HOUSEHOLD FUEL AND ENERGY USE IN DEVELOPING COUNTRIES - A MULTICOUNTRY STUDY

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EXECUTIVE SUMMARY

Household survey data from eight different countries are employed in this study to assess patterns of household fuel and energy use, spending on energy, and fuel switching behavior. Surveys from Brazil, Nicaragua, South Africa, Vietnam, Guatemala, Ghana, Nepal, and India are used. The data sources are LSMS surveys except for India, where the NSS survey is used.

The usefulness of LSMS surveys for energy policy analysis is very mixed. Some LSMS surveys support basic energy policy analysis of patterns of household energy usage and spending quite well. Other countries' LSMS surveys are weak on information pertaining to energy and fuel use. It is an important deficiency if surveys only ask for the major cooking fuel of the household; households frequently rely on multiple cooking fuels in many developing countries. A simple and cheap improvement over current survey practice would be to always allow for several cooking fuels and to ask households how often they have their LPG cylinder(s) refilled.

The major energy-related pieces of data that can be extracted from standard LSMS surveys relate to the ability to identify patterns of electricity and fuel usage and spending at the household level. This information can be cross-tabulated with household expenditures and other household characteristics to gain insight into the distributional profile of particular fuels as well as the determinants of fuel use. Such analysis is particularly helpful for evaluating energy subsidies and taxes.

There are large and important differences between countries in the cooking fuel mix, both between solid and non-solid and within the group of solid fuels. Non-solid fuel use tends to be highly normal; usage of all modern fuels increases with income except kerosene, which tends to be neither clearly progressive nor regressive. Subsidies on the recurrent price of many modern cooking fuels would often have adverse distributional profiles.

Usage of solid fuels – firewood, dung, and straw is strongly inferior, declining with income, particular in urban areas. However, solid fuels are widely in use in rural areas of all of the study countries, even in the top expenditure brackets. Even inferior solid fuels such as dung and straw are used by all income groups in rural areas of South Asia and Vietnam. In fact, fuels such as dung or straw peak in the middle of the income distribution and remain widely used in the top rural quintile. In India, the quantity of wood is fairly constant in most rural income groups. The implication is that in rural areas economic development and income growth will not in itself lead to displacement of dirty cooking fuels.

The urban poor in many parts of the world rely on purchased firewood and kerosene. Different fuels matter to the urban poor and the rural poor. Self-collected or homegrown wood is very common in rural areas. However, a surprisingly large share of rural households relies on wood purchases. Although rural wood purchases are more common among the higher deciles, it is especially surprising to see that many low-income rural households also purchase wood, for example in countries such as Guatemala or India.

Summing up, modern fuels play a relatively modest role in rural areas of many low-income countries. Here, they are often used mostly by rural elites. And once rural households start using them, modern fuels sometimes complement and sometimes displace solid fuels. The prospect for modern fuels to combat indoor air pollution is therefore significantly better in urban than in rural areas.

Fuel and electricity pricing is politically sensitive and important for poverty. There is very large variation across countries in the composition of households' energy expenditures. In the poorest countries, biomass and kerosene often feature heavily. In Ghana, kerosene and charcoal are the two largest energy expenditure items. In Nepal, it is kerosene and market wood. In the other countries electricity is the energy source on which most money is spent. Among the cooking fuels, LPG and kerosene tend to be where most of the fuel budget is spent; however, consumers in Guatemala and Vietnam spend as much or more on wood as they do on hydrocarbons. The significant variation in energy composition and spending implies that detailed local knowledge is required when designing energy market and pricing reforms.

Data on the budget share of lighting and cooking fuels show that the urban poor generally are the most exposed to energy price fluctuations; they often consume a mix of electricity, purchased wood or charcoal, and kerosene. There are curiously large variations in energy budget shares across countries, varying from a low of 2.5 percent in Nepal to 6.5 percent in Guatemala.

The observed variations in energy budget shares across countries reflect a mix of measurement issues, affordability, and access factors. Since access to modern energy services generally increases the share of expenditures going to energy – as well as the services rendered to people – the low energy budget share in rural Nepal should not be interpreted as something positive. Instead of reflecting affordable modern energy services, a low energy budget share could simply mean that modern energy services are unavailable or so unaffordable that households resort to biomass reliance; it could also mean that free biomass is available in sufficient quantities so that nobody wants to spend on commercial energy.

Within each country, the energy budget share of households tends to decrease with income and with household size. This reflects the fact that energy is a basic good, and that there are economies of scale in household size. The implication is that the poor are the most exposed to energy price fluctuations. Cash energy budget shares are often largest in urban areas, especially in low-income countries. In countries and areas where households have shifted out of wood their vulnerability to fuel price fluctuations is increased.

The tendency for the energy budget share to decrease with income is more pronounced in urban areas. Due to better possibilities for substituting collected or homegrown biomass for purchased fuels, rural households are better able to limit their energy expenses and their exposure to energy price fluctuations. Lack of an electricity connection also contributes to lower energy spending among the rural poor; although lighting with kerosene and candles is vastly more expensive per unit of light, the absence of appliances can mean that unconnected households spend less overall on energy than connected households.

Among all of the energy sources considered, firewood has the highest budget share among its users. The urban poor in countries such as Nepal and Guatemala spend significant shares of their total expenditures on wood, around 5 percent when averaged over all households in the bottom quintile and around 10-15 percent when averaged over wood users only. This implies that wood users are very vulnerable to price fluctuations in firewood markets. If mechanisms could be found to improve firewood markets, leading to lower and more stable prices, it could bring serious benefits to a substantial number of households depending on wood purchases. Use of purchased fuelwood weights heavily on the budgets of poor people in urban areas. Firewood taxes would be clearly regressive. The overall budget share of (purchased) firewood is much lower in rural areas, and does not exhibit any clear distributional pattern.

One frequently hears concerns about the affordability of energy and the need to help the poor pay for energy. Such concerns sometimes serve as window-dressing for the urban middle-classes to lobby for continued benefits. Nevertheless, arguments about the unaffordability of energy cannot be dismissed entirely – energy is a basic good and the poorer households frequently spend sizeable shares of their income on cooking fuels and electricity. Two approaches are possible to concerns about the affordability of energy. One, subsidies need to be much better targeted towards poor consumers, and fiscal support re-directed towards grid expansion and fuel uptake. Second, a level energy playing field where households can choose freely among a variety of cooking fuels can help reduce the energy bill as people switch fuels in response to price fluctuations.

There are not many policy options for promotion of fuel switching. Price subsidies for modern fuels is probably the most important potential policy for fuel switching – but price subsidies may be undesirable in many circumstances due to the high fiscal costs and, sometimes, the regressive distributional profile of LPG subsidies. Kerosene subsidies would in many cases have the most pro-poor distribution – much more progressive than LPG subsidies – but kerosene sold for fuel unfortunately tends to get re-directed to automotive uses. As mentioned, some of the most vulnerable households are those using purchased firewood – they are often low-income and sometimes spend very high budget shares on household energy. This group contains many candidates for fuel switching. They would likely benefit to a large extent if a way could be found to deliver subsidized kerosene in a targeted manner. Kerosene subsidies only help promote switching away from firewood if diversion of kerosene for automotive fuel can be avoided.

Better functioning fuelwood markets would bring important benefits to many poor people. Fuelwood markets are extremely important for the poor, who often rely on them either as buyers or as sellers. Lower and more stable fuelwood prices could bring real benefits to this group, until in the longer run they may be able to switch to kerosene or LPG. The benign neglect that tends to accompany fuelwood markets in energy policy is a mistake.

General economic development will in itself to some extent help trigger fuel switching. This is particularly true in urban areas. In rural areas, however, the quantity of firewood used per household in India and Guatemala is almost constant except in the top decile. Some of the processes accompanying development – urbanization, electrification, and education – will however help promote fuel switching.

Uptake of modern cooking fuels is associated with access to other infrastructure services. Analysis suggests that modern cooking fuels tend to be adopted only after households are electrified. Electrified households exhibit much greater use of LPG and other modern fuels at all levels of income. Access to an improved water source also often precedes modern cooking fuels.

A number of variables are shown to affect fuel choice and fuel switching: household expenditures, education, urbanization, electrification status, and water source: these variables all have a significant impact on the choice between modern and traditional solid fuels. Household size, in contrast, is found to increase the use of all energy sources – it matters for fuel choice but not for switching.

Modern fuels are much more likely to displace solid fuels in urban areas. In rural areas partial switching tends to predominate. The reason seems to be that the levels of the variables that could help trigger a fuel switch are lower in rural areas: development of infrastructure, education, and income is less progressed there, and biomass much more accessible. The prospect for modern fuels to combat indoor air pollution is therefore significantly better in urban than in rural areas. One needs to be wary of attempts to accelerate fuel-switching processes beyond what is compatible with the general level of development of the intended beneficiaries.

Fuel and energy interventions aiming for fuel switching need to be carefully targeted to areas and households where the purchasing power, level of infrastructure development and other motivating factors such as biomass scarcity are in place. Areas not yet electrified, for example, would very rarely adopt modern fuels. Large groups of households – particularly in rural areas of low-income countries – will remain unrealistic targets for fuel switching for quite some time to come. Other interventions may be more appropriate for such households – improved stoves, better ventilation of kitchens. Keeping in mind the limited purchasing power of this group, it will be required that effective technologies are available at low cost.

It may be appropriate to implement and publish to a greater extent quantitative development targets in the field of household energy. Appendix 2 makes the point that key indicators in the field of household energy to compile, publish, and follow for each country would be: (i) The rate of household electrification (share of households with electric light) and (ii) household adoption of modern cooking fuels.

These indicators are feasible to measure and to adopt as a quantitative development targets alongside other targets. They are available from Demographic and Health Surveys (DHS) as well as from LSMS and other household surveys for a substantial number of countries. Greater use of household energy indicators such as those proposed in appendix 2 have the potential to draw more badly needed attention to household energy among development practitioners and researchers.

Limited analysis using small sample sizes available at this time show that modern cooking fuel use has been growing in several countries at a fairly encouraging speed and reacts to economic growth as expected. Among 22 panel observations on household electrification analyzed, all but 3 countries have been growing over time; the average growth in electrification (over a time period that varies but may average 5 years) is 2 percentage-points.

To complement these statistics on energy access, indicators on affordability and quality are required. Affordability of electricity can best be measured based on utility tariffs for representative consumers, say households consuming 100 KWH or 200 KWH per month. Budget share data are not good indicators of affordability. The traditional energy package consumed by the ‘energy poor’ consists of only biomass for cooking and a small amount of either kerosene or candles to provide a limited amount of lighting at nighttime; to save on lighting costs unelectrified households are known to cut back on nighttime activities. The data on budget share represent a combination of access and affordability factors, and is therefore not easy to interpret.

1. INTRODUCTION

Energy and fuel use are important for the welfare of households in developing countries. Using an energy source for lighting and cooking is essential to human life and part of what first defined the human race as separate from animals in pre-historic times.

To this day, many people remain dependent on traditional biomass fuels for cooking and on inefficient and costly sources of light such as candles and kerosene. Improving access to modern energy sources – electricity for light and appliances and clean cooking technologies – is an important development goal; it is complementary with other goals of development such as improving health and education.

Purchase of energy claims a substantial portion of poor people's budgets, and collection of cooking fuels often absorbs a significant amount of time for women and children. Efficient lighting is crucial for educational performance because it enables studying at night. Clean cooking fuels are important for combating the high levels of indoor air pollution encountered whenever traditional solid fuels are used for cooking or heating. The use of clean cooking fuels can also have positive effects on the external environment by reducing outdoor air pollution from venting of kitchen smoke as well as by combating forest degradation; collection of wood for firewood or charcoal production is thought to contribute to forest degradation in certain locations, especially near cities and major roads (ESMAP, 2001; Heltberg, 2001). Modern fuel and energy use can improve productivity in numerous ways, for example by re-directing scarce labor, biomass and land resources away from fuel collection and production towards agricultural and other uses. This is seen most clearly in the case of animal dung, which is used in South Asia and parts of Africa as a household cooking fuel instead of as a fertilizer.

Policy interventions targeting cooking fuels and cooking practices were earlier mostly motivated from a desire to control deforestation; increasingly, such interventions are now being motivated due to concerns regarding indoor air pollution. Indoor air pollution has been estimated by the WHO (2002) to be the world's 4^{th} largest killer, causing perhaps 2.5 million premature deaths a year. Policies to reduce indoor air pollution focus on either inducing a healthier fuel choice or on making biomass use cleaner and safer, for example through improved stoves or better ventilation in the cooking area.

Household energy is therefore as important as ever. It is however unfortunate that there exist a relative lack of solid data on household energy. For example, the World Bank's *World Development Indicators* – a broad-spanning and fairly comprehensive source of statistics on many development-related issues – does not contain a single indicator on household fuel use. Neither does it contain indicators on household access to electricity (nor to the affordability or quality of electricity services. Policy relevant indicators that could be usefully adopted to help improve the statistical foundation for international household energy policy are discussed in appendix 2 of this report. It is here documented that comparable, nationally representative indicators of cooking fuel use and electrification coverage are already available for a substantial number of countries. The appendix makes a first attempt at compiling these indicators in a comparable cross-country format.

Policy analysis and thinking concerning fuel choice is usually rooted in the concept of the energy ladder. The energy ladder theory posits that in response to higher income and other factors households will shift from traditional biomass and other solid fuels to more modern and efficient cooking fuels such as LPG, kerosene, natural gas, or even electricity. This process is usually termed ‘fuel switching’ or ‘interfuel substitution’ (Barnes and Qian, 1992; Hosier and Kipondya, 1993; Leach, 1992).

Unfortunately, many authors and practitioners in the field of household energy use the terms fuel switching and interfuel substitution in an imprecise fashion. Uptake of a new cooking fuel is sometimes mistakenly referred to as ‘fuel switching’. Since uptake of a new fuel far from always displaces previously used energy sources, this confusion of terminology is far from innocuous. Many households in developing countries routinely use multiple cooking fuels. That is why introduction of a new fuel may not displace other fuels. In fact, if uptake of a new fuel coincides with an expansion of household energy consumption it may not even reduce the consumption of other fuels.

The confusion between fuel uptake and fuel switching can affect energy policy – it may lead to excessive optimism regarding the potential for hydrocarbon fuels to displace firewood. A cool-headed assessment is required of the extent to which hydrocarbon-cooking fuels displace traditional cooking fuels and thereby combat indoor air pollution. What are the variables that drive fuel choice? And how do these variables affect interfuel substitution? Which households are potential targets for fuel interventions?

This paper is an attempt to address these issues in a systematic fashion using a multicountry database. It does so mainly by comparing patterns of energy use, energy spending, and fuel switching across eight very diverse developing countries: Brazil, Nicaragua, South Africa, Vietnam, Guatemala, Ghana, Nepal, and India. In doing so, this report builds upon a large body of work on household energy carried out in the World Bank and other places during the 1980s and 1990s. Much of that earlier research was based on specialized energy surveys – see Barnes, Krutilla, and Hyde (2002) for a summary of many of the earlier findings; The earlier research has been a great source of inspiration and has, among other things, helped formulate many of the questions addressed here.

A major motivation for this study is that formulation of policy reform in the energy sector requires solid and up-to-date information on fuel usage, electricity coverage, distributional implications of subsidies and taxes, and the affordability of energy prices. The analysis of this report helps confirm a number of stylized facts regarding household energy use, and sheds new light on old questions. The question in focus include:

- Which cooking fuels are used by the poor/the middle classes/the rich? Who have access to electricity?
- What would be the distributional implication of any energy pricing reform? What would be its implications for the affordability of energy for specific user groups? Who benefit from current energy subsidies and/or who pay the costs of taxes?
- What are the drivers of household fuel choice and fuel switching? How does electrification relate to fuel switching?
- Why do households well up the income distribution continue using firewood, even when the cost of instead using LPG or kerosene would not appear prohibitive?
- How can government policies be designed to promote fuel switching, thereby increasing household welfare and reducing indoor air pollution?

A purpose-built database with quantitative household survey data from 8 developing countries is used to address these and other questions. The data has been made comparable to the extent possible. All surveys are nationally representative and, as a minimum, support analysis of the distribution of fuel usage and fuel expenditures across income categories. The data sources are LSMS surveys except for India, where the NSS survey is used.

After this introduction, Chapter 2 briefly discusses theoretical approaches to analyze household energy choices, while Chapter 3 introduces the multicountry database used in the main part of this report. Chapter 4 describes the basic patterns of energy usage found in the study countries, and in Chapter 5 fuel switching is considered. Energy affordability is assessed in Chapter 6, while Chapter 7 takes a detailed look at the data on spending and usage of LPG and kerosene in India and Brazil. Chapter 8 starts by discussing the determinants of household fuel usage – building on regression results reported in appendix 1 – followed by a closer analysis of the relationship between fuel use and access to electricity and water. Concluding remarks and suggestions for future research are offered in Chapter 9.

2. THEORIES ABOUT HOUSEHOLD FUEL CHOICE

Household fuel choice has often been conceptualized using the "energy ladder" model. This model places heavy emphasis on income in explaining fuel choice and fuel switching.

The energy ladder model envisions a three-stage fuel switching process. The first stage is marked by universal reliance on biomass. In the second stage households move to "transition" fuels such as kerosene, coal and charcoal in response to higher incomes and factors such as deforestation and urbanization. In the third phase households switch to LPG, natural gas, or electricity. The main driver affecting the movement up the energy ladder is hypothesized to be income and relative fuel prices (Leach, 1992; Barnes, Krutilla, and Hyde, 2002; Barnes and Floor, 1999).

The major achievement of the energy ladder model in its simplest form is the ability to capture the strong income dependence of fuel choices. Many energy surveys, conducted mostly in urban areas, have found a strong normality of modern fuel consumption. Yet the ladder image is perhaps unfortunate because it appears to imply that a move *up* to a new fuel is simultaneously a move *away from* fuels used hitherto. In other words, the risk of confusing fuel choice and fuel switching is embodied in the energy ladder model.

Evidence from a growing number of countries is showing multiple fuel use to be common; the fact that households consume a portfolio of energy sources spanning different points of the energy ladder does not fit easily with the traditional energy ladder model (see for example Barnes and Qian, 1992; Hosier and Kipondya, 1993; Davis, 1998). This phenomenon has been termed fuel *stacking* (Masera, Saatkamp, and Kammen, 2000).

To the extent multiple fuel usage for cooking is the norm, promotion of petroleum fuels may not induce the abandonment of traditional fuels and may therefore generate fewer benefits than sometimes hypothesized.

It is illuminating to consider the exceptions from the general energy model. In many countries, one can find a substantial number of non-poor households who in principle could afford modern, clean and convenient fuels yet continue to rely fully or partly on traditional fuels. A number of plausible reasons have been advanced to account for this *firewood puzzle*. Sometimes there is a preference for cooking with fuelwood due to the taste or texture it imbibes to food or due to the ability to use certain traditional cooking techniques. There is little indication that the smoke from solid fuels is perceived as a nuisance by large numbers of households; however, women's time savings from cooking with modern fuels seem to a major factor in fuel switching decisions. Other times, factors relating to the supply of modern fuels may curtail their full impact: households may be rationed due to supply shortages in fuel markets; large distances to retailers can be prohibitive, especially in rural areas; waiting lists for access to government-distributed fuels was a major issue in India until recently. Moreover, the affordability of modern fuels needs to be seen in light of the 'lumpiness' of modern fuel expenditures: whereas fuelwood costs are evenly spread out, modern fuel expenditures tend to come in spikes with particularly severe start-up costs. The uptake costs of LPG and natural gas are often thought to deter potential users. Better understanding of the obstacles for greater spread of clean cooking fuels would clearly be of policy interest.

The new perspective on household energy choice sees it as a portfolio choice more than as a ladder. Households' energy portfolio can be described by their size, composition, and diversification. Heltberg (2003) outlines how a household economic model can help incorporate opportunity costs – influenced by factors such as education and the availability of labor and natural resources – to study energy use. This perspective is important when households use biomass they produce or collect themselves in an environment of imperfect or missing markets. Self-collected fuels do not have a monetary cost; their collection and use is guided by opportunity costs that depend on the productivity of labor in fuelwood collection vis-à-vis the opportunity cost of time in alternative employment (Heltberg, Arndt, and Sekhar, 2000).

3. DATA SOURCES ON HOUSEHOLD ENERGY

Most of the empirical results reported in this paper are based on the following household survey data sets:

- India: National Sample Survey Organisation (NSS) 55th round, 1999/2000
- Guatemala National Survey of Living Conditions (ENCOVI), 2000
- Nicaragua Living Standard Measurement Survey, 1998
- Vietnam Household Living Standards Survey (VLSS II), 1997/98
- South Africa Integrated Household Survey, 1993/94
- Brazil: Pesquisa Sobre Padrões de Vida, 1996/97
- Ghana Living Standards Survey (GLLS4), 1998/99
- Nepal Living Standards Survey I, 1995/96

LSMS and similar household surveys are becoming increasingly popular as a readily available – if not ideal – source of data to assess energy sector reform (Foster and Tre, forthcoming; refs). The surveys mentioned above were chosen for the most part because they contain somewhat more information on household energy and fuel use than the average LSMS survey. This section describes how relevant information was extracted from the surveys in a comparable fashion. In addition, Appendix 2 draws upon information from Demographic and Health Surveys (DHS) and other sources to discuss means of improving the available international statistical information on household energy issues also for countries not covered in the main part of this report.

3.1 Energy data

Energy generally appears in two different parts of any LSMS survey: In the housing section and in the expenditure section. Table 1 summarizes the kind of energy information that was extracted from each survey for the purposes of this report.

In the housing section, respondents are asked questions about amenities and network services such as water supply, sanitation, garbage collection, and energy for light and cooking. LSMS surveys generally ask for the source of lighting and the most common cooking fuel(s); many surveys, though, only provide for enumeration of one major cooking fuel. Since usage of multiple cooking fuels is widespread, and given the aim of this paper to study fuel switching, surveys that only enquire about one cooking fuel are of limited use. Thus, all of the above surveys except India, Ghana, and Nicaragua contain provisions for listing both the households' primary and its secondary cooking fuel. This enables construction of dummy variables for the two most commonly used cooking fuels.

In addition, households are probed for expenditures on cooking fuels. And the source of lighting is always provided, often along with expenditures on electricity and lighting. This enables construction of a dummy variable for whether the household is electrified; one can safely assume that households with access to electricity (be it grid or non-grid) would name electricity as their main source of lighting.

Energy re-appears in the expenditure section. Here, households are asked to report their expenses on electricity and fuels. With some exceptions, only amount spent is reported; quantity of each energy source consumed is often not available. And where it is available the information is often not reliable.[1]

The energy expenditure data enables an adjustment to the dummies for fuel usage. If a household reports expenditure on LPG the dummy for LPG usage can be adjusted to reflect this, even if LPG was not mentioned as one of the main cooking fuels. The same adjustment can be made for wood and other solid fuels.[2] The last column of Table 1 documents the information that went into identifying the variables measuring fuel usage.

The expenditure section also allows the construction of a variable for the total amount spent on electricity and purchase of cooking and lighting fuels. This can be compared to total real household expenditures in order to judge the importance of energy in household budgets. I use the measure of aggregate expenditures that is provided along with each set of survey data.

These LSMS surveys provide a mixed amount of information on energy use. Their advantage is that they allow identification of the major fuels used; they are reasonably comparable across countries; they allow computation of the budget share devoted to energy; and energy use can be correlated with other variables thought to influence fuel choice.

In addition, a few surveys provide a more detailed picture of energy use. This is true of Nepal, Guatemala, and South Africa. The Nepal and Guatemala surveys collected additional information on fuelwood collection practices and type of stove. South Africa and Guatemala asked for a detailed breakdown of the purposes for using each energy source.

[1] Energy quantities are subject to special recall problems. LPG consumption cannot be estimated as fractions of a cylinder: only if households are asked cylinder refill frequency can LPG consumption reliably be estimated. It is unrealistic to expect households to recall electricity consumption in kilowatt-hours; they would need to show the actual bill to the enumerator. Firewood consumption is often measured in headloads – enumerators would need to weight a typical headload. These necessary steps to ensure the quality of energy quantity data are usually only taken in specialized energy surveys, not in all-purpose household surveys.

[2] The vast majority of fuel use observations come from the information on major cooking fuel(s), not from these adjustments. The adjustment does not work for kerosene, however, since kerosene can be used for both lighting and cooking. This is not really a drawback since arguably the use of kerosene for occasional cooking complementing the household's other fuels does not constitute genuine *fuel switching.*

In conclusion, the amount and quality of energy information collected by LSMS surveys is mixed. The importance attached to energy in many LSMS survey questionnaires seems unreasonably small, especially when compared to the detailed questions on other aspects of household welfare such as education, water, sanitation, and health. They could easily be improved. A major improvement would be to consistently ask households for the two most commonly used cooking fuels. Firewood users need to be asked the source of their wood. Households consuming LPG should also be asked the refill frequency of their cylinder(s).

For expenditures, total daily per capita expenditures were used. [3] Quintiles and deciles are in this paper defined separately for urban and rural areas (referred to as "sectorally defined deciles"). This implies that a given urban quintile/decile will have average real per capita expenditure that is higher than the corresponding rural quintile/decile. This needs to be kept in mind when interpreting tables and figures, but it does not affect the estimated income effects in regression analysis that are based on the raw rather than the tabulated data.[4]

Table 1: Summary of energy information available in household surveys

Country	Main cooking fuel asked?	Secondary cooking fuel asked?	Fuel expen-ditures	Source of lighting asked?	Lighting expen-ditures	Energy quantities	Cooking fu usage as defin this report is b upon:
Brazil	Yes	Yes	For main and 2nd fuel	Yes, main and 2nd	For main and 2nd source	No	Main and 2nd
Nicaragua	Yes	No	Total fuel exp.	Yes, main	Electricity expenses	No	Main fuel on
South Africa	Yes	Yes	By fuel	Yes, main and 2nd	By fuel	No	Main and 2nd amended w spending*
Guatemala	Usage, purpose and spending asked for each fuel type					Yes, by fuel	Fuel usage f cooking
Vietnam	Yes	Yes	By fuel	Yes, main	By fuel	No	Main and 2nd amended w spending*
Ghana	Yes	No	By fuel	Yes, main	Electricity + kerosene/pal m oil expenses	No	Main fuel amended w spending*
Nepal	Yes	Yes	By fuel	Yes, main	By fuel	For firewood	Main+2nd fuel amended spending*
India	Yes	No	By fuel	Yes	By fuel	Yes, by fuel	Main fuel amended w

[3] In most cases a measure of total household expenditures adjusted for spatial and sometimes temporal price differences is provided from the World Bank's LSMS office along with the raw data files. For the Indian NSS data, I use a spatial Tornqvist price index calculated by Deaton (2001,Table 3 column 5) to deflate total monthly expenditures.

