Household Energy Use in Developing Countries
A Multicountry Study

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(ESMAP)

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Abbreviations and Acronyms

COCPO	Acronym for World Bank Oil, Gas, Mining, & Chemicals Department, Oil and Gas Policy Division
CV	Coefficient of variation
DHS	Demographic & Health Surveys
ENCOVI	Guatemalan National Survey of Living Conditions
ESMAP	Joint UNDP/World Bank Energy Sector Management Assistance Programme
GDP	Gross Domestic Product
GLSS4	Ghana Living Standards Survey
IEA	International Energy Association
LPG	Liquified petroleum gas
LSMS	Living Standards Measurement Survey
NSS	India: National Sample Survey Organization
OLS	Ordinary least squares
pc	Per capita
PDS	Public Distribution System
UNDP	United Nations Development Programme
VLSSI	Vietnam Household Living Standards Survey
WHO	World Health Organization

Units of Measure

Lb.	Pound
kg	Kilogram
kWh	Kilowatt hours
MJ/kg	Megajoules per kilogram
Q	Quetzales
Rs	Rupees

Executive Summary

1. Compared to many other development issues, there is relatively limited solid empirical documentation of household energy in developing countries. This paper is an attempt to address household energy use and spending in a systematic and comparable fashion, aiming at documenting the "stylized facts" regarding patterns of energy use, energy spending, and fuel switching across countries. For this purpose, a multicountry database consisting of household surveys from eight very diverse developing countries—Brazil, Ghana, Guatemala, India, Nepal, Nicaragua, South Africa, and Vietnam—has been assembled and analyzed. The data sources are Living Standard Measurement Surveys (LSMS) except for India, where the survey carried out by the National Sample Survey Organisation (NSS) is used.

2. The questions in focus include:

- Usage of cooking fuels
- Access to electricity and its impact on fuel use
- Energy and fuel spending (budget shares)
- Distribution of energy subsidies and taxes
- Determinants of household fuel choice and fuel switching
- Policies for fuel switching, and
- Improving the statistics on household energy.

3. A distinction needs to be made between fuel uptake and fuel switching since multiple fuel use is common. The study seeks to assess the extent to which hydrocarbon cooking fuels can displace traditional solid cooking fuels. Only if modern fuels displace traditional biomass can they be used to combat the indoor air pollution, collection time, forest degradation, and other ills associated with solid fuels. The paper also identifies household characteristics associated with fuel switching. This can help determine which households can be realistically targeted for fuel and energy interventions.

4. This report builds upon a large body of work on household energy carried out by World Bank and other researchers during the 1980s and 1990s. Much of that earlier research was based on specialized energy surveys (see Barnes and others (2002) for a summary of many of the earlier findings). The earlier research has helped formulate many of the issues and hypotheses addressed in this report. The major novel contributions of this report stem from its systematic and comparable use of energy-related household survey data. The report presents an explorative overview of what can be achieved in terms of household energy analysis with LSMS and Demographic and Health Survey (DHS) data. The analysis helps confirm a number of stylized facts regarding household energy—for example LPG is mostly used by the urban better-off, the urban poor use cash

wood, firewood is universally used in rural areas, and so on—and it contributes ideas and data sources for a proposed comprehensive global database on household energy access. The report also presents regression analysis of the fuel uptake decision, and pursues this by quantifying fuel switching. This can be useful for targeting purposes in cooking fuel interventions, and leads to caution regarding the prospects of large-scale wood displacement in rural areas. The report confirms a universal correlation between electrification and fuel switching and quantifies the linkage.

5. There are several limitations of the analysis in this report: behavior is notoriously hard to infer from cross-sectional data where households are only observed once; the quality and quantity of energy information contained in the underlying surveys varies—some of the surveys did not distinguish between LPG and natural gas, and some did not distinguish between coal and charcoal. Energy prices could only be included in the analysis to a limited extent. The report has little or nothing to say about renewables or clean use of biomass since there are far too few examples of such cooking technologies being observed in the surveys. Therefore, when the report talks about solid fuels (biomass and charcoal) as the opposite of modern fuels this is despite the realization that there is nothing inherently dirty in solid fuels. It reflects the fact that in the vast majority of cases solids fuels are being burnt in a traditional manner often causing air pollution.

Patterns of Fuel Usage

6. The report confirms previous findings of large and important differences between countries in the cooking fuel mix. Modern fuels—including Liquid Petroleum Gas (LPG), kerosene, natural gas, renewables, and electricity for cooking—are more prevalent in urban areas and the better off is the country. Solid fuels—mostly wood, charcoal, coal, dung, and other biomass—are used much more in rural areas and in low-income countries. Modern fuel use tends to be highly normal; uptake of most modern fuels increases with income. The exception is kerosene usage, which sometimes peaks in the middle of the income distribution, giving rise to the notion that uptake of kerosene may mark the first step in the “fuel transition” away from biomass. Modern fuels play a relatively modest role in rural areas of many low-income countries, where they tend to be confined to the rural elites.

7. Most solid fuels—firewood, dung, and straw—show a strongly inferior incidence, with their use declining with income, particular in urban areas. Usage of coal/charcoal increases with expenditure group, however, in several low-income countries. Solid fuels remain widely in use in rural areas of all of the study countries, including in the top expenditure brackets. Even inferior solid fuels such as dung and straw are used by all quintiles in rural areas of South Asia and Vietnam where they peak in the middle of the income distribution. In India, the quantity of wood used per household is fairly constant in most rural income groups. The implication is that in rural areas economic development and income growth should not be expected to automatically and by itself lead to displacement of traditional biomass cooking fuels in the short and medium run.

8. Different fuels matter to the urban poor and the rural poor. Many of the urban poor rely on purchased firewood, kerosene, or charcoal. Self-collected or homegrown wood is very common in rural areas. Significant amounts of time are frequently spent collecting fuelwood, and most often by females. Thus, in rural Nepal half of wood-collecting households spend more than 7.5 hours per week, while in rural South Africa half spend more than 6 hours per week (almost all of it by women). Although wood purchasing remains more common among the higher rural deciles, it is especially surprising to see that many low-income rural households also purchase wood, for example in Guatemala or India.

Energy Affordability

10. Fuel and electricity pricing is politically sensitive and important for poverty. One frequently hears concerns about the affordability of energy and the need to help the poor pay for energy. Although such arguments sometimes serve as window-dressing for the urban middle-classes to lobby for continued benefits they may also reflect legitimate concerns in some cases. Energy is a basic good and low-income households frequently spend sizeable shares of their income on cooking fuels and electricity. Indeed, the poorest are entirely cut off from modern energy services largely because of the unaffordability of currently available energy technologies.

11. The energy sources on which most money is spent differ substantially across countries. In low-income countries, purchases of biomass and kerosene often feature heavily in family budgets. 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 absorb most of the fuel budget; however, consumers in Guatemala and Vietnam spend as much or more on wood purchases 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.

12. Comparison of the budget share of cash energy reveals curiously large variations in energy budget shares across countries, varying from a low of 2.5 percent in Nepal to a high of 6.5 percent in Guatemala. Generally speaking, countries and areas where households have shifted out of collected or home-grown biomass have higher energy budget shares and therefore increased vulnerability to fuel price fluctuations. Within each country, the energy budget share of households tends to decrease with income; it also decreases with household size. This reflects the fact that energy is a basic good, and that there are economies of scale in energy use. The urban areas often have the highest energy spending (in cash terms), reflecting the availability of ‘free’ biomass in rural areas. The implication is that the urban poor often suffer the most from problems of energy affordability and are exposed the most to energy price fluctuations. The energy sources on which the urban poor spend their energy budgets are typically electricity

combined with purchased wood, charcoal, or kerosene. Being electrified is associated with higher energy spending relative to total expenditures.

13. Comparison of fuel spending among users of specific fuels is useful for energy affordability analysis. Among all of the energy sources considered, market-purchased firewood has the highest budget share among its users. Many urban poor in countries such as Nepal and Guatemala spend significant shares of their total expenditures on wood, around 10-15 percent when averaged over users of wood. This implies that wood users are very vulnerable to price fluctuations in firewood markets. Users of purchased fuelwood are likely candidates for fuel switching since modern fuels would not cost them significantly more; start-up costs and expenditure indivisibilities may deter greater uptake of LPG. Improving access to a variety of energy sources is important and may to some extent help households reduce their energy bill by switching fuels in response to price fluctuations.

14. Comparison of the budget shares of individual fuels across all households in each quintile can be used to assess the distributional implications of subsidies (actual or considered) on specific energy sources. Of course, many other factors also need to be taken into account when deciding upon energy subsidies, including externalities, fiscal costs, and the tendency of subsidies to create vested interest groups. The budget shares of individual fuels averaged over all households in a quintile are a function of the rate of uptake and the budget share of the users of the fuel. The budget share of electricity is higher in the upper quintiles in many of the study countries—including Nicaragua, Vietnam, rural India, rural Ghana, rural Guatemala, and rural South Africa—largely because the rate of connection increases with quintile. Electricity subsidies if delivered as flat reductions in rates per kilowatt-hour would be regressive in those instances. Lifeline and escalating rates are justified—also because the electricity budget share is quite large among those of the poor who are connected. In fact, electrified households in the lower quintiles almost always spend as large or a larger share of their budget on electricity as compared to the upper quintiles. In India, the electricity budget share among users is flat but differences in connection rates translate into higher electricity budget shares among the upper quintiles and in urban areas when averaged over all households.

15. The budget share of LPG averaged over both users and non-users is distributed much more equally than uptake of LPG. This shows the need for looking at both patterns of usage and spending. The reason spending is more equal than usage is because, once adopted, the quantity used and the amount spent on LPG does not depend strongly on income. Subsidies on LPG could potentially be progressive in countries where LPG is used quite widely, as for example in Brazil. India's LPG subsidy is clearly regressive, however, because LPG adoption increases strongly with expenditure group in India. Subsidizing uptake costs could potentially be a manner in which LPG subsidies could be distributed better. Kerosene subsidies would often show quite a progressive pattern—but this is only in theory since subsidized kerosene in practice often gets redirected as an automotive fuel substituting for diesel.

Fuel Switching

16. A number of variables are found 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, increases the use of all energy sources—it matters for fuel choice but not for switching. Prices of fuels could be included only for India (and for Guatemala, in a separate but related study) and are found to have the expected effect. 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. This is because uptake of modern cooking fuels correlates with access to other infrastructure services. Interestingly, electrified households exhibit substantially greater incidence of cooking with LPG and other modern fuels, controlling for expenditure and other factors. Although the exact direction of causality is hard to pinpoint, a significant impact of electrification remains once unobserved community-level factors are controlled for.

17. Modern fuels sometimes complement and sometimes displace solid fuels. Modern fuels appear to substitute for solid fuels much more often in urban areas. Once rural households start using modern fuels, partial switching tends to predominate. The reason seems to be that the levels of the variables that could help trigger a fuel switch—infrastructure, education, and income—are lower in rural areas, while biomass is much more accessible. The prospects for and expected benefits of introducing and promoting modern fuels—in terms of combating indoor air pollution, wood collection, and so forth—are therefore likely to be 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. Supply-driven approaches have often failed in the past.

18. 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, appear unlikely candidates for fuel switching. Large groups of households—particularly in rural areas of low-income countries—will therefore remain unrealistic targets for fuel switching for quite some time to come. It may be more appropriate to consider other interventions for such areas—for example improved stoves or better ventilation of kitchens—although such interventions have also shown a mixed record in the past. Because of the limited purchasing power of this group, effective technologies need to be available at low cost.

Data and Statistics on Household Energy

19. Comparing the energy-related information obtained in various household surveys shows that the usefulness of LSMS surveys for energy policy analysis is very mixed. Many LSMS surveys support basic energy policy analysis of patterns of household energy usage and spending rather well. Other LSMS surveys, however, are weak on energy information. It is an important deficiency that many surveys only ask for the major cooking fuel of the household; households in many developing countries frequently rely on multiple cooking fuels. Future surveys should strive to include some additional energy questions. It is recommended that, as a minimum, surveys always allow for several cooking fuels; ask respondents how often their LPG cylinder(s) are refilled (to better assess quantities); and enquire about the source of fuelwood (to assess fuelwood spending and the scope for switching).

20. It would be desirable and feasible for international institutions including the World Bank to publish more and better statistics on household energy. Quantitative development targets in the field of household energy could also be adopted. It is argued that key indicators in the field of household energy to compile, publish, and follow for each country would include: (i) The rate of household electrification (share of households with electric light from any source of electricity, grid or non-grid, legal or illegal, but excluding batteries) and (ii) household adoption of modern cooking fuels. The suggested definition for modern fuel use is an aggregate statistic for the share of households using any modern energy source as their main cooking fuel. The reason for the proposed focus on the main cooking fuel is pragmatic: there is vastly more data on the main household cooking fuel.

21. The proposed indicators of electrification rates and modern fuel use are feasible to compile, comparable across countries, and may be adopted as quantitative development targets alongside other targets. As documented in appendix 2, these indicators can be compiled from Demographic and Health Surveys (DHS) as well as from LSMS and other household surveys for a substantial number of countries, and sometimes also for multiple time periods. Limited analysis using the small sample size 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 three countries have seen expansion of electrification coverage over time; the average growth in electrification (over a time period that varies, but averages around five years) is 2 percentage-points. Publication of household energy indicators such as those proposed in appendix 2 would draw more attention to household energy among development practitioners and researchers.

1

Introduction

1.1 Energy and fuel use are important for the welfare of households in developing countries. For most people in developing countries, energy comes from wood, waste, dung, candles, and occasionally kerosene. Most work and transport is carried out using human energy. To this day, modern energy bypasses large parts of the population. Many people remain dependent on traditional biomass fuels for cooking and on inefficient and costly sources of light such as candles and kerosene. Greater use of modern energy sources—electricity for light and appliances and clean cooking technologies—is an important development goal; as explained in the following, it is complementary with other goals of development such as improving health and education. Greater use of modern energy requires improved access to and greater uptake of affordable modern energy carriers.

1.2 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, not everywhere, but in certain locations such as near cities and major roads (ESMAP, 2001; Heltberg, 2001). Modern fuel and energy use can improve productivity in numerous ways, for example by redirecting 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. Moreover, cooking and cleaning time is reduced with modern fuels. There are many gender aspects of household energy; the disadvantages of collecting and using fuelwood fall disproportionately on women, and likewise fuel switching brings significant improvements for women.

1.3 Policy interventions targeting cooking fuels and cooking practices were earlier mostly motivated from a desire to control deforestation; increasingly, such interventions are now motivated with reference to concerns regarding indoor air pollution. Indoor air pollution has been estimated by the World Health Organization (2002) to be the world's 4th largest health risk, 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.

1.4 Household energy is therefore as important as ever. Unfortunately there remains a relative lack of solid data on household energy. For example, the World Bank's World Development Indicators does not contain indicators on household fuel use or electrification. 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.

1.5 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).

1.6 The terms "fuel switching" and "interfuel substitution" are sometimes used 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 not 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.

1.7 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. This report seeks to assess the extent to which hydrocarbon-cooking fuels displace traditional cooking fuels and thereby combat indoor air pollution. The report investigates the variables associated with fuel choice and with interfuel substitution. This can help identify households that are potential targets for fuel interventions.

1.8 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, Ghana, Guatemala, India, Nepal, Nicaragua, South Africa, and Vietnam. In doing so, this report builds upon a large body of work on household energy carried out by

World Bank and other researchers during the 1980s and 1990s. Much of that earlier research was based on specialized energy surveys (see Barnes and others (2002) for a summary of many of the earlier findings). The earlier research has helped formulate many of the issues and hypotheses addressed in this report.

1.9 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 questions in focus include:

- Which cooking fuels are used by the poor/the middle classes/the rich? Who has 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 variables associated with 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?

1.10 A purpose-built database with quantitative household survey data from eight 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.

1.11 After this introduction, Chapter 2 briefly discusses theoretical approaches to analyzing 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

Household Fuel Choice Theories

2.1 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 and others, 2002; Barnes and Floor, 1999).

2.2 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.

2.3 Evidence from a growing number of countries is showing multiple fuel use to be fairly common. A common cooking fuel combination in urban Guatemala, for example, is firewood and LPG. In rural Vietnam wood complemented with straw is the predominant combination, while in rural parts of South Africa firewood is often complemented with kerosene. Thus, a large number of households simultaneously use a variety of cooking fuels spanning both upper and lower levels on the energy ladder. This does not easily fit in with the view held by some proponents of the traditional energy ladder model that households tend to stand on one step of the ladder at a time and move (mostly upwards) between adjacent steps on the ladder. Instead, fuel use better resembles a menu choice in which households choose both high-cost and low-cost items depending on their budgets, preferences, and needs.[1] Where multiple fuel usage for cooking is

[1] Multiple fuel use has also been termed fuel *stacking* (Masera, Saatkamp, and Kammen, 2000). See also Barnes and Qian, 1992; Hosier and Kipondya, 1993; Davis, 1998.

common, promotion of petroleum fuels may not induce the abandonment of traditional fuels and may therefore generate fewer benefits than sometimes hypothesized.

