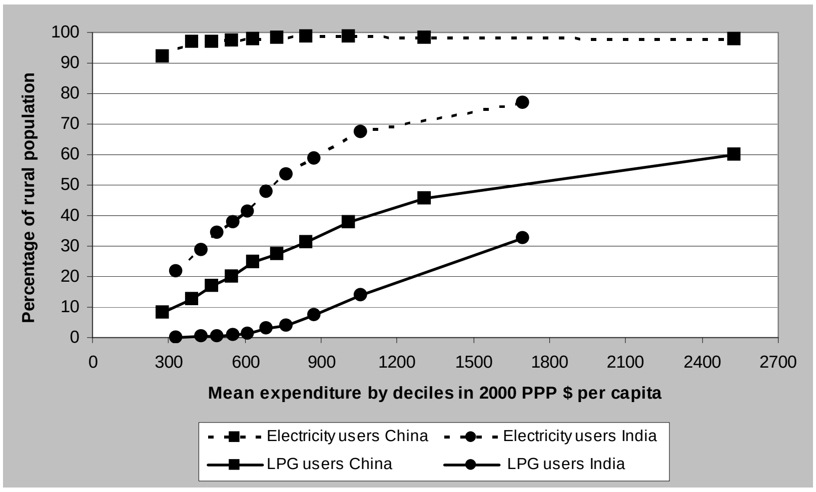
Figure 6. Percentage of rural population using LPG and Electricity





A comparison of household energy choices and access among rural households across the two countries suggests that rural Chinese households are further along in the transition to cleaner modern energy than rural Indian households, with almost universal access to electricity and a much larger percentage using LPG. At a per capita expenditure level of about 1000 PPP$, 98% of rural Chinese use electricity and 38% use LPG, whereas at this level of expenditure, only 67% of rural Indians use electricity and 14% use LPG (Figure 7).

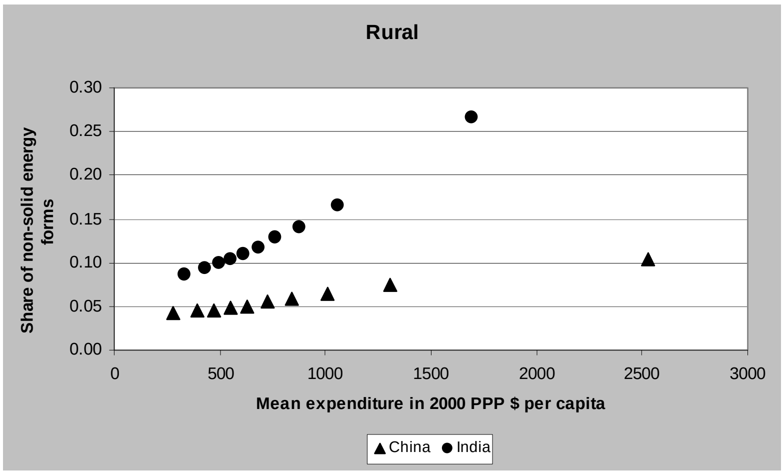
Figure 7. Percentage of rural population using LPG and Electricity

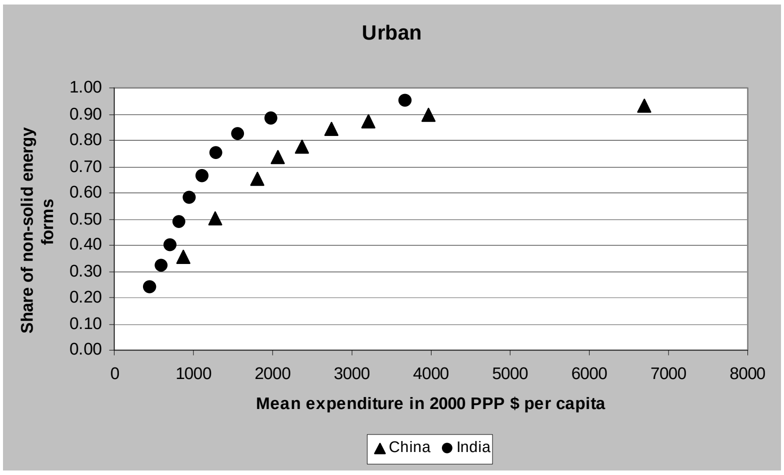


Average quantities of energy consumed and per capita expenditure levels in China are higher than in India, and a comparison of percentage of users of different energy types suggests that Chinese households are transitioning to cleaner liquids and grid sources of energy at a more rapid pace than Indians. However, a comparison of actual quantities and proportions of non-solid energy in total household energy use across Chinese and Indian households with similar expenditure levels provide deeper insights on the relationship between affluence and modern energy consumption in the two nations. Indian households derive a slightly larger fraction of their total household energy needs from liquid and grid sources of energy than Chinese with comparable incomes. Among rural households with a per capita expenditure level of 500 PPP$ in 2000 prices, over 95% of household energy needs in rural China and about 90% of those in India are still met from solid fuels. The top rural decile in China derives only about 10% of its total energy use from non-solid fuels (Figure 8). The richest rural decile in