[4] In much of this report, urban and rural areas are treated as quite distinct. It is therefore appropriate to define deciles sectorally so as to think of the urban and the rural income distribution as distinct; the advantage is that tables and figures are based on equally sized groups in each sector.

							spending*

Note *: spending on kerosene does not affect the dummy for use of kerosene for cooking; kerosene-spending information does not differentiate between kerosene used for cooking and for lighting.

4. PATTERNS OF ENERGY USE

In this chapter, basic descriptive ‘stylized facts’ regarding patterns of electrification, usage of modern fuels, and usage of traditional solid fuels are presented.

4.1 Electrification

Table 2 shows the share of households with access to electricity in rural and urban areas in the study countries calculated on the basis of the raw survey data. The data are for use of electricity for lighting – regardless of the source and the quality of electricity. In addition, Figure 1 shows the same data broken down by both sector and quintile.

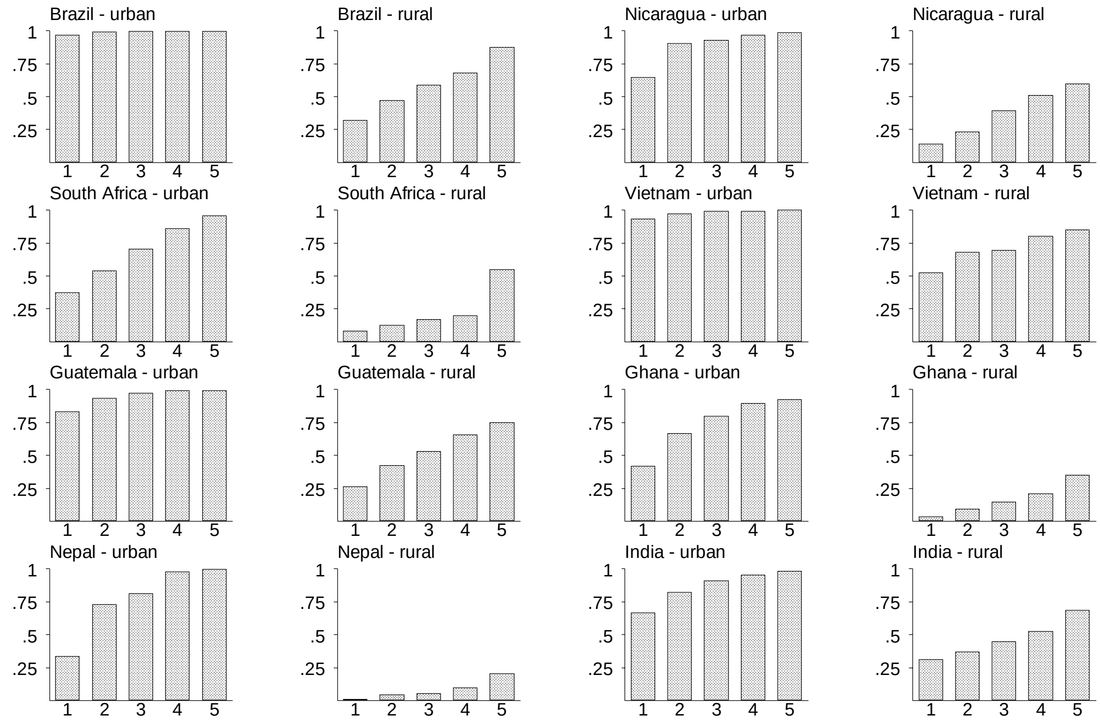
Urban areas expectedly are much more electrified. Moreover, electrification tends to be uniformly high in urban areas, depending less on income than in rural areas. In rural areas the difference in electricity access between the bottom and the top quintile is often very large. It is typically the case that the bottom urban quintile has a higher connection rate than the top rural quintile.

4.2 Usage of non-solid fuels

Table 2 also shows the extent to which modern nonsolid cooking fuels penetrate the study countries. As explained in Chapter 3, the table is based on the survey questions regarding the household’s main and secondary cooking fuel amended by information on LPG expenditures.

As could be expected, there are enormous differences in the extent to which nonsolid fuels are used in the study countries. This difference would appear to correlate well with average income levels in the countries concerned. For example, the cross-country correlation between the share using any non-solid fuel and average per capita expenditure is 0.84.

Figure 1: Electrification



Electrification rates by country, sector and quintile

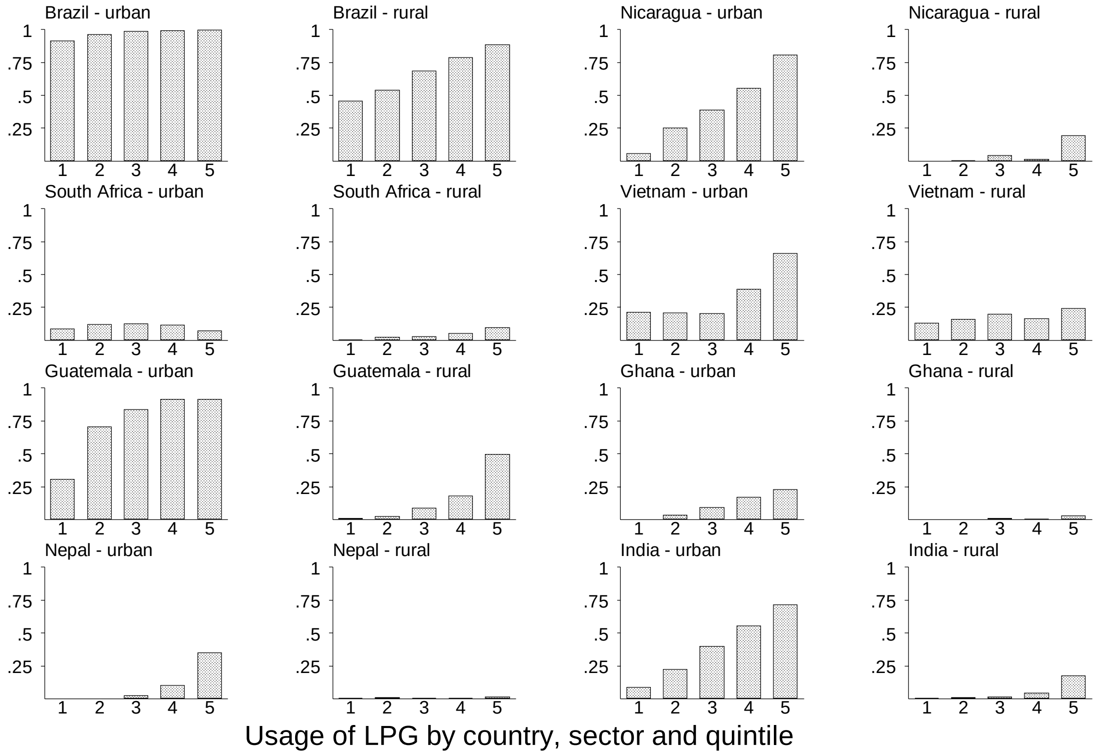
Table 2: Electrification status and usage of modern cooking fuels (share of households)

	Electrified	LPG for cooking	Kerosene for cooking	Electricity for cooking	All nonsolid cooking fuels
Brazil	0.92	0.92	0	0.02	0.93
Nicaragua	0.69	0.29	0.02	0.01	0.32
South Africa	0.54	0.08	0.43	0.46	0.86
Vietnam	0.78	0.22	0.08	0.13	0.33
Guatemala	0.73	0.45	0.05	0.02	0.50
Ghana	0.41	0.05	0.01	0	0.07
Nepal	0.14	0.02	0.07	0	0.09
India	0.59	0.16	0.08	0	0.24

Notes: Row shares of individual nonsolid fuels may not sum to the total for all nonsolid fuels due to multiple fuel use by households.
[a] The Brazil questionnaire does not allow distinction between LPG and other types of gas (piped gas).

More surprising, however, is the fact that the relative importance of the different nonsolid cooking fuel differs markedly. LPG is by far the most widely used modern fuel in Brazil, Ghana, Central America, and India. Kerosene is the most widely used nonsolid fuel in Nepal; it is also quite important in India. South Africa is a special case – kerosene and electricity are both very widespread for cooking at 44 percent, while LPG is little used there.

Figure 2: Use of LPG



Note: For Brazil, the data refer to LPG plus natural gas.

Figure 3: Kerosene use for cooking

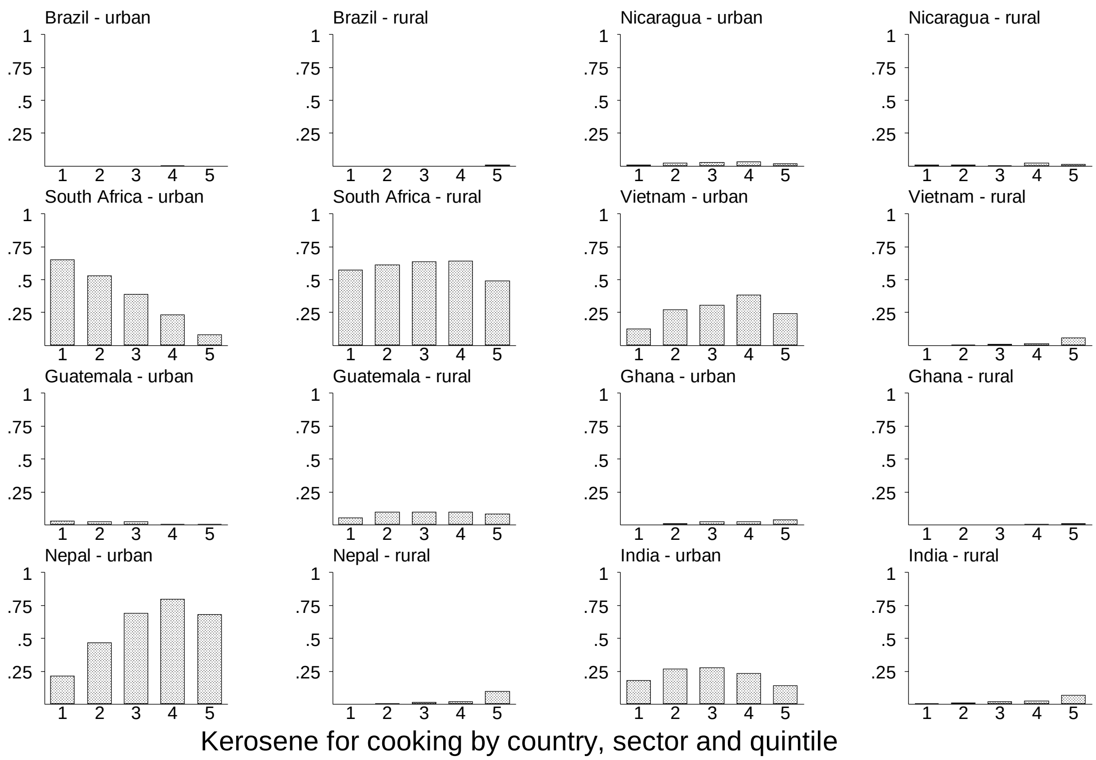
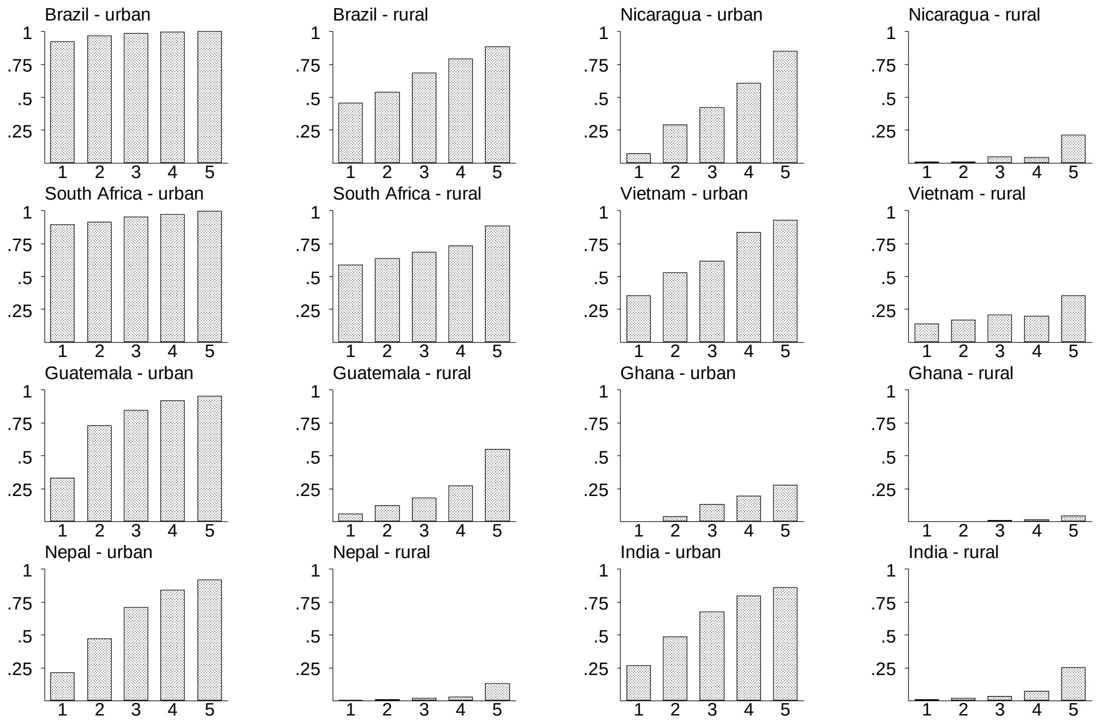


Figure 4: Non-solid fuel use



Usage of non-solid cooking fuels by country, sector and quintile

Figure 2 shows how usage of LPG is distributed across income groups in each of the sample countries; Figure 3 does the same for kerosene as a cooking fuel. Figure 4 combines the use of all nonsolid cooking fuels into a single indicator, showing how uptake of modern fuels varies across countries, sectors, and quintiles. The figures demonstrate that LPG and use of any nonsolid fuel more generally consistently is much higher in urban as compared to rural areas. The figure also shows non-solid fuel penetration to grow with quintile. This demonstrates a strong income-dependence and normality in the usage of clean cooking fuels such as LPG and electricity.

For kerosene, there is no universal pattern of growing or declining usage across the income distribution (see Figure 3). Kerosene for cooking is mostly found in urban areas of low-income countries with the exception of South Africa. The most common pattern is for kerosene usage for cooking to first increase with expenditures and later decline. This is consistent with the notion that kerosene might play the role of a transition fuel at an intermediate level of the energy ladder between solid fuels and LPG.

Some countries subsidize the consumption of modern cooking fuels directly or indirectly. The fiscal cost of such subsidies can be large. Because of fiscal constraints, fuel subsidies sometimes cause supply shortages, restricting access to the fuels they are meant to promote. Moreover, subsidies on recurrent use of any good, including energy, often create vested interests that will lobby for their continuation. Subsidies are therefore hard to reverse even when they become fiscally unsustainable. Jensen and Tarr (2002) have shown using a Computable General Equilibrium model for Iran that if energy subsidies are replaced with direct income transfers the intended beneficiaries will be much better off.

Figure 2 and Figure 4 clearly suggest that unless careful targeting is in place, such subsidies will often benefit many better-off households and fail to reach many poor households. Households in the upper urban quintiles consistently show much higher LPG penetration than rural and low-income households. The exception is kerosene, the modern fuel that is used the lowest down the income distribution. An alternative policy of subsidizing uptake costs such as LPG cylinder deposits or a one-off electricity connection charge could in some cases be considered (ESMAP, 2000). The advantage of this is the better distributional profile of directing the subsidy to new users lower down the income distribution than the average existing user. The fiscal costs of subsidizing uptake may also well be more manageable, and does not create a vested interest among benefiting consumers lobbying for its continuation in the way that subsidies on recurrent use do.

The amount of kerosene consumed by the typical user is shown in Table 3 for Nepal, India, and Guatemala. It could not be calculated for the other countries. The table shows total kerosene consumption for all households using kerosene as the main cooking fuel; only in the case of Guatemala was it possible to distinguish between kerosene used for lighting and for cooking. This shows that cooking with kerosene consumes a far greater amount than lighting. A ‘typical’ amount of kerosene when used as the primary cooking fuel is around 15 liters per month in Nepal and India (the mean and the median do not differ much here). In Guatemala, a small number of very high kerosene observations distort the average; when those outliers are removed, the average is only 4 liters per month. This low figure is because kerosene is often used to supplement other fuels (The Guatemala survey does not identify primary and secondary cooking fuel).

The table also shows that the public distribution system (PDS) in India does manage to supply subsidized kerosene to the poor – households in the bottom deciles cooking with kerosene obtain on average 7-8 liters per month of kerosene from the PDS. In rural areas, the corresponding figure is 5-6 liters. This is insufficient to meet cooking needs and all deciles procure substantial additional quantities of kerosene from the private market where prices are higher. The PDS system also supplies significant amounts of kerosene to non-poor consumers.

Table 3: Quantity of kerosene consumed for households cooking with kerosene (in liters per month)

	Sectoral decile										
Country	1	2	3	4	5	6	7	8	9	10	Total
Nepal											
Urban	15.8	24.9	20.6	14.2	15.5	17.6	19.7	16.7	17.4	16.1	17.3
Rural	0.0	0.0	0.0	0.0	8.9	17.8	23.0	22.2	13.9	13.1	14.9
India											
Urban											
From the Public Distribution System (PDS)	7.9	7.5	7.3	8.1	8.0	7.4	6.5	7.2	3.3	2.9	6.7
From the market	6.7	9.2	8.8	8.8	8.7	9.7	9.8	10.3	9.8	8.4	9.2
Total	14.6	16.7	16.1	16.9	16.7	17.1	16.3	17.4	13.0	11.2	15.8
Rural											
From the Public Distribution System (PDS)	5.4	5.9	4.7	5.6	5.3	5.0	5.9	6.0	3.7	3.7	4.5

From the market	2.5	5.0	6.5	7.3	9.0	7.5	8.6	8.6	8.9	9.1	8.5
Total	7.8	10.9	11.1	12.9	14.2	12.4	14.5	14.5	12.6	12.8	13.0
Guatemala (all values)											
Urban											
For lighting	2.1	0.3	1.5	0.5	0.3	0.7	0.1	0.2	0.0	0.0	0.8
For cooking	2.3	1.8	4.6	1.8	5.5	104.9	1.9	6.4	4.7	4.0	14.3
Total	4.4	2.2	6.1	2.2	5.8	105.5	2.0	6.6	4.8	4.0	15.1
Rural											
For lighting	1.4	2.3	3.1	19.9	3.1	1.9	3.2	1.5	1.9	0.9	3.8
For cooking	1.1	1.8	2.6	6.2	5.3	1.7	2.9	2.2	8.6	10.4	4.9
Total	2.5	4.1	5.7	26.1	8.4	3.6	6.1	3.7	10.5	11.2	8.7
Guatemala (outliers exceeding 50 liters/month excluded)											
Urban											
For lighting	2.1	0.3	1.5	0.5	0.3	0.9	0.1	0.2	0.0	0.0	0.8
For cooking	2.3	1.8	4.6	1.8	3.9	2.5	1.9	6.4	4.7	4.0	3.3
Total	4.4	2.2	6.1	2.2	4.2	3.3	2.0	6.6	4.8	4.0	4.2
Rural											
For lighting	1.4	2.3	2.3	2.3	3.3	1.9	3.2	1.5	1.9	0.9	2.0
For cooking	1.1	1.8	1.8	1.9	2.7	1.7	2.9	2.2	2.0	3.9	2.4
Total	2.5	4.1	4.1	4.2	6.0	3.6	6.1	3.7	3.9	4.7	4.3

Note: All values are means for households using kerosene as their main cooking fuel (in Guatemala: for households using kerosene as one of their cooking fuel(s)). For Guatemala and India, the data was provided directly in the household surveys used for the study. For Nepal, the data were calculated as the quantities implicit from the stated value of kerosene based on a national (administered) kerosene price of Rs 8.5/liter prior to April 4, 1995 and Rs 9.5 after that date.

4.3 Energy poverty

The concept of energy poverty has been increasingly debated in recent years (IEA, 2002). Energy poverty is often defined as lack of access to modern energy services. The extent of energy poverty in the sample countries is shown in Table 4. For the purpose of this table, energy poverty is defined as being unelectrified and consuming only solid cooking fuels; the energy poor may well consume commercial energy sources such as charcoal, marketed wood, or kerosene for lighting (but not for cooking).

Table 4: Energy poverty - unelectrified households consuming only solid cooking fuels

	Urban	Rural	Total
Brazil	0	0.2	0.04
Nicaragua	0.09	0.59	0.31
South Africa	0.03	0.22	0.12
Vietnam	0.02	0.23	0.18
Guatemala	0.03	0.36	0.22
Ghana	0.21	0.79	0.58
Nepal	0.15	0.89	0.84
India	0.09	0.5	0.39

Defined in this manner, energy poverty ranges from 4 percent of households in Brazil, 12 percent in South Africa, 58 percent in Ghana, and 84 percent in Nepal. It is little surprising that energy poverty is higher in rural areas and in poorer countries. Among the poorer of the sample countries Vietnam stands out with only 18 percent energy poverty due to its achievements in electrifying large parts of the country.

4.4 Solid fuel use

Table 5 shows the proportion of households cooking with different solid fuels in the study countries. There is enormous variation across countries, reflecting differences in living standards to a large extent. The cross-country correlation between the share using solid fuels and average per capita expenditure is -0.9.

In Brazil, only 16 percent cook with a solid fuel (firewood), while 96 percent of Ghanaian households cook with solid fuels (firewood dominates in rural areas; most use charcoal in urban Ghana). Animal dung for cooking is widespread in South Asia with 37 percent of Indian and 28 percent of Nepali households using it. Sixty percent of Vietnamese and thirty-two percent of Nepalese use straw and leaves.[5]

Figure 5 shows that usage of coal or charcoal is mostly an urban phenomenon. Like kerosene, it does not show any distinct universal distributional profile – charcoal usage increases with expenditures in rural Ghana and Vietnam, it decreases in urban South Africa and Vietnam, and it is widely used by all groups in urban Ghana. Data from Demographic and Health Surveys reported in appendix 2 show charcoal usage to be very prevalent throughout much of urban Africa as well as in urban Haiti.

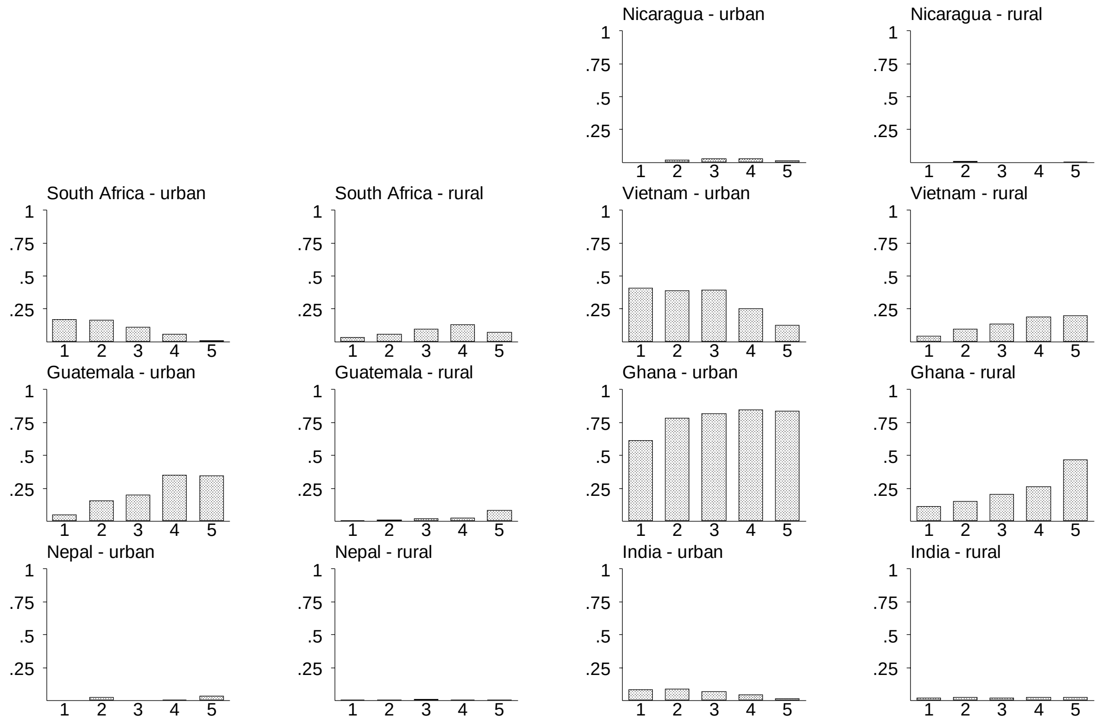
Table 5: Use of solid fuels

	Fuelwood	Coal/ Charcoal	Dung	Straw/leaves/ twigs	Any solid fuel
Brazil	0.16	0			0.16
Nicaragua	0.66	0.01			0.67
South Africa	0.31	0.08	0.01		0.38
Vietnam	0.67	0.18		0.60	0.89
Guatemala	0.74	0.12			0.82
Ghana	0.62	0.46			0.96
Nepal	0.78	0.01	0.28	0.32	0.96
India	0.72	0.03	0.37		0.78

Notes: Row shares of individual solid fuels may not sum to the total for use of any solid fuel due to multiple fuel use by households. [a] The Brazilian questionnaire does differentiate between wood, coal, and charcoal.