2.4 It is illuminating to consider the exceptions from the general energy ladder model. In many countries, one can find a substantial number of nonpoor 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 because of the taste or texture it imbibes to food or 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 be 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 because of aggregate 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 many modern fuel expenditures: whereas fuelwood costs are evenly spread out, expenditures on LPG, natural gas, and electricity 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, while kerosene can be purchased in small quantities. Better understanding of the obstacles for greater spread of clean cooking fuels would clearly be of policy interest.

2.5 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 and others., 2000). This perspective helps explain why households with more education have a greater tendency to use modern fuels, even after controlling for income: their opportunity costs are higher and modern fuels offer significant time savings, particularly for the women.

3

Data Sources on Household Energy

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

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

3.2 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). 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.

Energy Data

3.3 Energy generally appears in two different parts of any LSMS survey: In the housing section and in the expenditure section. Table 3.1 summarizes the kind of energy information that was extracted from each survey for the purposes of this report.

3.4 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, it would be preferable to allow respondents to state at least two cooking fuels. Among the surveys used here, India, Ghana, and Nicaragua only listed respondents' main cooking fuel. Brazil, Nepal, South Africa, and Vietnam listed main and secondary cooking fuel, while the Guatemala survey asked about usage and purpose of all possible fuel sources. Wherever possible, dummy variables were constructed for the two most commonly used cooking fuels.

3.5 In addition, 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.

3.6 Energy usually re-appears in the expenditure section, where households are asked to report their fuel expenses.[2] With some exceptions, only the amount spent is reported; the quantity of each energy source consumed is often unavailable. And where it is available the information is sometimes questionable.[3]

3.7 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. The last column[4] of Table 3.1 documents the information that went into identifying the variables measuring fuel usage.

3.8 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.

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[2] The normal procedure is to ask for fuel expenditures by each fuel type; in the case of Nicaragua only aggregate fuel expenditures were collected, however. See Table 3.1.

[3] Energy quantities are subject to special recall problems. It may be hard for households to accurately report their LPG consumption per month in kilogram when they use fractions of a cylinder. A better practice would be to ask households their LPG cylinder size and refill frequency in order to give more accurate LPG consumption estimates. It is unrealistic to expect households to recall electricity consumption in kilowatt-hours; they would need to show the actual bill to the enumerator as done in some specialized energy surveys. Firewood consumption is often measured in headloads – enumerators would need to weight a typical headload. These steps to ensure the quality of energy quantity data are usually only taken in specialized energy surveys, not in all-purpose household surveys.

[4] 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*.

Table 3.1: Summary of Energy Information Available in Household Surveys for Study Countries

Country	*Main cooking fuel asked?*	*Secondary cooking fuel asked?*	*Source of lighting asked?*	*Fuel expen-ditures*	*Lighting expenditures*	*Energy quantities*	*Cooking fuel usage as defined in this report is based upon:*
Brazil	Yes	Yes	Yes, main and 2nd	For main and 2nd fuel	For main and 2nd source	No	Main and 2nd fuel
Nicaragua	Yes	No	Yes, main	Total fuel expenses	Electricity expenses	No	Main fuel only
South Africa	Yes	Yes	Yes, main and 2nd	By each energy source, regardless of purpose		No	Main and 2nd fuel amended with spending*
Guatemala	Usage, purpose, and spending asked for each fuel type					Yes, by fuel	Fuel usage for cooking
Vietnam	Yes	Yes	Yes, main	By each energy source regardless of purpose		No	Main and 2nd fuel amended with spending*
Ghana	Yes	No	Yes, main	By each energy source, regardless of purpose		No	Main fuel amended with spending*
Nepal	Yes	Yes	Yes, main	By each energy source, regardless of purpose		For firewood	Main+2nd fuel amended by spending*
India	Yes	No	Yes, main	By each energy source, regardless of purpose		Yes, by fuel	Main fuel amended with 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.

3.9 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.

3.10 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.

3.11 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. Households consuming LPG should be asked the size and the refill frequency of their cylinder(s). Firewood users need to be asked the source of their wood—purchased, homegrown, or collected. A community survey that includes energy prices and biomass access would be useful.

3.12 For expenditures, total daily per capita expenditures were used.[5] Quintiles and deciles are in this paper defined separately for urban and rural areas (referred to as "sectorally defined deciles").[6] 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.[7] Average daily expenditures per capita are shown in Table 3.2. The vast disparities between the study countries in standards of living come out clearly. Brazil and South Africa constitute the upper end in terms of average standards of living. They are followed by Guatemala, Nicaragua, and Ghana in an intermediate category, and by Vietnam, India, and Nepal in the low end. To help provide

[5] 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.

[6] In this report, deciles and quintiles are defined with respect to the number of individuals in each sector: all individuals are assigned the average expenditure of their household, sorted in ascending order of per capita expenditure in both rural and urban areas, and grouped into equal-sized groups in each sector. The statistical results in tables and figures, however, take households as the units of analysis since households, not individuals, are the primary users of energy. Hence results show the share of households using a particular energy source in each rural and urban quintile defined to include an equal number of individuals.

[7] 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.

a quick overview of the survey countries, the degree of urbanization and the average household size in urban and rural areas is shown in Table 3.3.

Table 3.2: Average Expenditures Per Capita Per Day (US$ market exchange rates)

Country	*Sector* Urban	Rural	Total
Brazil	17.51	5.22	15.16
Nicaragua	2.60	1.26	2.02
South Africa	8.80	2.92	6.05
Vietnam	1.11	0.50	0.64
Guatemala	4.25	1.53	2.70
Ghana	2.40	1.38	1.75
Nepal	0.67	0.31	0.33
India	0.74	0.39	0.49

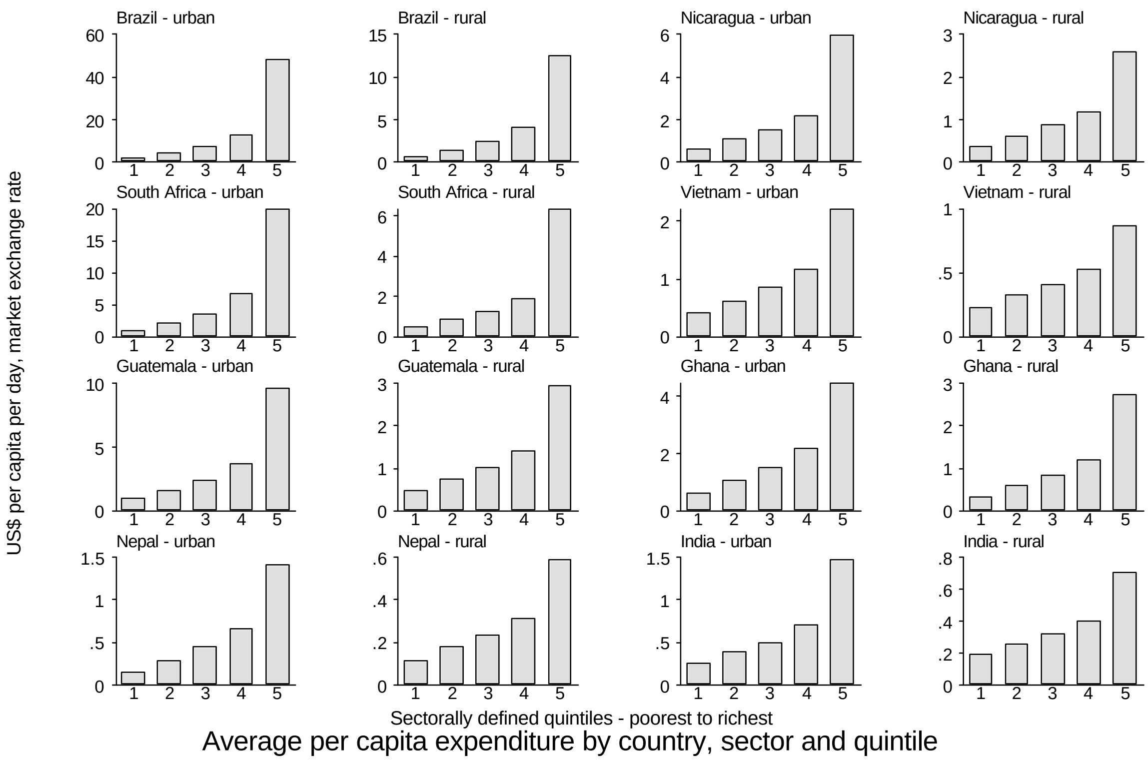
Table 3.3: Urbanization and Average Household Size

	Urbanization (%)	*Household size*		
		Urban	*Rural*	*Total*
Brazil	80.7	3.7	4.3	3.9
Nicaragua	56.7	5.2	5.7	5.4
South Africa	53.3	3.9	5.1	4.5
Vietnam	24.1	4.4	4.8	4.7
Guatemala	43.1	4.7	5.7	5.2
Ghana	36.7	3.9	4.5	4.3
Nepal	7.3	5.4	5.7	5.7
India	27.3	4.5	5.0	4.9

3.13 In addition, Figure 3.1 shows how average per capita expenditures vary over quintiles in each country and sector. The variation in living standards within each country is arguably as significant as the cross-country variation. The differences in living standards are important to keep in mind when studying the figures for fuel use and fuel switching later in this report.

Figure 3.1: Average Per Capita Expenditures By Country, Sector, And Quintile

(US$ per capita per day, market exchange rates)



4

Energy Use Patterns

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

Electrification

4.2 Table 4.1 shows the share of electrified households 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 4.1 shows the same data broken down by both sector and quintile.

4.3 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.

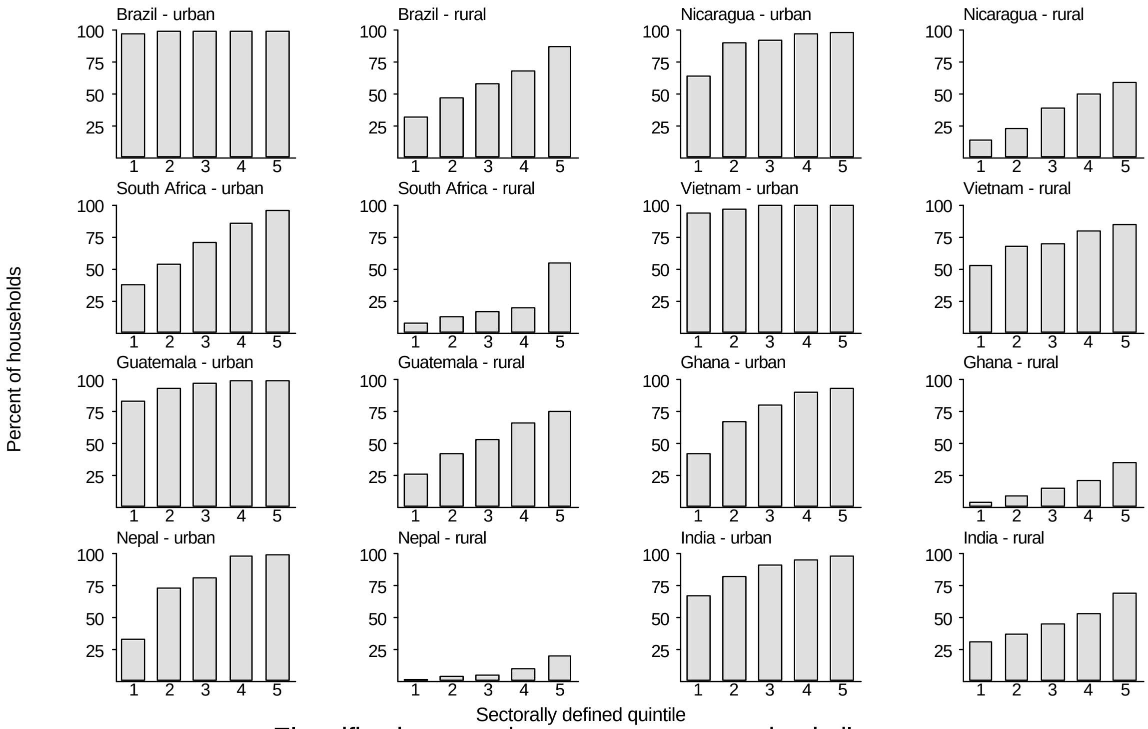
Nonsolid Fuel Use

4.4 Table 4.1 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.

4.5 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 nonsolid fuel and average per capita expenditure is 0.84.[8]

[8] Calculated using market exchange rates.

Figure 4.1: Electrification



Electrification rates by country, sector and quintile

Table 4.1: Electrification Status and Modern Cooking Fuels Use

(in % of households)

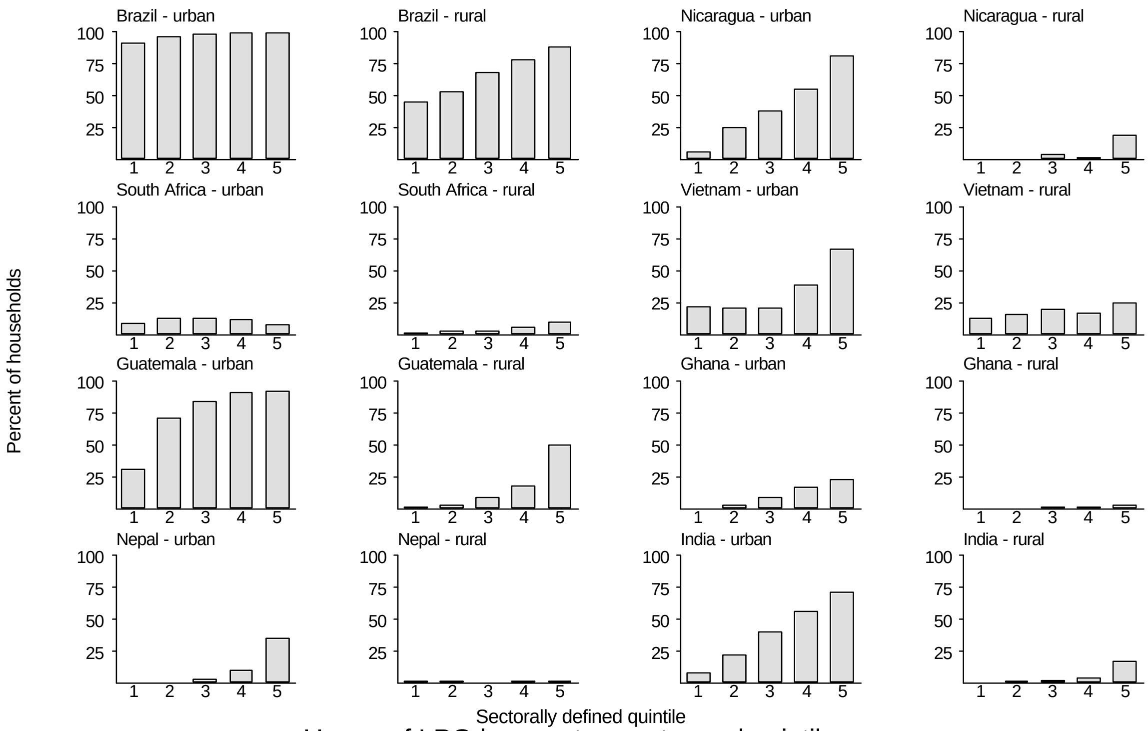
	Electrified	*LPG for Cooking*	*Kerosene for Cooking*	*Electricity for Cooking*	*All Nonsolid Cooking Fuels*
Brazil	92.3	92.3	0.1	1.6	92.8
Nicaragua	68.7	29.0	1.8	1.0	31.7
South Africa	53.6	7.9	43.2	45.8	85.8
Vietnam	78.5	22.3	8.0	13.1	33.0
Guatemala	73.1	44.9	5.5	2.0	50.1
Ghana	41.0	5.4	1.1	0.4	6.9
Nepal	14.1	1.6	7.1	0.3	9.0
India	59.4	16.0	7.9	0.2	24.3

Notes: Row shares of individual nonsolid fuels may not sum to the total for all nonsolid fuels because of multiple fuel use by households.

[a] The Brazil questionnaire does not allow distinction between LPG and other types of gas (piped gas).

4.6 More surprising, however, is that the relative importance of the different modern cooking fuels differs markedly. LPG was by far the most widely used modern fuel in Brazil, Ghana, Central America, and India. Kerosene was the most widely used nonsolid fuel in Nepal and also quite important in India. South Africa is a special case—kerosene and electricity were both widely used for cooking there, while LPG was little used there.