India while being less affluent than the richest Chinese, derive a significantly higher proportion of total household energy from electricity (10%) and LPG (8%). This is despite significantly higher access to electricity and cleaner cooking fuels like LPG among rural Chinese households as compared to rural Indian households. Among urban households as well, a similar trend is evident. For instance, among urban households with a per capita expenditure level of about 1250 PPP$ in 2000 prices, in China about 50% of total household energy needs are met from liquids and grid sources, whereas in India, this proportion is about 75%.

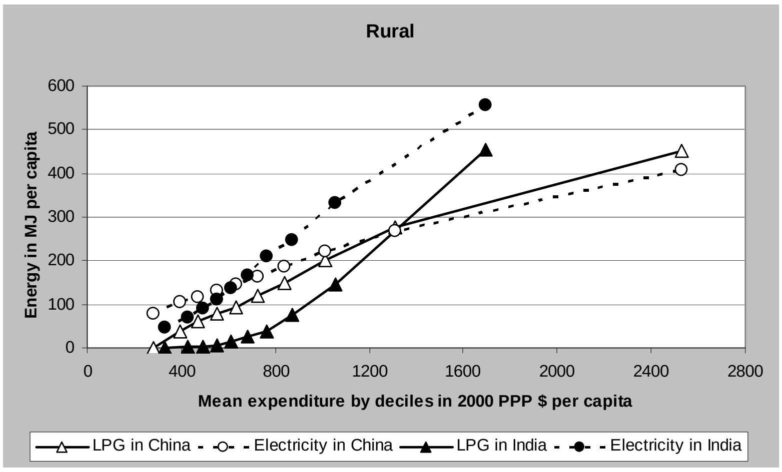
Figure 8. Share of non-solid energy consumption across deciles.

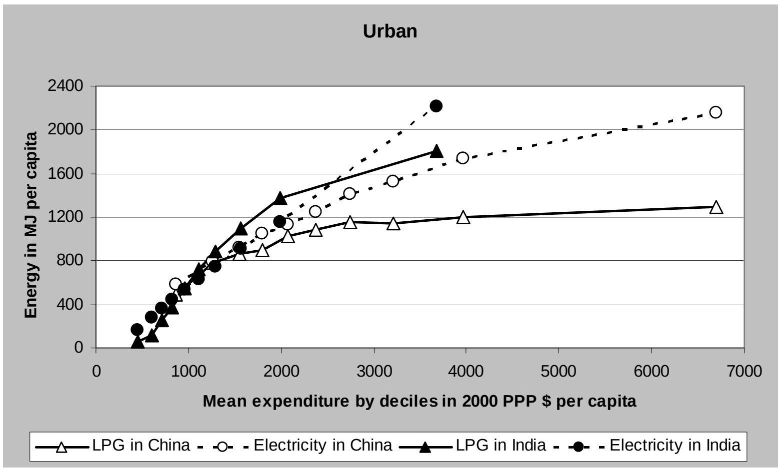




A comparison of actual quantities of LPG and electricity consumption in households with different expenditure levels across the two countries is presented in figure 9. This shows that among rural households, the Chinese use significantly more LPG, except for the richest deciles, than the Indians. However, while poorer Chinese use more electricity on average than poorer Indians, the richer Indians use more than the Chinese. A comparison of modern fuel consumption among urban households across the two countries shows that the richest Indians consume more LPG and electricity than Chinese with comparable incomes. The lower LPG use among rich urban Chinese is likely to be due to the switch to the use of piped natural gas in these households.