Figure 5: Use of coal/charcoal

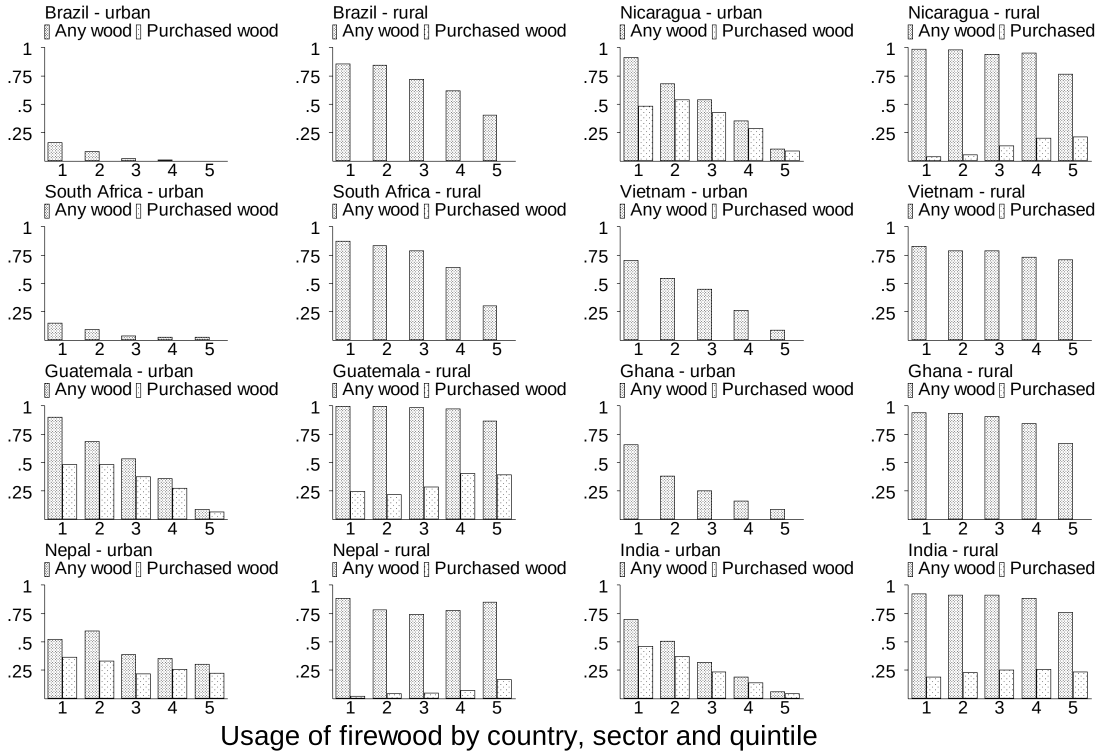
[5] The "straw and leaves" fuel category was not present in the questionnaires for the other countries so no comparison can be made here.



Usage of coal/charcoal by country, sector and quintile

Figure 6 shows that firewood usage is very widespread in rural areas in all of the sample countries. In fact, firewood usage persists well up the rural income distribution in all countries. Many households who would be able to afford other fuels continue cooking with firewood, at least partly. The continued substantial reliance on wood fuels well up the income distribution is something of a puzzle. It challenges the energy ladder model; clearly, household income and the affordability of alternatives cannot be the only reason for using firewood.

Figure 6: Usage of firewood



Note: The Brazilian questionnaire does not distinguish between wood, coal, and charcoal. Hence, some of what is labeled here as firewood could instead be other solid fuels. For India, Nepal, Nicaragua and Guatemala the data distinguishes the source of wood. The figure shows usage of wood from all sources (including market purchases, self-collected, and home grown) as well as usage of wood purchased from the market (where available).

In urban areas use of firewood tends to be associated with the lower quintiles; Heltberg (2003) has shown that many urban households in Guatemala cooking with firewood spend more on wood than those cooking with LPG. Firewood is often a commercial good in urban areas, where most wood consumers purchase their firewood. Wood sold on markets is more or less an inferior good in urban areas – the urban rich cook with LPG and kerosene instead.

In contrast, self-collected or homegrown wood is much more common in rural areas. However, a surprisingly large share of rural households rely on wood purchases. In rural areas the upper quintiles are not surprisingly more likely to purchase their wood. It is surprising however to see that many low-income rural households also purchase wood, for example in Guatemala or India. Summing up, the urban poor in many parts of the world rely on purchased firewood and kerosene. Different fuels matter to the urban poor and the rural poor.

Information on the quantity of wood used is available for Guatemala and India only (see Figure 7). Quantity of firewood used drops with income in urban areas. In rural areas, the amount of firewood used peaks in the middle of the income distribution and only declines to any notable extent in the top decile. This means that income growth cannot be expected to generate significant improvements in indoor air quality in rural areas.

Figure 7: Firewood consumption in India and Guatemala

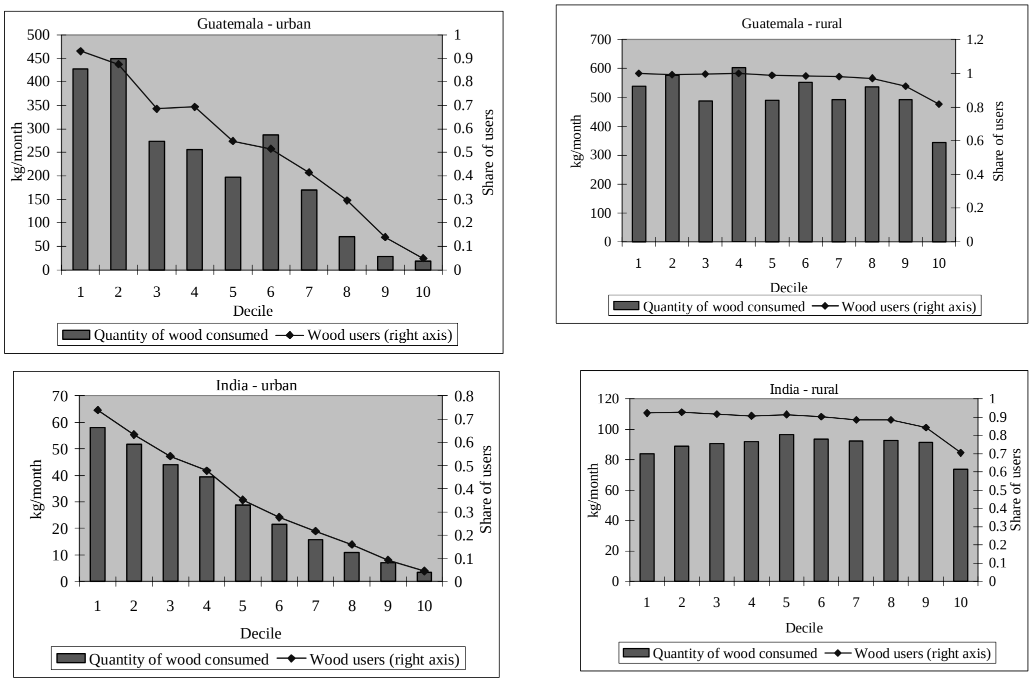


Figure 8: Usage of dung/straw by sector and quintile, select countries

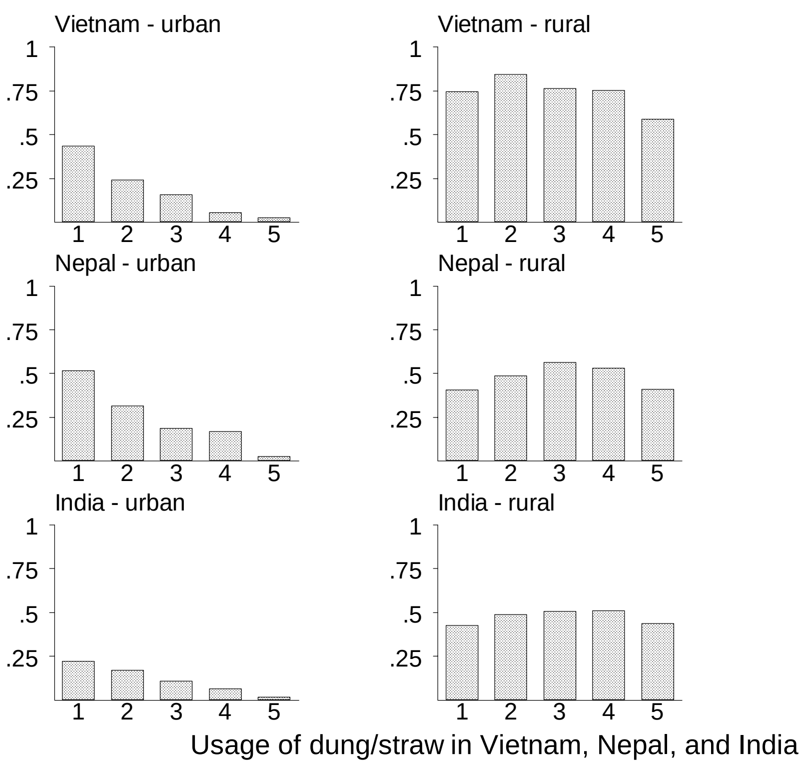


Figure 8 shows those at the lowest rung of the energy ladder – households using dung, straw, or leaves for cooking. In urban areas these inferior solid fuels quickly disappear as one moves up the income distribution. They are much more commonly used in rural areas, and their users are by no means just the poor. In fact, fuels such as dung or straw peak in the middle of the income distribution and remain widely used in the top rural quintile. The implication is again that in rural areas economic development and income growth will not in itself lead to displacement of dirty fuels such as dung. This situation resembles the firewood puzzle, and the potential explanations are similar: the rural elites often own more animals and therefore have easier access to dung; certain traditional foods or methods of preparation sometimes require use of dung; and more generally, users of dung or straw may not perceive these fuels to be undesirable.

Figure 9: Solid fuel use (any solid fuel)

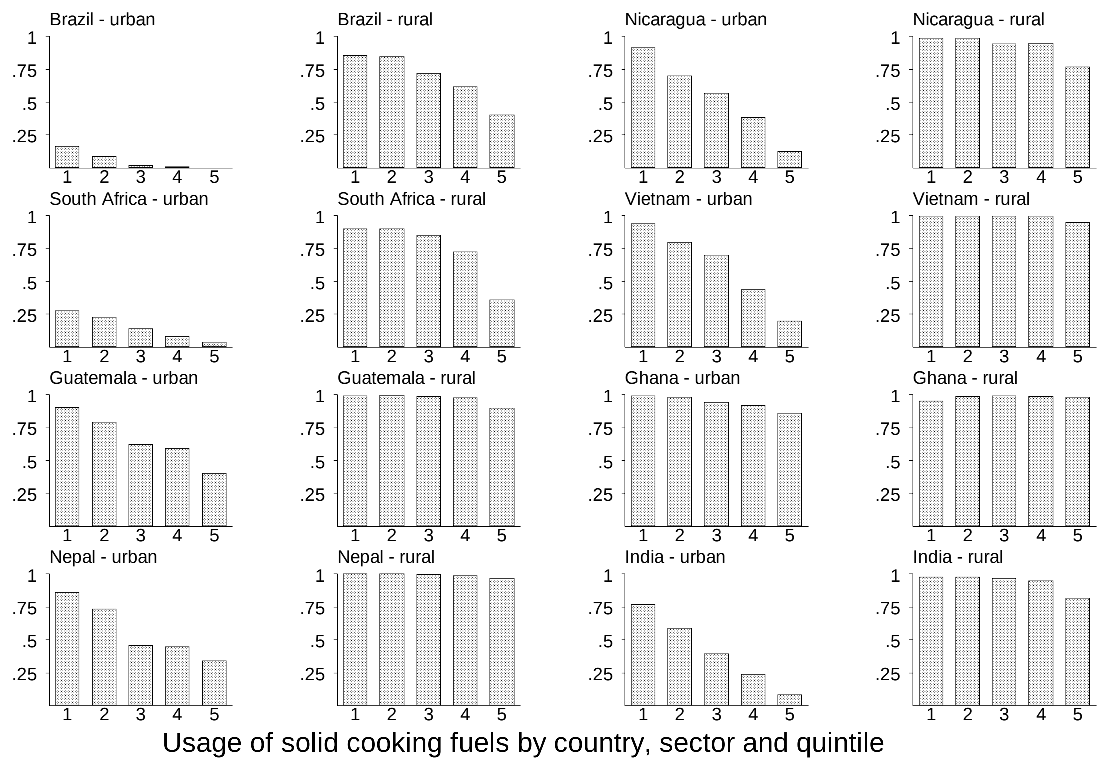


Figure 9 presents a breakdown for all solid fuels combined, where for ease of exposition all of the solid fuels have been aggregated into a single variable. Not unexpectedly, this figure shows a pattern that is the reverse of the picture for nonsolid fuels: solid fuel use is consistently much higher in rural as compared to urban areas. Solid fuel use declines with quintile, especially in urban areas. In many rural areas, however, solid fuel use is nearly universal in all income groups, possibly with some decline in the richest rural quintile. The exception is Brazil and South Africa, where rural solid fuel use shows relatively strong income dependence.

The figures suggest that fuel switching from solid to nonsolid potentially could play quite a role in urban areas of many developing countries. In rural areas, however, fuel switching away from solid fuels and in particular biomass fuels would seem to play a much more modest role except in the higher middle-income countries or among the rural elites of poor countries. We will return to the issue of fuel switching below.

5. FUEL SWITCHING RECONSIDERED

Where the analysis in the previous chapter focused on fuel usage patterns, this section sets out to explore fuel switching. The difference is that fuel switching refers to the displacement of one fuel by another. It remains an empirical question to be addressed here to what extent uptake of modern fuel(s) helps displace solid fuels.

5.1 Fuel switching: an operational definition

Unless some convenient simplification is imposed on the data, fuel switching is horrendously complex to analyze. People consume cooking fuels in a myriad of combinations: wood alone; wood and kerosene; wood and LPG; wood, charcoal and LPG; charcoal and LPG; and so on.

To avoid the confusion of dealing with a large number of categories of fuel combinations, a simplification is imposed. Fuel switching is here defined in the simplest manner possible, as the choice between traditional solid fuels and modern non-solid fuels. In this simplified framework, all households belong in one of three 'exclusive fuel switching' categories:

- No switching – the household consumes only solid fuel(s)
- Partial switching – the household consumes both solid and non-solid fuels
- Full switching – the household consumes only non-solid fuel(s)

Table 6: Fuel switching status, by country

	No switching – only solid fuel(s)	Full switching – only non-solid fuel(s)	Partial switching – both solid and non-solid fuels
Brazil	0.07	0.83	0.09
Nicaragua	0.67	0.32	-
South Africa	0.14	0.62	0.24
Vietnam	0.81	0.11	0.09
Guatemala	0.49	0.17	0.33
Ghana	0.92	0.03	0.04
Nepal	0.91	0.04	0.05
India	0.73	0.20	0.05

Note: The shares do not sum to one since some households have missing data on fuel use, including households reporting their fuel as "other".

The distinction between these three fuel-switching categories is made in order to isolate the problem of what determines fuel switching to a simple, tractable issue that can be studied with the multicountry data at hand. The share of households in each fuel-switching category is shown in Table 6. fuel switching is least progressed in Nepal and Ghana and most advanced in Brazil followed by South Africa.

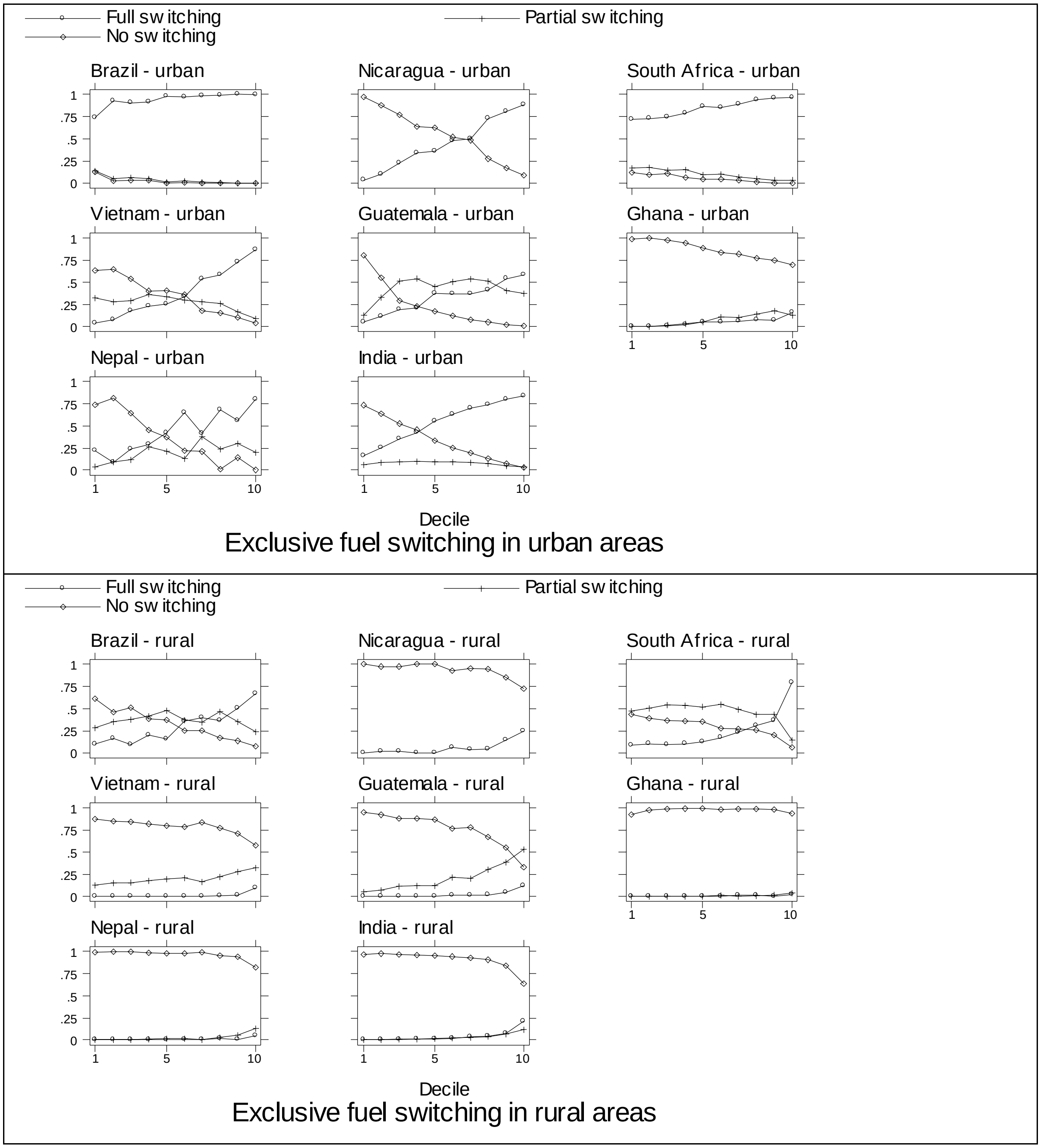
It is not postulated that indoor air pollution is perfectly predicted by the household's fuel switching status as defined here. Many other factors determine smoke levels: location and technique of cooking, ventilation in cooking areas, type of stove, the exact nature of the fuel (dry wood is better than wet wood and dung), and so on. This definition of exclusive fuel switching categories can help analyze the extent to which adoption of modern non-solid fuels displace solid fuels. Displacement of solid fuels to a significant extent is required if modern fuels are to have an impact on combating indoor air pollution and other problems associated with the use of traditional fuels.

Figure 10 shows, for each country, the share of households in each decile in urban areas that belong in the three exclusive fuel-switching categories. **Error! Reference source not found.** shows the same for rural areas. Note that in both figures, Nicaragua does not show any joint solid and non-solid fuel use; this is due to limitations in the survey that does not allow identification of multiple fuel use.

For urban areas of all of the countries, it is clear that the share of households using only solid fuels decreases with decile while the share using only modern non-solid fuels increases. Do they change at the same speed, pointing to solid fuels being displaced? This can be assessed from the share using both solid and non-solid fuels. In urban areas, partial switching is fairly uncommon except in urban Guatemala. The proportion of partial fuel switchers does not generally increase in tandem with the rise in modern fuel use. This suggests that introduction of modern non-solid fuels in urban areas helps displace solid fuels.

The picture is dramatically different in rural areas (see the lower part of Figure 10). First of all it is really only the upper rural deciles that are candidates for fuel switching in many of the poorer developing countries. There is almost no fuel switching what so ever in Ghana and Nepal. The middle-income countries in the sample show some degree of fuel switching throughout the rural income distribution, although in rural South Africa solid fuel displacement happens more often in the upper deciles. Second, partial switching is very predominant in rural areas. This can be seen most clearly in Guatemala where joint use of solid and non-solid fuels (in this case often wood and LPG) is more common at all income levels than complete switching – there is little wood displacement in Guatemala. Partial switching is also very widespread in rural areas of South Africa and Brazil. In fact, partial switching is more common than complete switching in the rural areas of most study countries.

Figure 10: Fuel switching status in urban and rural areas, by decile



Note: Full switching refers to the share of households cooking only with modern fuels; No switching refers to only solid fuel use; and Partial switching refers to joint modern and solid fuel use.

Summing up, modern fuels play a relatively modest role in rural areas of many low-income countries. Here, they are often used mostly by rural elites. And once rural households start using them, modern fuels sometimes complement and sometimes displace solid fuels. The prospect for modern fuels to combat indoor air pollution is therefore significantly better in urban than in rural areas.

Development agencies must target fuel interventions carefully to countries and areas where the purchasing power, infrastructure, and other conditions are present for their adoption. Where adoption of commercial cooking fuels is unrealistic, other energy improvements such as improved stoves or better ventilation of the cooking area would be required. These will also need to take into account the limited purchasing power of target households, and look for low-cost technologies.

6. AFFORDABILITY - ENERGY IN HOUSEHOLD BUDGETS

The cost of purchasing energy is one of the most important interactions between energy and welfare. Pricing of modern energy is often politicized. There are many examples from a variety of countries of energy pricing reforms meeting stiff resistance, sometimes causing those reforms to be cancelled, reversed, or altered. The reason is basically the non-negligible share of energy in household budgets combined with its role as a basic household good; fuels for lighting and cooking are nearly impossible to live without. A high budget share for energy services translates into vulnerability to energy price fluctuations.

In countries and areas where households have shifted out of wood their vulnerability to fuel price fluctuations is increased. To assess these topics, it is important to know the total share of energy costs in household budgets, and the burden imposed on specific groups of households of purchasing individual fuels. This chapter analyzes these affordability issues, looking first at the total energy budget share and next at the budget share of individual energy sources.

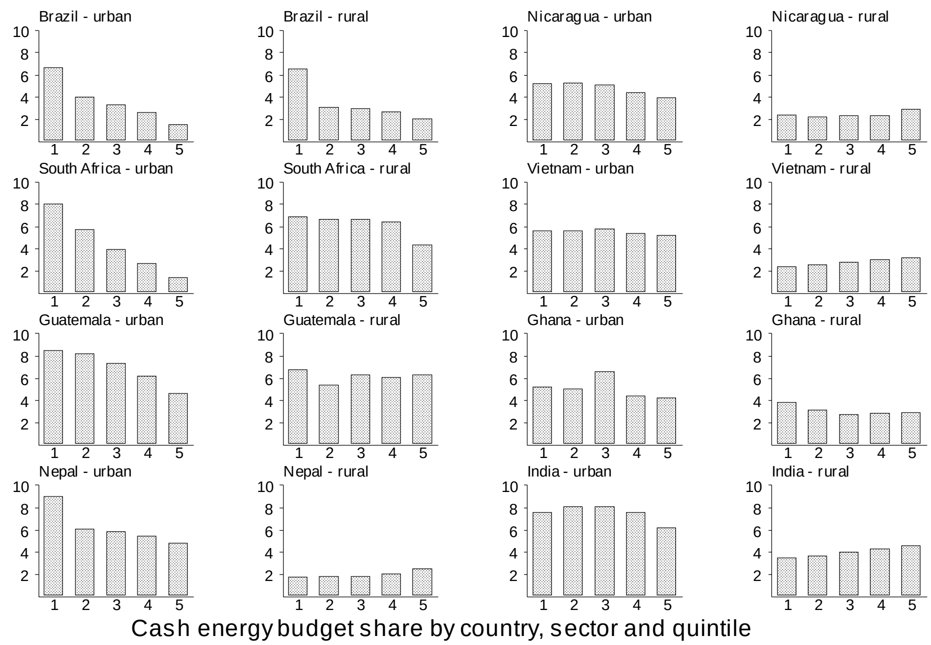
6.1 Total household budget share of energy

Table 7: Average budget share of all household energy (in percent)

(a) Budget share of cash energy (purchased cooking fuels and lighting)			
	Sector		
Country	Urban	Rural	Total
Brazil	3.4	3.24	3.37
Nicaragua	4.78	2.53	3.81
South Africa	3.67	5.93	4.73
Vietnam	5.58	2.88	3.53
Guatemala	6.69	6.22	6.42
Ghana	5	3.11	3.8
Nepal	5.99	2.09	2.38
India	7.46	4.14	5.04
(b) Budget share of all energy (including the value of home-grown, collected, and purchased fuels)			
Vietnam	5.94	4.8	5.07
Nepal	6.18	2.42	2.7
India	7.95	8.29	8.2

Table 7 shows energy outlays as a percentage of total household expenditures. The top panel shows cash energy budget share while the bottom panel includes the imputed value of self-collected and homegrown fuels in countries where this is available. Many caveats apply to these numbers: they are basically ratios between two figures that are both determined with a great deal of imprecision, and are therefore quite uncertain. Moreover, these statistics are sensitive to whether means or medians are reported and how outliers are dealt with.[6] The table above shows simple means with no exclusion of outliers. Using the same data and making different but sensible choices regarding outliers and mean or median one could reach rather different results.

Figure 11: Total energy budget share by quintile



The results need to be interpreted with caution. A low budget share for commercial energy, as is found for example in rural Nepal, is not necessarily a good sign. Rather than reflecting affordable modern energy services, a low energy budget share could simply mean that modern energy services are unavailable or so unaffordable that households resort to biomass reliance; it could also mean that free biomass is available in sufficient quantities so that nobody wants to spend on commercial energy. The 'traditional' energy package consumed by the 'energy poor' consists of only biomass for cooking and a small amount of either kerosene or candles to provide a limited amount of lighting at nighttime; to save on lighting costs unelectrified households are known to cut back on nighttime activities. The data on budget share represent a combination of access and affordability factors, and is not an easily interpreted indicator.

Since energy is a basic good, the budget share of energy tends to fall as incomes increase. Cash energy budget shares are often largest in urban areas; in South Africa, however,

[6] Generally, all results in this paper are based on the full number of observations with no effort to remove outliers. In the case of budget share, however, a few logically inconsistent observations exceeding 100 were removed before taking the means.