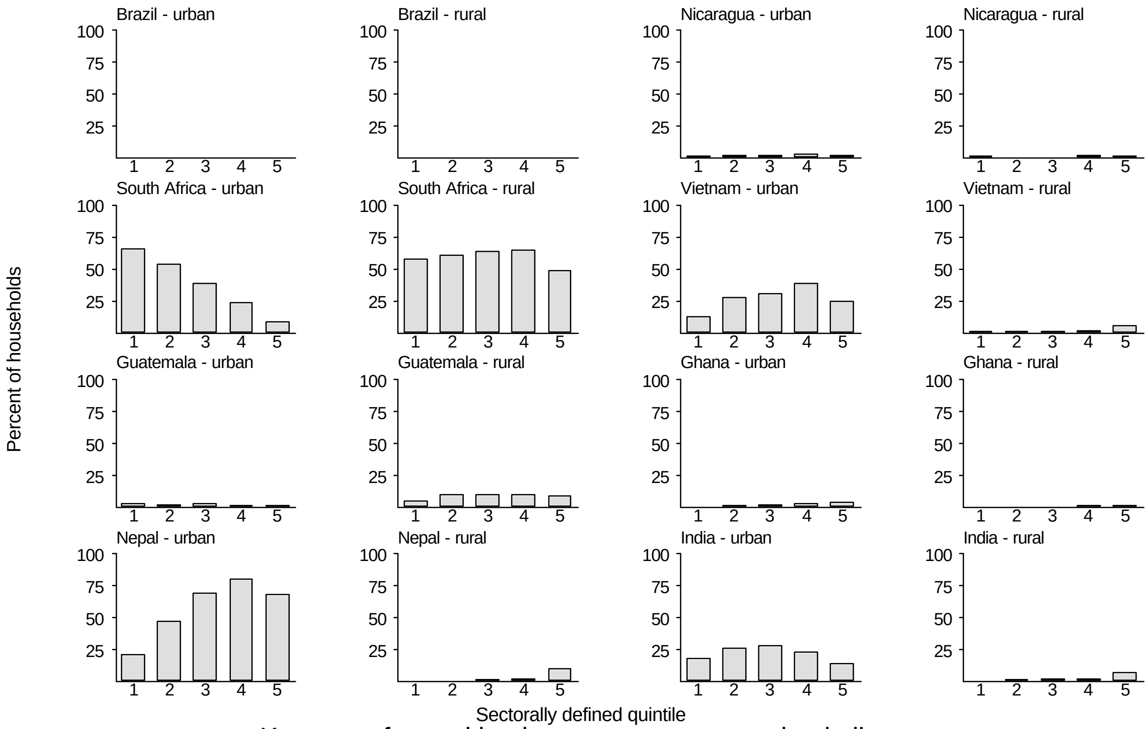
Figure 4.2: LPG Use



Usage of LPG by country, sector and quintile

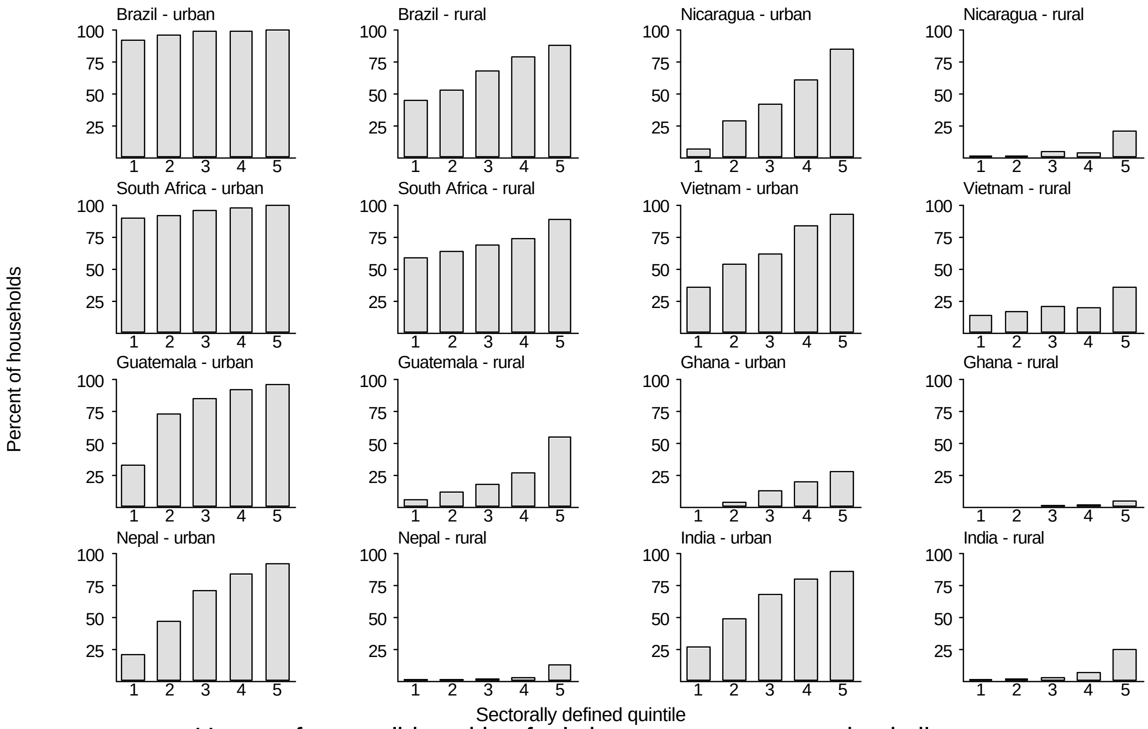
Note: For Brazil, the data refer to LPG plus natural gas.

Figure 4.3: Kerosene Use for Cooking



Kerosene for cooking by country, sector and quintile

Figure 4.4: Any Modern Fuel Use



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

4.7 Figure 4.2 shows how LPG use is distributed across income groups in each of the sample countries; Figure 4.3 does the same for kerosene as a cooking fuel. Figure 4.4 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 nonsolid 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.

4.8 For kerosene, there is no universal pattern of growing or declining usage across the income distribution (see Figure 4.3). 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.

4.9 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 lobby for their continuation. Subsidies are therefore hard to reverse even when they have become fiscally unsustainable.

4.10 Figures 4.2 and 4.4 clearly suggest that unless careful targeting is in place, subsidies on modern fuels 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. Subsidized kerosene however is often redirected for automotive uses. 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 who will almost always be lower down the income distribution than the average existing user; subsidies of uptake costs will only be progressive, however, if there are many new users among the lower quintiles, something that is likely to occur only once the urban high-end market is saturated. 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.

4.11 The quantity of kerosene consumed by households using kerosene for cooking is shown in Table 4.2 for Nepal, India, and Guatemala (it could not be calculated for the other countries). The table shows the average total quantity of kerosene used by all households using kerosene as the main cooking fuel (in Nepal and India) and the average quantity for all households using kerosene as one of its cooking fuels (in Guatemala). In the case of Guatemala it was possible to distinguish between kerosene used for lighting and for cooking. A ‘typical’ quantity 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.)

4.12 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 (note that the quantities are for all who cook with kerosene, regardless of whether they procure it from the PDS or the market). The PDS system also supplies significant amounts of kerosene to non-poor consumers.

Table 4.2: Quantity of Kerosene Used by Households Cooking with Kerosene
(in liters per month)

Country	Sectoral decile 1	2	3	4	5	6	7	8	9	10	Total
Nepal (mean for households whose main cooking fuel is kerosene)											
Urban	15.8	24.9	20.6	14.2	15.5	17.6	19.7	16.7	17.4	16.1	17.3
Rural	-	-	-	-	8.9	17.8	23.0	22.2	13.9	13.1	14.9
India (mean for households whose main cooking fuel is kerosene)											
Urban											
From the Public Distribution System	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	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 (average of households cooking with kerosene; 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.

Energy Poverty

4.13 The concept of energy poverty has been increasingly debated in recent years (IEA, 2002). Energy poverty is often defined as a complete absence of any modern energy sources. The extent of energy poverty in the sample countries is shown in the Table 4.3. For the purpose of this table, energy poverty is defined as being nonelectrified 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 4.3: Energy Poverty

	Urban	*Rural*	*Total*
Brazil	0.4	19.7	4.1
Nicaragua	8.9	58.9	30.5
South Africa	2.6	21.8	11.5
Vietnam	1.8	22.6	17.6
Guatemala	3.2	36.1	21.9
Ghana	21.3	78.9	57.8
Nepal	15.0	89.1	83.7
India	8.6	50.3	39.0

4.14 Defined in this manner, energy poverty ranges from 4 percent of households in Brazil, 12 percent in South Africa, and 58 percent in Ghana, to 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 as a result of its achievements in electrifying large parts of the country. Energy poverty is closely correlated with both electrification and modern fuel use.[9]

Solid Fuel Use and Collection

4.15 Table 4.4 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.

[9] At the quintile/sector level, the correlation between the share in energy poverty and the share electrified is –0.89; the correlation between energy poverty and share using modern fuels is –0.81.

Table 4.4: Solid Fuel Use in %

	Fuelwood	*Coal/Charcoal*	*Dung*	*Straw/leaves/twigs*	*Any solid fuel*
Brazil	16.2[a]	[a]			16.2
Nicaragua	65.9	1.2			67.1
South Africa	31.4	8.1	1.2		37.9
Vietnam	67.5	17.9		59.6	89.1
Guatemala	73.8	12.4			81.8
Ghana	62.2	46.4			96.2
Nepal	77.7	0.5	28.4	32.3	95.5
India	72.0	3.1	37.2		77.7

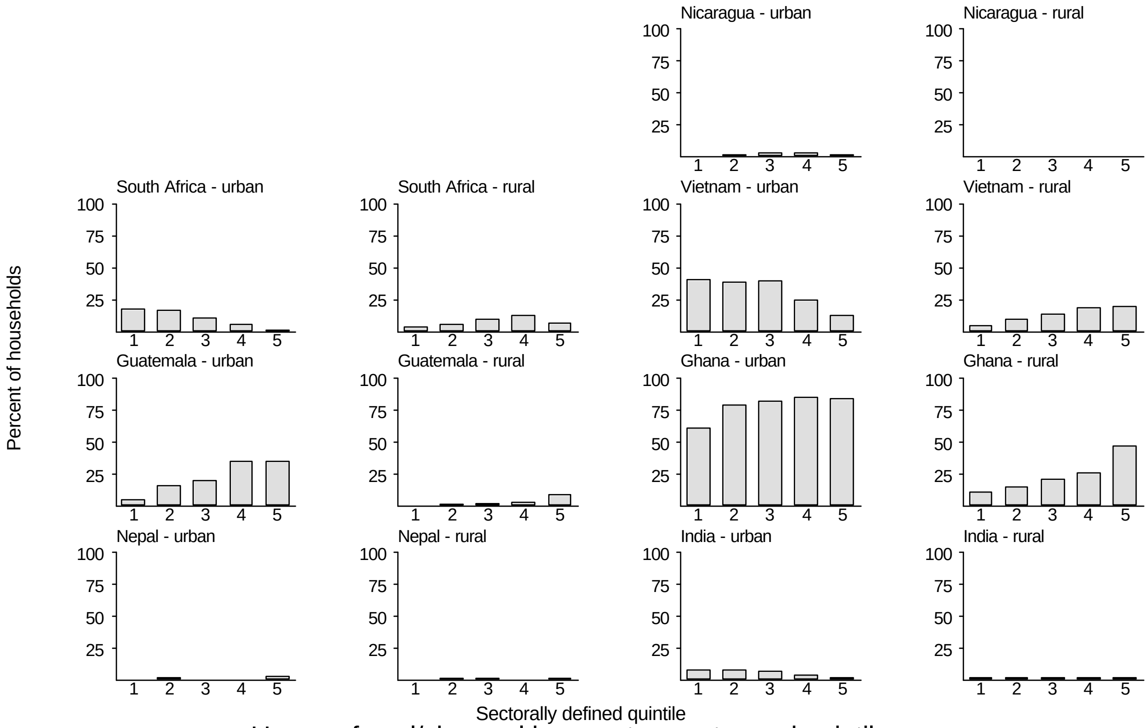
Notes: Row shares of individual solid fuels may not sum to the total for use of any solid fuel because of multiple fuel use by households.
[a] The Brazilian questionnaire does differentiate between wood, coal, and charcoal.

4.16 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 32 percent of Nepalese use straw and leaves.[10]

4.17 Figure 4.3 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.

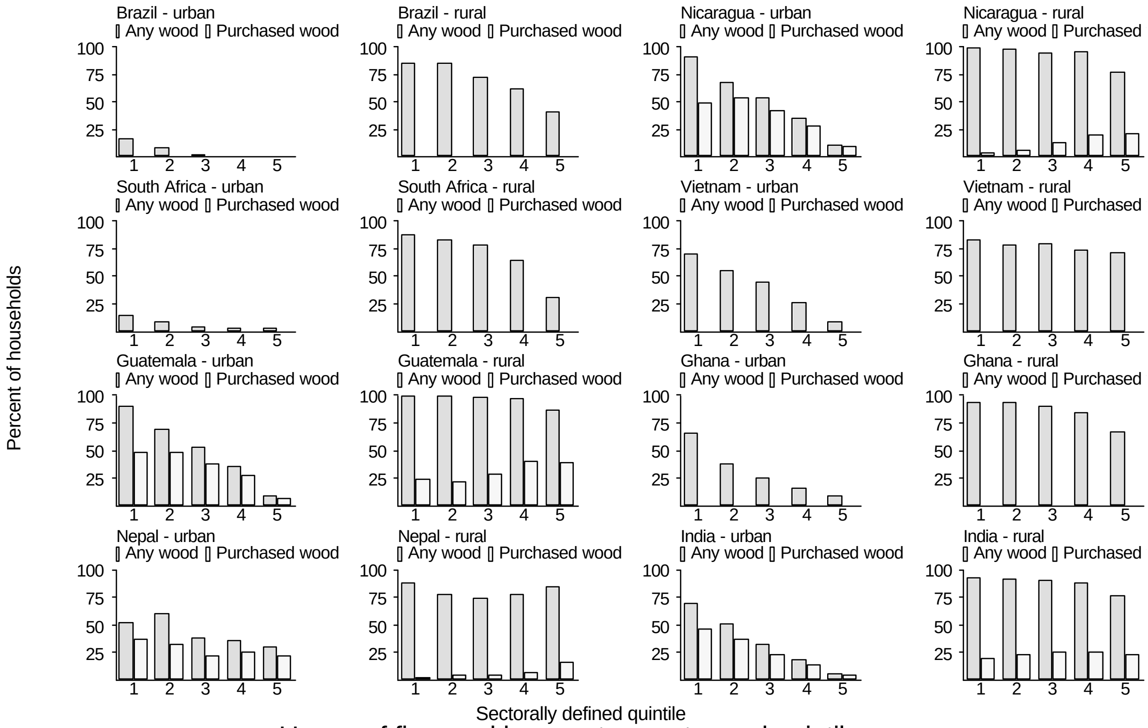
[10] The "straw and leaves" fuel category was not present in the questionnaires for the other countries so no comparison can be made here.

Figure 4.5: Coal Use



Usage of coal/charcoal by country, sector and quintile

Figure 4.6: Firewood Use



Usage of firewood by country, sector and quintile

4.18 Figure 4.6 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 in most countries leads to some skepticism regarding how easily development and income growth can displace solid fuels. In urban areas use of firewood tends to be associated with the lower quintiles. 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 middle classes and rich usually cook with LPG or kerosene instead (or electricity, especially in the case of South Africa).

4.19 Self-collected or homegrown wood is much more common in rural areas. However, surprisingly large shares of rural households rely on wood purchases. In rural areas the upper quintiles are 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. In Guatemala, Heltberg (2003) found that many households spend considerable amounts purchasing firewood—in fact, more than households cooking with LPG spend on LPG. This leads to a belief that fuelwood use often is motivated by factors other than the affordability of alternatives, for example cooking practices and preferences. 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.

4.20 Information on the quantity of wood used is available for Guatemala and India only (see Figure 4.7). Quantity of firewood used per wood-consuming household 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 suggests that income growth cannot be expected to automatically generate significant improvements in indoor air quality in rural areas.

4.21 The time spent collecting firewood is often mentioned as a major burden on rural women. Reducing firewood collection is frequently cited as a key motivator for development interventions in the field of household energy. Anecdotal evidence on this problem such as “rural women have to spend up to two hours (or some other number) per day fetching wood…” often appear in a context where it can be hard for the reader to judge whether the firewood collection time cited is really just an extreme observation or represents a common experience for many women. In order to better judge the magnitude of the problem, data on firewood collection time were extracted from the surveys of Nepal and South Africa, where the data were collected in a comparable manner.

4.22 Figure 4.8 shows collection time only for those households that reported to spend time collecting wood—quite a substantial share in both countries. Since collection time differs substantially across households, averages can be misleading, and the data are therefore reported as the 25th percentile (75 percent of collectors spend at least this much time per week), the median (half of collectors spend at least this much time per week), and the 75th percentile (one-quarter of collectors spend more time per week than this).

4.23 The figures are large—collecting firewood definitely has a non-negligible opportunity cost in terms of time foregone for a large share of wood collectors. The anecdotal evidence does not appear to have exaggerated the issue, at least not widely. Among wood collectors in rural Nepal, one-quarter of households spends more than 13.8 hours per week per household fetching wood, half spend more than 7.5 hours, and three-quarters spend more than 3.8 hours; in rural South Africa, one-quarter of collectors spends more than 12 hours per week, half spend more than 6 hours, and three-quarters spend at least 2 hours. In urban areas, wood collection is generally less time consuming, but many collectors there also spend long hours every week fetching fuelwood.

4.24 As often cited in the literature on gender and development, much collection labor is female. The share of female labor in the total fuelwood collection labor time ranges from 58 percent in the urban areas of both Nepal and urban South Africa to 87 percent in rural South Africa, shown in Table 4.5.