Figure 9. LPG and electricity consumption across deciles



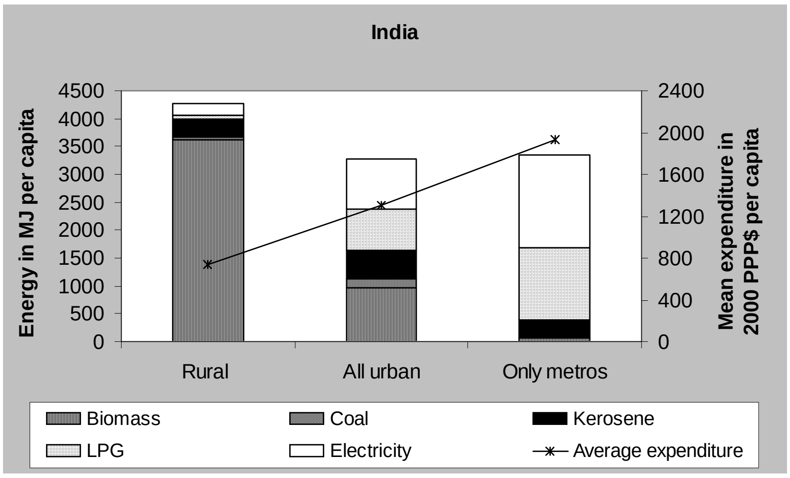


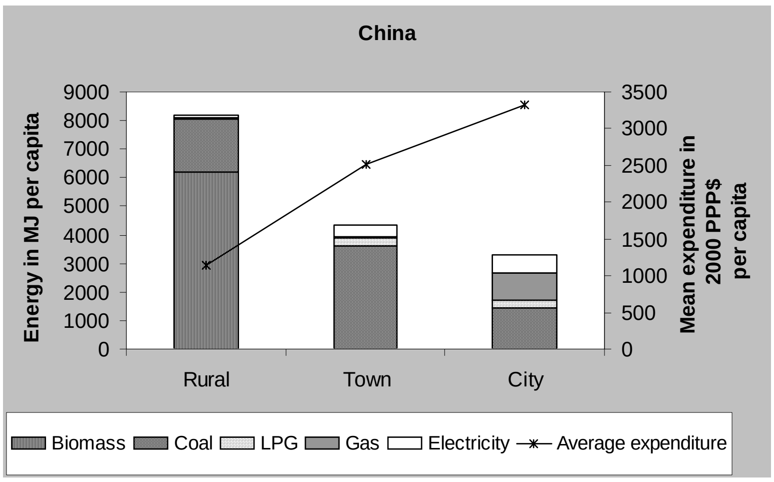
Level of urbanization

In the previous section, it has been shown that rural and urban households differ substantially in their levels and patterns of energy consumption. While disparities in incomes across rural and urban households explain some of these differences in energy choices and consumption, variations in the ease of access to modern energies across these regions also compound differences. Urban areas, with their higher population densities and space limitations in fuel storage and collection, necessitate and also make easier the delivery of higher-density fuels and electricity. Rural areas that are remote, and where the density of population and purchasing power is lower, are less likely to have access to electricity grids or distribution networks for modern fossil fuels. In general, even where households are electrified, the quality of supply is poorer in rural areas. Markets for energy using equipments and appliances are also lacking in these areas, so that rural households often lack the opportunity to use modern energy forms and enhance their consumption of energy services. As modern markets are generally less well developed in rural areas, barter exchanges are often still the norm, and cash flows relatively more limited. In such circumstances, the choice to use modern fuels is also restricted by the large initial capital outlays that are often involved for connections and equipments needed to use modern energy.

Data from the household surveys reveal stark differences, both in terms of expenditure levels and energy use patterns across rural and urban households, as has been shown in Section 5.1. Moreover, differences in the patterns of energy consumption exist beyond the rural-urban dichotomy. The degree of urbanisation also has implications for the types and amounts of energy used. Figure 10 compares average per capita energy consumption by type of energy for rural, town and city residents in China and rural, urban and metropolitan city residents in India from the household surveys. In India, biomass use does not disappear in urban areas, as has been mentioned earlier. However, as city size increases, the use of biomass drops off as firewood gets harder to obtain and has to be purchased for in cash. In China, we see a similar trend of declining coal use across rural, town and city populations. Thus, urban size has an important influence on the types and amounts of energy used. Again, this is in part clearly a reflection of the higher per capita incomes in larger metropolitan areas, but also has to do with the ease of availability and accessibility of alternative energy types. Similar results regarding city size and fuel choice have been reported by Sathaye and Tyler (1991) and Barnes et al. (2005).

Figure 10. Per capita energy consumption patterns across rural, urban, town city and metropolitan households.





Differences among the rural and urban population are also evident when examining shares of expenditures spent on energy and the average prices (quantity consumed/amount spent). In India, the average price per unit of energy for different fuels and electricity were similar in rural and urban regions of the country in 1999-00, with them being marginally lower for most fuels and electricity for rural households (Table 4). However, given the higher share of inefficient traditional fuels being used in rural households, effectively the price per unit useful energy being paid by the rural populations is significantly more than that by urban residents. Accounting for all fuels and electricity, rural households also spent a higher proportion of their total household budget on energy in 1999-00 (about 6% compared to 4% in urban households).