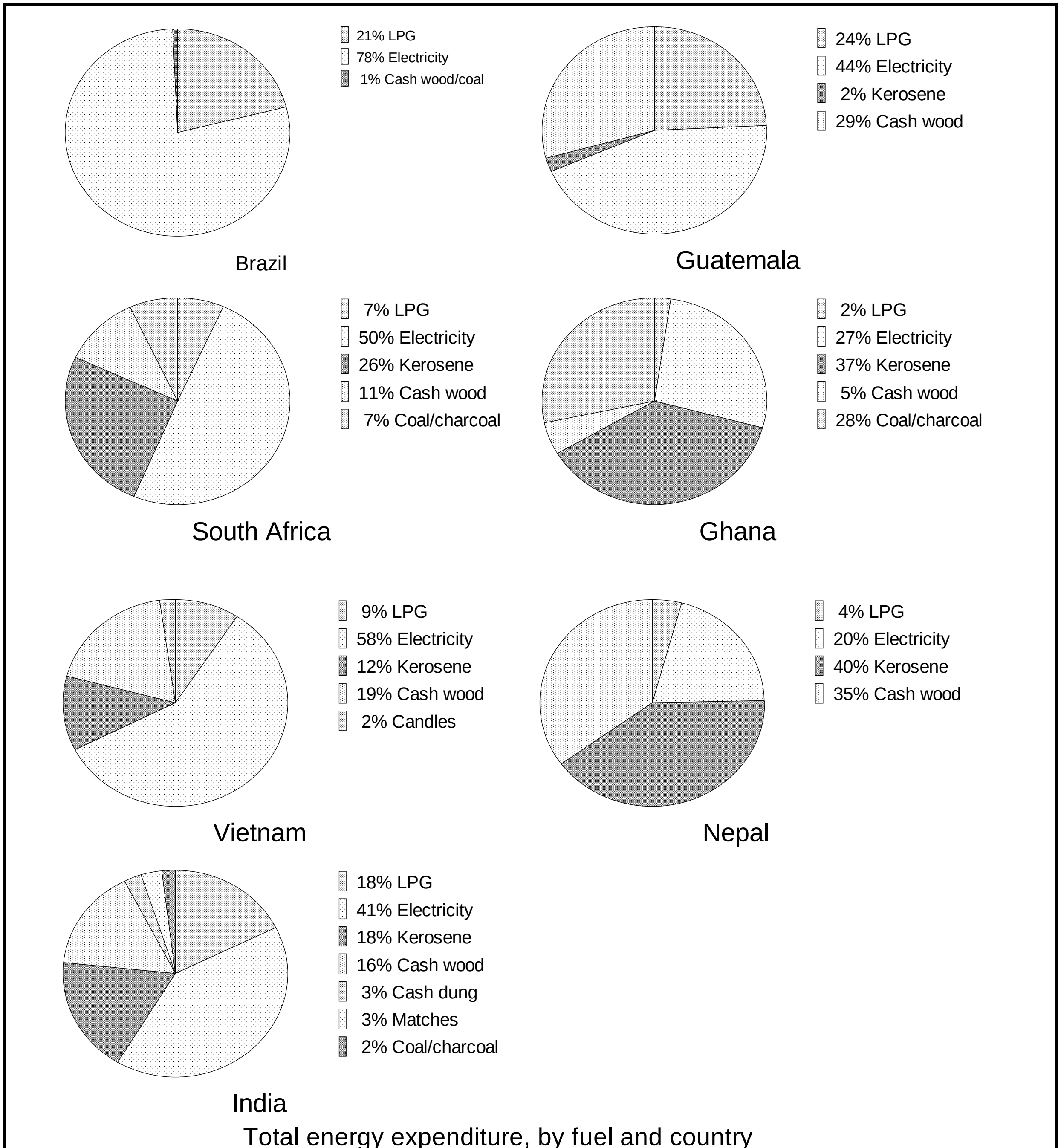
rural households spend more on energy relative to their income and in Brazil it is comparable. Fuel and electricity pricing is politically sensitive and important for poverty. Figure 11 shows that energy budget shares tend to be the largest in low-income urban groups, implying that poor urban consumers are especially vulnerable to energy price fluctuations. In India, however, both rural and urban groups appear vulnerable to changes in fuel and electricity costs.

The tendency for the energy budget share to decrease with income is more pronounced in urban areas. In rural areas people often have better possibilities for substituting collected or homegrown biomass for purchased fuels, and poor rural households are therefore better able to limit their energy expenses and their exposure to energy price fluctuations. And the lack of a electricity may also contribute to lower energy spending among the rural poor; although lighting with kerosene and candles is vastly more expensive per unit of light, the absence of appliances can mean that unconnected households spend less overall on energy than connected households.

6.2 Energy costs

There is very large variation across countries in the composition of households' energy expenditures (see Figure 12). In the poorest countries, biomass and kerosene often feature heavily. In Ghana, kerosene and charcoal are the two largest energy expenditure items. In Nepal, it is kerosene and market wood. In the other countries electricity is the energy source on which most money is spent. Among the cooking fuels, the hydrocarbons (LPG and kerosene) tend to be where most of the fuel budget is spent; however, consumers in Guatemala and Vietnam spend as much or more on wood as they do on hydrocarbons. The significant variation in energy composition and spending implies that detailed local knowledge is required when designing energy market and pricing reforms.

Figure 12: Composition of total energy expenditures, by country



Note: kerosene expenditures include kerosene for ligthing as well as for cooking except in Brazil where kerosene was not included among the ligthing options in the questionaire.

An important aspect when assessing energy subsidies and pricing reform is how the budget shares of individual fuels are distributed across the population. This enables policy analysts to judge which groups benefit the most by subsidies on individual fuels or are hurt by taxes. If the budget share of a particular item increases for growing deciles it means that taxes on that item would be progressive and that subsidies would be regressive (that is, subsidies would be distributed more unequally than overall expenditure).

The budget shares of individual energy sources in each country, sector, and quintile are shown in Figure 13 for electricity, Figure 14 for kerosene, Figure 16 for LPG, and Figure 16 for wood from the market. For each energy source, two different values of the budget share are plotted:

- The budget share of the fuel for all households in a particular quintile regardless of whether they used that fuel. This value is important when assessing the distributional implications of subsidy and price reform for the population at large.

- The budget share of the fuel defined over all households that actually used that fuel. This statistic is particularly useful for assessing whether the energy source in question has a critical impact on the budget of any specific group; the budget share of users shows whether there are particular vulnerabilities to price change. It will always equal or exceed the budget share of all households.

Electricity tends to weight most heavily on the urban budgets. Rural households spend a smaller proportion of their expenditures on electricity. Looking at all households, whether connected or not, the upper quintiles in several of the study countries spend relatively more on electricity. This means that electricity subsidies (delivered as reduced rates per kilowatt-hour) such as those given in India to domestic consumers are regressive: they are distributed more unequally than total consumption. There is little indication than India’s poor are particularly vulnerable to electricity tariff changes – the budget share of electricity among its user is constant across quintiles in India, at 3-4 percent in urban areas and 2-3 percent in rural.

There are several other countries where the budget share of electricity among its users appears rather large in the bottom quintile: Nepal, Brazil, rural South Africa and rural Guatemala. These countries could consider lifeline rates to help reduce the fiscal cost of electricity to poor users. The idea behind a lifeline rate is to charge a low rate for a basic monthly level of consumption – 50-100 KWH per month. This way, users of larger amounts of electricity cross-subsidize small electricity users who are usually poorer.

Figure 13: Electricity budget share by quintile

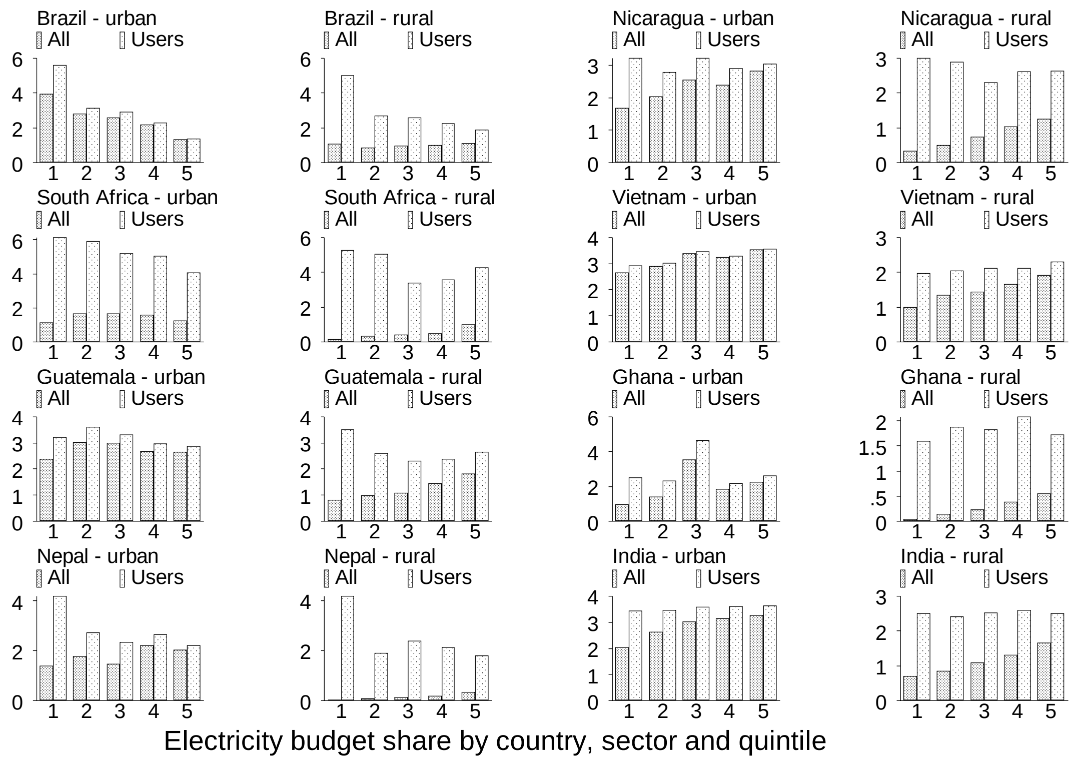
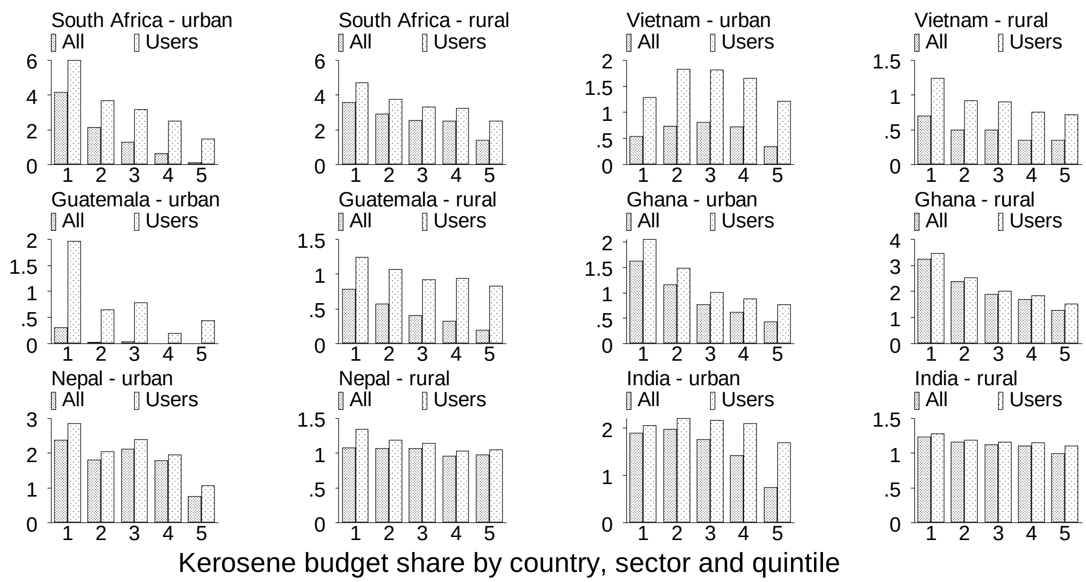


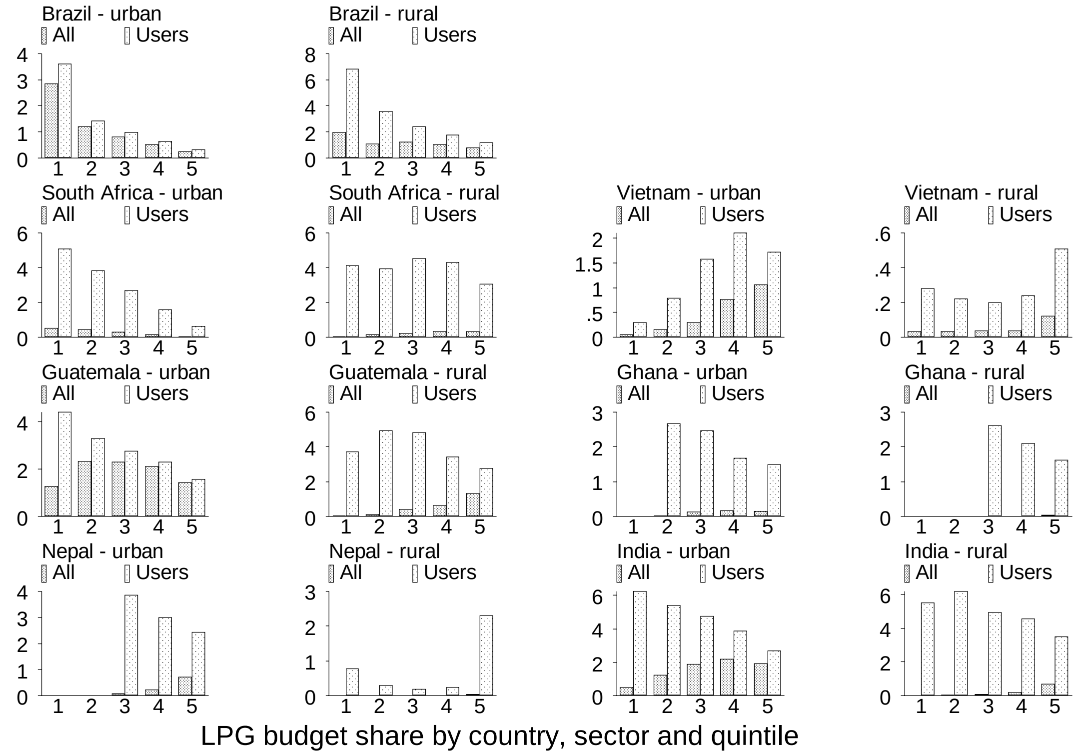
Figure 14: Kerosene budget share by quintile



Compared to electricity, kerosene is not nearly as important for spending patterns. The budget share of kerosene does not appear particularly high in any group, except for the poor in South Africa. In most of the countries considered here, kerosene subsidies would actually show a progressive pattern, and likewise kerosene taxes would be regressive.

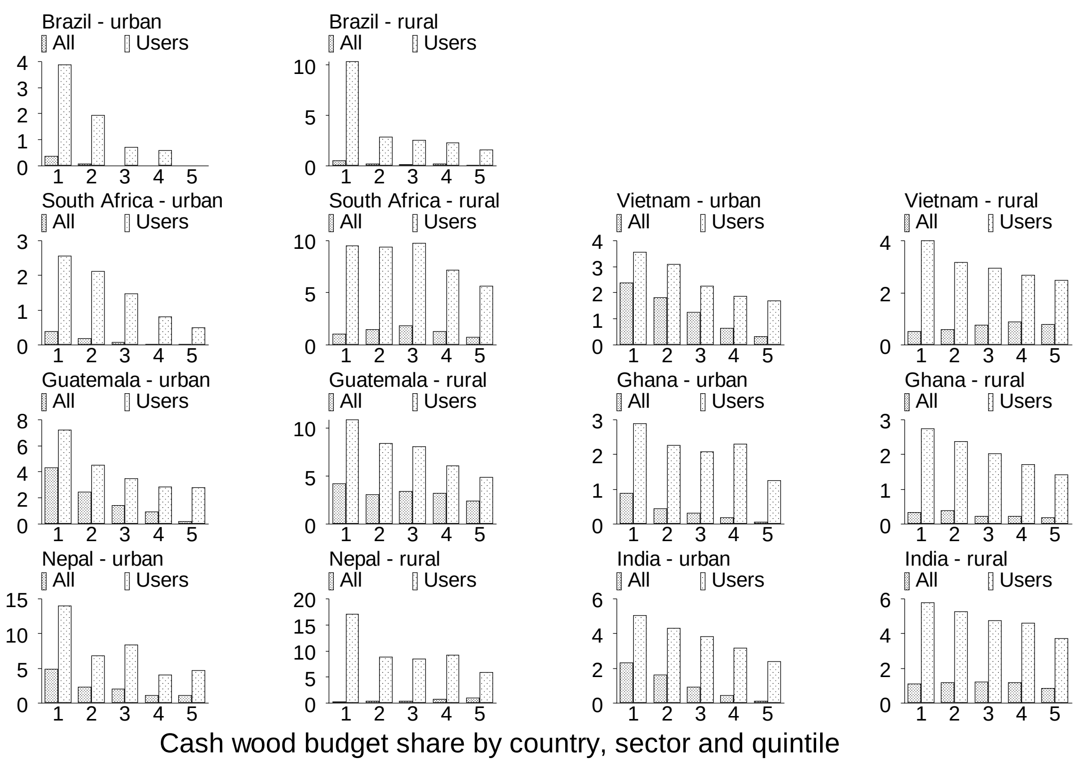
LPG, as we saw before, is mostly the fuel for the non-poor. India's LPG subsidy is clearly regressive – the higher quintiles benefit more from price subsidies on LPG as a share of their budget than do the lower quintiles (see the bars for all households); those urban low-income households that do use LPG in India are very exposed to its price, though (see the bars for users only. LPG subsidies would not be regressive in all countries, however: Spending on LPG relative to total expenditures is generally much more equally distributed than LPG usage. The reason is that once adopted the quantity of LPG consumed does not vary that much across quintiles; in India, average LPG consumed per month in households where LPG is the main fuel varies from 11.3 liters in the lowest quintile to 13.7 liters in the highest. Therefore, subsidies on LPG could potentially be progressive in countries where uptake is quite widespread, as for example in Brazil.

Figure 15: LPG budget share by quintile



Note: In Brazil the survey did not distinguish between LPG and natural gas.

Figure 16: Budget share of purchased wood by quintile



Among all of the energy sources considered, firewood has the highest budget share among its users. The urban poor in both Nepal and Guatemala spend significant shares of their total expenditures on wood, around 5 percent when averaged over all households in the bottom quintile and around 10-15 percent when averaged over wood users only. This implies that wood users are very vulnerable to price fluctuations in firewood markets. If mechanisms could be found to improve firewood markets, leading to lower and more stable prices, it could bring serious benefits to a substantial number of households depending on wood purchases. Fuelwood shows a very clear distributional profile in urban areas, where it weights heavily on the budgets of poor people. Firewood taxes would be clearly regressive. The overall budget share of (purchased) firewood is much lower in rural areas, and does not exhibit any clear distributional pattern. We know from the previous chapter that relatively few among the rural poor purchase wood on the market. However, among those rural poor that do need to purchase their wood the expenses on wood reach 10 percent or more of total spending in several instances.

7. A CLOSER LOOK AT LPG AND KEROSENE SPENDING AND UPTAKE

Energy analysts sometimes need to assess the potential of new household cooking fuels in countries where markets for this cooking fuel are not well developed. This is for example the case when contemplating fuel market reforms that will provide households with greater access to modern cooking fuels. Lacking reliable market surveys, one is left to pure speculation about potential fuel uptake in such situations. The issue of affordability poses a particular problem – we know that the poor are not going to be LPG consumers in most cases, but at which expenditure level exactly is the threshold for LPG uptake? What is the threshold for kerosene uptake? How much do consumers of LPG and kerosene normally spend on fuel, relative to their budgets? Seeking to address those issues, this chapter takes a closer look at LPG and kerosene markets in Brazil and India, two countries that have relatively well-developed fuel markets.

7.1 LPG spending and uptake in Brazil

In order to help understand better the potential market for LPG focus in the following is on households that are using LPG as their main cooking fuel. Figure 17 shows the budget share of LPG for this group – each dot in the figure marks an individual household observation. The rectangle depicts the area between the 10^{th} and the 90^{th} percentiles of the data. In other words, 80 percent of the observations on per capita expenditures and 80 percent of the observations on LPG budget share of households cooking with LPG fall within the rectangle. The LPG budget share declines markedly with expenditures. Uptake of LPG appears to take off only where incomes are such that LPG expenditures do not exceed 2-3 percent of the total household budget. The average LPG user in Brazil spends 1.3 percent of the household budget on that fuel.

Figure 17: LPG budget share among LPG users, Brazil

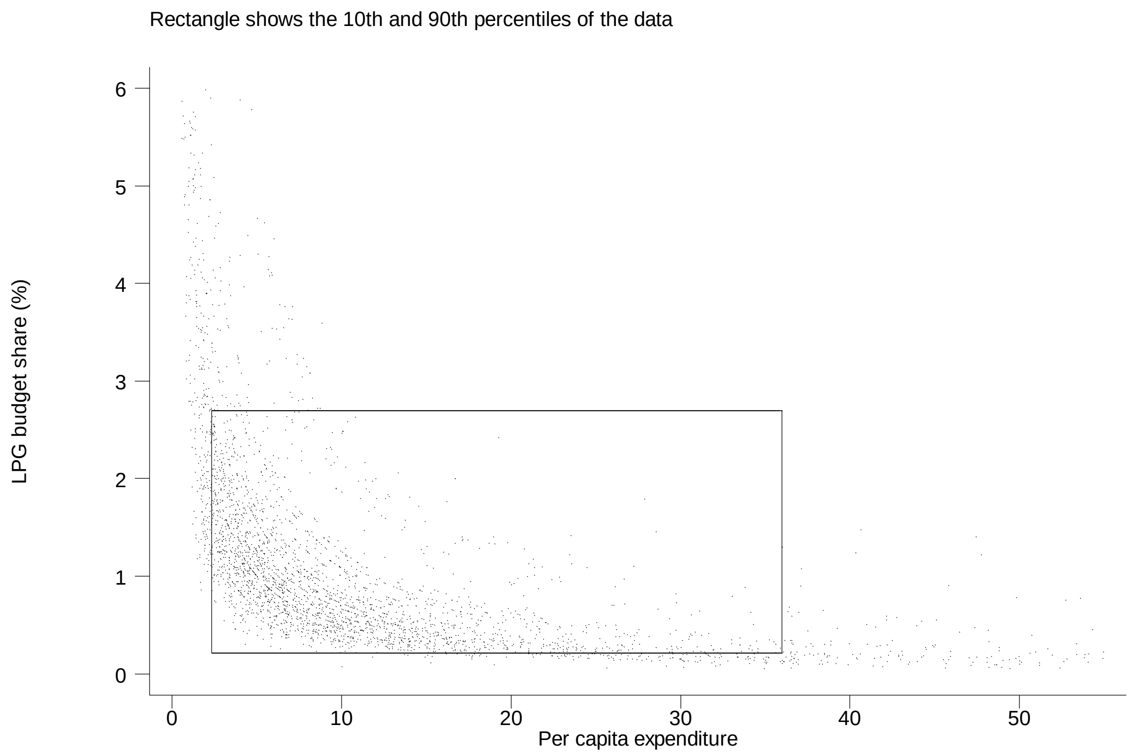
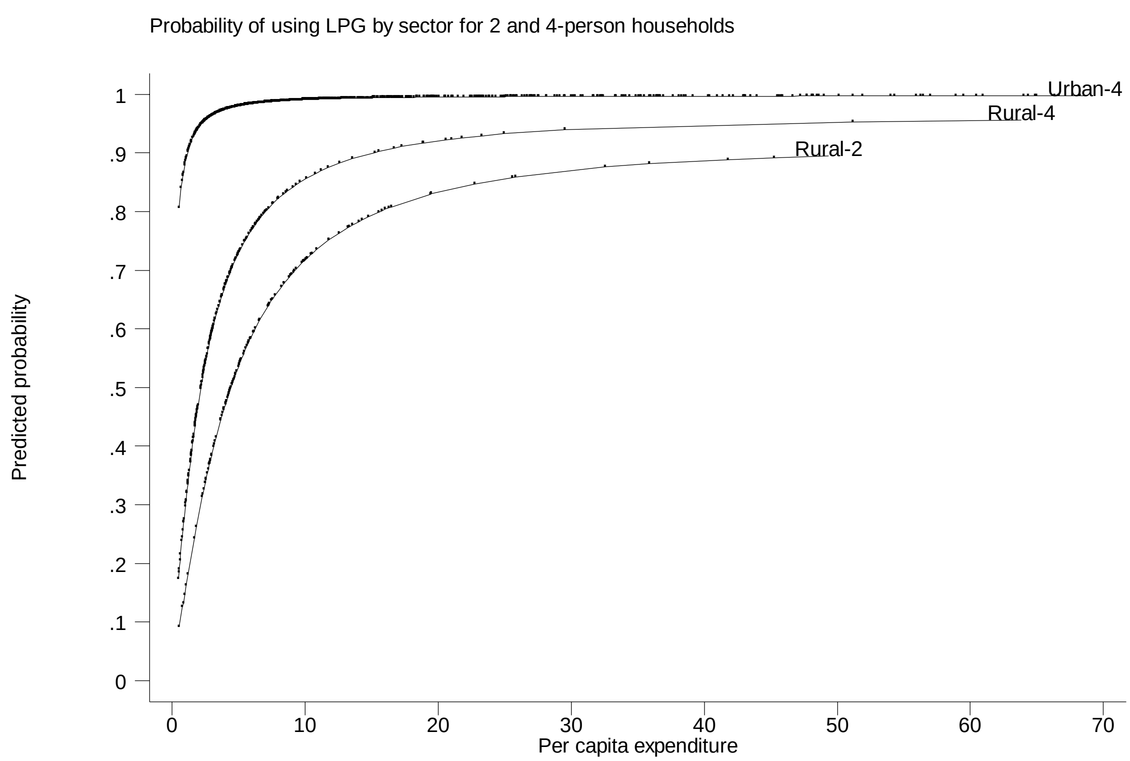
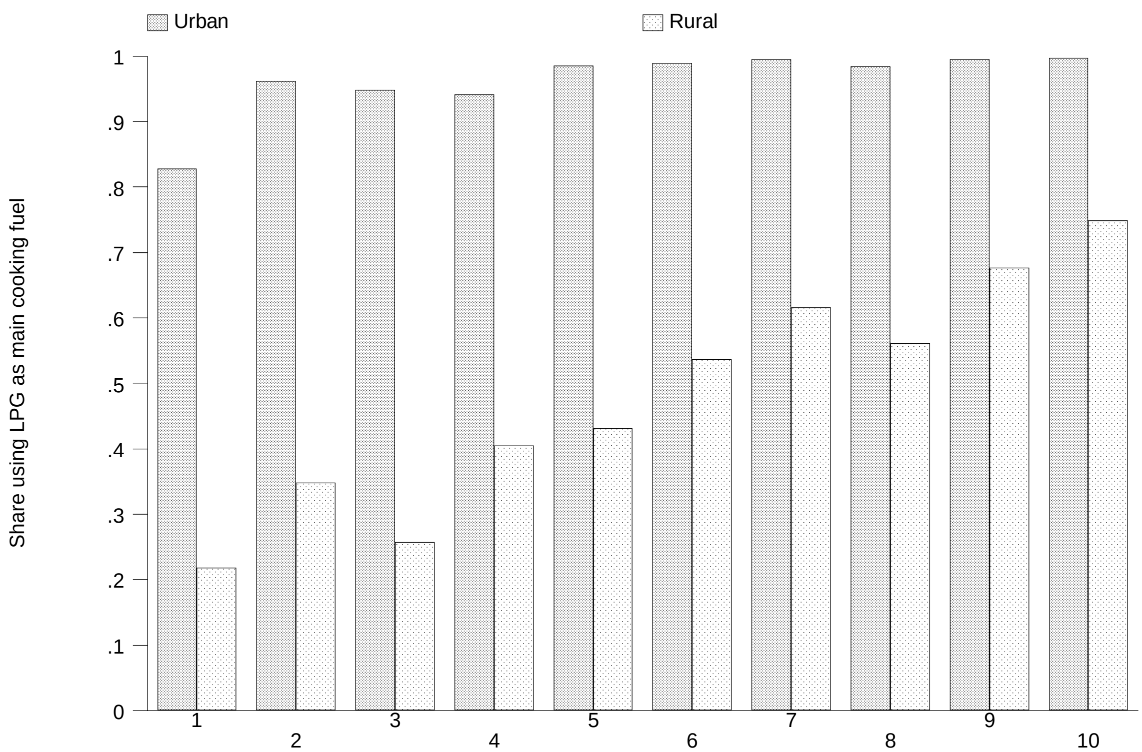


Figure 18: Predicted probability of using LPG, Brazil



Uptake of LPG depends strongly on sector and household size and is best understood as a probability. Hence, it is not possible to define a clear income threshold above which households are almost certain to use LPG. Income does matter to a great extent, though. Figure 18 makes this point by showing how the predicted probability of using LPG depends on per capita expenditures for urban and rural households of varying sizes.[7] Urban households and larger households have a greater probability of cooking with LPG at all levels of expenditures. Figure 19 relates all of this information to the urban and the rural deciles by showing the actual probability of using LPG as main cooking fuel for each decile in each sector.