4.25 Figure 4.9 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 4.7: Firewood Consumption in India

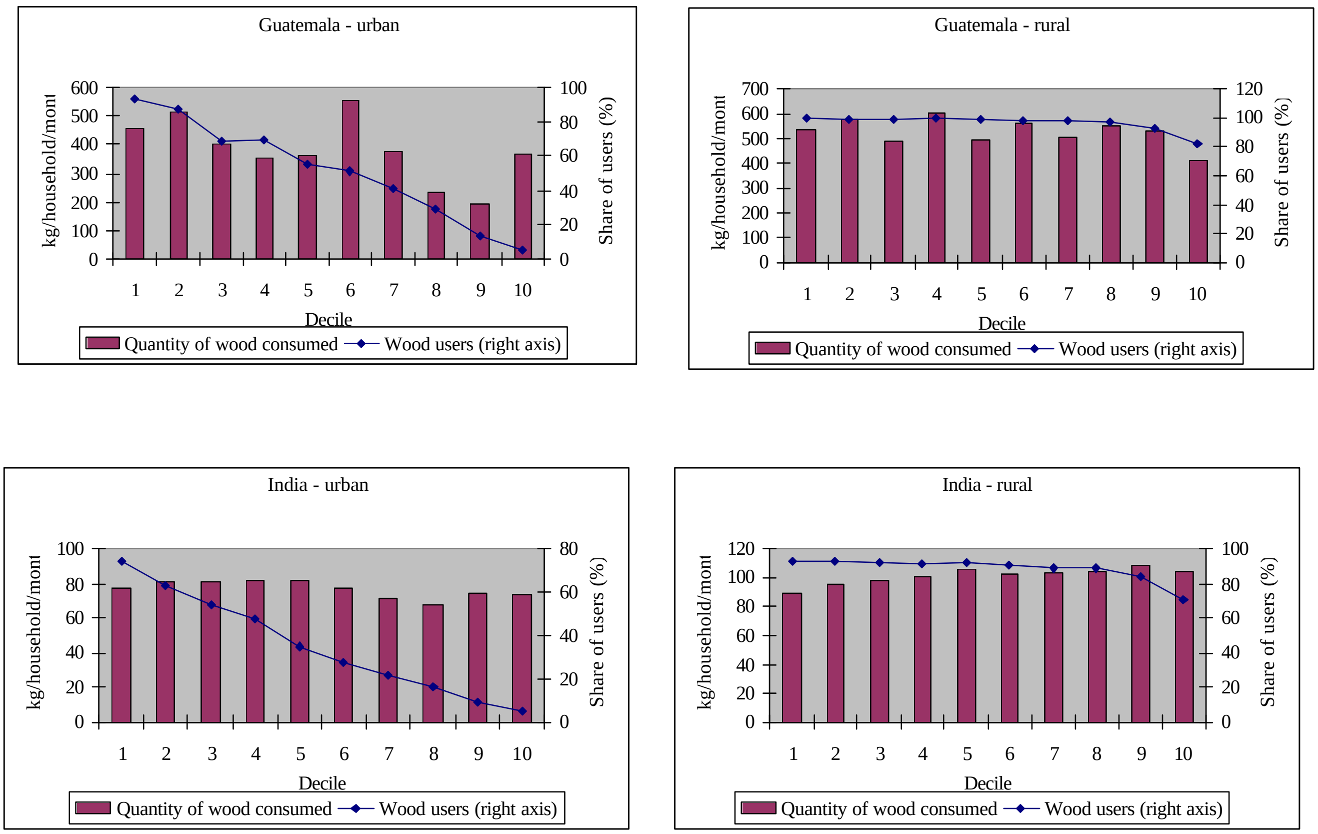


Table 4.5: Female Share of Firewood Collection Time (in %)

	South Africa	*Nepal*
Urban	58	58
Rural	87	62

Figure 4.8: Firewood Collection Time in Nepal, and South Africa

Quartiles (in hours per household per week)

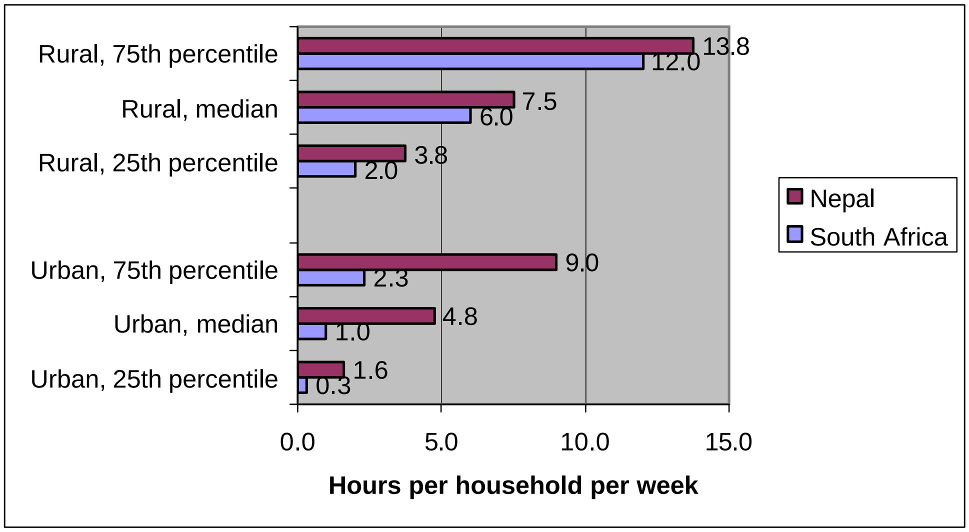
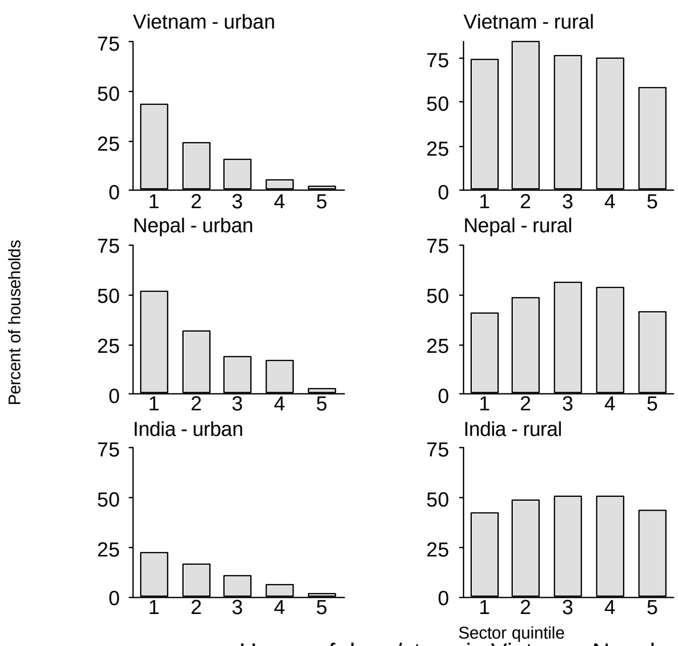
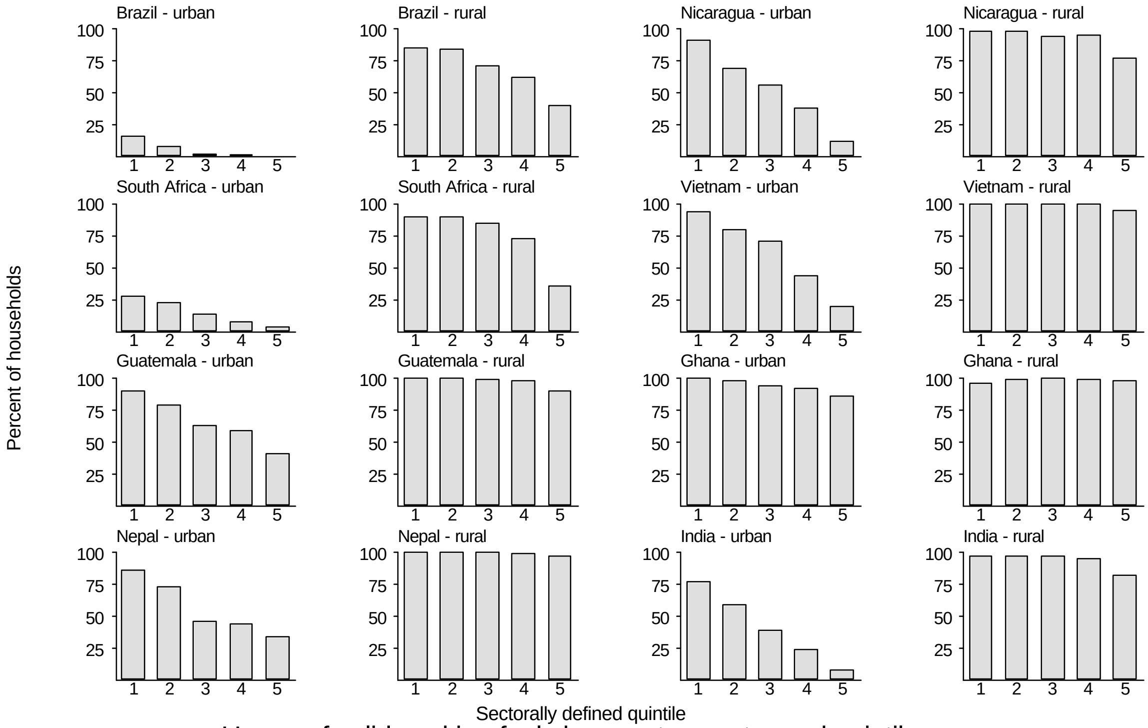


Figure 4.9: Dung/Straw Use by Sector and Quintile, Select Countries



Usage of dung/straw in Vietnam, Nepal, and India

Figure 4.10: Any Solid Fuel Use



Usage of solid cooking fuels by country, sector and quintile

4.26 Figure 4.10 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, the two richest countries, where rural solid fuel use shows relatively strong income dependence.

4.27 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

5.1 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.

Fuel Switching: An Operational Definition

5.2 Unless a convenient simplification is adopted, fuel switching is very 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 proposed. Fuel switching is defined in this report in the simplest manner possible, as the choice between traditional solid fuels and modern nonsolid fuels. In this simplified framework, all households belong in one of three "exclusive fuel switching" categories:

- No switching—the major fuel(s) used by the household are only solid
- Partial switching—the household's major fuels include both solid and nonsolid fuels[11]
- Full switching—the household uses only nonsolid fuel(s).

[11] The measurement of fuel switching is not always comparable across countries since the extent to which multiple fuel use is captured in the surveys varies. For example, households that complement fuelwood with an occasional small amount of kerosene would be categorized as "partial switcher" only if the survey for that country included a secondary fuel and the household had stated kerosene as its secondary fuel.

Table 5.1: Fuel Switching Status, by Country

(% of households)

	No switching—only solid fuel(s)	*Partial switching—both solid and nonsolid fuels*	*Full switching—only nonsolid fuel(s)*
Brazil	6.9	9.4	83.4
Nicaragua	67.1	-	31.7
South Africa	13.9	24.0	61.8
Vietnam	67.0	22.1	10.9
Guatemala	48.8	32.9	17.2
Ghana	92.1	4.1	2.8
Nepal	91.0	4.5	4.4
India	73.0	4.7	19.6

Note: The shares do not sum to one since some households have missing data on fuel use, including households reporting their fuel as "other". There is no data on multiple fuel use in Nicaragua, where the survey only allows identification of the primary cooking fuel.

5.3 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 5.1. Fuel switching is least progressed in Nepal and Ghana and most advanced in Brazil followed by South Africa.

5.4 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 (for example, indoor or outdoor), 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 nonsolid 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.

5.5 Figure 5.1 (upper panel) shows, for each country, the share of households in each decile in urban areas that belong in the three exclusive fuel-switching categories. The lower panel of Figure 5.1 shows the same for rural areas.[12] 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 nonsolid fuels increases. Do they change at the same speed, pointing to solid fuels being displaced? This can be assessed from the share

[12] Note that in both figures, Nicaragua does not show any joint solid and nonsolid fuel use; this is because of limitations in the survey that does not allow identification of multiple fuel use.

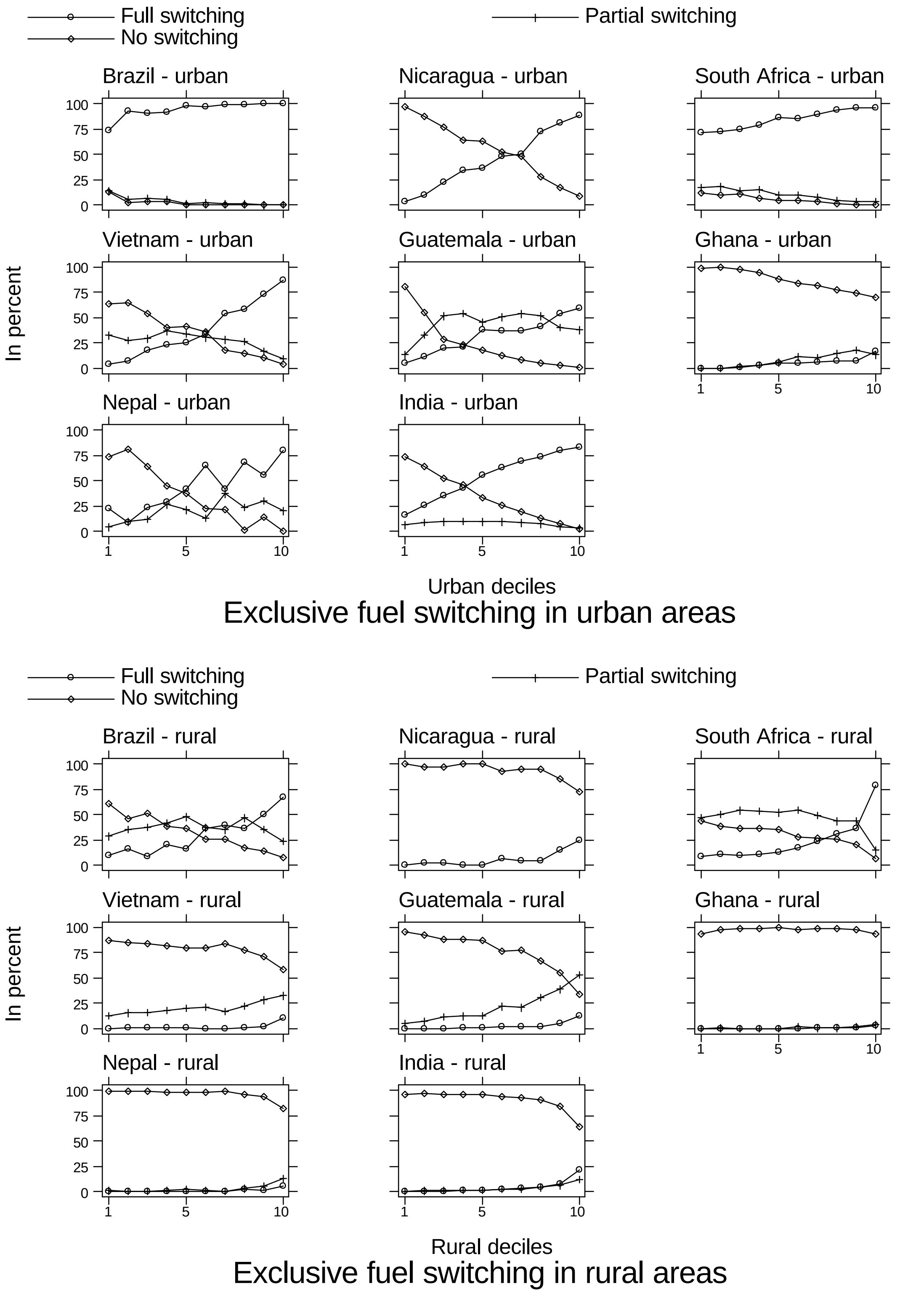
using both solid and nonsolid fuels. In urban areas, partial switching is fairly uncommon except in urban Guatemala. The proportion of partial fuel switchers does not generally increase in tandem with the rise in modern fuel use. This suggests that introduction of modern nonsolid fuels in urban areas helps displace solid fuels.

5.6 The picture is dramatically different in rural areas (see the lower part of Figure 5.1). First of all it is really only the upper rural deciles that have switched fuel in many of the poorer developing countries. There is almost no fuel switching what so ever in rural areas of 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 nonsolid 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.

5.7 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.

5.8 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.

Figure 5.1: Fuel Switching Status in Urban and Rural Areas, by Decile (in %)



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.

6

Affordability: Energy in Household Budgets

6.1 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. Households that have shifted out of self-collected biomass therefore experience heightened vulnerability to fuel price fluctuations. To assess these topics, it is important to know the total share of energy costs in household budgets, and the burden imposed on groups of households purchasing specific 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.

Total Household Budget Share Of Energy

6.2 Table 6.1 shows energy outlays as a percentage of total household expenditures. The top panel shows cash energy budget share, that is, including only purchased fuels. The bottom panel includes in addition households' self-assessed or imputed value of self-collected and homegrown fuels in select countries.[13] 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.[14] 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.

[13] The value of homegrown and collected fuels are respondents' own assessment of the market value of collected biomass fuels; no attempt has been made by the data analyst at imputing prices or values.