Table 4: Percentage of users and average energy prices across rural and urban households in India

	Urban	Rural
Percentage of users (%)		
Firewood	34.6	88
Coal	3.1	1.1
Kerosene	74.9	96
LPG	47.1	6.4
Electricity	83.8	46.8
Average prices in 2000 PPP$/MJ		
Firewood		
Coal	0.011	0.008
Kerosene	0.025	0.021
LPG	0.034	0.035
Electricity	0.053	0.048
Mean expenditure per capita in 2000 PPP$	1317	749
Share of energy expenditures to the total	3.90%	6.10%

In contrast to India, while the average price of coal in China was almost the same across all areas, the average prices of modern fuels were the lowest in big cities and highest in rural areas, with the average prices in towns lying in between but closer to city prices in 1999. For instance, the price of LPG faced by rural households was more than double that in urban areas in 1999, while piped gas was generally not available in rural areas. The differences in prices reflect the lower installation and operation costs in more densely populated areas and the higher subsides provided to urban Chinese. As a share of total per capita household expenditure, households in cities and towns had a similar budget share on energy, which was about half that of the average rural household in 1999 (Table 5).

Table 5: Percentage of users and average energy prices across rural, city and town households in China

	City	Town	Rural
Percentage of users (%)			
Biomass	0	0	62.2
Coal	20.9	46.2	38.2
Electricity	96.3	96.2	96.1
LPG	53.6	66.4	28.4
Piped Gas	42.3	4.3	0
Average prices in 2000 PPP$/MJ			
Biomass			0.002
Coal	0.004	0.004	0.004
Electricity	0.018	0.019	0.032
LPG	0.026	0.027	0.067
Piped Gas	0.011	0.014	
Mean expenditure per capita in 2000 PPP$	2771	1948	828
Share of energy expenditures to the total	2.50%	2.50%	5.00%

Prices and costs

We have seen in the previous section that many rural and poor households still spend a significant fraction of their household budget on energy. Literature on household energy choice and use suggests that prices have an important influence on the choice and use of different energy types. Analysis of the impact of prices on fuel choices and energy demand can be complicated by the fact that often consumers respond to tariff changes with a time lag (Hosier & Kipondya, 1993). For urban Indian households results of an ordered multinomial probit model by Farsi et al (2007) suggest that LPG and kerosene prices do affect fuel choice and that higher prices of these fuels result in households moving to the use of less efficient energy types. In particular, LPG price is shown by them to have an important effect on energy choice, with higher LPG prices associated with a significant shift away from LPG. In addition, they find that the marginal effects of LPG price changes are particularly significant among moderate and median income households as compared to high income households.

Given the limited nature of the data on prices in the household surveys, we highlight here some of the key similarities and differences in household energy pricing in the two countries. In both nations energy for the household sector is highly subsidized. While both countries have made attempts at liberalization and price reforms over the last couple of decades and introduced dual track pricing (state controlled and free market-determined) for certain household fuels, at least part of the supply remains state controlled for most fuels and electricity. Yet, there is an important difference in the subsidy policies adopted in the two nations. In India the degree of subsidy delivered does not vary across rural and urban households. However, in China most subsidies are specifically targeted to urban households. Rural Chinese households, by contrast, have to pay the full market price for fuels like coal and LPG, and electricity is also supplied to rural households at higher prices than to urban households. More recently, the government has been undertaking price reforms in an attempt to unify prices across rural and urban regions of China.

Given that, on average, rural incomes and expenditure levels are significantly lower than that of urban households, the existing tariff based subsidy policies adopted in both countries tend to be regressive with richer households benefiting the most from the lower prices. This result has been highlighted for the case of India by Gangopadhyay et al. (2005), who conclude that existing subsidies are fiscally unsustainable and also of little help in meeting social policy objectives as they are seriously misdirected and disproportionately benefit richer urban households, who already have greater access to modern energy.

In the case of China, due to varying price levels under different subsidy regimes across regions, households of cities, towns and rural areas pay increasing amounts of money for purchasing the same amount of commercial energy (see table 5). If average efficiencies of the different energy types are taken into consideration, the ratio of cost per unit useful energy consumed across residents in city, town and rural areas is 1:1.14:1.56. In India, while energy prices don't differ significantly across rural and urban households, large differences in levels of access to modern energy also result in the cost per unit useful energy among rural households being effectively higher than that in urban households.

Energy pricing policies in the two countries are complicated by conflicting objectives. In India, in particular, the existing level of energy poverty, which by one measure was over 35% of all households in 1999-00[4], calls for greater and more targeted subsidies to increase access for these deprived households and to meet social objectives of improving equity. In China, while many more households have access to modern energy than in India, consumption levels are still low, particularly among rural and poor households. Thus the political pressure to keep prices low is high, in the short run at least. However, in the long run, clearly such artificially low prices hinder the development of new energy supplies, result in fiscal and financial unsustainability of fuel and electricity providers and can even become an obstacle to an energy transition.