Figure 19: Brazil - share using LPG as the main cooking fuel, by sector and decile



7.2 LPG spending and uptake, India

In India, where per capita expenditures are much lower than in Brazil, LPG users spend much more in relative terms on LPG. Figure 20 demonstrates that 90 percent of LPG users spend less than 6 percent of their total budget on LPG. The mean LPG budget share in India among its users is 3.8 percent – three times as much as in Brazil. Note that this is

[7] The predicted probability of using LPG as the main cooking fuel was obtained from a logit regression in which a dummy for using LPG was regressed on a number of terms in expenditures, household size, and an urban dummy, using a very flexible functional form.

despite a substantial government subsidy on LPG in India – it is a result of relatively low total expenditures combined with a high penetration of LPG for a country at that level of income.

Figure 20: LPG budget share among LPG users, India

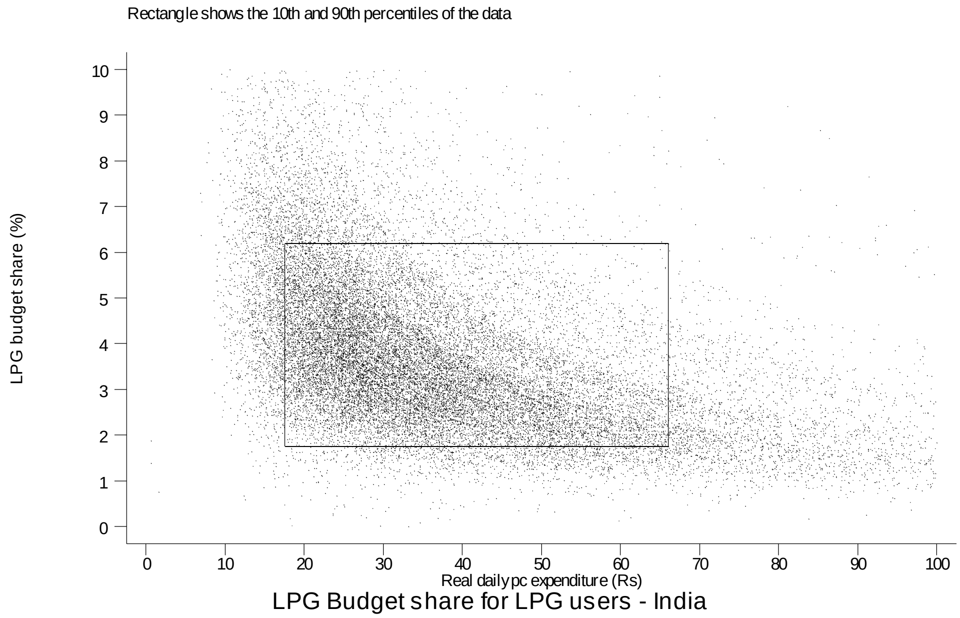


Figure 21: Predicted probability of using LPG, India

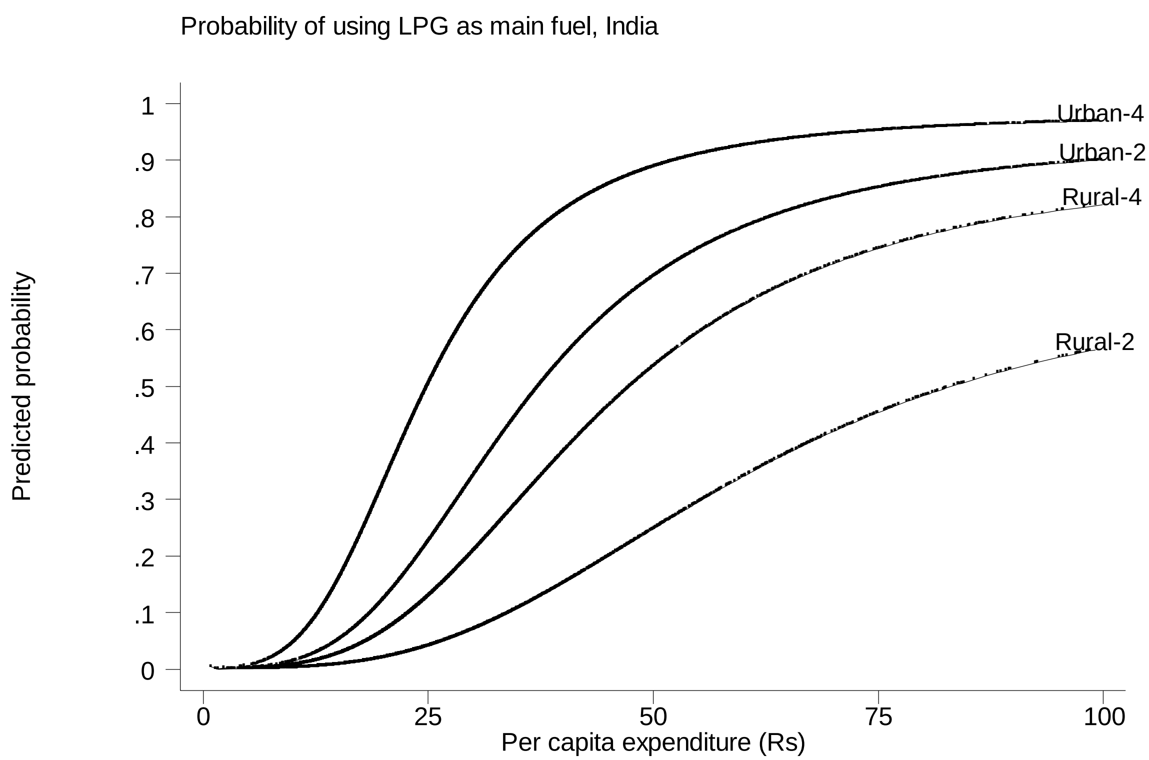
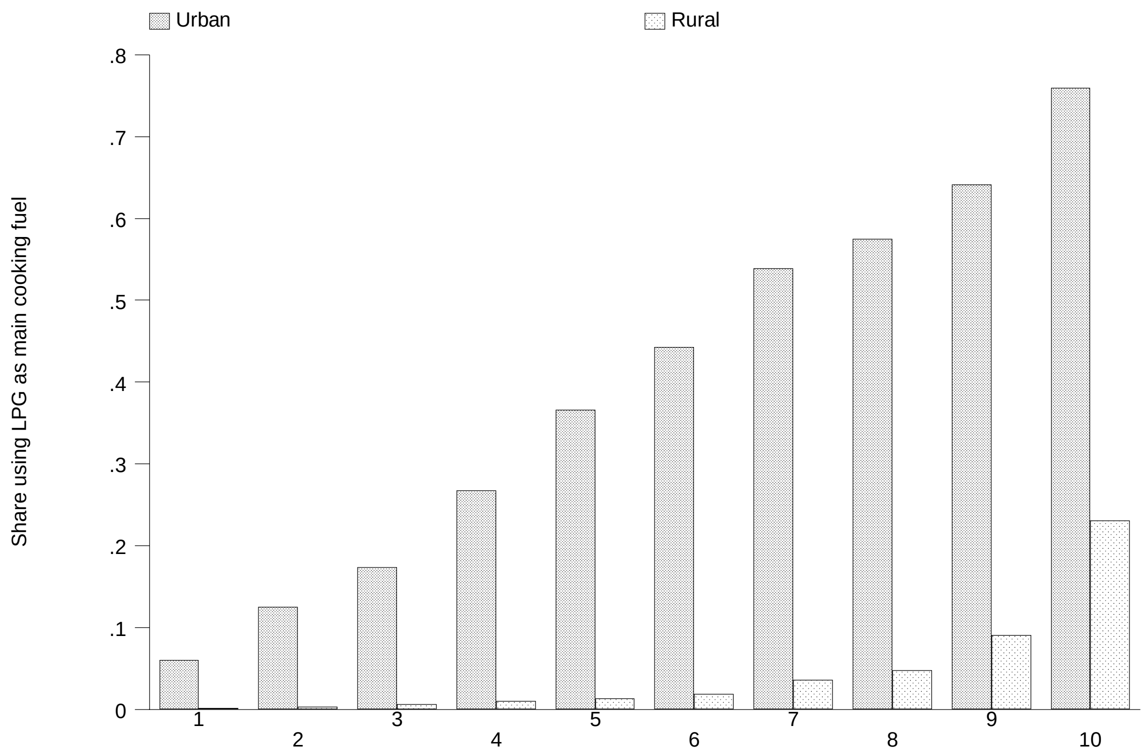


Figure 21 suggests that for India it is even harder to define a clear income threshold for LPG uptake than it is for Brazil. Although the probability of using LPG grows with expenditures, it only exceeds 50 percent towards the top of the urban income distribution and never does so in any rural decile (see also Figure 22). Household size and sector also matter to large extents. The probability of using LPG grows monotonously with household size – the economies of scale of cooking with LPG make it much more attractive and affordable to larger households. There are economies of scale of cooking with LPG because of uptake costs, fixed costs of getting a connection. Uptake costs – including the cost of the LPG stove and the cylinder deposit – are much smaller on a per capita basis for larger households.

Figure 22: India - share using LPG as the main cooking fuel, by sector and decile



The findings on LPG uptake and spending in India can be used to generate a “rule of thump” for the potential LPG market in other poor countries contemplating energy market reforms that will reduce barriers to LPG uptake. One way in which potential demand can be assessed is to start with an income threshold level above which a large share of households are thought to be candidates for switching to LPG. Potential demand can then be calculated as the number of households above the threshold times the probability of their uptake times their expected consumption quantity (usually 12-15 liters per household per month).

Table 8: Thresholds for LPG uptake (in US$ per capita per day)

Household size	Low price scenario	High price scenario
Lower threshold for household LPG uptake (LPG budget share of 6%)		
2	1.67	2.92
3	1.11	1.94
4	0.83	1.46
5	0.67	1.17
6	0.56	0.97
Realistic threshold for household LPG uptake (LPG budget share of 3.5%)		
2	2.86	5.00
3	1.90	3.33
4	1.43	2.50
5	1.14	2.00
6	0.95	1.67

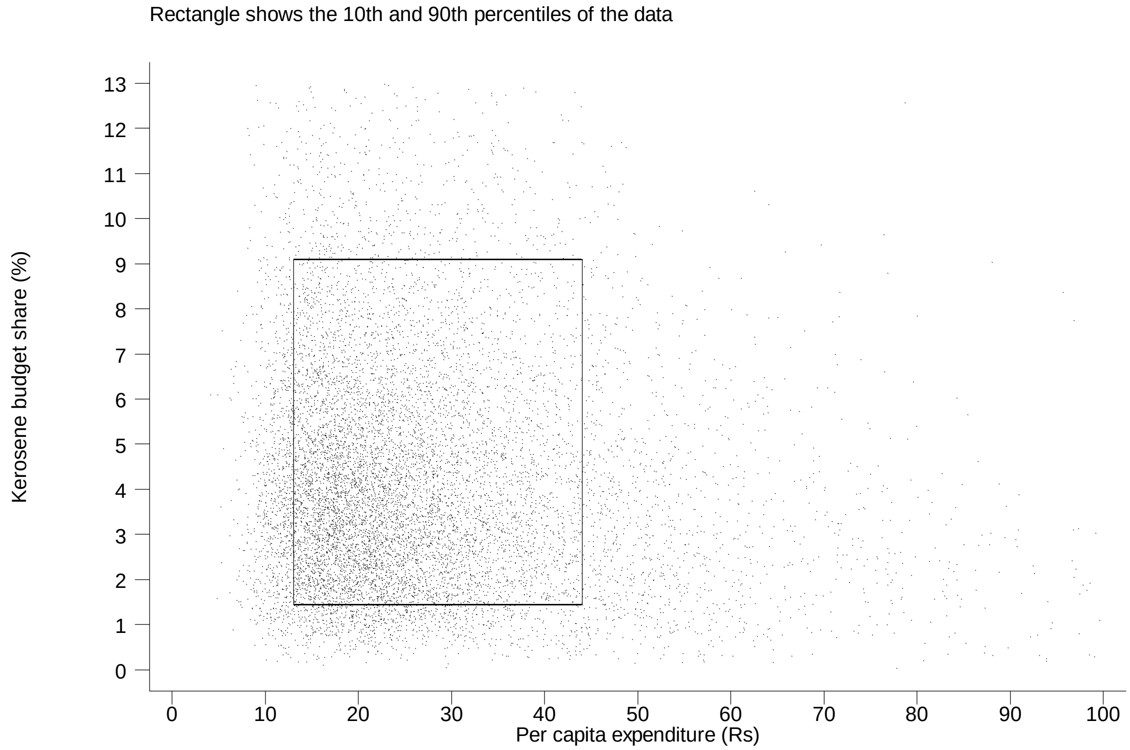
Note: The thresholds are defined as the level of daily per capita expenditures where the cost of using LPG falls below a certain level, defined in terms of the LPG budget share. The low price scenario assumes a wholesale LPG price of $200 per ton and the high price scenario assumes $400 per ton. Retail prices are assumed 100% higher. Monthly household consumption is set at 15 liters.

Table 8 illustrates the first step in this approach, the determination of the income threshold. The findings from the Indian LPG market are used as parameters, purely for illustrative purposes. When adopting the "realistic threshold" – an LPG budget share of 3.5 percent – the total expenditures of a large household needs to exceed $1-2 per day before LPG uptake is realistic. In most low-income countries in Africa and South Asia, average expenditures do not reach this level. Therefore, only the top of the income distribution in these countries are likely candidates for switching to LPG.

7.3 Kerosene spending and uptake – India

Kerosene users in India tend to be lower down the income distribution than LPG users. With an average kerosene budget share of 4.4 percent, they devote a larger share of their budget to their main cooking fuel than do the LPG users. Also, 10 percent of kerosene users spend more than 9 percent of their budget on this fuel. Affordability of cooking fuel clearly is more of an issue for kerosene users than it is for LPG users. In that sense, pricing is of critical importance, and the high budget share of kerosene for some of its users will need to be taken into account when the Indian government implements the fuel pricing reforms it has announced will take place over the coming years.

Figure 23: India - kerosene budget share of households using kerosene as their main fuel



Note: Expenditures on kerosene used for cooking as well as for lighting are included; but only for households where kerosene is the main cooking fuel.

The probability of using kerosene depends on household size in the opposite manner that LPG does – it is larger for small households. Depending on the type of stove used, kerosene need not have significant uptake costs and it therefore does not exhibit the economies of scale associated with LPG. The tendency for small households to opt for kerosene instead of LPG is indirect evidence of the critical importance of start up costs in deterring greater LPG usage in low-income settings.

The probability of using kerosene is highest in the middle of the urban income distribution and in the top rural decile (see also Figure 25)[8]; yet in no decile does kerosene use exceed 30 percent. In rural areas of India kerosene is widely used for lighting but plays a rather minor role as a cooking fuel.

[8] In rural areas only the very richest show a decreasing probability of cooking with kerosene, basically due to switching to LPG.

Figure 24: India - predicted probability of cooking with kerosene

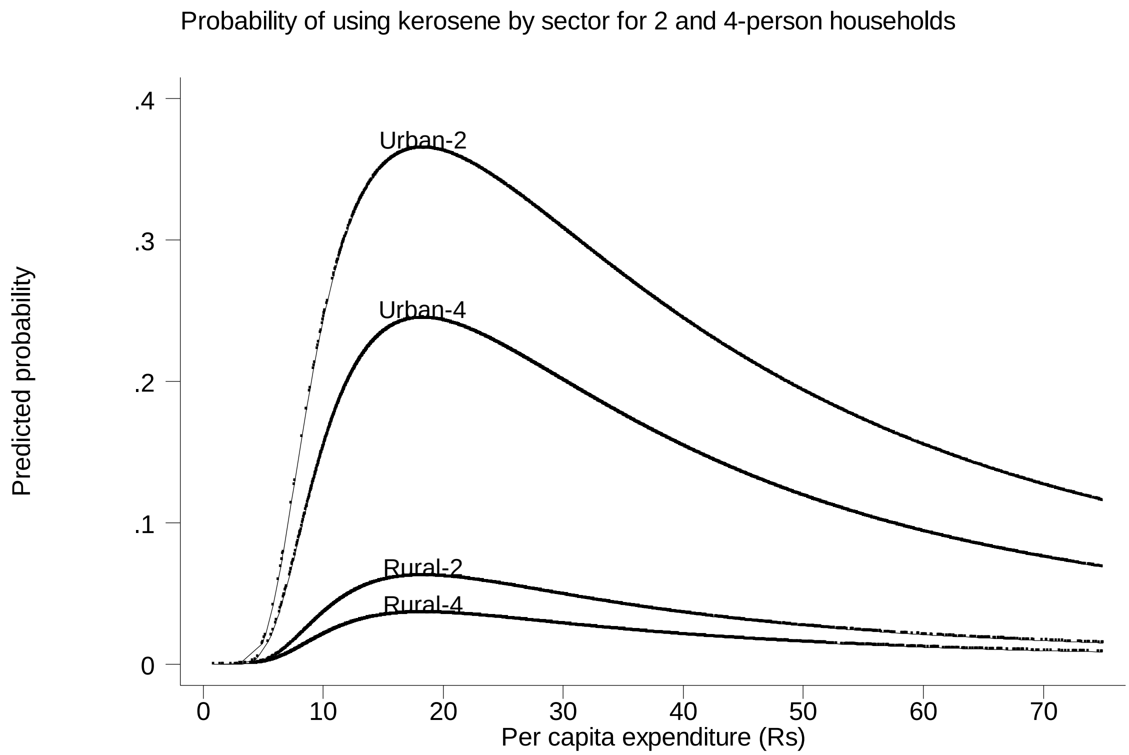
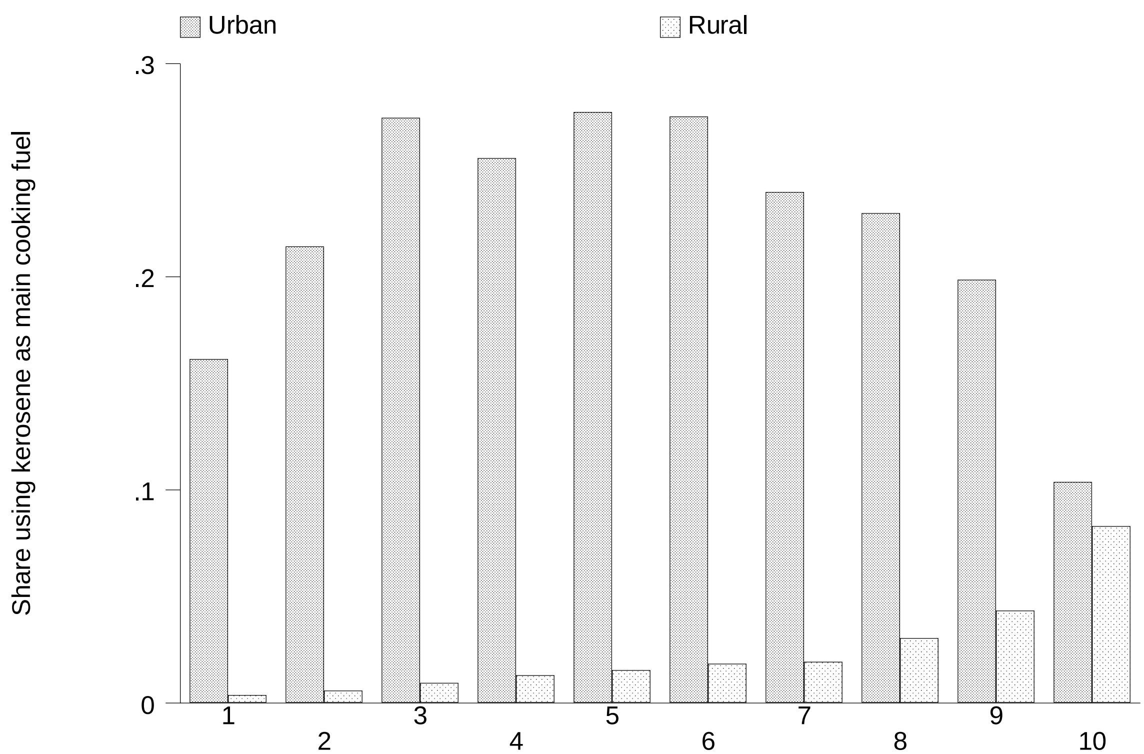


Figure 25: India - share using kerosene as main cooking fuel, by sector and decile



8. DETERMINANTS OF HOUSEHOLD FUEL USE

The aim of this chapter is to help gain a better understanding of some of the factors that are important for fuel choice. We already saw above that income group and urbanization matter for fuel choice, and this is in accordance with the energy ladder model. What other factors matter for fuel choice? In particular, this chapter sets out to explore the interaction between cooking fuels and other infrastructure services, motivated in part by the findings of Barnes, Krutilla, and Hyde (2002) who report that electrification appears to spur fuel switching.

Regression results carried out separately on the rural and the urban sub-samples of all 8 countries and documented in detail in appendix 2 show that

- Modern fuel use relates positively to per capita expenditures; solid fuels are negatively related to expenditures.
- Modern fuel use is positively correlated with electrification of the household; usage of solid fuels declines in response to electrification.
- Having tap water inside the house is also associated with fuel switching in most instances
- Larger households tend to use a greater number of fuels, both solid and non-solid.
- Education is a driver of fuel switching: increasing levels of education are associated with a higher probability of using modern fuels and a lower incidence of solid fuel use.

Results for LPG usage in urban India and rural Brazil show that the above results hold up when the regressions are extended with additional explanatory variables such as prices, community dummies and state dummies, and different education variables. In urban India, education of the household head and of the spouse are both simultaneously associated with LPG usage. In rural Brazil, only the education of the spouse is significantly associated with use of LPG; the education of the head of the household is insignificant.

Efforts were taken to assess whether the measured impact of electrification might be ascribed to unobserved household factors jointly correlated with electrification and fuel switching. The significant impact of electricity on fuel use appear robust, however: Access to electricity at the community level is also associated with higher incidence of LPG usage at the household level. Moreover, the results are not changed when the regressions are performed only on that part of the sample that have access to LPG and to electricity (defined as at least one household in the community using either of these). This suggests that household choices rather than pure supply factors drive these results.

8.1 The impact of access to electricity and water

The impact of electrification and access to improved water on fuel use is particularly intriguing. After all, electricity is very rarely used for cooking in developing countries and it is not obvious *a priori* why better lighting should change cooking practices. The remaining part of this chapter uses descriptive tools to further help pinpoint this link.