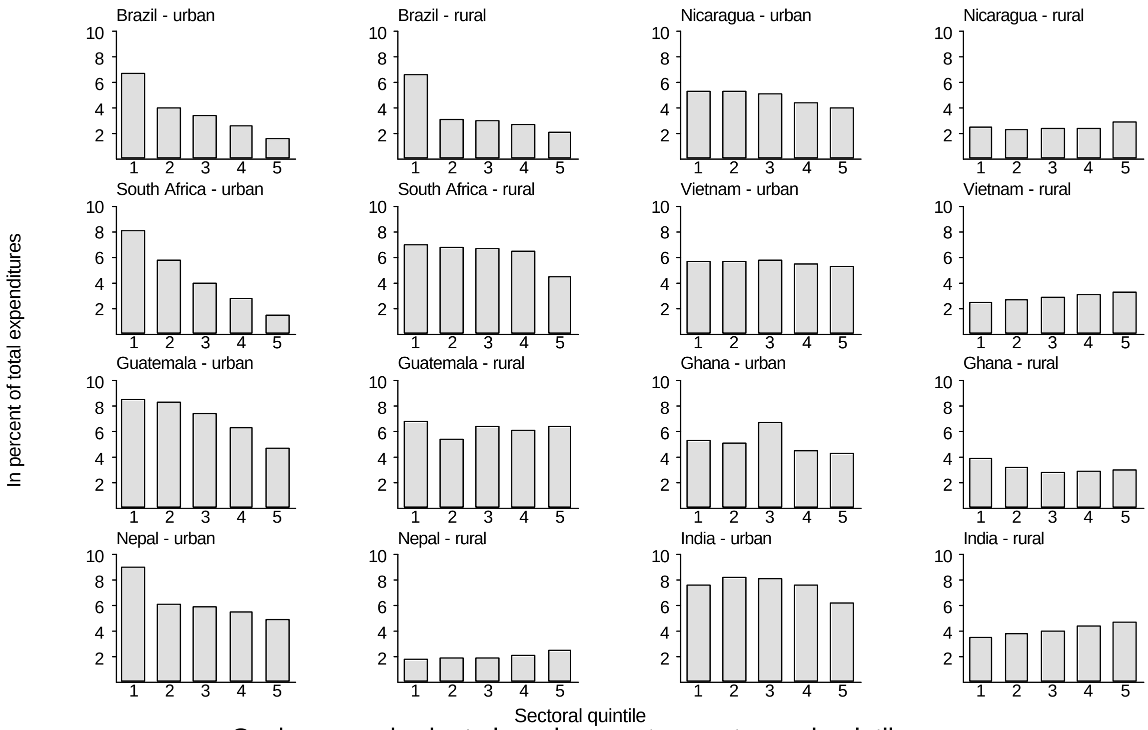
[14] Generally, all results in this paper are based on the full number of observations with no effort to remove outliers. In the case of budget share, however, a few logically inconsistent observations exceeding 100 were removed before taking the means.

Table 6.1: Average Budget Share of All Household energy (in percent)

	Sector		
Country	*Urban*	*Rural*	*Total*
(a) Budget share of cash energy (purchased cooking fuels and lighting)			
Brazil	3.4	3.2	3.4
Nicaragua	4.8	2.5	3.8
South Africa	3.7	5.9	4.7
Vietnam	5.6	2.9	3.5
Guatemala	6.7	6.2	6.4
Ghana	5.0	3.1	3.8
Nepal	6.0	2.1	2.4
India*	7.5	4.1	5.0
(b) Budget share of all energy (including the value of home-grown, collected, and purchased fuels)			
Vietnam	5.9	4.8	5.1
Nepal	6.2	2.4	2.7
India	8.0	8.3	8.2

Note: * In the case of India, the NSS questionnaire contains a source code for fuels that are both homegrown and purchased; fuels in this category were assumed to be purchased. The value of homegrown and collected fuels is respondents' own assessment of market value; no attempt has been made by the data analyst at imputing prices or values.

Figure 6.2: Total Energy Budget Share by Quintile (Only Purchased Energy)



Cash energy budget share by country, sector and quintile

Note: see note to Table 6.1.

6.3 The data on budget share represent a combination of access and affordability factors, and is therefore an indicator that needs to be interpreted cautiously. A low budget share for commercial energy is not necessarily a sign of affordable energy. A low energy budget share could simply mean that modern energy services are unavailable or so unaffordable that households resort to biomass reliance; for example, this is likely to be the explanation for the low energy budget share found in rural Nepal. In contrast, households in rural India where there is much better access to electricity and modern cooking fuels are more widely used spend a larger share on energy. A low energy budget share 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 nonelectrified households are known to cut back on nighttime activities.

6.4 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, 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 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.

6.5 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. These conjectures are supported by limited regression analysis undertaken for India. Controlling for expenditures (in log form), household size (log form), urban residence, and interaction between urban residence and expenditures, electrified households on average have an energy budget share that is almost 1 percentage-point higher:

$$\text{Cash energy budget share} = \underset{(163)}{15.5} - \underset{(66.7)}{2.05} \times \text{Per capita expenditures} + \underset{(34.6)}{0.93} \times \text{Electrified}$$
$$- \underset{(70)}{1.42} \times \log(\text{Household size}) + \underset{(15.5)}{1.98} \times \text{Urban dummy} - \underset{(13.1)}{0.53} \text{ x Urban dummy} \times \log(\text{expenditures})$$

R-squared = 0.09.[15]

Energy Costs

6.6 There is very large variation across countries in the composition of households' energy expenditures (see Figure 6.2). 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.

6.7 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).

6.8 The budget shares of individual energy sources in each country, sector, and quintile are shown in Figure 6.2 for electricity, Figure 6.3 for kerosene, Figure 6.5 for LPG, and Figure 6.6 for wood from the market. For each energy source, two different values of the budget share are plotted:

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[15] Ordinary Least squares was used; absolute values of t-statistics in parenthesis.

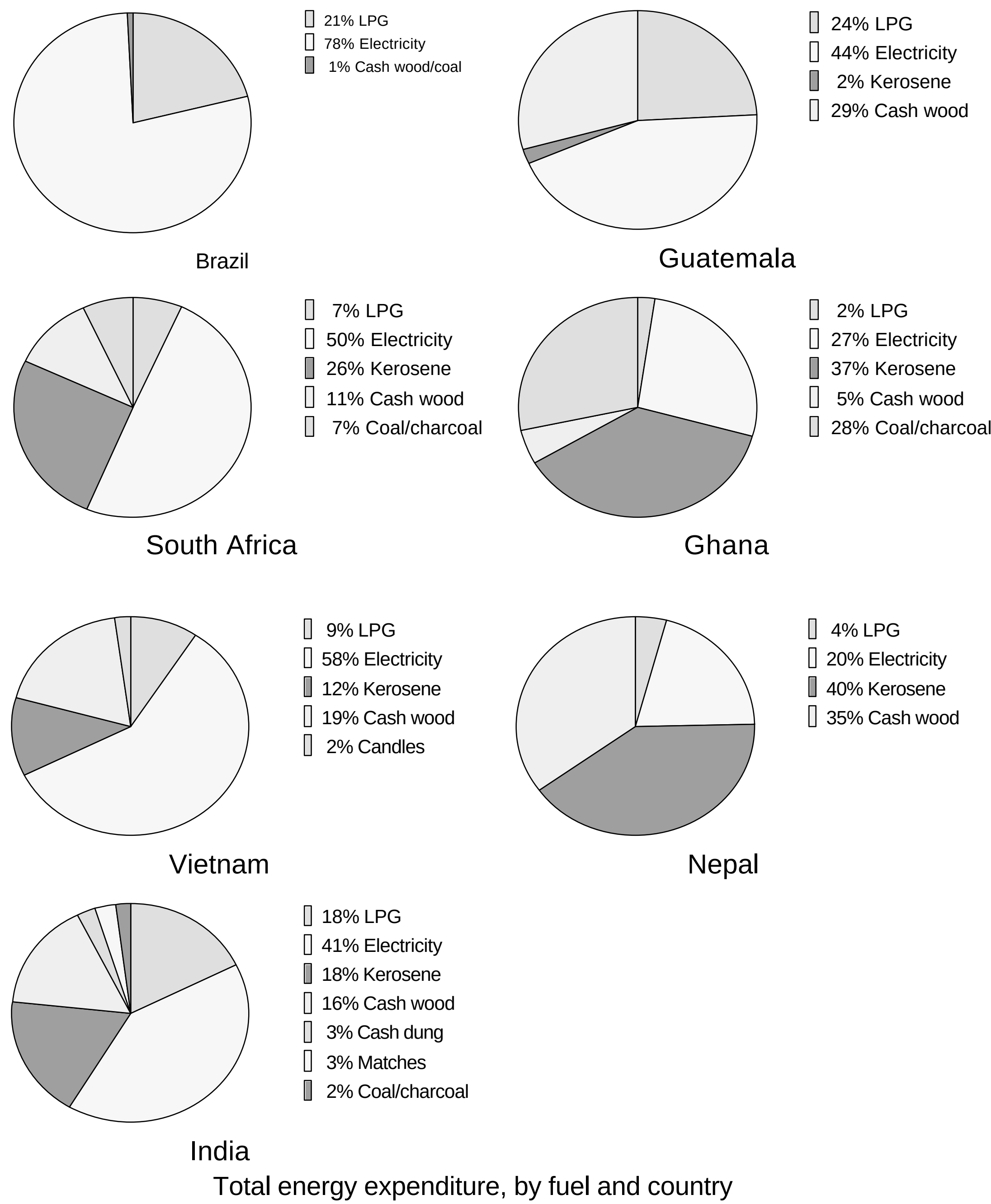
- The budget share of the fuel for all households in a particular quintile regardless of whether they used that fuel. This is an important figure for assessing the distributional implications of subsidy and price reform for the population at large.
- The budget share of the fuel defined over all households 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 groups have particular vulnerabilities to fuel price changes. It will always equal or exceed the budget share of all households.

6.9 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 universal electricity subsidies to domestic consumers are regressive if they are delivered as reduced rates per kilowatt-hour to all consumers: they would be distributed more unequally than total consumption. Electricity subsidies can be progressive, however, if rising block tariffs are used to cross-subsidize poor consumers of very small quantities of electricity. This requires that the low-price blocks be small enough.

6.10 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 kilowatt hours (kWh) per month. This way, users of larger amounts of electricity cross-subsidize small electricity users who are usually poorer.

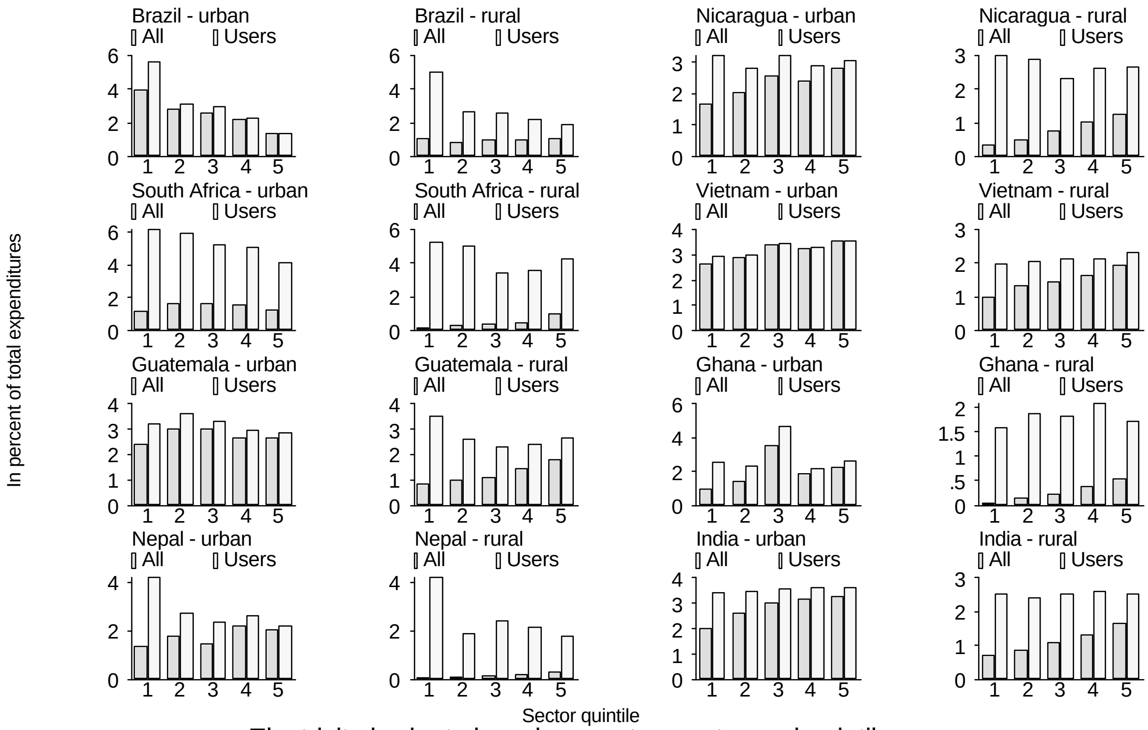
6.11 Compared to electricity, kerosene is not nearly as important for spending patterns. The budget share of kerosene does not appear particularly high in any group, except for the poor in South Africa. In most of the countries considered here, subsidies on kerosene for cooking would potentially show a progressive pattern (and likewise taxes on kerosene for cooking would be regressive). This is rather theoretical, however, as kerosene and diesel are almost perfect substitutes and any subsidized kerosene tends to get diverted from household use towards automotive uses.

Figure 6.2: Composition of Total Energy Expenditures, by Country



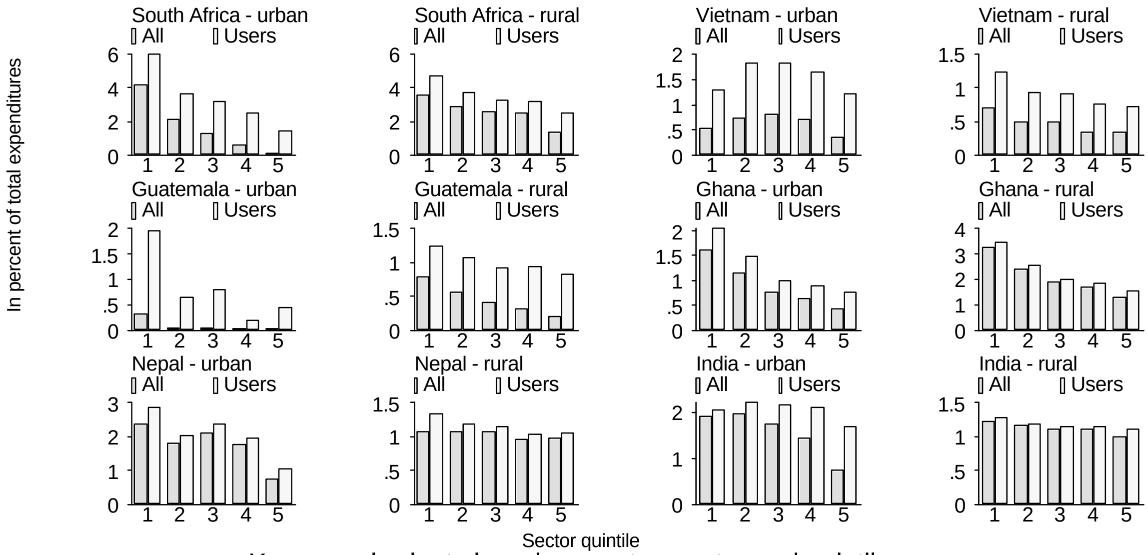
Note: kerosene expenditures include kerosene for ligthing as well as for cooking except in Brazil where kerosene was not included among the ligthing options in the questionaire.