Demographic factors

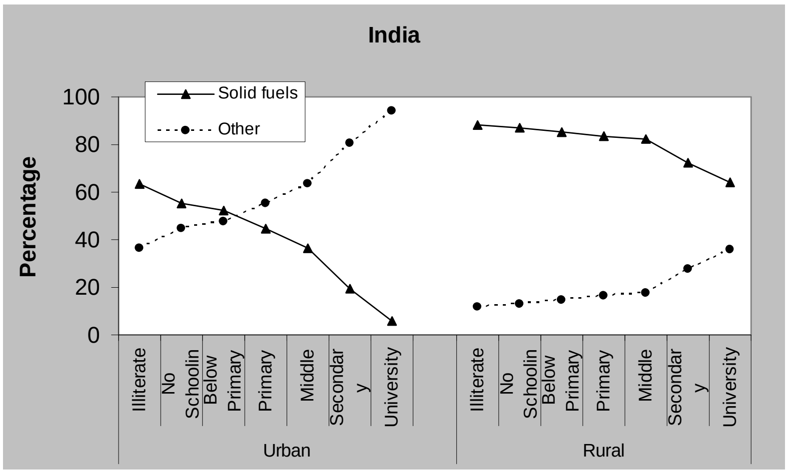
Previous literature examining the influence of demographic characteristics on household energy consumption highlights significant economies of scale in energy use (Pachauri, 2007; Jiang & O'Neill, 2004). However, whether and if demographic factors are in any way related to the patterns of energy consumption and transitions in types of energy used has been relatively less explored. Jiang & O'Neill report that household size and age structure have little influence on the probability of using biomass as an energy source. However, the level of education of the head of the household is clearly related to household fuel choice (Jiang & O'Neill, 2004; Farsi et al., 2007). In general, a higher

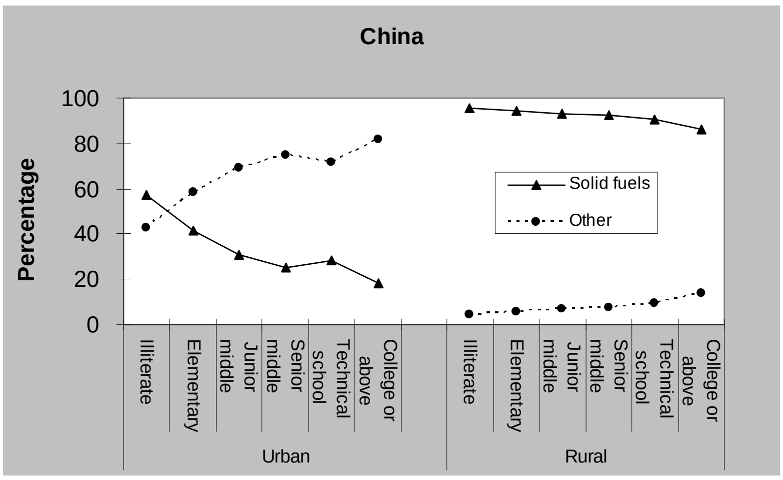
[4] Pachauri et al. (2004) measure energy poverty for Indian households and define it as inadequate access to efficient and clean energy and consumption in inadequate amounts to meet basic cooking and lighting needs.

level of education is associated with households choosing to use more modern and efficient sources of energy. This is, of course, in part, because higher education translates into higher incomes and expenditure levels for these households. However, both Farsi et al (2007) and Jiang & O'Neill (2004) report results from discrete choice regression estimations that control for income or expenditure and find an independent influence of education on fuel choice. Other demographic factors such as sex of the head of the household may also affect fuel choice as Farsi et al (2007) report in their study.

Figure 11 below shows the patterns of energy use in Indian and Chinese households with different levels of education of the head of the household. As already observed in previous studies, the data show that households shift to the use of more efficient fuels as their education level improves. This shift is more pronounced among households in urban areas as compared to those living in rural areas in both countries, as a consequence of the lower access to reliable supplies of modern energy in these areas, and the lower average purchasing power of rural households. However, in urban households of both countries, above the primary/elementary level of education, the share of energy from non-solid fossils and electricity exceeds that from solid fuels.

Figure 11. Proportion of solid fuel consumption in households with varying education levels of the head.