A number of different physical infrastructure services bring households in poor countries in contact with the modern world and improve welfare by easing drudgery or making a wider set of activities possible. Arguably, the most important and the most basic of these physical infrastructure services are electricity, water supply, roads, and cooking fuels.[9]

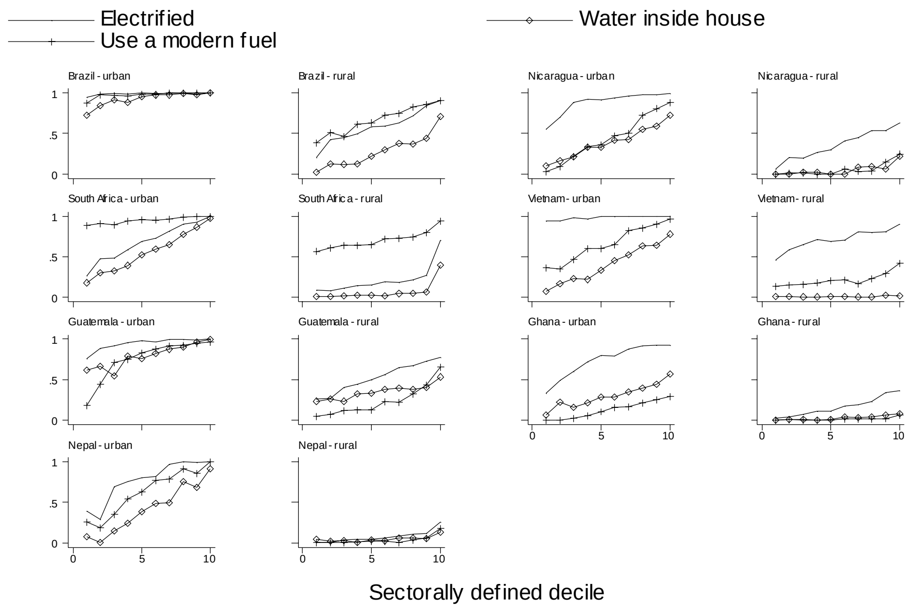
Figure 26 shows, for each country, sector, and decile the proportion of households with access to electricity; the proportion of households with water inside the house (tap or similar); and the proportion using any modern non-solid fuel. This can be used to assess the typical order in which poor people receive basic infrastructure services.[10]

Modern fuels rarely arrive the first. In most countries, electricity is the most widely available of the services covered here. Either tap water or a modern cooking fuel, depending on country, follows this. The exception is South Africa, where modern cooking fuels (kerosene or electricity) are widely used while electricity access is relatively low.

[9] Data on roads are often unavailable or impossible to compare across surveys. India had to be excluded from this analysis since the NSS survey does not contain data on the household’s water source.

[10] The order in which these services are acquired may not reflect private preferences, though. Water and electricity are often publicly provided goods partly paid for by the public while fuels are much more likely to be privately purchased.

Figure 26: Electricity, water in house, and modern fuels by country, sector, and decile



Improved water does not necessarily have to come into the dwelling. For improved hygiene and health, having access to an improved water source such as a secure well or a public standpipe within a reasonable short distance of the dwelling is often sufficient.

The analysis was therefore repeated with any improved water source be it outside or inside the dwelling. Note that in poor countries and especially in rural areas most of the people with access to an improved water source have it outside their dwelling.[11] Water is typically a public good provided by governments or aid agencies, and therefore not necessarily paid for by the household. The order in which these infrastructure services arrive therefore need not reflect the priorities of the people who benefit from them.

Figure 27 shows that improved water, defined in this manner, often arrives before electricity. This is particularly the case in rural areas where electrification is costly and slow. There are however also countries, Vietnam for example, where people get electrified before they get access to safe water. Modern fuels typically follow quite a bit later in the development process, ranking well after improved water and electricity for most deciles in most of the countries. The exception is Brazil where access to all three infrastructure services tends to be good and to go hand-in-hand.

[11] Table 10 in the appendix summarizes the distribution of water source by country.

Figure 27: Electrification, use of any improved water source, and modern fuel usage by country, sector, and decile

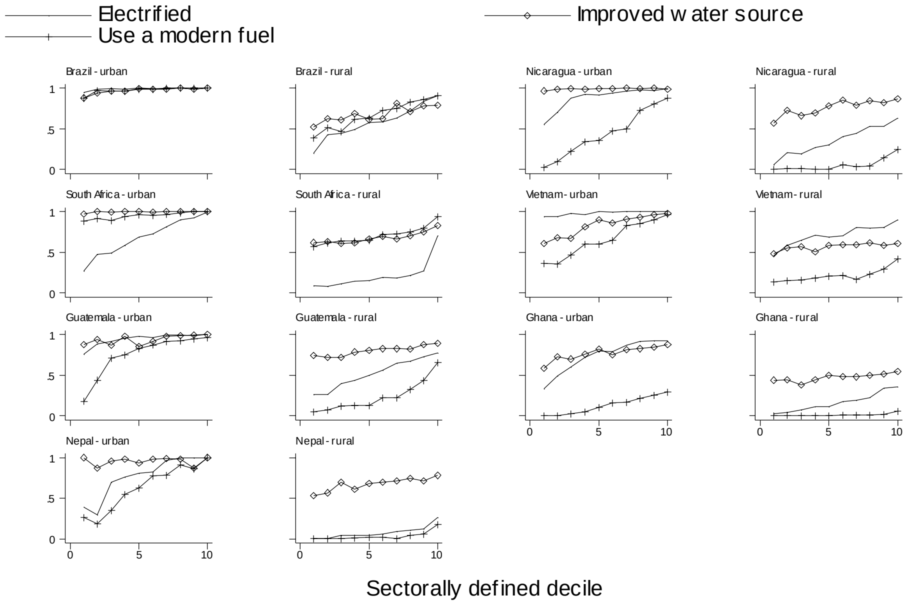
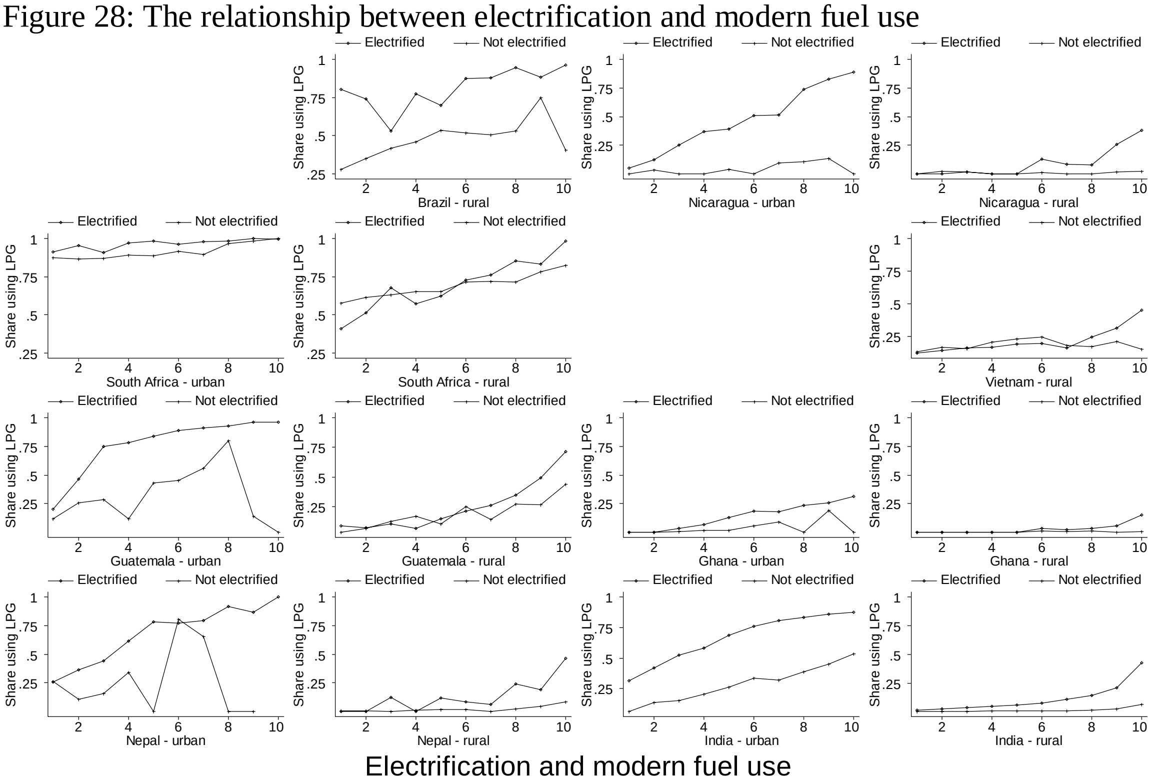


Figure 28: The relationship between electrification and modern fuel use

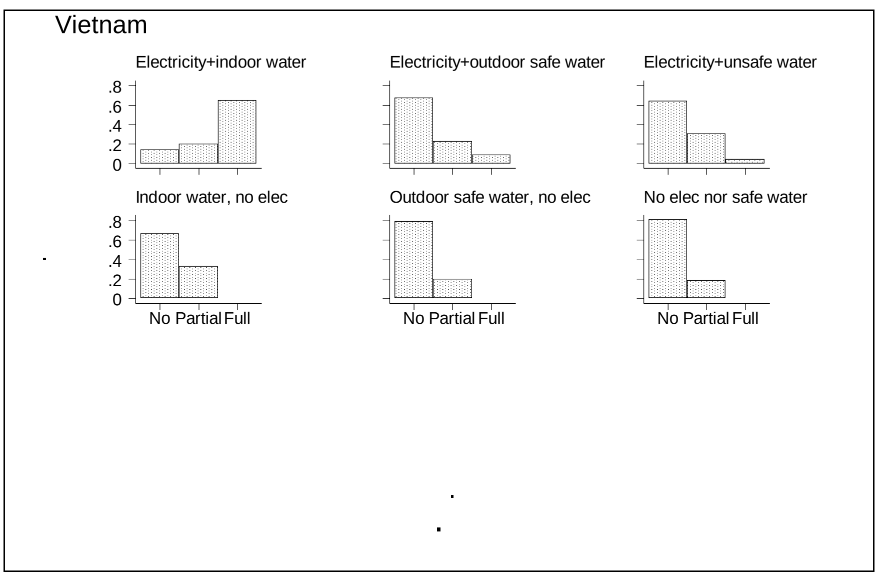


How large an impact does electrification have on fuel choice?

Figure 28 shows the share of households using any modern fuel in each decile, sector, and country among electrified and non-electrified households, respectively.[12] Electrified households have a much large probability of using a modern fuel; the difference is particularly pronounced in urban areas almost everywhere – the difference often runs into 20-40 percentage points or more; the impact of electrification on modern fuel use appears to be smaller in rural areas except in Brazil.[13]

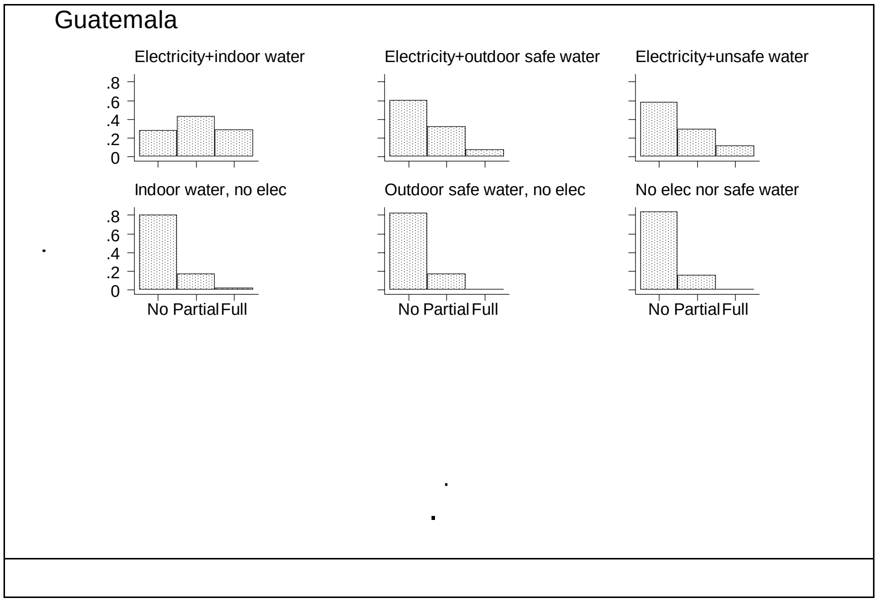
Figure 29 shows histograms for Vietnam and Guatemala depicting how the share of households in each fuel-switching category varies depending upon the household's electrification status and type of water source. In both countries, fuel switching is much more predominant in the group of households that have access to both electricity and indoor tap water – most Vietnamese with electricity and indoor water have switched fully to modern fuels. Electrified households with other water sources occasionally also switch partially or fully to modern fuels. Unelectrified households rarely fuel switch, and when they do mostly partly. Of course, these are all correlations and do not demonstrate a causal link from electrification to fuel switching. Yet these correlations do suggest some kind of association between electrification (and indoor water to a lesser extent) and fuel switching. Areas and households lacking electricity and improved water may be unrealistic targets for cooking fuel interventions.

Figure 29: Fuel switching by electrification status and water source, Vietnam and Guatemala



[12] Urban Brazil and urban Vietnam were omitted from this analysis due to the low number of households in the unelectrified group.

[13] The same analysis was also carried out for improved water source. No clear pattern was found; the curves for use of modern fuels among households with and without improved water often crossed, making them hard to interpret. These figures are therefore not shown.



Note: The figure shows how fuel switching depends on electrification and source of water. Households are divided into three fuel switching categories: No switching (only solid fuels); partial switching (both solid and modern fuels); and full (only nonsolid).

9. CONCLUDING REMARKS AND DIRECTIONS FOR FUTURE RESEARCH

There is an enormous differentiation in the combination in which households use cooking fuels. The mix of cooking fuels differs across countries, sectors, and income groups. Some of this variation is quite predictable: urban and better-off households are more likely to use modern fuels; rural and low-income households more often rely on firewood. However, although income levels do play a large role in shaping fuel choices as predicted by the energy ladder model, many other factors also matter and would sometimes have been harder to predict *a priori*: kerosene is used heavily in some countries, South Africa for example, and not at all in other; the incidence of using kerosene is higher in small households, while the incidence of using LPG is higher for larger households due to the economies of scale in LPG adoption. In fact, large households are more likely to use several fuels, both solid and modern.

Fuel switching is quite advanced in the urban areas of the study countries, with the exception of Ghana. In rural areas, however, modern fuels play a relatively modest role, and are often used mostly in the top income brackets. And once rural households start using them, modern fuels sometimes complement and sometimes displace solid fuels. The prospect for modern fuels to combat indoor air pollution is therefore significantly better in urban than in rural areas. The observation that biomass use persists well up the income distribution particularly in rural areas serves to remind that many factors besides affordability also matter for cooking fuel choice.

This paper identified expenditures, urbanization, electrification, water source, and education as important drivers of fuel switching: higher levels of each of these variables is associated with a shift towards cleaner and more efficient modern fuels – mostly LPG and kerosene – away from biomass and other solid fuels. As mentioned, household size affects fuel choices but does not trigger switching: larger households are more likely to use multiple cooking fuels. There is evidence that fuel use reacts to fuel prices in the manner one would expect: the probability of using LPG use is lower where LPG prices are high or where the market price of kerosene and wood are low.

The association between electrification and fuel use is intriguing; quantitatively, the difference in modern fuel uptake between electrified and un-electrified households is very sizeable. The findings appear robust to several controls including community fixed effects and restricting the analysis to that part of the sample that has access to electricity and LPG in their community. It was not possible, however, to firmly establish a causal link from electrification to fuel use.

The observation that the fuel mix differs in sometimes surprising ways calls for a certain degree of humility among energy practitioners. We should be careful when seeking to promote any specific fuel – it may or many not find acceptance with the intended beneficiaries. Energy interventions need to consider demand factors and be less supply-driven than in the past. Energy market reforms that seek to make fuels more widely available by removing restrictions and bottlenecks on fuel distribution should be promoted. The goal should be an even playing field in which households choose energy sources freely from a menu of available options.

One frequently hears concerns about the affordability of energy and the need to help the poor pay for energy. Such concerns sometimes serve as window-dressing for the urban middle-classes to lobby for continued benefits. Nevertheless, arguments about the unaffordability of energy cannot be dismissed entirely – energy is a basic good and the poorer households frequently spend sizeable shares of their income on cooking fuels and electricity. Two replies are possible to concerns about the affordability of energy. One, subsidies need to be much better targeted towards poor consumers, and fiscal support re-directed towards grid expansion and fuel uptake. Second, a level energy playing field where households can choose freely among a variety of cooking fuels can help reduce the energy bill as people switch fuels in response to price fluctuations.

There are not many policy options for promotion of fuel switching. Price subsidies for modern fuels is probably the most important potential policy for fuel switching – but price subsidies may be undesirable in many circumstances due to the high fiscal costs and, sometimes, the regressive distributional profile of LPG subsidies. Kerosene subsidies would in many cases have the most pro-poor distribution – much more progressive than LPG subsidies – but kerosene sold for fuel unfortunately tends to get re-directed to automotive uses. Some of the most vulnerable households are those using purchased firewood – they are often low-income and sometimes spend very high budget shares on household energy. This group contains many candidates for fuel switching. They would likely benefit to a large extent if a way could be found to deliver subsidized kerosene in a targeted manner. Kerosene subsidies only help promote switching away from expensive firewood if diversion of kerosene for automotive fuel can be avoided.

Better functioning fuelwood markets would bring important benefits to many poor people. Fuelwood markets are extremely important for the poor – who often rely on them either as buyers or as sellers. Urban buyers of fuelwood are among the poorest and are those who are the most exposed to energy prices in the sense that they spend large shares of their budgets on cooking fuels. Lower and more stable fuelwood prices could bring real benefits to this group, until in the longer run they may be able to switch to kerosene or LPG. The benign neglect that tends to accompany fuelwood markets in energy policy is a mistake.

General economic development will in itself to some extent help trigger fuel switching. This is particularly true in urban areas. In rural areas, however, the quantity of firewood used per household in India and Guatemala is almost constant except in the top decile.

Some of the processes accompanying development – urbanization, electrification, and education – will however help promote fuel switching.

Energy interventions need to be targeted to areas and households where results can be realistically expected. Areas not yet electrified, for example, would very rarely adopt modern fuels. Areas where the purchasing power is insufficient or where biomass fuels are easily available are also not realistic targets for fuel switching. Instead, improved low-cost biomass cook stoves or interventions to promote ventilation in the kitchen may be appropriate.

It may be appropriate to implement and publish to a greater extent quantitative development targets in the field of household energy. Appendix 2 makes the point that key indicators in the field of household energy to compile, publish, and follow for each country would be: (i) The rate of household electrification (share of households with electric light) and (ii) household adoption of modern cooking fuels. These indicators are feasible to measure and to adopt as a quantitative development targets alongside other targets. They are available from Demographic and Health Surveys (DHS), LSMS and other household surveys, and other sources for a substantial number of countries. Greater use of household energy indicators such as those proposed in appendix 2 have the potential to draw more attention to household energy among development practitioners and researchers.

Future research should continue searching for effective means of promoting fuel switching and for a better understanding of the persistence of wood and other biomass use. Future research should not rely excessively on the energy ladder model but consider using a household economics framework incorporating opportunity costs and non-monetary aspects in the analysis. The database for monitoring household energy issues in developing countries also needs to be improved, as already argued.

Better empirical evaluations of the impact of electrification are also called for, moving beyond mere correlations between having electricity and socio-economic outcomes. There is also a need to identify low-cost interventions in the areas of improved stoves, better ventilation, and renewable energy sources that can be scaled up.

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APPENDIX 1: REGRESSIONS OF FUEL USE AND FUEL SWITCHING

In order to help pinpoint the drivers of fuel choice, a number of explanatory variables were constructed from the eight data sets. Due to differences in survey design it is hard to ensure completely identical definitions for all the countries, but care was taken to achieve as high a degree of comparability as possible.

1. Data assembly

The search for drivers of fuel choice was guided chiefly by two factors. First, previous studies of fuel choice were consulted in order to identify potential variables to be included. In this context, the results from a similar study undertaken for Guatemala (Heltberg, 2003) pointed towards a number of likely drivers of fuel choice. Second, a multicountry study such as the present by necessity has to focus on standard variables that are routinely collected in LSMS and other household survey data sets in a more or less comparable manner. This leads to an emphasis on basic household characteristics such as household size, expenditures, education, and urbanization.

In addition, variables describing the household's access to key infrastructure services such as electrification and water are also included. The baseline results are based on a dummy for whether the household is electrified; an alternative indicator, whether any household in the community has electricity, is also used sometimes.[14] Electrification status is available in all the sample surveys. Water supply is available in all surveys except India's NSS.

For water connections and education the surveys collected the data in different formats, and standardized definitions had to be imposed. The education variables were constructed based on the highest education level achieved by any household member. Dummies were

[14] The definition of community is the primary sampling unit (enumeration area, census block), generally a cluster of villages or neighborhoods.

constructed for highest education being primary school; secondary school; or above secondary (technical, college, or university). The omitted category is no household member having completed primary school. The water connection variables are dummies for having an improved water source (tap water) inside the dwelling; for having access to improved water outside the dwelling (standpipe; protected well, and so on); and for having access only to an unimproved water source (open well, river, lake).

Table 9 and Table 10 show the means of the household characteristics, urbanization and water source for each of the surveys used. It also shows the survey sample sizes; in all, information from more than 160,000 households has been assembled.

2. Factors affecting household fuel choice

To explore how fuel choice is affected by household characteristics and infrastructure variables, a number of exploratory regressions were carried out. The basic regressions employ a very simple probit specification to model the probability of using any modern fuel and of using any solid fuel as a function of a small number of variables that were available in all of the country data sets. This helps generate stylized facts concerning some of the key determinants of fuel choice; however, these basic regressions are subject to a number of shortcomings, and most notably they are very simple and omit many potentially important explanatory variables, including fuel prices. Therefore, additional regressions were run for a couple of countries exploring the impact of adding additional regressors on the probability of using LPG, the most important of the modern fuels.

Table 9: Means of household characteristics, by country

	Household size	Daily per capita expenditures (US$, market exchange rate)	Highest education: Primary school	Highest education: Secondary school	Highest education: Above secondary school
Brazil	3.86	15.16	0.08	0.71	0.13
Nicaragua	5.41	2.02	0.39	0.37	0.17
South Africa	4.46	6.05	0.21	0.61	0.14
Vietnam	4.70	0.64	0.19	0.65	0.13
Guatemala	5.24	2.70	0.51	0.27	0.11
Ghana	4.31	1.75	0.13	0.51	0.12
Nepal	5.69	0.33	0.22	0.26	0.05
India	4.90	0.49	0.33	0.24	0.11

Table 10: Means of non-energy variables, by country

	Urbaniza tion	Indoor water	Outdoor improved water	Unimproved water source	Number of observations (survey sample size)
Brazil	0.81	0.82	0.10	0.08	4,940

Nicaragua	0.57	0.27	0.63	0.10	4,040
South Africa	0.53	0.40	0.46	0.14	8,809
Vietnam	0.24	0.11	0.53	0.36	5,999
Guatemala	0.43	0.56	0.31	0.13	7,321
Ghana	0.37	0.15	0.45	0.40	5,998
Nepal	0.07	0.08	0.62	0.30	3,373
India	0.27	-	-	-	120,316

Table 11 summarizes the country and sector specific probit regressions of non-solid fuel use. Results are largely as expected: in all or most cases electrification, expenditures, and education significantly increase the likelihood of using modern fuels. Household size often increases modern fuel usage, but there are also exceptions.

Table 11: Probit results for non-solid fuel use, summary of country/sector results

Summary of individual country and sector regression results
Dependent variable: Use of any non-solid fuel

Regressor:	Range of parameter estimates			Number of parameter estimates that are			
	Mean	Mini-mum	Maxi-mum	Positive and significant	Positive and insig-nificant	Negative and significant	Negative and insig-nificant
Household has electricity	0.89	0.12	1.78	16	0	0	0
Per capita expenditure (log)	0.86	0.32	1.65	16	0	0	0
Household size (log)	0.16	-0.18	0.53	7	5	2	2
Highest education: primary	0.24	-0.51	0.52	8	5	1	2
Secondary	0.54	-0.33	1.13	11	4	0	1
Post-secondary	0.83	-0.23	1.62	12	1	0	1

Note: This is a summary of individual probit regressions by country and sector. "Significant" refers to statistical significance at the 5% level or better.

Table 12 shows the summary results for the country/sector specific results for use of any solid fuel. The table clearly demonstrates that solid fuel use decreases with electrification (significant in all cases except one); decreases universally with rising per capita expenditure; decreases the higher is the education level in most cases; and tends to increase for larger households.

Some might argue that unobservable household characteristics may affect fuel choice and electrification jointly. If this were true, the correlation between them reported above would not reflect a causal link stemming from electrification. In order to avoid undue influence of unobserved household factors an alternative indicator for electrification at the community level was included in the regressions instead of household electrification.

Table 12: Probit results for solid fuel use, summary of individual country/sector specific results

Summary of individual country and sector regression results
Dependent variable: Use of any solid fuel

Regressor:	Range of parameter estimates			Number of parameter estimates that are			
	Mean	Mini-mum	Maxi-mum	Positive and significant	Positive and insig-nificant	Negative and significant	Negative and insig-nificant
Household has electricity	-0.77	-1.53	-0.28	0	0	14	1
Per capita expenditure (log)	-0.57	-1.64	0.30	1	0	14	1
Household size (log)	0.28	-0.62	0.65	12	2	2	0
Highest education: Primary	-0.15	-0.57	0.56	1	2	5	8
Secondary	-0.45	-0.95	0.44	1	1	10	4
Post-secondary	-0.77	-1.37	0.16	0	1	11	3

Note: This is a summary of individual probit regressions by country and sector. "Significant" refers to statistical significance at the 5% level or better.

When the country and sector specific regressions are rerun with community level electrification the results of Table 11 and Table 12 also hold up well. Community access to electricity has the expected positive impact on non-solid fuel use and negative impact on solid fuel use; this impact is statistically significant in a big majority of cases (results not reported).

3. Expanded LPG regressions for urban India and rural Brazil

The above results are based on a short list of explanatory variables available in all of the countries; in this section it is investigated whether the results hold up when additional explanatory variables and controls are added. Key additional regressors include prices, community dummies and state dummies, and the education of the head and of the spouse. Table 13 reports the results of logit analyses of LPG usage in urban India; Table 14 shows the same for rural Brazil. Urban India and rural Brazil were selected for this because both samples have quite significant penetration of LPG and are mostly electrified, ensuring that supply considerations or special characteristics of early adopting households do not drive any results.