Figure 6.3: Electricity Budget Share by Quintile



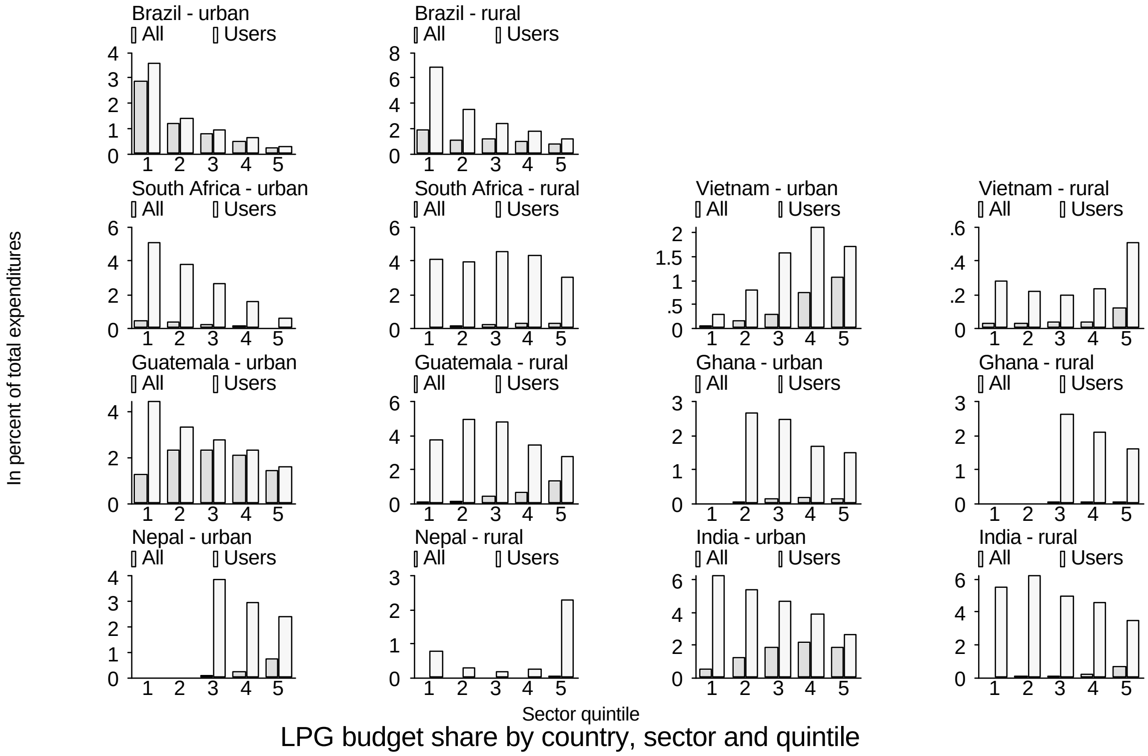
Electricity budget share by country, sector and quintile

Figure 6.4: Kerosene Budget Share by Quintile



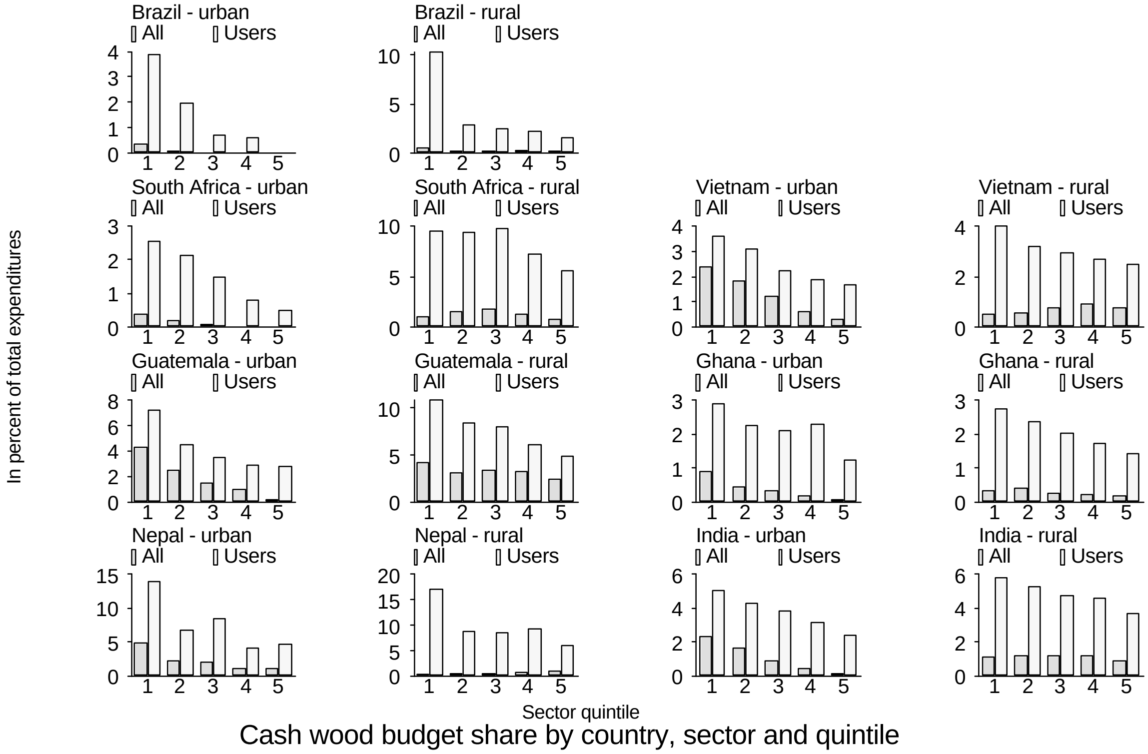
Kerosene budget share by country, sector and quintile

Figure 6.5: LPG Budget Share by Quintile



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

Figure 6.6: Budget Share of Purchased Wood by Quintile



Note: In Brazil the survey did not distinguish among solid fuels.

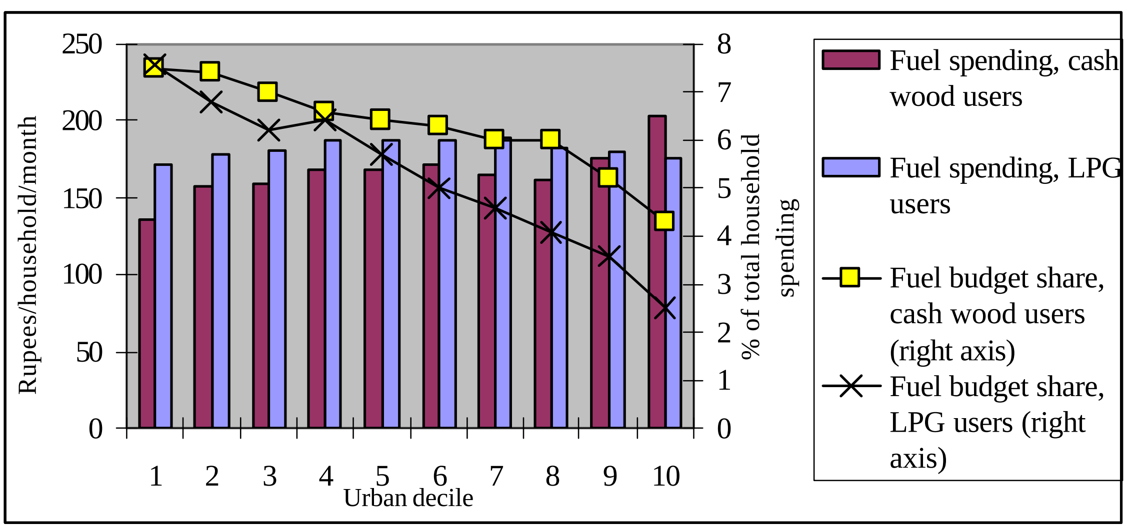
6.12 LPG, as we saw before, is mostly the fuel for the non-poor. India's universal LPG price subsidy is clearly regressive—the higher quintiles benefit more from price subsidies on LPG as a share of their budget than do the lower quintiles (see the bars for all households); those urban low-income households 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, reported average quantity of 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.

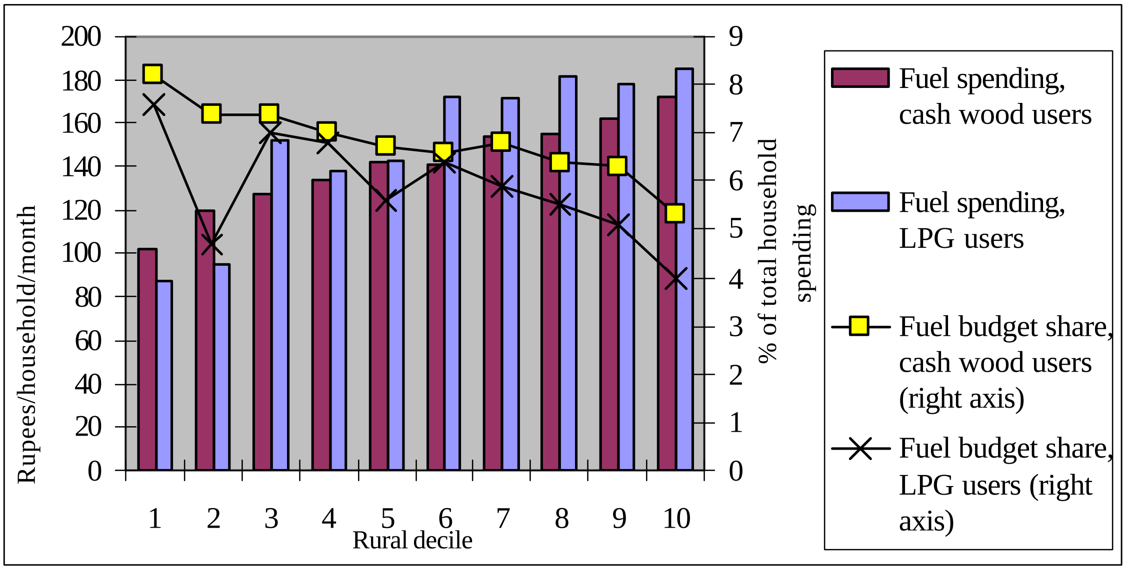
6.13 Among all of the energy sources considered, firewood has the highest budget share among its users. The urban poor in both Nepal and Guatemala spend significant shares of their total expenditures on wood, around 5 percent when averaged over all households in the bottom quintile and around 10-15 percent when averaged over wood users only. This implies that wood users are very vulnerable to price fluctuations in firewood markets. 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 need to purchase their wood the expenses on wood reach 10 percent or more of total spending in several instances.

6.14 The predominant reason for using fuelwood is usually thought to be cost. Yet growing evidence is suggesting things are rather more complex. Collected or homegrown wood of course has no monetary cost besides the opportunity cost of collection time, yet large numbers of households purchase wood from the market. Market wood is highly commercialized, and as shown above many poorer households spend large shares of their budgets on wood purchases. Access to modern fuels can sometimes be difficult, particular in rural areas. But large budget shares for market wood can also be found in urban areas in countries where modern fuels are quite widely available.

6.15 What is the ranking of individual cooking fuels in terms of their costs? The standard approach to energy cost comparison is to calculate the cost per unit of heat delivered to the pot. The difficulty inherent in the standard approach is that the efficiency of stoves and the energy content of woodfuels vary significantly across users. Instead, I here take the alternative approach of comparing actual fuel spending (on all cooking fuels combined) across households grouped according to their main cooking fuel. This is shown in Figure 6.7 for urban and rural India. Comparison is made decile for decile in order to compare at the same expenditure levels. Focus here is on comparing between users of fuelwood and users of LPG, India's two major cooking fuels. Households whose main cooking fuel is home-grown or collected wood quite naturally spend the least on cooking fuel; Figure 6.7 therefore narrows the comparison to users of purchased wood and users of LPG. Cooking fuel expenditures are shown in two ways: as amount spent on fuels per month and as a percentage of total household expenditures.

Figure 6.7: Fuel Spending and Fuel Budget Share for Users of Market-Purchased Wood and LPG, India





Note: The bars show total fuel spending on all fuel sources combined and the lines show fuel spending as a percent of total household spending. Both variables are shown for two groups: households whose main fuel is purchased wood, and households use main cooking fuel is LPG.

6.16 When interpreting the figure it must be kept in mind that at the time of the 55th NSS survey, the LPG market of India was severely supply-constrained. The waiting list for LPG had 13 million names in January 2000. This is 40 percent of the total number of households that reported using LPG in the survey. Therefore, users of fuelwood were not always free to switch to LPG.

6.17 The lowest 40-50 percent in the rural areas have very little LPG usage, and the sample size may therefore be insufficient to make comparison for that group. In the remaining deciles, users of LPG tend to incur higher fuel spending in terms of the Rupee amount spent per household.[16] In contrast, users of cash wood always have higher fuel budget shares. Thus, LPG users pay more in absolute terms while cash wood users pay more for fuel in relative terms. This is because users of wood on average have smaller household sizes than users of LPG. Since energy is a basic good, the absolute amount spent on energy increases less than proportional with household size, resulting in budget shares that are declining in household size. In conclusion, fuel expenditures are roughly comparable in the two groups studied here; the judgment of whether cash wood or LPG users spend the most depends on how the comparison is made, and in particular on the treatment of differences in household size. Users of purchased wood are an obvious target for fuel switching since the difference in cost of switching appear to be small or negligible (at least in terms of recurrent fuel costs).

6.18 Apart from supply constraints, two major obstacles of greater fuel switching to LPG are likely to be its start-up costs and the 'lumpiness' or indivisibility of

[16] The decile-for-decile average fuel expenditure among users of LPG is 16-17 Rupees or 10-11 percent higher as compared to users of cash wood. When taking these averages, the bottom 4 rural deciles are excluded because of the low incidence of LPG use here.

LPG spending. Note that these factors should not deter kerosene usage, since kerosene can be purchased in small quantities and can have very low uptake costs depending on stove type. Users of kerosene on average have smaller fuel expenditures and budget shares than users of either cash wood or LPG (the also have smaller households sizes, however). Traditions, norms, and preferences for using wood may also play a role. An additional factor peculiar to the Indian rationing system is that by getting an LPG connection many households would loose their allocated quota of subsidized kerosene; this may deter some LPG uptake among households that are not electrified and hence depend on kerosene for lighting.

7

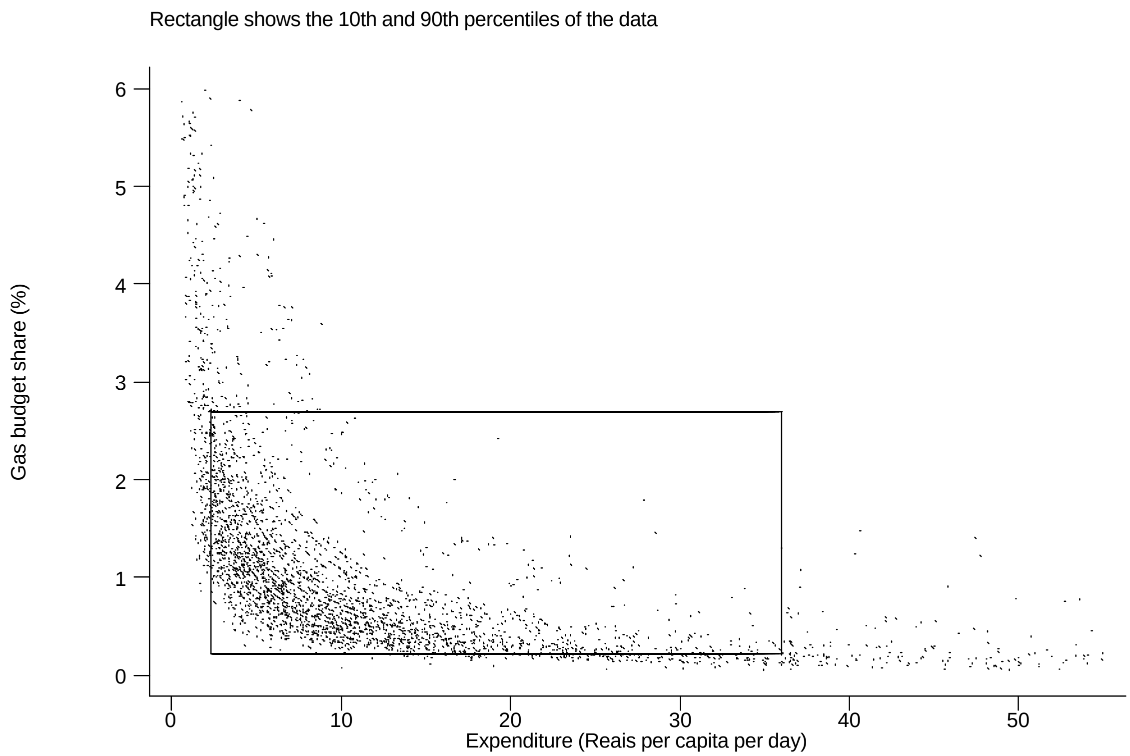
A Closer Look at LPG and Kerosene Spending and Uptake

7.1 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/gas and kerosene markets in Brazil and India, two countries that have relatively well-developed fuel markets.

Gas Spending and Uptake in Brazil

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

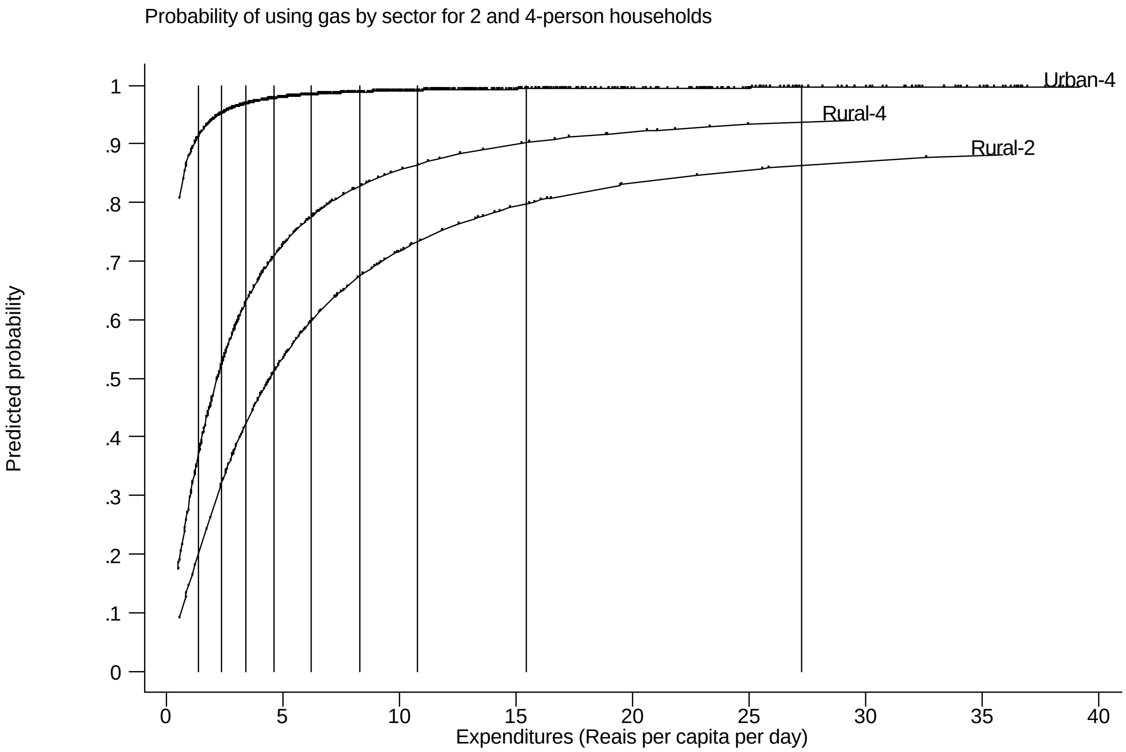
Figure 7.1: Gas Budget Share among Gas Users Brazil



7.3 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 7.2 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.[17] Urban households and larger households have a greater probability of cooking with LPG at all levels of expenditures.