Geography and region

A detailed analysis of regional variations in household energy consumption patterns across India and China is beyond the scope of this paper. However, we highlight here the large regional variations in geography, climate, resource endowments, and development and urbanisation levels across both nations and the importance of these differences for household energy use patterns and the transition process. In both China and India, the amounts and patterns of household energy use vary tremendously across regions. In China, however, the degree of regional variation is greater than in India. This is partially because the degree of disparity in development levels across provinces is greater than across states in India. But part of the larger regional variation in household energy use across China is also explained by larger climatic differences across Chinese provinces. In India, only a few states in the northern higher altitude regions of the country experience a short winter and require some heating. For most of the rest of India, the climate is tropical or sub-tropical and cooking is the activity that accounts for most of total household energy needs. In China, by contrast, the northern regions, experience longer periods with colder temperatures, and therefore require more energy for heating purposes. And yet, there are certain provinces in the central and south-west region of China, where households have higher energy consumption despite experiencing higher average temperatures because of greater local availability of biomass. Local resource availability also has a significant impact on energy choices and consumption in India. For instance, coal is only used in households in Indian states where there is significant coal mining activity. For the most part, in both countries differences in development and urbanisation levels explain the regional variations in household energy use. In certain regions local customs, habits and tastes also affect household energy use patterns.

In mainland China, the country is divided into 31 provinces, municipalities and autonomous regions[5]. India is divided into 35 states and union territories for administrative purposes with states having populations of over 160 million to less than a million[6]. Figure 12 below shows average per capita household energy use patterns across provinces in China and states in India. In China households in provinces of the colder Northern provinces generally use more energy than in other regions. However, households in most provinces of the poorer northwest region use less energy per capita than those in richer Beijing and Tianjin in northern China, even though they experience lower average temperatures. Households in provinces such as Shanghai, Jiangsu, Fujian, and Guangdong in the southeast and south use significantly more commercial energy per person than households in northern regions, because of their high income and urbanisation levels. However, Jiangsu one of the richest provinces, is an exception. Here, biomass still accounts for more than 45% of total residential energy use since rural residents of Jiangsu traditionally prefer using stalks for cooking.

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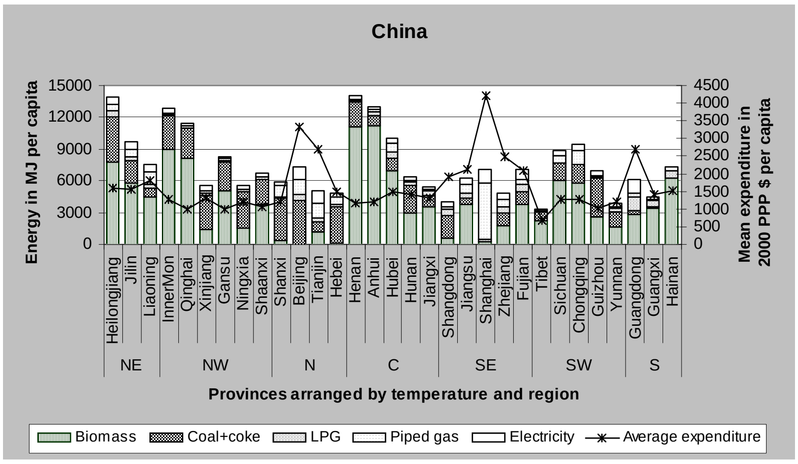
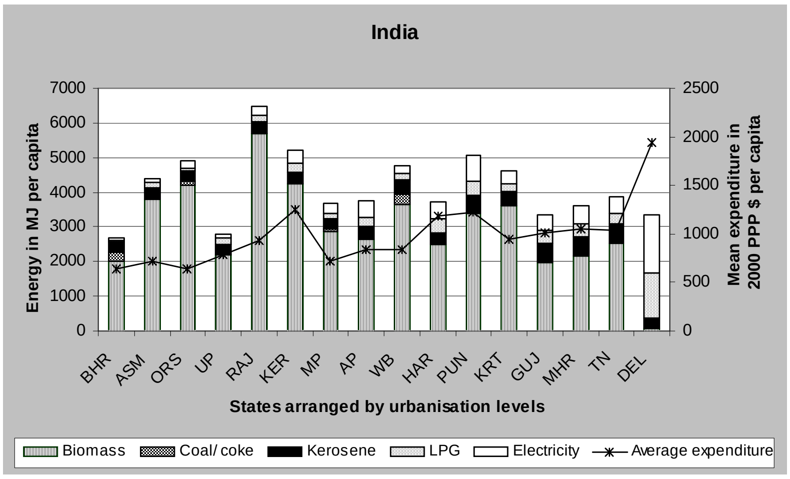
[5] The four municipalities (Beijing, Tianjin, Shanghai and Chongqing) and five autonomous regions (Xinjiang, Inner Mongolia, Ningxia, Guangxi, and Tibet) rank at provincial level. Therefore, they are simply referred to as provinces in this paper.