In urban India, education of the head and of the spouse of the household are both simultaneously associated with LPG usage. In rural Brazil, only the education of the spouse is significantly associated with use of LPG; the education of the spouse is insignificant.

The “baseline” columns (1) in Table 13 and Table 14 show results for a specification similar to that reported in Table 11 and Table 12 above except that fuel unit costs ("prices") and state dummies are added in the case of India and dummies for water source and six geographical regions are added for rural Brazil.[15] The results from before hold up quite well. Specifically, LPG usage relates in a positive and significant manner to per capita expenditures, to electrification of the household, and to the highest level of education attained by any household member. Household size is significant in India only. Improved water inside the house is associated with LPG usage in Brazil; outside improved water is not.

The unit cost results show LPG usage in India to increase where firewood prices are high – LPG and wood are substitutes. As an ordinary good, LPG responds negatively to its own price. The results for kerosene unit costs suggest LPG and kerosene from the public distribution system (PDS) are substitutes. LPG and market kerosene, however, appear to be complements, something which is puzzling and hard to explain.[16]

Column (2) replaces the education variable (highest level of any household member) with two sets of variables measuring (a) education of the household head and (b) education of the spouse. It turns out that in rural Brazil only the education of the spouse matters to LPG usage (higher levels are associated with greater probability of using LPG); education of the head is insignificant. Two plausible but distinct explanations for this come to mind: (i) it could be that spouses are the more important for fuel choice decisions in Brazil, and/or (ii) higher education of the women in the household translates into higher opportunity costs of fuelwood collection time, motivating fuel switching in order to save on the time of these women. In urban India, both education of the head and of the spouse remain significant for LPG usage.

Column (3) in both tables look at electrification in a new light; instead of defining it as the household level as done previously, a dummy variable is included that measures access to electricity at the community level. This dummy measures whether any household in the sample in each primary sampling unit ("community") is electrified. Access to electricity at the community level defined in this manner is also associated with higher incidence of LPG usage. Although the estimated magnitude of the impact drops sizably in the case of rural Brazil, the finding of a significant link means that the measured impact of electrification cannot be ascribed solely to unobserved household factors jointly correlated with electrification and fuel switching.

Column (4) restricts the sample to households that have access to both LPG and electricity (defined as at least one household in the community using either of these). This is to control for the possibility that some exogenous supply problems rather than

[15] Unit costs are constructed by dividing the value of fuel purchased with the quantity and then taking average in each primary sampling unit ("community"). Where this resulted in missing observations, the average unit cost in the district and, in a few instances, the region was used instead. The state and geographical dummies are included to control for differences in climate and to some extent access factors that affect all households within a state/region equally.

[16] The opposite unit cost effects for market and PDS kerosene are not just due to covariance of these two variables; the opposite signs remain once the variables are entered separately one at a time in the regression.

household choice could be driving the association between electrification and LPG use. They do not – the results hold up well.

Column (5) adds community fixed effects – dummy variables for each community. This controls for all factors that are constant within a community, including prices and energy access.[17] The impact of expenditures, education, and electrification are not altered. Summing up, the results reported earlier about fuel choice appear very robust to varying regression specifications. Specifically, the impact of electrification holds up well when household unobservables are accounted for by including electrification at the community level; it also holds up well when community factors are removed using fixed effects. It was not possible with the data at hand to control simultaneously for both household and community unobservables.

Table 13: Logit results for LPG usage in urban India

	(1) Baseline	(2) Spouse and head education	(3) Community electricity access	(4) Only where access to electricity and LPG	(5) Community Fixed effects
Highest education: primary	0.759				
	(13.45)**				
Highest education: secondary	1.776				
	(32.45)**				
Above secondary	2.737				
	(46.10)**				
Fuelwood unit cost (log)	0.119	0.131	0.133	0.127	
	(6.46)**	(7.00)**	(7.14)**	(6.53)**	
LPG unit cost (log)	-0.092	-0.088	-0.093	0.040	
	(3.55)**	(3.34)**	(3.57)**	(1.48)	
Market kerosene unit costs (log)	-0.099	-0.108	-0.121	-0.169	
	(2.36)*	(2.60)**	(2.92)**	(3.90)**	
PDS kerosene unit costs (log)	0.217	0.240	0.238	0.199	
	(5.37)**	(5.94)**	(5.89)**	(4.82)**	
Expenditures per capita (log)	2.231	2.359	2.469	2.297	2.674
	(57.28)**	(59.49)**	(62.83)**	(56.02)**	(54.63)**
Household size (log)	1.570	1.646	1.699	1.662	1.969
	(52.38)**	(54.58)**	(56.76)**	(53.18)**	(51.64)**
Electrified	1.719	1.795		1.718	1.746
	(21.61)**	(22.56)**		(20.73)**	(18.05)**
Average # meals at home per day		0.065	0.059	0.097	0.217
		(2.08)*	(1.90)	(3.02)**	(4.68)**
Head's education: primary		0.474	0.521	0.444	0.383
		(13.65)**	(15.21)**	(12.44)**	(8.88)**
Head's education: secondary		1.093	1.152	1.058	0.990
		(28.72)**	(30.57)**	(26.95)**	(20.91)**

[17] It does not control for household unobservable factors, however. State/regional dummies are collinear with the community fixed effects and therefore cannot be retained here; the same goes for unit costs.

Head's education: above secondary		1.531	1.598	1.494	1.390
		(29.47)**	(30.85)**	(27.85)**	(21.27)**
Spouse's education: primary		0.421	0.438	0.374	0.326
		(13.14)**	(13.75)**	(11.38)**	(8.13)**
Spouse's education: secondary		1.002	1.017	0.970	0.883
		(24.40)**	(24.85)**	(22.93)**	(17.23)**
Spouse's education: above secondary		1.524	1.533	1.537	1.256
		(18.63)**	(18.86)**	(17.91)**	(12.88)**
Household electrified			2.270		
			(5.89)**		
Constant	-12.562	-12.672	-13.624	-12.484	
	(60.16)**	(56.98)**	(30.82)**	(54.75)**	
Observations	48924	47684	47684	43364	39669

Robust z statistics in parentheses

* Significant at 5%; ** significant at 1%

Table 14: Logit results for LPG usage in rural Brazil

	(1) Baseline	(2) Spouse and head education	(3) Community electricity access	(4) Only where access to electricity and LPG	(5) Community Fixed effects
Expenditures per capita (log)	0.610	0.603	0.695	0.523	0.388
	(5.13)**	(5.18)**	(5.88)**	(4.42)**	(2.88)**
Household size (log)	0.060	0.028	0.149	-0.055	-0.083
	(0.30)	(0.15)	(0.80)	(0.26)	(0.39)
Electrified	1.452	1.397		1.371	1.180
	(7.61)**	(7.19)**		(6.82)**	(4.57)**
Inside water	0.528	0.567	0.974	0.618	0.348
	(2.11)*	(2.23)*	(4.06)**	(2.38)*	(0.89)
Outside improved water	-0.330	-0.356	-0.470	-0.419	-0.313
	(1.79)	(1.88)	(2.61)**	(2.02)*	(0.99)
Highest education: primary	0.939				
	(2.59)**				
Highest education: secondary	0.961				
	(3.86)**				
Number of rooms		0.137	0.149	0.169	0.293
		(2.16)*	(2.43)*	(2.49)*	(3.74)**
Head's education: primary		0.102	0.164	0.089	0.423
		(0.25)	(0.41)	(0.21)	(0.92)
Head's education: secondary		-0.228	-0.099	-0.156	0.098
		(0.55)	(0.24)	(0.35)	(0.20)
Head's education:		-0.479	-0.516	-0.356	-0.028

above secondary					
		(1.24)	(1.37)	(0.85)	(0.06)
Spouse's education: primary		0.649	0.681	0.863	0.967
		(2.37)*	(2.60)**	(3.08)**	(2.87)**
Spouse's education: secondary		1.047	1.000	1.157	1.205
		(3.76)**	(3.77)**	(4.02)**	(3.55)**
Spouse's education: above secondary		0.249	0.151	0.549	0.401
		(1.00)	(0.65)	(1.98)*	(1.40)
Household electrified			0.594		
			(2.11)*		
Constant	-1.212	-1.021	-1.181	-1.003	
	(2.39)*	(1.79)	(1.92)	(1.72)	
6 Region dummies added	Yes	Yes	Yes	Yes	
Observations	1046	1070	1070	984	840

Robust z statistics in parentheses

* Significant at 5%; ** significant at 1%

4. Multinomial logit analysis of fuel switching

Multivariate regression analysis was also undertaken to help determine the variables associated with fuel switching. It is interesting to assess whether the variables found earlier to affect fuel choice also matter for fuel switching. Multinomial logit is used. This is a standard technique for assessing how exogenous variables affect the choice between different discretionary outcomes. Fuel switching category is the endogenous variable and partial switching – using both solid and non-solid fuels – is set as the base (the omitted category against which the other outcomes are assessed).

Table 15 and Table 16 report multinomial regression results for each country and sector. Results need to be interpreted relative to the base, which is partial switching. Hence, parameters in the "no switching" columns show how each variable affects the probability of households belonging to the "No switching" relative to the "Partial switching" category. Likewise, parameters in columns for "Full switching" show how the exogenous affect the probability of moving from partial switching to using only modern fuels.

Since the extent of fuel switching is much greater in urban areas it is of interest to examine whether and how the underlying fuel switching behavior differs across sector. The regressions are therefore performed separately on the urban and the rural sub-samples in order to allow the regressors to impact differentially.

The results confirm that a number of variables are drivers of genuine fuel switching. This is true for electrification, per capita expenditures, education, and tap water. These variables are all associated with a statistically significant reduction in the probability of using only solid fuels and an increase in the probability of using non-solids. The higher the level of education, the greater the effect on fuel switching. Household size affects fuel choice but does not trigger fuel switch: larger households are more likely to consume multiple fuels including solid and non-solid.

It is interesting that the same parameters are significant in urban and rural areas, although the magnitude of the effect often differs. This implies that similar mechanisms drive fuel switching in urban and rural areas. When we observe so much less fuel switching in rural areas it must be due to lower rural levels of the variables triggering fuel switching. Thus, absence of electrification and of tap water combined with lower levels of education and income makes rural households reluctant to switch to modern cooking fuels. Fuel switching on a large scale will not occur until rural areas have seen a substantial amount of development.

Table 15: Multinomial logit of fuel switching in urban areas, individual countries

	Brazil		South Africa		Vietnam		Guatemala		Ghana		Nepal		India	
	No	Full	No	Full	No	Full	No	Full	No	Full	No	Full	No	Full
Electrified	-2.522	0.269	-0.759	0.565	-2.066	15.586	-1.059	0.356	-1.244	-0.154	-1.136	0.648	-1.220	0.507
	(2.11)*	(0.24)	(2.78)**	(3.90)**	(1.93)	(22.33)**	(5.06)**	(1.02)	(2.77)**	(0.23)	(2.30)*	(1.09)	(15.99)**	(6.14)**
Log pc expenditure	-0.308	0.507	-0.463	-0.123	-1.597	1.579	-2.200	0.405	-1.488	-0.326	-1.958	-0.106	-1.428	0.412
	(3.12)**	(5.71)**	(3.25)**	(1.36)	(8.85)**	(9.09)**	(16.95)**	(4.84)**	(8.46)**	(1.28)	(6.05)**	(0.53)	(26.91)**	(9.30)**
Log household size	-1.082	-1.172	-0.533	-1.210	-0.624	0.215	-0.533	-0.843	-1.102	-1.150	-1.095	-1.090	-0.477	-0.628
	(2.46)*	(4.08)**	(2.59)**	(9.70)**	(3.62)**	(1.26)	(3.70)**	(7.97)**	(6.40)**	(4.71)**	(3.09)**	(3.98)**	(11.16)**	(16.68)**
Primary education	-1.731	-0.746	-0.991	0.296	0.709	0.595	-0.715	0.653	1.679	1.374	-0.135	0.344	-0.422	0.148
	(1.93)	(1.15)	(1.77)	(0.73)	(1.34)	(0.79)	(3.01)**	(2.18)*	(2.34)*	(1.44)	(0.28)	(0.78)	(6.53)**	(2.25)*
Secondary education	-1.270	0.992	-0.526	0.692	1.048	0.896	-1.318	1.122	0.223	0.685	-0.900	-0.015	-0.833	0.431
	(1.85)	(1.75)	(0.98)	(1.76)	(2.05)*	(1.25)	(5.26)**	(3.75)**	(0.63)	(1.27)	(2.33)*	(0.04)	(12.76)**	(6.63)**
Above secondary	0.069	34.226	-1.101	0.821	0.743	0.409	-1.422	1.324	-0.391	0.866	-0.729	0.452	-1.170	0.927
	(0.05)	(25.94)**	(1.56)	(1.92)	(1.41)	(0.56)	(4.50)**	(4.24)**	(1.05)	(1.57)	(1.32)	(1.18)	(14.51)**	(12.65)**
Inside water	-0.870	1.302	0.562	1.147	-0.849	0.768	-0.113	0.471	-0.910	0.412	-0.362	1.212		
	(1.97)*	(4.67)**	(1.96)*	(7.48)**	(5.03)**	(5.08)**	(0.90)	(3.52)**	(5.14)**	(1.58)	(1.10)	(4.63)**		
Constant	5.085	2.184	1.178	2.527	2.430	-16.436	3.777	-1.451	6.173	0.366	1.969	1.280	2.601	2.071
	(3.21)**	(1.54)	(2.08)*	(5.97)**	(2.14)*	(.)	(11.32)**	(3.24)**	(10.51)**	(0.41)	(2.96)**	(1.82)	(26.32)**	(20.49)**
Observations	3568	3568	4412	4412	1729	1729	3387	3387	2174	2174	715	715	46886	46886

Robust z-statistics in parentheses

* Significant at 5 percent; ** significant at 1 percent

Table 16: Multinomial logit of fuel switching in rural areas, individual countries

	Brazil		South Africa		Vietnam		Guatemala		Ghana		Nepal		India	
	No	Full	No	Full	No	Full	No	Full	No	Full	No	Full	No	Full
Electrified	-1.114	0.917	0.228	1.403	-1.538	-0.655	-0.071	1.377	-2.307	-1.442	-1.576	1.176	-1.846	0.493
	(5.78)**	(3.94)**	(1.92)	(13.22)**	(4.58)**	(1.00)	(0.73)	(3.73)**	(4.25)**	(1.60)	(6.38)**	(2.34)*	(29.22)**	(5.19)**
Log pc expenditure	-0.432	0.410	-0.403	0.595	-2.711	1.700	-1.999	0.512	-1.191	0.077	-1.313	0.512	-1.725	-0.017
	(3.93)**	(3.38)**	(6.03)**	(7.09)**	(14.92)**	(4.91)**	(18.28)**	(2.62)**	(4.20)**	(0.14)	(4.89)**	(1.27)	(40.29)**	(0.36)
Log household size	-0.269	-0.532	-0.173	-0.981	-0.393	1.080	-0.751	-1.136	-0.188	-0.607	0.319	-0.263	-0.189	-1.069
	(1.34)	(2.75)**	(2.15)*	(10.61)**	(2.12)*	(3.21)**	(6.72)**	(4.95)**	(0.72)	(1.09)	(1.10)	(0.51)	(4.95)**	(23.22)**
Primary education	-0.848	-0.310	-0.473	-0.066	-0.620	-0.758	-0.356	0.910	22.057	43.777	-1.044	0.537	-0.453	0.480
	(2.29)*	(0.81)	(2.39)*	(0.29)	(0.77)	(0.46)	(2.17)*	(1.46)	(16.69)**	(.)	(2.86)**	(0.75)	(6.23)**	(4.77)**
Secondary education	-0.676	0.496	-0.851	0.411	-0.824	-0.852	-1.224	1.872	0.010	22.173	-1.122	-0.315	-1.337	0.558
	(2.73)**	(1.48)	(4.22)**	(1.78)	(1.03)	(0.52)	(6.53)**	(2.86)**	(0.02)	(19.41)**	(3.36)**	(0.42)	(19.19)**	(5.78)**
Above secondary	-31.054	1.525	-0.860	0.972	-1.087	-0.668	-0.790	2.365	-1.558	22.553	-2.116	0.271	-1.810	0.971
	(40.33)**	(1.88)	(3.00)**	(3.43)**	(1.34)	(0.40)	(2.86)**	(3.40)**	(2.32)*	(17.77)**	(4.89)**	(0.33)	(23.12)**	(9.40)**
Inside water	-0.154	0.846	0.817	1.578	-1.480	1.362	-0.330	0.052	-1.728	0.545	-0.849	0.422		
	(0.62)	(4.87)**	(2.92)**	(6.95)**	(2.78)**	(2.58)**	(3.69)**	(0.24)	(4.22)**	(0.78)	(2.89)**	(0.87)		
Constant	1.603	-1.368	0.506	-0.288	4.109	-1.194	3.518	-3.476	6.971	-21.539	2.736	-1.390	4.047	0.615
	(5.00)**	(3.59)**	(2.58)**	(1.24)	(5.05)**	(0.69)	(15.96)**	(5.69)**	(10.50)**	(.)	(7.06)**	(1.70)	(43.47)**	(4.87)**
Observations	1078	1078	4301	4301	4269	4269	3848	3848	3758	3758	2657	2657	70474	70474

Robust z-statistics in parentheses

* Significant at 5 percent; ** significant at 1 percent

APPENDIX 2: COMPARISON OF DATA SOURCES AND STATISTICS ON HOUSEHOLD ENERGY[18]

This Appendix presents newly assembled data on household fuel use and electrification rates from a number of countries. A variety of data sources are compared, assessed and analyzed with a view to investigate the extent to which trends over time in fuel usage and electrification can be established.

The World Bank is a major publisher of development statistics in many areas of its work: economics, health, education, and so on. Researchers and practitioners from around the world working in these areas frequently use World Bank publications, including World Development Indicators, as statistical reference works. In the area of energy, and in particular household energy, it is very limited what the World Bank publishes. All the energy-related statistical series published in the World Development Indicators (complete, on-line version) are shown in Box 1 below.

The series all relate to national energy systems, mostly grid electricity. None of them reflect on any of the potential development targets at the household level that countries or donor agencies might consider adopting: access and affordability of household energy are not covered. To the knowledge of this author, no other institution publishes comprehensive statistics on household energy in developing countries, although IEA (2002) does contain a recent attempt at gathering fuel use and electrification data.

Box 1: Energy in World Bank statistics

Series related to energy published by the World Bank in WDI (online version)
Electric power consumption (kwh per capita) Electric power consumption (kwh) Electric power transmission and distribution losses (% of output) Electricity production (kwh) Electricity production from coal sources (% of total) Electricity production from hydroelectric sources (% of total) Electricity production from natural gas sources (% of total) Electricity production from nuclear sources (% of total) Electricity production from oil sources (% of total)

[18] Prepared by Rasmus Heltberg, Oil and gas policy division as part of a larger multicountry study on household fuel use. This appendix can however be read in isolation from the larger study of which it is a part. It is designed to give an overview of indicators of access to household energy at the global level. Appreciation is expressed of the cooperation by ORC Macromedia in providing the data used here.

Commercial energy production (kt of oil equivalent)
Commercial energy use (kg of oil equivalent per capita)
Commercial energy use (kt of oil equivalent)
Energy imports, net (% of commercial energy use)
GDP per unit of energy use (1995 US$ per kg of oil equivalent)
GDP per unit of energy use (PPP $ per kg of oil equivalent)
Traditional fuel use (% of total energy use)

The Demographic and Health Surveys (DHS) have been undertaken in a number of developing countries by the company ORC Macro with funding from the USAID, the World Bank, and others. The DHS surveys have in most cases included a question on the major cooking fuel of the household; it has also included a question on the household's source of light.

The questions asked by the DHS were more or less as follows:

- What is the main source of light for this household?
- What is the main cooking fuel used by this household?

Thus, DHS surveys provide a comparable, readily available, and potentially valuable source of statistical data on household energy. The following sections present, describe, and analyze the DHS data on household cooking fuels and electrification with a view to establish the usefulness of this data to the World Bank and other donors working on household energy in poor countries.

1. Household fuel use

Table 17 shows the proportion of adult women in age 15-49 using modern and solid cooking fuels in all of the countries for which this information is available from a DHS survey. Most DHS surveys undertaken since 2000 have included this question on cooking fuels, and some earlier surveys occasionally included it. ORC Macromedia has specially provided this data to the World Bank.[19] Modern fuel use for cooking is here defined as LPG, natural gas, biogas, kerosene (for cooking), electricity (for cooking), or gasoline. Solid fuels are wood, coal, charcoal, and dung. Most of the surveys allowed one cooking fuels – in a few surveys (South Africa and Yemen) households could report multiple fuels, and these countries therefore show up with totals that exceed 100 percent.[20] The data on individual fuels for each country and sector underlying Table 17 are reproduced in Table 20 below.

[19] The data is representative at the level of women age 15-49; the results would probably not be much different with the alternative of using household weights. The World Bank has been provided with a special tabulation of the DHS data. Without access to the raw data it is not possible to experiment with alternative methods of weighting.

[20] It was not possible from the tabulated data to assess the share of households cooking with any modern fuel in South Africa and Yemen.

The data show that modern fuel use is higher in urban areas and in economically more developed countries. Modern fuels are also widely used in the countries of the Former Soviet Union, and in the Middle East. Modern fuels penetrate little in Africa.

Table 17: Modern and solid cooking fuel use in various countries

Distribution of women 15-49 by type of fuel used for cooking, by sector. Various countries and years. In %

	Urban			Rural			National		
	Modern fuels[a]	Solid fuels[b]	Total[c]	Modern fuels[a]	Solid fuels[b]	Total[c]	Modern fuels[a]	Solid fuels[b]	Total[c]
Benin 1996	14.8	85.1	100	0.7	98.9	100	6.3	93.4	100
Benin 2001	10.3	88.4	100	0.7	99.2	100	4.6	94.8	100
Bolivia 1998	96.0	3.8	100	23.7	76.3	100	75.3	24.6	100
Cambodia 2000	20.9	79.1	100	1.5	98.5	100	5.0	95.1	100
Colombia 1990	88.7	6.5	100	30.6	65.8	100	73.8	21.7	100
Colombia 1995	96.7	3.3	100	35.9	64.3	100	81.3	18.7	100
Colombia 2000	97.7	2.2	100	40.9	59.2	100	85.0	15.1	100
Dominican 1991	83.1	16.9	100	25.8	74.2	100	65.0	35.0	100
Dominican 1996	96.1	3.7	100	63.8	36.1	100	85.3	14.6	100
Egypt 2000	100.0	0.0	100	96.4	3.6	100	98.0	2.0	100
Eritrea 1995	74.4	25.6	100	2.7	97.4	100	26.1	73.9	100
Ethiopia 2000	29.6	70.4	100	0.0	99.9	100	5.4	94.6	100
Gabon 2000	85.3	14.3	100	18.7	81.2	100	72.1	27.6	100
Guatemala 1999	69.9	30.1	100	23.6	76.4	100	44.4	55.6	100
Haiti 2000	7.9	91.9	100	0.7	99.2	100	4.1	95.8	100
India 1993	57.5	42.4	100	4.3	92.5	100	18.2	79.5	100
India 1999	68.6	31.0	100	7.9	84.0	100	23.8	70.1	100
Malawi 2000	19.3	80.7	100	0.3	99.6	100	3.4	96.6	100
Mali 2001	1.0	99.1	100	0.1	99.7	100	0.3	99.7	100
Nepal 2000	58.8	0.0	100	3.6	0.0	100	8.9	0.0	100
Nicaragua 2001	62.0	38.0	100	7.6	92.4	100	42.0	58.1	100
Peru 2000	90.2	9.8	100	11.7	87.3	100	66.5	33.2	100
Rwanda 2000	2.0	97.9	100	0.0	99.9	100	0.3	99.5	100
South Africa 1998	111.0	16.1	127	67.3	69.5	137	93.8	37.2	131
Sudan 1990	13.8	82.5	100	0.8	97.8	100	5.6	92.0	100
Turkmenistan 2000	100.0	0.0	100	99.6	0.4	100	99.8	0.2	100
Uganda 2000	10.8	89.0	100	1.1	98.9	100	2.7	97.3	100
Yemen 1991	92.2	10.8	103	34.8	72.9	109	41.1	66.0	108
Yemen 1997	95.5	16.5	112	65.5	85.8	151	73.0	68.4	141
Zambia 2002	43.0	56.9	100	2.4	97.3	100	18.7	81.1	100
Zimbabwe 1988	82.9	17.2	100	3.7	96.3	100	30.2	69.8	100
Zimbabwe 1999	95.5	4.5	100	5.1	94.9	100	40.0	60.0	100

Source: Demographic and Health Surveys (DHS) specially tabulated by ORC Macromedia for the World Bank.

a: Modern cooking fuels include electricity, LPG, natural gas, kerosene, and gasoline.

b Solid fuels include fuelwood, straw, dung, coal, and charcoal.

c: The total exceeds 100% in 3 surveys which allowed multiple entries – in those cases it is not possible to determine the share of households using any modern fuel. The sum for modern fuels and solid fuels may not add to the total due to an omitted category of other fuels.