[17] The predicted probability of using LPG as the main cooking fuel was obtained from a logit regression in which a dummy for cooking with gas as the main fuel was regressed on expenditures, expenditures squared, expenditures cubed, inverse expenditures, expenditures logged, household size, household size logged, inverse household size, and an urban dummy, resulting in a very flexible functional form.

Figure 7.2: Predicted Probability of Using Gas for Cooking, Brazil

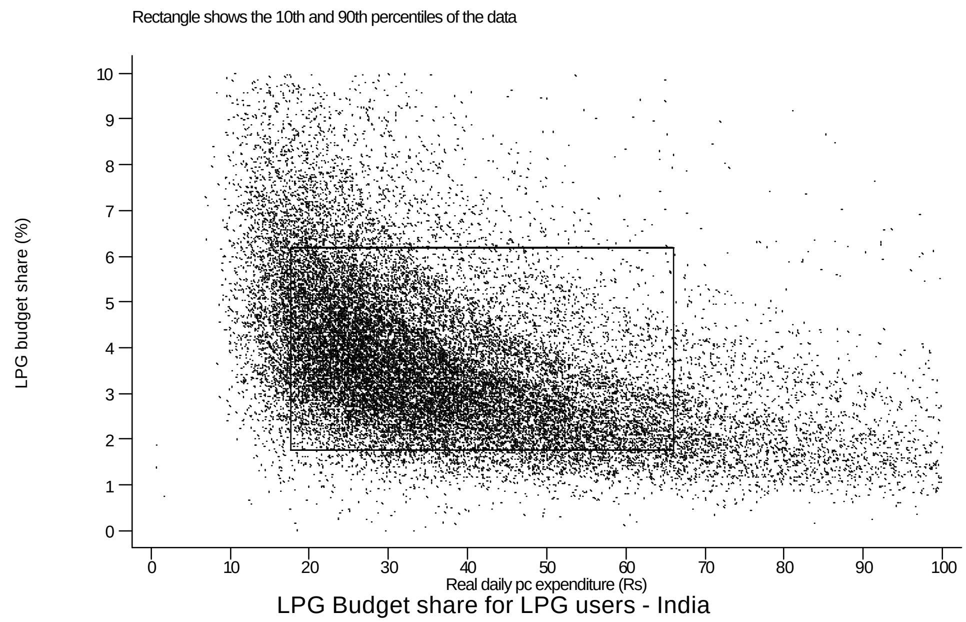


Note: The vertical lines show the location of the decile cut-off points. The exchange rate at the time of the survey was approximately US$1=1 Real.

LPG Spending and Uptake in India

7.4 In India, where per capita expenditures are much lower than in Brazil, LPG users spend much more in relative terms on LPG. Figure 7.3 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 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.

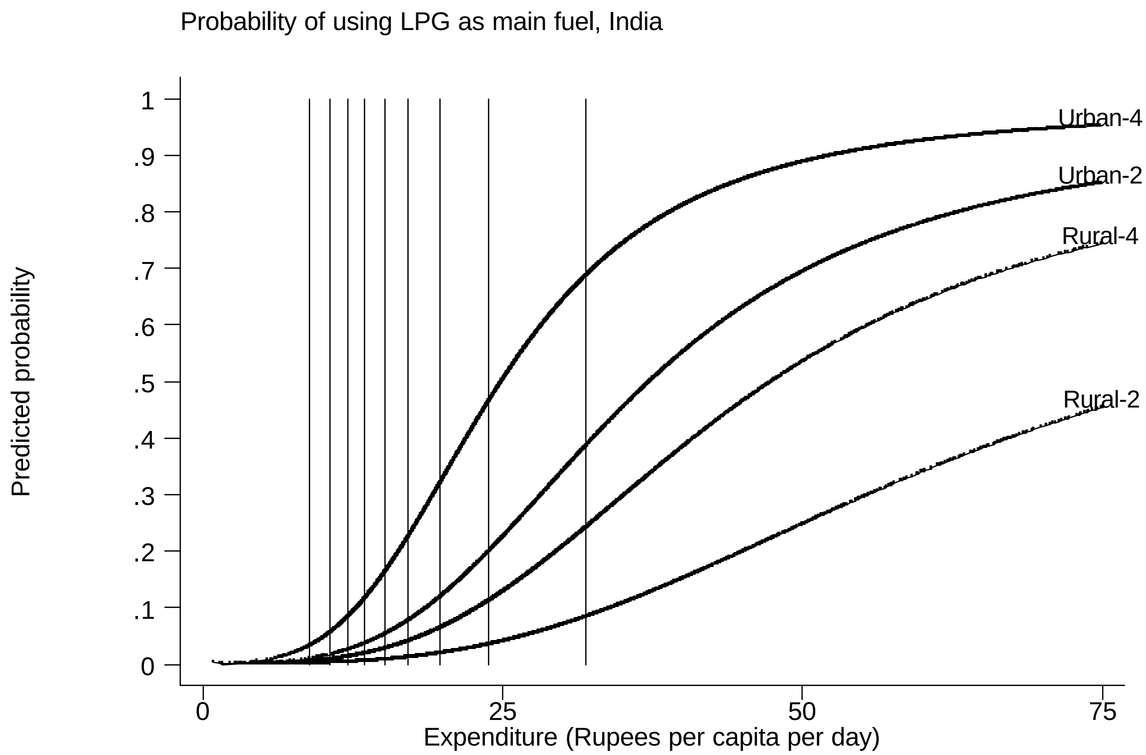
Figure 7.3: LPG Budget Share among LPG Users, India



7.5 Figure 7.4 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. 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 at any given level of per capita expenditures. Uptake costs—including the cost of the LPG stove and the cylinder deposit—are much smaller on a per capita basis for larger households.[18]

[18] If we were to use total household expenditures instead of per capita as a basis for comparison, smaller households would – for any level of total expenditures – have larger probability of using LPG; this merely reflects that at any given level of total expenditures, small households are better off on a per capita basis.

Figure 7.4: Predicted Probability of Using LPG, India



7.6 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 large shares 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 kg per household per month).

7.7 Table 7.1 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—total expenditures of a large household need to exceed US$1-2 per day depending on the price of LPG before LPG uptake is realistic. In most low-income countries in Africa and South Asia, average expenditures do not reach this level. Therefore, only households in the top of the income distribution in these countries are realistic candidates for switching to LPG.

Table 7.1: Thresholds for LPG Uptake

(in US$ per capita per day)

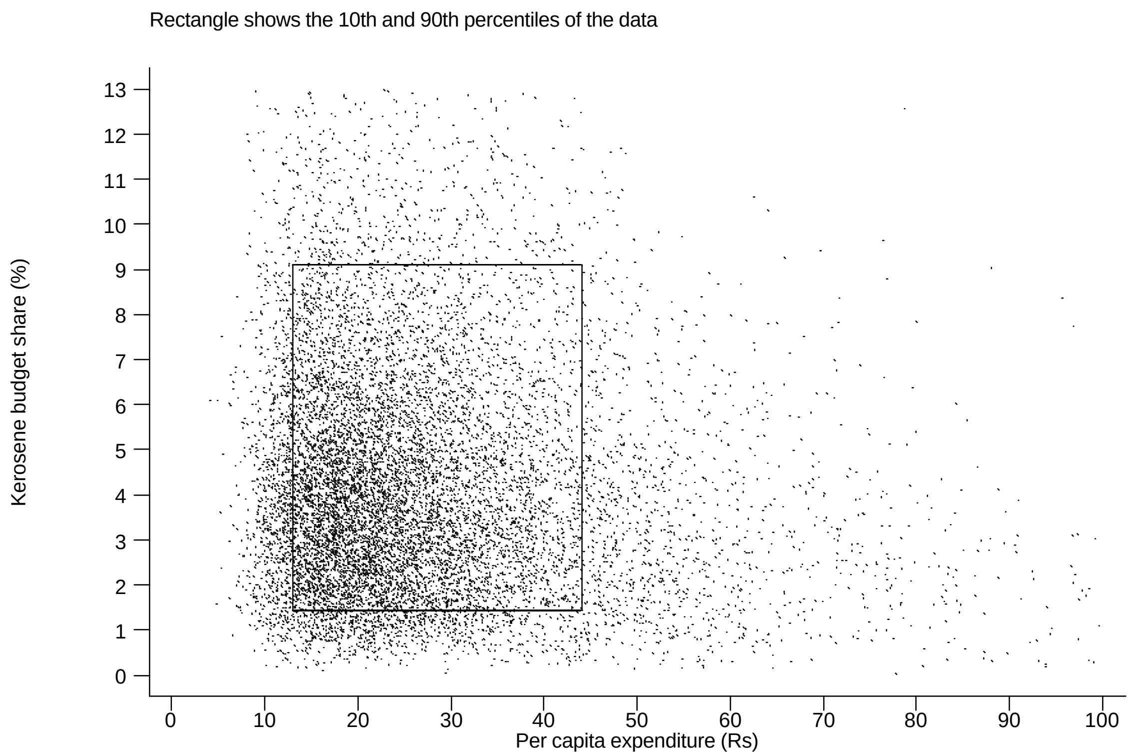
Household size	*Low price scenario*	*High price scenario*
Lower threshold for household LPG uptake (LPG budget share of 6%)		
2	1.67	2.92
3	1.11	1.94
4	0.83	1.46
5	0.67	1.17
6	0.56	0.97
Realistic threshold for household LPG uptake (LPG budget share of 3.5%)		
2	2.86	5.00
3	1.90	3.33
4	1.43	2.50
5	1.14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

Kerosene Spending and Uptake in India

7.8 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 7.5: India: Kerosene Budget Share of Households Using Kerosene as Their Main Fuel



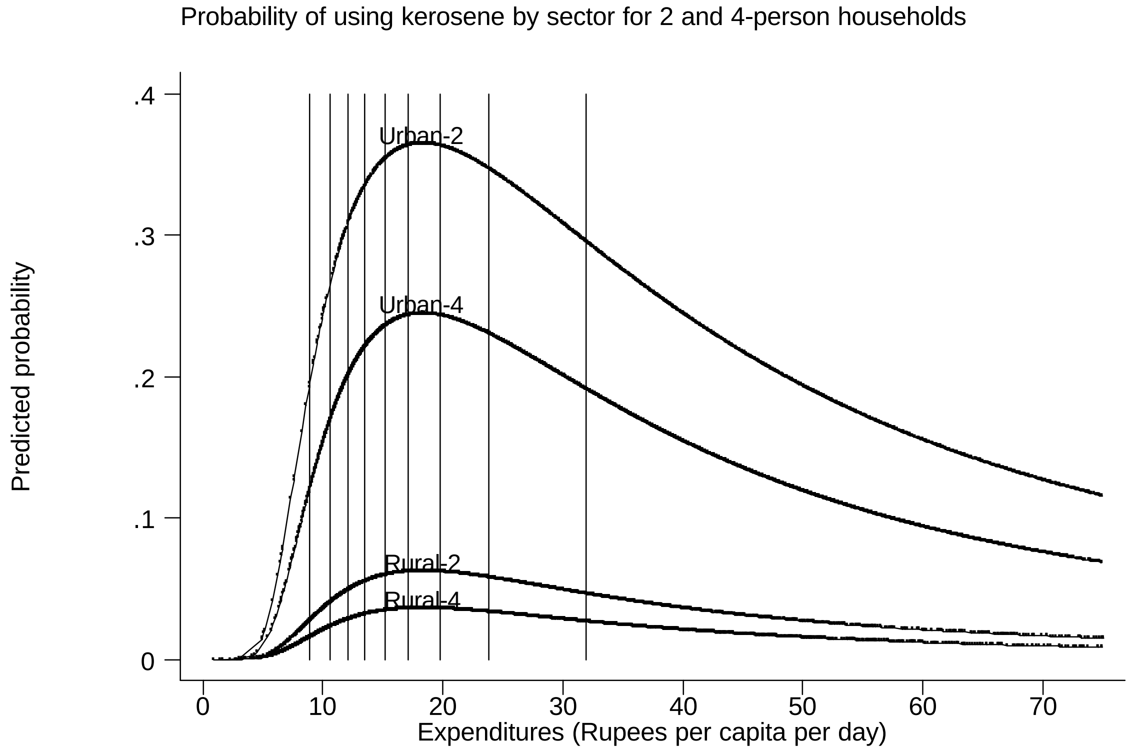
Note: Expenditures on kerosene used for cooking as well as for lighting are included; but only for households where kerosene is the main cooking fuel.

7.9 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. This is reinforced by the possibility of purchasing small amounts of kerosene at a time, as compared to indivisible or "lumpy" LPG cylinder refills. The tendency for small households to opt for kerosene instead of LPG is indirect evidence of how economies of scale can deter greater LPG usage in low-income settings.

7.10 The probability of using kerosene is highest in the middle of the urban income distribution and in the top rural decile.[19] 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.

[19] In rural areas only the very richest show a decreasing probability of cooking with kerosene because of switching to LPG.

Figure 7.6: India: Predicted Probability of Cooking with Kerosene



8

Determinants of Household Fuel Use

8.1 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 and others (2002) who report that electrification appears to spur fuel switching.

8.2 Basic descriptive regression analyses were carried out separately on the rural and the urban sub-samples of all eight countries; use of any modern fuel and any solid fuel was regressed on, among other things, per capita expenditures, household electrification, household size, and education; a major limitation is that relative fuel prices could not be included except for India (results for Guatemala that also include fuel prices are available in Heltberg, 2003). The results, which are documented in appendix 1, 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 nonsolid.
- 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.

8.3 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 fuel 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.

8.4 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 appears 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 do not change 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.

The Impact of Access to Electricity and Water

8.5 The impact of electrification and access to improved water on fuel use is particularly intriguing. Electricity is very rarely used for cooking in most developing countries (again, South Africa is an exception). The major benefits of electricity are improved lighting and power for consumer appliances. It is not obvious a priori why electricity should be associated with cooking with hydrocarbons at a given per capita expenditure. The remaining part of this chapter uses descriptive tools to further help explore this link. Appendix 1 uses regression techniques to control for a variety of confounding factors that could give rise to a false correlation between electrification and fuel use. However, it goes beyond this paper to prove causality, for which much more sophisticated techniques and data are required.[20]

8.6 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.[21]

8.7 Figure 8.1 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 nonsolid fuel. This can be used to assess the typical order in which poor people receive basic infrastructure services.[22]

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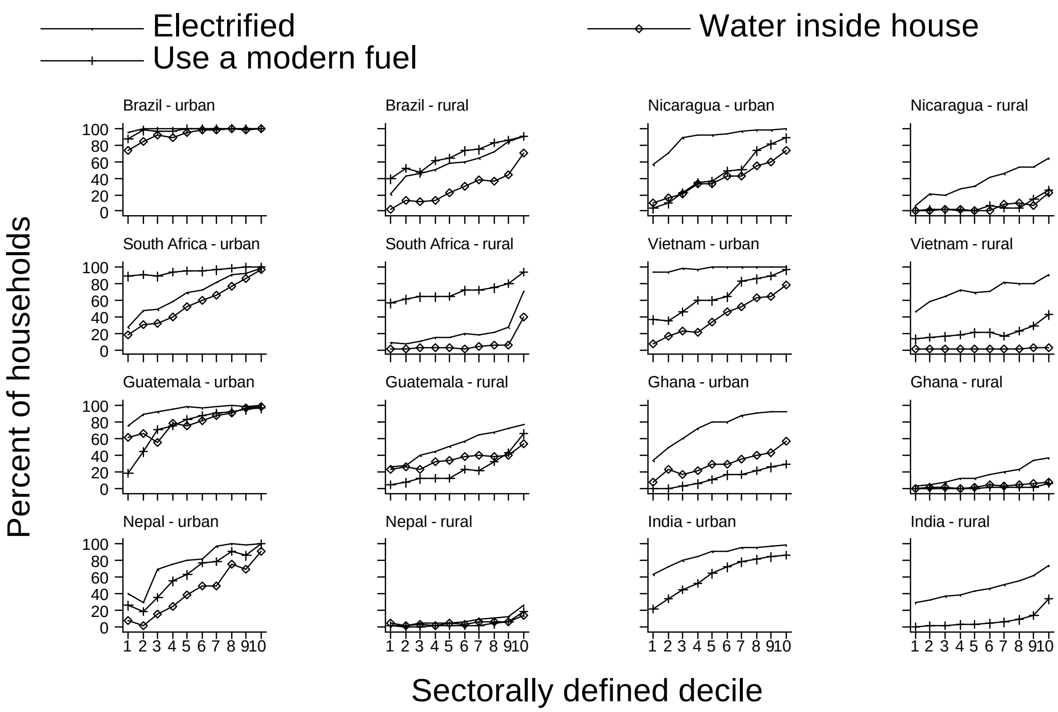
[20] A conclusive proof of causality would probably require panel data on fuel use before and after being electrified.