[6] In Figure 12 we use samples drawn from 16 major states of India that account for over 97 percent of the total Indian population and over 93 percent of sampled household and persons as sample sizes for some of the smaller states and union territories are not representative. Refer to Appendix Table-B for a list of the states included in our analysis.

In India regional differences in per capita household energy use are explained largely by differences in development and urbanisation levels. As in China, households in Indian states with higher income and urbanisation levels like Delhi, Gujarat and Maharashtra, use a larger proportion of commercial fuels and electricity. By contrast, in Orissa and Rajasthan, where the average income level is low, average biomass and consequently, average total energy use in households is high. Across states, actual levels of consumption also differ as a result of differences in energy availability. As for instance, in Bihar and West Bengal where coal use is higher due to the presence of large coal mines.

Figure 12. Variations in household energy consumption patterns across geographic regions.





Discussion and conclusions

Households in China use twice the amount of energy, in aggregate and per capita terms, as Indian households. In addition, in rural areas Chinese households have greater access to modern energy than Indian households. At an aggregate level, urban households in China derive a larger share of their total energy from liquid fuels and grids (77%) as compared to urban Indian households (65%). Inequalities in the distribution of energy consumption across different geographical regions, across rural and urban households, and among rural and urban households with different levels of affluence, are starker in China as compared to India. For instance, the Gini coefficient of the distribution of electricity consumption among urban households in China is 0.2 as compared to 0.07 in India. Disparities in the percentage of population with access to modern energy, however, are much larger in India than in China, especially in rural areas.

Yet despite these differences, patterns of residential energy use in the two nations are similar in many regards. At an aggregate level, solid fuels (traditional biomass and coal) still comprise 80% of total residential energy use in both countries. Among rural households, the share of solid fuels in total energy consumption is also similar at over 85% in both countries. Differences in patterns and amounts of energy consumption show a rural-urban dichotomy in the case of both nations. Compared with rural households, urban households in both nations consume a disproportionately larger share of commercial energy and are much further along in the transition to modern energy.

The modus and pace of household energy transitions: An assessment of the transition at an aggregate level in terms of the amounts of energy consumed and in terms of the percentage of persons using modern fuels indicates that Chinese households are further along in the transition to modern energy as compared to Indian households. China's success with rural electrification and India's poor record in this regard has meant that electricity access is almost universal in China today whereas in India only about half of the rural population has access to electricity and close to 10% of the urban population also still lacks access. However, an analysis of differences in patterns of energy consumption across rural and urban households with differing levels of affluence provides deeper insights. The top rural decile in China derives only about 10% of its total energy use from non-solid fuels. The richest rural decile in India while being less affluent than the richest Chinese, derive a significantly higher proportion of total household energy from electricity (10%) and LPG (8%). This is despite significantly higher access to electricity and cleaner cooking fuels like LPG among rural Chinese households as compared to rural Indian households. Among urban households as well, a similar trend is evident. The significantly higher solid coal dependence in Chinese households may be due to larger local reserves and higher heating requirements. Differences in the availability and costs of fuels across the two nations also contribute to reliance on a slightly different set of fuels, (biomass, LPG and kerosene in India, as opposed to coal, LPG and piped gas in China).

While there are differences in the types and amounts of energy used across Chinese and Indian households, the modes of transition to modern energy are similar across the two countries. The fact that rural households are at a much earlier stage of the energy transition than urban households is also common to both countries. Even among rich rural households, there is a tendency to stack on the use of cleaner modern energy rather than switch over completely. This complementary addition rather than complete substitution to modern energy in rural areas is also due to the poorer infrastructure for modern energy in these areas and consequent lack of adequate and reliable supplies. Despite almost universal access to electricity in China, even where households are electrified, the quality of supply is poorer and the price is higher in rural areas In addition, rural households that are often cash strapped prefer spending available time resources for collecting nearby sources of biomass or coal, rather than money for purchasing commercial energy and the equipments and appliances required for their use. While there is little evidence of a transition among rural households in either country, in China a transition away from biomass towards coal is evident. Among urban households, there appears to be a much more rapid substitution process taking place in both nations. In China, urban households at the lower end of the income scale use largely coal for cooking and electricity for lighting. With increasing income, an initial transition takes place to LPG and finally to piped gas. In India, poor urban households still largely rely on biomass for cooking and either kerosene or electric lighting. With a rise in income levels, urban households at first substitute kerosene for biomass in cooking and finally switch over to the use of LPG for cooking and electricity for lighting and appliances. The share of electricity and modern fuels rises to over half beyond an expenditure threshold of about 850 PPP$ in 2000 prices in urban India and about 1250 PPP$ in 2000 prices in urban China.