For a few countries it was possible to match the DHS fuel use data with other household surveys in order to compare the answers. Table 18 shows such a comparison for Nicaragua and India. For India, these two data sources largely agree. This is re-assuring as it suggests survey instruments can be a reliable tool of obtaining information on household energy. For Nicaragua, there is agreement regarding rural fuel use – largely wood – but a significant disparity regarding urban LPG and wood usage. It cannot be ruled out, however, that this disparity is genuine and caused by rising LPG uptake in the 3-year period between the two surveys

Table 18: Primary fuel use in India and Nicaragua, LSMS and DHS

Comparison of primary fuel use according to various data sources for India and Nicaragua (in %)

	LSMS/NSS surveys				DHS		
	Urban	Rural	Total		Urban	Rural	Total
Nicaragua, LSMS 1998				Nicaragua 2001			
Cooking fuels				Cooking fuels			
Electricity main fuel	1.5	0.2	1.0	Electricity	1.2	0.1	0.8
LPG main fuel	46.4	6.1	29.0	LPG, natural gas	59.9	7.2	40.5
Kerosene main fuel	2.3	1.2	1.8	Kerosene	0.9	0.3	0.7
Coal main fuel				Coal, lignite	0	0	0
Charcoal main fuel	2.0	0.3	1.2	Charcoal	0.7	0.1	0.5
Wood main fuel	46.4	91.4	65.9	Firewood, straw	37.3	92.3	57.6
Dung main fuel				Dung	0	0	0
Other				Other	0	0	0
Total*	98.6	99.1	98.8	Total	100	100	100
India (NSS 55th round 1999-2000)							
Cooking fuels				Cooking fuels			
Electricity main fuel	0.4	0.1	0.2	Electricity	0.8	0.2	0.4
LPG main fuel	44.1	5.4	16.0	LPG, natural gas	47.9	5.1	16.3
Biogas main fuel	0.1	0.3	0.2	Biogas	0.5	0.5	0.5
Kerosene main fuel	21.7	2.7	7.9	Kerosene	19.4	2.1	6.6
Coal main fuel	4.1	1.5	2.2	Coal, lignite	4.4	1.6	2.3
Charcoal main fuel	0.1	0.0	0.1	Charcoal	0.5	0.2	0.3
Wood main fuel	22.2	75.4	60.9	Firewood, straw	24.6	73.4	60.6
Dung main fuel	2.1	10.6	8.3	Dung	1.5	8.8	6.9
Other	0.7	2.7	2.2	Other	0.5	8.1	6.1
Total*	95.5	98.8	97.9	Total	100	100	100

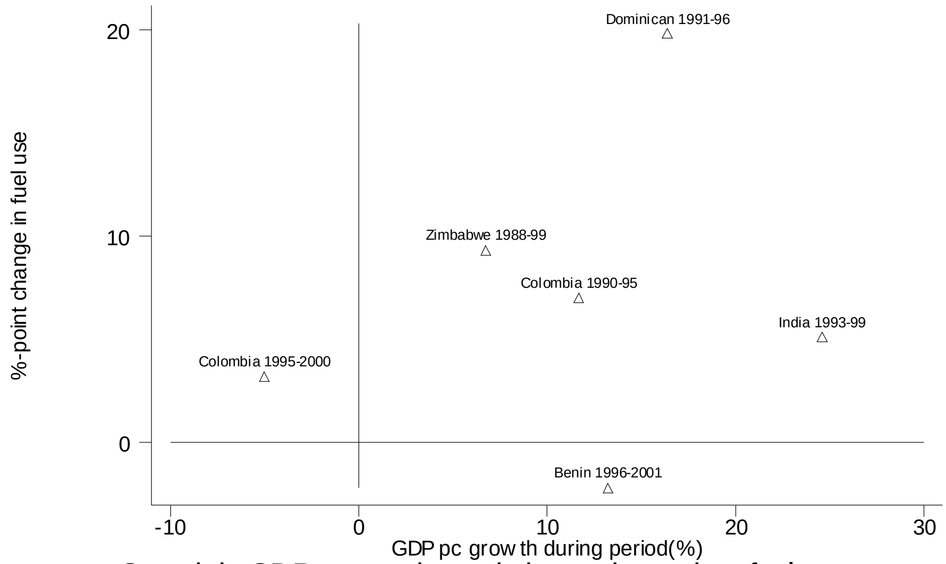
* The totals due not sum to 100 due to missing observations for some households on major cooking fuels.

The DHS data contain six panel data observations – instances where for the same country fuel use data is available at different points in time. This information can be useful for assessing the rate of change over time in modern and solid fuel usage – something that has scarcely been studied previously.

The six panel observations are summarized in Table 19 along with data on the rate of change in GDP. With the exception of Benin, all observations show increasing share of modern fuel usage. Figure 30 plots for each country the percentage-point change in modern and solid fuel usage and its rate of change in real GDP per capita over the period covered by the data. There are several examples of very good progress in uptake of modern fuels – for example 20.5 percentage-point growth in modern fuel usage in the Dominican Republic in the first half of the 1990s and 5.5 percentage-point growth in India's during the latter part of the 1990s. Benin looks like an outlier – one could suspect problems with the data in this case since the underlying data show a questionable shift towards using gasoline as cooking fuel (see Table 20).

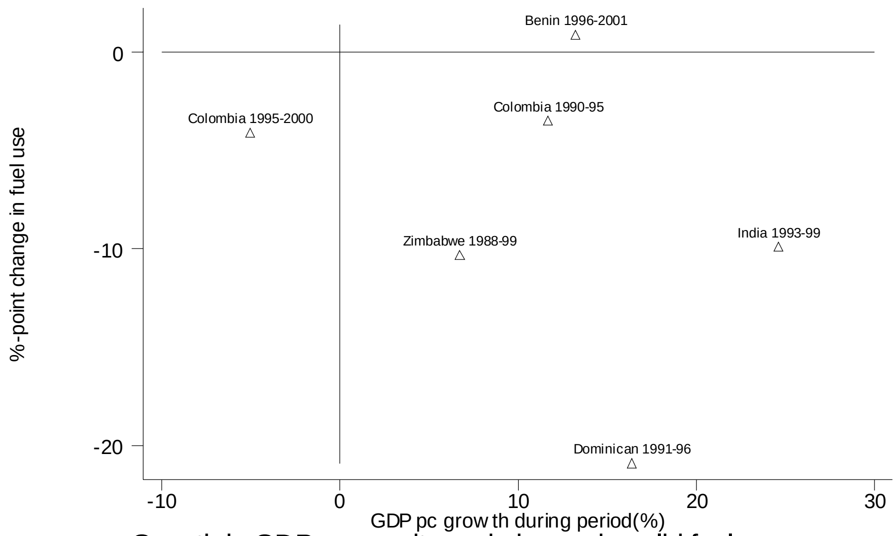
Figure 30: Rate of change of fuel use and of GDP per capita in panel countries

(a) Modern fuel use



Growth in GDP per capita and change in modern fuel use

(b) solid fuel use



Growth in GDP per capita and change in solid fuel use

Table 19 also calculates the average elasticity of fuel usage with respect to GDP per capita, following a method that has been widely used to study the poverty elasticity of growth. For these six observations, a one percent change in GDP per capita on average resulted in around 1 percent change in the share of women cooking with modern fuels and a 0.6 percent fall in the share cooking with solid fuels. When the outlier, Benin, is excluded, the growth elasticity of modern fuel use increases to 1.6. Thus, the preliminary conclusion to draw from this admittedly small sample size is that cooking fuel use reacts to economic growth and changes over time in a manner that makes it feasible to adopt it as a development target alongside other infrastructure and human development targets.

Table 19: Panel observations on fuel use

Country	Period	Modern fuel usage beginning of period	Solid fuel usage beginning of period	Modern fuel usage end of period	Solid fuel usage end of period	% change in modern fuel usage	% change in solid fuel usage	% change in real GDP per capita
Benin	1996-2001	6.3	93.4	4.6	94.8	-27.0	1.5	13.2
Colombia	1990-95	73.8	21.7	81.3	18.7	10.2	-13.8	11.7
Colombia	1995-2000	81.3	18.7	85.0	15.1	4.6	-19.3	-5.0
Dominican	1991-96	65.0	35.0	85.3	14.6	31.2	-58.3	16.4
India	1993-99	18.2	79.5	23.8	70.1	30.8	-11.8	24.6
Zimbabwe	1988-99	30.2	69.8	40.0	60.0	32.5	-14.0	6.7
Average change						13.7	-19.3	11.3
Average elasticity of fuel use w.r.t. per capita GDP (Benin included)						1.0	-0.6	
Average elasticity of fuel use w.r.t. per capita GDP (Benin excluded)						1.6	-0.7	

Table 20: Distribution of women 15-49 by type of fuel used for cooking, by sector. Various countries and years. In %

	South Africa 1998			Yemen 1991			Yemen 1997		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	75.0	22.3	54.2	0.0	0.0	0.0	0.2	0.1	0.1
LPG, natural gas	8.1	6.6	7.5	83.0	32.3	37.9	90.7	56.8	65.3
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kerosene	27.9	38.4	32.1	9.2	2.5	3.2	4.6	8.6	7.6
Coal, lignite	10.6	9.1	10.0	0.0	0.0	0.0	0.4	0.4	0.4
Charcoal	0.0	0.0	0.0	0.3	1.2	1.1	0.0	0.0	0.0
Firewood, straw	5.4	58.5	26.4	10.5	71.7	64.9	16.0	81.7	65.2
Dung	0.1	1.9	0.8	0.0	0.0	0.0	0.1	3.7	2.8
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.3	0.0	0.2	0.2	1.5	1.4	0.0	0.0	0.0
Total*	127.4	136.7	131.1	103.2	109.1	108.4	112.0	151.3	141.4
Number of women	7041	4599	11640	719	5772	6491	2620	7794	10414

*Multiple selections allowed

	Zimbabwe 1988			Zimbabwe 1999			Zambia 2002		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	68.4	2.3	24.4	75.0	2.2	30.3	42.9	2.4	18.7
LPG, natural gas	0.8	0.2	0.4	0.5	0.1	0.3	0.1	0.0	0.0
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kerosene	13.7	1.2	5.4	20.0	2.8	9.4	0.0	0.0	0.0
Coal, lignite	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Charcoal	0.2	0.1	0.1	0.0	0.1	0.1	48.0	12.8	26.9
Firewood, straw	17.0	96.2	69.7	4.5	94.4	59.7	8.8	84.4	54.1
Dung	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.1	0.1
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of women	1404	2793	4197	2279	3625	5904	3073	4585	7657

	Malawi 2000			Mali 2001			Turkmenistan 2000		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	17.4	0.2	3.0	0.0	0.0	0.0	0.6	0.3	0.4
LPG, natural gas	0.0	0.0	0.0	0.9	0.1	0.3	98.2	94.6	96.3
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	1.2	4.7	3.1
Kerosene	1.9	0.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0
Coal, lignite	0.0	0.0	0.0	0.7	0.0	0.3	0.0	0.0	0.0
Charcoal	24.2	0.9	4.6	28.4	4.5	11.7	0.0	0.0	0.0
Firewood, straw	56.5	98.7	92.0	69.0	90.7	84.2	0.0	0.4	0.2
Dung	0.0	0.0	0.0	1.0	4.5	3.5	0.0	0.0	0.0
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0

Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of women	2106	11114	13220	3860	8970	12830	3687	4223	7909

	Eritrea 1995			Nicaragua 2001			Bolivia 1998		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	1.3	0.0	0.4	1.2	0.1	0.8	1.2	0.0	0.8
LPG, natural gas	5.9	0.5	2.2	59.9	7.2	40.5	94.1	23.4	73.9
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kerosene	67.2	2.2	23.5	0.9	0.3	0.7	0.7	0.3	0.6
Coal, lignite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Charcoal	5.1	1.6	2.7	0.7	0.1	0.5	0.0	0.0	0.0
Firewood, straw	19.7	76.2	57.7	37.3	92.3	57.6	3.8	70.3	22.9
Dung	0.8	19.6	13.5	0.0	0.0	0.0	0.0	6.0	1.7
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of women	1647	3400	5047	8234	4804	13038	7923	3181	11105

	Benin 2001			Benin 1996			Peru 2000		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	0.0	0.0	0.0	0.2	0.0	0.1	1.3	0.0	0.9
LPG, natural gas	2.1	0.1	0.9	1.2	0.0	0.5	62.7	7.5	46.0
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kerosene	0.0	0.0	0.0	13.4	0.7	5.7	26.2	4.2	19.6
Coal, lignite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Charcoal	38.0	4.7	18.2	17.8	1.4	7.9	1.0	0.4	0.8
Firewood, straw	50.4	94.5	76.6	67.3	97.5	85.5	8.3	77.6	29.2
Dung	0.0	0.0	0.0	0.0	0.0	0.0	0.5	9.3	3.2
Gasoline	8.2	0.6	3.7	0.0	0.0	0.0	0.0	0.0	0.0
Other	1.3	0.1	0.6	0.1	0.4	0.3	0.0	0.8	0.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of women	2527	3685	6211	2174	3305	5479	19332	8348	27680

	Cambodia 2000			Uganda 2000			Colombia 1990		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	0.2	0.1	0.1	6.1	0.1	1.1	40.7	14.6	34.0
LPG, natural gas	19.2	1.2	4.4	0.3	0.0	0.1	0.0	0.0	0.0
Biogas	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Kerosene	1.5	0.2	0.5	4.2	1.0	1.5	38.2	12.4	31.6
Coal, lignite	0.0	0.0	0.0	74.7	6.6	18.0	1.4	3.6	2.0
Charcoal	27.0	4.1	8.1	14.3	92.3	79.3	0.0	0.0	0.0
Firewood, straw	52.1	94.4	87.0	0.0	0.0	0.0	5.1	62.2	19.7
Dung	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	9.8	3.6	8.2
Other	0.0	0.1	0.0	0.2	0.0	0.0	4.9	3.6	4.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Number of women	2692	12658	15350	1206	6037	7243	6310	2172	8482

	Colombia 1995			Sudan 1990			Colombia 2000		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	32.5	10.2	26.8	1.3	0.2	0.6	15.8	4.8	13.4
LPG, natural gas	59.1	20.8	49.4	12.5	0.6	5.0	80.0	35.0	69.8
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kerosene	1.3	2.0	1.5	0.0	0.0	0.0	0.7	0.5	0.7
Coal, lignite	0.7	2.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Charcoal	0.0	0.0	0.0	72.6	32.1	47.1	0.2	2.7	0.8
Firewood, straw	2.6	61.9	17.6	9.9	65.7	44.9	2.0	56.5	14.3
Dung	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gasoline	3.8	2.9	3.6	0.0	0.0	0.0	1.2	0.6	1.1
Other	0.0	0.0	0.0	3.7	1.4	2.3	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of women	8288	2822	11111	2180	3679	5859	8941	2610	11552

	Dominican 1991			Rwanda 2000			Dominican 1996		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	0.1	0.1	0.1	1.7	0.0	0.3	0.0	0.0	0.0
LPG, natural gas	83.0	25.6	64.8	0.2	0.0	0.0	96.1	63.6	85.2
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kerosene	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.1
Coal, lignite	14.6	21.3	16.7	2.2	0.2	0.5	2.8	6.9	4.2
Charcoal	0.0	0.0	0.0	59.4	2.7	12.5	0.0	0.0	0.0
Firewood, straw	2.3	52.9	18.3	36.3	96.9	86.4	0.9	29.2	10.4
Dung	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of women	4958	2296	7254	1796	8617	10413	5554	2780	8334

	Egypt 2000			Haiti 2000			Ethiopia 2000		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	0.4	0.3	0.4	0.0	0.0	0.0	0.5	0.0	0.1
LPG, natural gas	95.4	73.4	83.1	2.9	0.3	1.5	0.6	0.0	0.1
Biogas	0.0	0.0	0.0	1.7	0.2	0.9	0.8	0.0	0.1
Kerosene	4.2	22.7	14.5	3.3	0.2	1.7	27.7	0.0	5.1
Coal, lignite	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Charcoal	0.0	0.3	0.2	86.6	17.9	49.4	9.6	0.2	1.9
Firewood, straw	0.0	2.7	1.5	5.3	81.3	46.4	57.1	83.1	78.4
Dung	0.0	0.4	0.2	0.0	0.0	0.0	3.7	16.6	14.3
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of women	6871	8702	15573	4655	5499	10154	2791	12575	15366

	Gabon 2000			India 1997-98			India 1993		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel									
Electricity	0.4	0.1	0.3	0.8	0.2	0.4	0.9	0.1	0.3
LPG, natural gas	82.7	18.5	70.0	47.9	5.1	16.3	34.8	2.0	10.6
Biogas	0.0	0.0	0.0	0.5	0.5	0.5	0.9	0.7	0.7
Kerosene	2.2	0.1	1.8	19.4	2.1	6.6	20.9	1.5	6.6
Coal, lignite	0.0	0.0	0.0	4.4	1.6	2.3	7.5	2.1	3.5
Charcoal	2.9	9.3	4.2	0.5	0.2	0.3	0.8	0.2	0.4
Firewood, straw	11.4	71.9	23.4	24.6	73.4	60.6	30.8	77.7	65.5
Dung	0.0	0.0	0.0	1.5	8.8	6.9	3.3	12.5	10.1
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.4	0.1	0.3	0.5	8.1	6.1	0.2	3.3	2.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of women	4956	1226	6182	23640	66646	90285	23314	65917	89231

	Guatemala 1999				Nepal 2000	
	Urban	Rural	Total	Urban	Rural	Total
Type of cooking fuel						
Electricity	1.8	0.7	1.2	0.3	0.0	0.0
LPG, natural gas	67.0	22.7	42.6	20.3	0.5	2.4
Biogas	0.0	0.0	0.0	4.4	1.5	1.8
Kerosene	1.1	0.2	0.6	33.8	1.6	4.7
Coal, lignite	0.0	0.0	0.0	0.0	0.0	0.0
Charcoal	0.0	0.0	0.0	0.0	0.0	0.0
Firewood, straw	30.1	76.4	55.6	0.0	0.0	0.0
Dung	0.0	0.0	0.0	0.0	0.0	0.0
Gasoline	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.1	0.0	41.3	96.3	91.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
Number of women	2679	3291	5969	841	7885	8726

2. Household electricity coverage

Information on the rate of electrification of households in different countries is available from DHS surveys. The column headed “DHS surveys” in Table 21 shows the data from the latest DHS survey available for each of the countries covered. Where available, this information has been compared to data from IEA (2002) and from the household surveys analyzed in the main part of this report.

Table 21: Electrification rates, various countries and data sources

Share of electrified households (%).By survey and year

	DHS surveys		International Energy Agency (IEA)		LSMS/expenditure surveys	
Country	Share electrified (%)	Year	Share electrified (%)	Year	Share electrified (%)	Year
Sub-Saharan Africa						
Benin	21.9	2001	12.0	2000		
Burkina Faso	6.9	1998/99				
Cameroon	40.7	1998	20.0	2000		
CAR	3.0	1994/95				
Chad	2.3	1996/97				
Comoros	28.9	1996				
Cote d'Ivoire	48.2	1998/99	50.0	2000		
Eritrea	22.9	1995	17.0	2000		
Gabon	73.6	2000	31.7	2000		
Ghana	42.6	1998	45.0	2000	41.0	1998/99
Guinea	16.4	1999				
Kenya	14.5	1998	7.9	2000		
Madagascar	10.9	1997	8.0	2000		
Malawi	3.2	1992	5.0	2000		
Mali	10.8	2001				
Mauritania	22.2	2000/01				
Mozambique	6.6	1997	7.2	2000		
Namibia	26.4	1992	34.0	2000		
Niger	6.7	1998				
Nigeria	44.9	1999	40.0	2000		
Rwanda	2.3	1992				
Senegal	32.2	1997	30.0	2000		
South Africa	64.9	1998	66.1	2000	53.6	1993/94
Tanzania	9.4	1996	10.5	2000		
Togo	15.3	1998	9.0	2000		
Uganda	8.6	2000/01	3.7	2000		
Zambia	17.3	1996	12.0	2000		
Zimbabwe	28.1	1994	39.7	2000		
North Africa/Middle East						
Armenia	98.9	2000				
Egypt	95.5	1995	93.8	2000		
Jordan	98.9	1997				
Morocco	49.2	1992	71.1	2000		
Yemen	42.6	1997				
Central Asia						
Kazakhstan	99.9	1995				
Kyrgyz Republic	99.8	1997				
Turkmenistan	99.6	2000				
Uzbekistan	99.6	1996				
South & Southeast Asia						
Bangladesh	17.8	1993/94	20.4	2000		
India	-		43.0	2000	59.4	999/2000
Nepal	24.6	2001	15.4	2000	14.1	1995/96
Pakistan	59.6	1990/91	52.9	2000		
Philippines	71.3	1998	87.4	2000		
Vietnam	78.4	1997	75.8	2000	78.5	1997/98
Latin America & Caribbean						
Bolivia	71.2	1998	60.4	2000		
Brazil	93.6	1996	94.9	2000	92.3	1996/97
Colombia	91.6	1995	81.0	2000		
Dominican Republic	91.0	1999	66.8	2000		
Guatemala	70.9	1998/99	66.7	2000	73.1	2000
Haiti	31.3	1994/95	34.0	2000		
Nicaragua	70.3	1997/98	48.0	2000	68.7	1998
Peru	67.0	1996	73.0	2000		

Sources: DHS survey tabulations from "STATCompiler" on www.measureDHS.com. The estimates from the International Energy Agency are from IEA (2002) "World Energy Outlook 2002". LSMS are World Bank estimates from the raw survey data.

The DHS and the LSMS estimates are both based on household surveys and measure households with electricity, regardless of the source. Thus, illegal connections and off-grid sources of electric power are included here. In contrast, the IEA estimates are based to a large extent on official published statistics, often from national energy ministries or electricity utilities. This has a tendency to result in lower figures than the survey-based estimates since authorities do not count many illegal and off-grid connections. It is encouraging, however, that the survey-based estimates from different sources tend to be in agreement, except where there is a large time span between the surveys; in those cases the rate of electrification may have genuinely changed. In countries or periods where DHS data on electrification are not available data from other household surveys that may exist can easily be used instead – the source of lighting is a routine question in LSMS and many other household surveys. Hence, it will be possible with a fairly small amount of effort to construct a database on electrification with very good global coverage and often with multiple observations at different points in time for specific countries to monitor progress or lack of it over time.

Summing up, if a development agency wants to measure household access to electricity (regardless of type, legality, quality) a survey-based measure arguably is the best approach. If, instead, a development agency wants to assess progress by official utilities in electrifying a developing country it would need to look at official statistics of utility coverage instead. For household welfare, arguably the first type of indicator is the most useful. This indicator will however have to be complemented by indicators of service quality (number of blackouts, for example) and affordability (preferably based on utility tariff rates).

As before, a number of panel data observations result from the DHS data. More DHS surveys asked about electrification than about cooking fuels and consequently a larger number of panel data observations are available on electrification: twenty-two panel observations are available.

The change in the share of household with electricity over the panel period (the length of which differs) varies from 12 to –3 percentage-points. The average rate of change is 2 percentage-points. This is to be compared to an average level of electrification in the panel sample of 38 percent. The progress by individual countries is shown in Figure 31: Electrification progress over time, countries (upper panel) for high and medium-electrification countries (above 25 percent connected) and for low-electrification countries in the lower panel.

Figure 31: Electrification progress over time, countries with middle-high initial levels of coverage

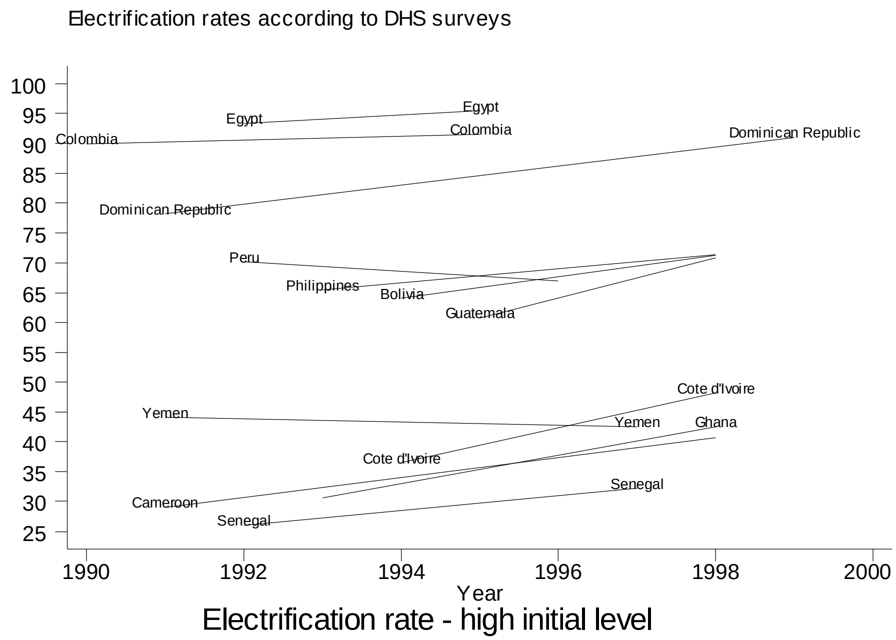
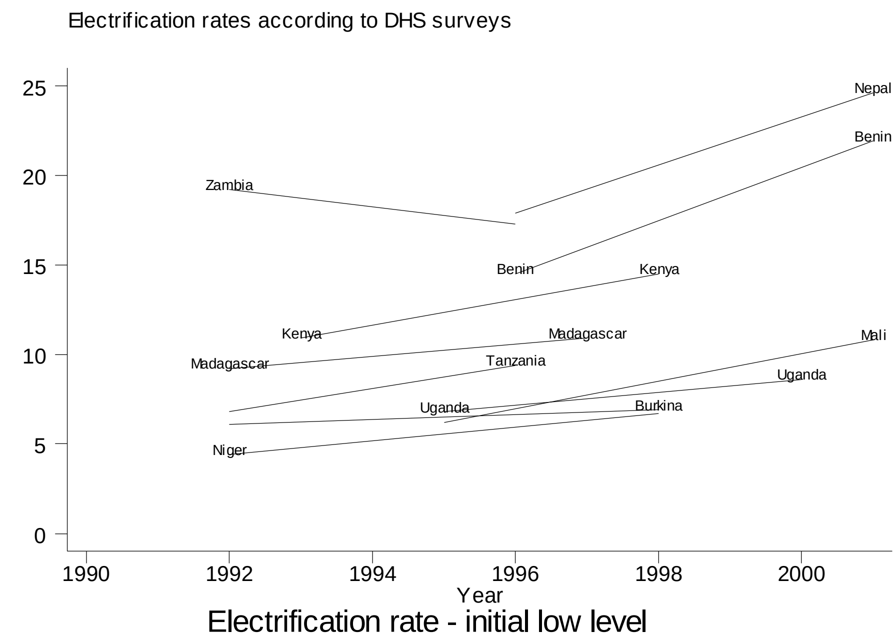


Figure 32: Electrification progress over time, countries with low initial coverage



Three countries have experienced falling electrification according to this data: Yemen, Peru, and Zambia. In general, electrification is the outcome of two forces: (1) progress in electrifying previously unserviced towns and rural areas, and (2) urbanization.

Urbanization can have a large impact on measured electricity coverage since people usually move from uncovered rural areas to covered urban areas. Population growth – particularly in unserviced areas – also affects the measured rate of electrification.

The size of investment required for electrifying rural areas means that progress is bound to be slow. Nevertheless, these data convincingly show that progress in household electrification is feasible to measure and to adopt as a quantitative development target alongside other targets.