The factors influencing the transitions: In both countries, the most important drivers of the household energy transition are income, urbanisation, energy access, and energy prices. The geographic variation in energy use patterns across households in different regions in both countries also suggests that climatic factors are of importance in China and that local resource availability, customs and tastes may also impact energy choices and use. In addition, demographic factors such as the education level of the head of the household also have an influence on energy choices. We find that transitions to modern fuels and electricity occur more rapidly in richer urban areas, as barriers to access are less limiting and people put a premium on cleanliness, convenience and efficiency as incomes rise. In rural areas too, while income clearly affects energy choices, the ease of access to local biomass or coal resources and availability and costs of alternatives have a greater impact on determining the pace of the energy transition.

Energy prices and costs and availability of alternatives play a crucial role in determining the types of energy households' use in both rural and urban areas. For example, in China, a ban on firewood and scarcity during the late 1990s led to a decline in biomass consumption in rural households. Energy tariff reforms altered the relative prices of alternative fuels and also had an influence on the pace of energy substitutions in both rural and urban households of China. In India, provision of subsidized kerosene through the public distribution system has resulted in widespread use of this fuel across both rural and urban households. While LPG is also provided at subsidized prices in India, high up-front costs associated with the equipment needed to use LPG (stoves and cylinders) and lack of supply security have acted as a hindrance to its wider adoption among rural households. Restricted supplies of LPG, even in urban areas of India till the mid 1990s, may have slowed the adoption of this fuel before the government allowed private parties to import LPG from the international market.

Thus, in addition to the future rate of urbanisation and growth of household income, we expect that government policies on accelerating access to modern energy, particularly on regulating the electricity and fuel sectors in both countries and on future energy price reforms, will have a significant impact on the future pace of the household energy transition in both nations. In addition, social policies aimed at providing greater access to higher education may also influence the pace of the transition.

Implications for sustainability: There is no simple straightforward answer to whether the transition to modern energy occurring among households in India and

China is likely to have a positive or negative overall impact on sustainability. A full assessment of this kind is also beyond the scope of this paper. It is clear though that the transition from solid fuels to cleaner and more efficient fossil based energy sources has significant social benefits and leads to an improvement in the local and indoor environment. A shift away from solid fuels is associated with improvements in living conditions and health, particularly for poor women and children most affected by indoor air quality. The provision of electricity and cleaner cooking fuels like LPG to households has also been shown to have significant economic benefits such as reduced drudgery, greater literacy, and enhanced opportunities for productive economic entrepreneurship and activity (Ranganathan and Ramanayya, 1998; World Bank, 2002). However, the regional and global atmospheric emissions implications of the household transition need further analysis. A switch from cooking with biomass to a modern fuel like LPG has been demonstrated to result in relatively little increase in overall carbon emissions due to the significantly higher efficiency of cooking with such fuels (IEA, 2007). This abstracts from the issue of whether the biomass is sustainably harvested or not. However, the dramatic rise in household electricity demand, particularly in urban households, is contributing to accelerating the increase in thermal electric generation, which is still largely coal based in both countries. The longer term implications for atmospheric emissions of this increase in thermal power generation are more worrying. Yet, a shift from thermal to cleaner renewables or nuclear based power generation and technical improvements in efficiencies of conversions and of equipments and appliances used in the household sector offer the prospect of real environmental and economic gains in the future. Thus, while the social and economic sustainability implications of the household energy transition in both countries are largely positive, the implications for longer-term environmental sustainability depend on the scale of the analysis, whether indoor, local, regional or global and are likely to be driven by future technological innovations.

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APPENDIX TABLE-A: Standard energy conversion factors

Energy Type	China		India	
	Standard unit	Standard energy content in MJ/std.unit	Standard unit	Standard energy content in MJ/std.unit
Coal	kg	21	kg	18
Kerosene	kg	43	litres	33
LPG	kg	50	kg	46
Electricity*	kwh	4	kwh	3.6
Firewood	kg	14	kg	15
Natural Gas	cu. m.	39	Not widely distributed in India.	

Note: Chinese convention accounts for electricity in primary energy terms. We divided all electricity data by a factor of 3 to make it comparable with the Indian data.

APPENDIX TABLE-B: List of major states of India

S.No.	State	Code
1	Andhra Pradesh	AP
2	Assam	ASM
3	Bihar	BHR
4	Gujarat	GUJ
5	Haryana	HAR
6	Karnataka	KRT
7	Kerala	KER
8	Madhya Pradesh	MP
9	Maharashtra	MHR
10	Orissa	ORS
11	Punjab	PUN
12	Rajasthan	RAJ
13	Tamil Nadu	TN
14	Uttar Pradesh	UP
15	West Bengal	WB