[21] 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.

[22] 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.

8.8 Modern fuels rarely arrive 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.

Figure 8.1: Electricity, Water in House, and Modern Fuels by Country, Sector, and Decile



Note: Water source not available for India.

8.9 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.

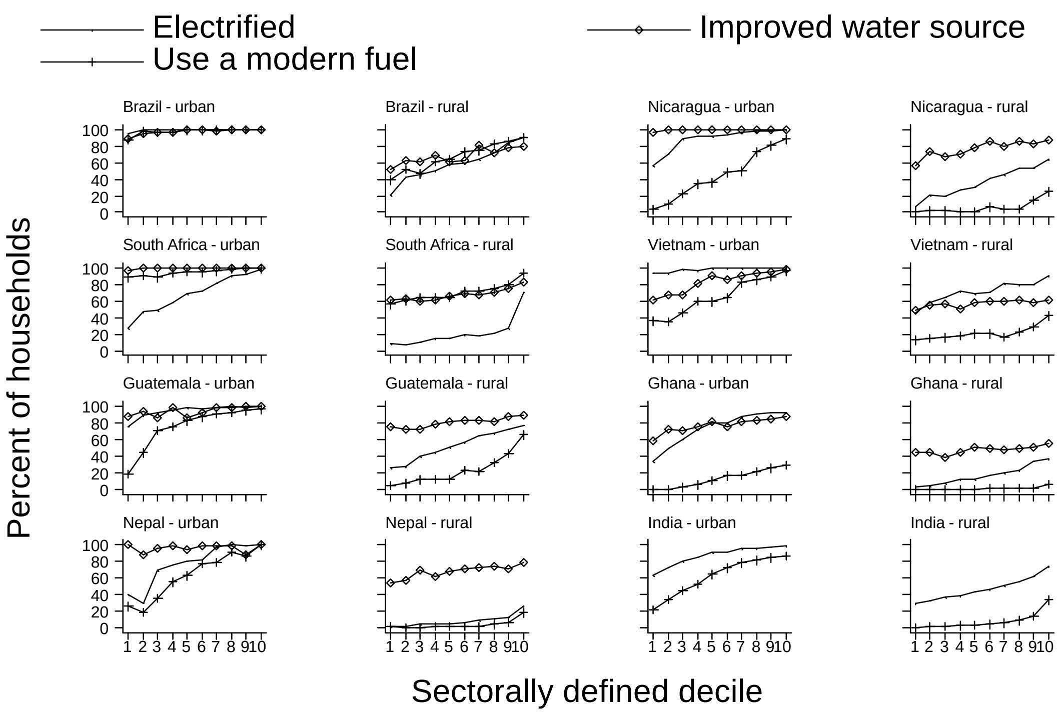
8.10 The analysis was therefore repeated with any improved water source be it outside or inside the dwelling. Note that in poor countries and especially in rural areas most of the people with access to an improved water source have it outside their dwelling.[23] Water is typically a public good provided by governments or aid agencies,

[23] Table A.1.2 in the appendix summarizes the distribution of water source by country.

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.

8.11 Figure 8.2 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 stand at comparable levels.

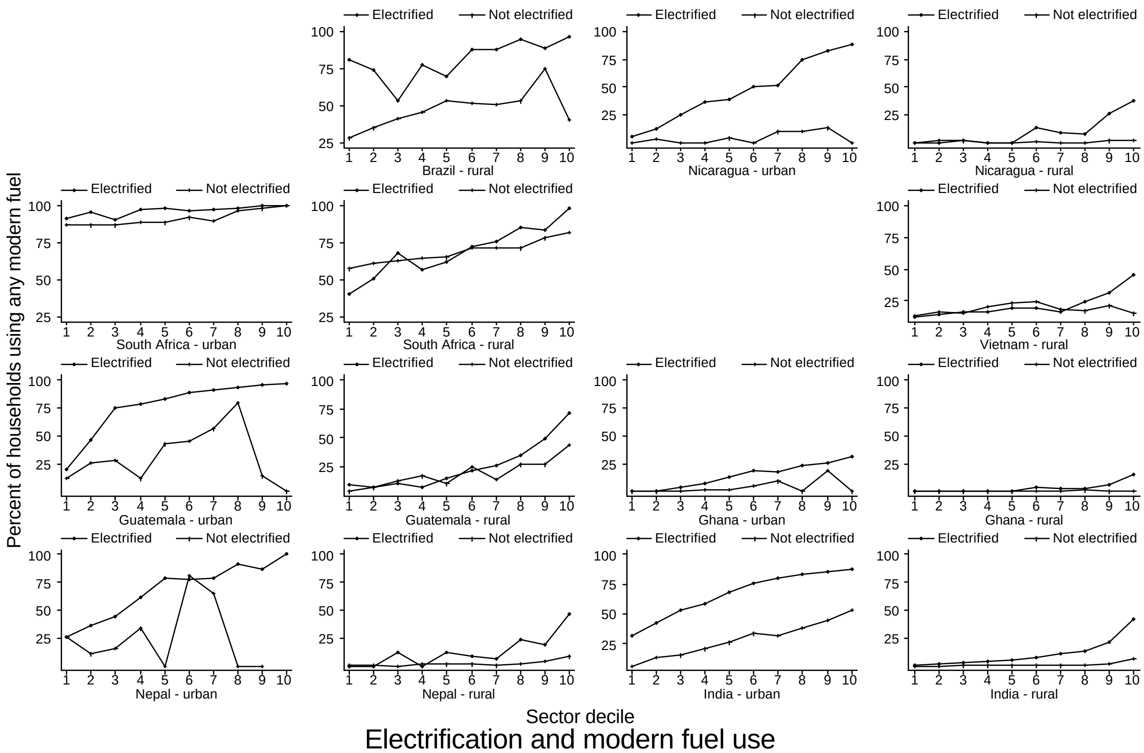
Figure 8.2: Electrification, Use of Any Improved Water Source, and Modern Fuel Use by Country, Sector, and Decile



Note: Water source not available for India

8.12 Figure 8.3 shows the share of households using any modern fuel in each decile, sector, and country among electrified and non-electrified households, respectively.[24] 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.[25]

Figure 8.3: The Relationship between Electrification and Modern Fuel Use



8.13 Figure 8.4 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

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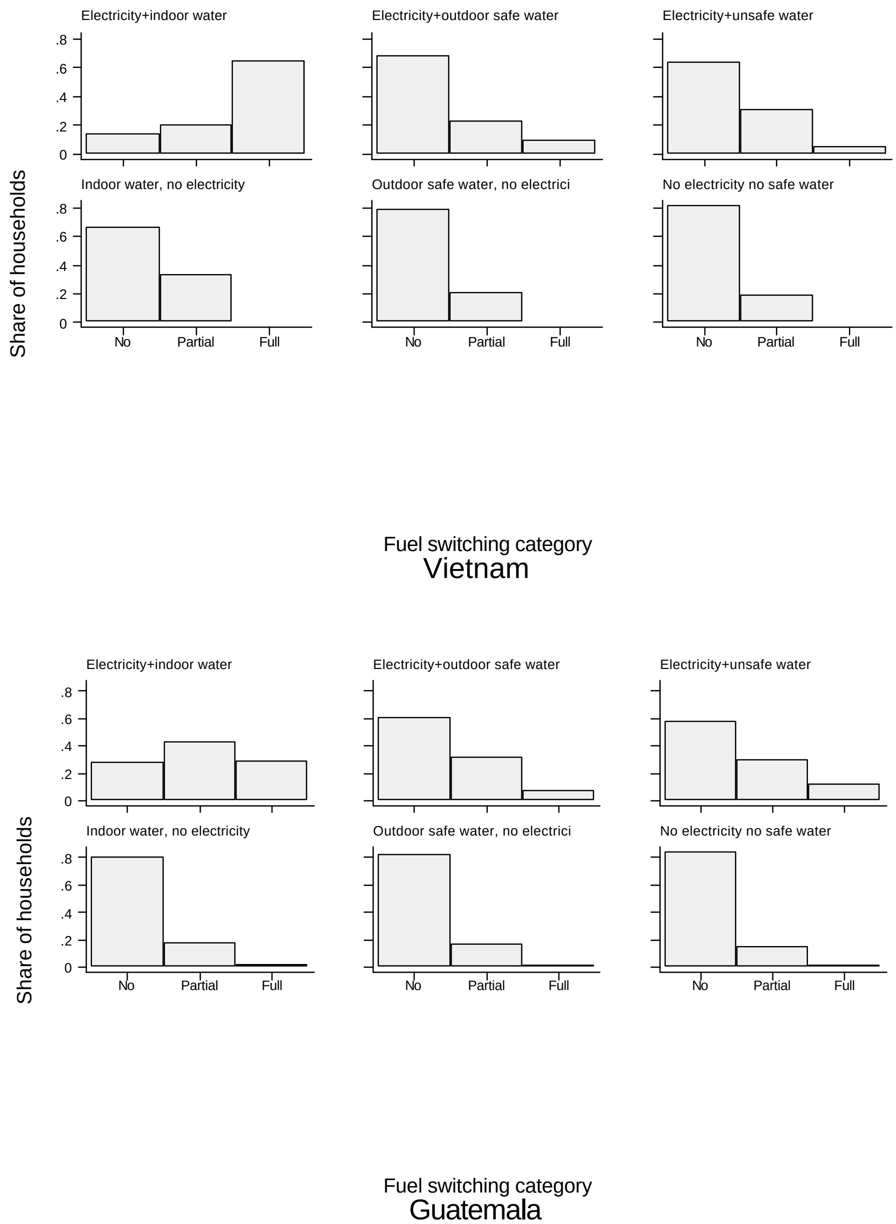
[24] Urban Brazil and urban Vietnam were omitted from this analysis with reference to the low number of households in the nonelectrified group. The analysis is a cross-tabulation – it does not purport to depict a causal effect from electrification.

[25] 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.

[25] 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.

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. Nonelectrified 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 8.4: Fuel Switching by Electrification Status and Water Source, Vietnam and Guatemala



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

9.1 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 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 and electricity are used extensively for cooking in some countries, South Africa for example, and not at all in others; the incidence of using kerosene is higher in small households, while the incidence of using LPG is higher for larger households because of economies of scale in LPG adoption. In fact, large households are more likely to use several fuels, both solid and modern.

9.2 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 persistence of biomass use well up the income distribution particularly in rural areas and the use by many poorer households of expensive purchased fuelwood suggest that many factors besides affordability help shape choice of cooking fuel.

9.3 Variables such as expenditures, urbanization, electrification, water source, and education are associated with 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. Household size affects fuel choices but does not trigger switching: larger households are more likely to use multiple cooking fuels. There is evidence from India and Guatemala that fuel use reacts to fuel prices in the manner one would expect—the probability of using LPG is lower where LPG prices are high or where the market price of kerosene and wood are low.

9.4 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. However, it was not possible with the available data to firmly establish a causal link from electrification to fuel use.

9.5 The observation that the fuel mix differs in sometimes surprising ways implies a need to be careful when seeking to promote any specific fuel—it may or many not find acceptance with the intended beneficiaries. Energy interventions need to be demand-driven. Energy market reforms that seek to make fuels more widely available at affordable prices by removing restrictions and bottlenecks on fuel distribution should be promoted.

9.6 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. However, countries that choose to have energy subsidies should try to target them much better towards poor consumers. For electricity, escalating or "lifeline" rates are often used for targeting purposes. Effective mechanisms for targeting kerosene and LPG subsidies to poor consumers are harder to design, however.

9.7 There are not many policy options for promotion of fuel switching. Price subsidies for modern fuels have historically been used in the name of promoting fuel switching—but price subsidies are often undesirable because of their high fiscal costs, poor targeting (especially in the case of LPG), and leakage (in the case of kerosene). The exception is in high-income countries where the rich have shifted to electricity. Kerosene subsidies would in many cases have the most pro-poor distribution, but kerosene sold for fuel is inevitably re-directed to automotive uses on a large scale. Subsidy schemes using coupons and ration cards have failed in the past—kerosene is a close substitute for diesel fuel and diversion occurs whenever kerosene is priced below diesel. Subsidized kerosene is therefore little effective as a tool for fuel switching, despite the fact that among all the modern cooking fuels kerosene probably competes the closest with firewood.

9.8 Fuelwood markets are extremely important for the poor, who often rely on them either as buyers or 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. In countries where biomass scarcity is growing and fuelwood prices are increasing, the impact of fuelwood market prices on poverty needs to be kept in mind. Modern fuels can help mitigate the impact of rising firewood prices once they can compete on price.

9.9 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—can however be expected to help promote fuel switching.

9.10 Energy interventions need to be targeted to areas and households where results can be realistically expected, including consumers of expensive purchased wood. Areas not yet electrified, with insufficient purchasing power, or with easily available biomass fuels remain unrealistic targets for fuel switching in the short and medium run. Instead, improved low-cost biomass cook stoves or interventions to promote ventilation in the kitchen can be considered as tools for combating indoor air pollution.

9.11 The database for monitoring household energy issues in developing countries needs to be improved. Besides facilitating research and analysis, such a database would support the implementation and publication of quantitative development targets for 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 (for example aggregated as the share using any clean and modern energy carrier for cooking). These indicators are feasible to measure and compile from Demographic and Health Surveys (DHS), LSMS, and other household surveys for a substantial number of countries. The indicators are suitable for official adoption as quantitative development targets in the area of household energy. Publication and use of such indicators would draw more attention to household energy among governments, civil society, development practitioners, and academics.

9.12 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. Energy choice needs to be conceptualized more as a menu in which households simultaneously can choose low-cost and high-cost options. 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 and evaluate low-cost interventions in the areas of improved stoves, better ventilation, or renewable energy sources that can be scaled up.

Appendix 1

Regressions of Fuel Use and Fuel Switching

A.1.1 This appendix documents the fuel switching regression results that are discussed in Chapter 8. The indicators of fuel use and the explanatory variables were constructed from the eight data sets. Differences in survey design make it hard to ensure completely identical definitions for all the countries, but care was taken to achieve as high a degree of comparability as possible.

Data Assembly

A.1.2 The search for variables explaining 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 determinants 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. Many other important variables could not be included in the multicountry regressions, and this includes fuel prices (extended regressions are presented below for India with prices included, though).

A.1.3 In addition, variables describing household 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. [26] Electrification status is available in all the sample surveys. Water supply is available in all surveys except India's NSS.

A.1.4 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 constructed for highest education being primary

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

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).

A.1.5 Tables A.1.1 and A.1.2 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, 120,000 of which are from India's NSS.

Table A.1.1: 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	3.9	15.2	8.2	71.4	13.3
Nicaragua	5.4	2.0	38.9	37.3	16.5
South Africa	4.5	6.1	20.8	61.5	13.9
Vietnam	4.7	0.6	18.7	65.0	13.0
Guatemala	5.2	2.7	51.4	26.6	11.0
Ghana	4.3	1.8	13.4	50.5	11.8
Nepal	5.7	0.3	22.4	25.9	5.4
India	4.9	0.5	33.5	24.1	10.8

Table A.1.2: Means of Nonenergy Variables, by Country

	Urbanization (%)	*Indoor water (%)*	*Outdoor improved water (%)*	*Unimproved water source (%)*	*Number of observations (survey sample size)*
Brazil	80.7	81.9	10.3	7.8	4,940
Nicaragua	56.7	27.0	63.0	10.0	4,040
South Africa	53.3	39.5	46.3	14.2	8,809
Vietnam	24.1	10.9	52.6	36.5	5,999
Guatemala	43.1	56.2	31.0	12.8	7,321
Ghana	36.7	14.7	44.9	40.4	5,998
Nepal	7.3	8.3	62.0	29.6	3,373
India	27.3	-	-	-	120,316

Factors Affecting Household Fuel Choice

A.1.6 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 —they are very simple and omit 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.

A.1.7 Table A.1.3 summarizes the country and sector specific probit regressions of nonsolid 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 A.1.3: Probit Results for Modern 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.

A.1.8 Table A.1.4 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.

Table A.1.4: 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	Minimum	Maximum	Positive and significant	Positive and insignificant	Negative and significant	Negative and insignificant
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.

Expanded LPG Regressions for Urban India and Rural Brazil

A.1.9 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 (for India), community and state dummies, and the education of the head and of the spouse.

A.1.10 Table A.1.5 reports the results of logit analyses of LPG usage in urban India; Table A.1.6 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 India, government control over the pricing of PDS kerosene and LPG at the time of the survey resulted in somewhat uniform pricing throughout the country.

A.1.11 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.

A.1.12 The "baseline" columns (1) in Tables A.1.4 and A.1.5 show results for a specification similar to that reported in Table 13 and Table 14 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. [27] 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 estimated impact of electrification is large in quantitative terms. Calculation of the marginal effects from the baseline regressions suggest being electrified increases the probability of using LPG by around 28 percent in rural Brazil and 34 percent in urban India.

A.1.13 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.[28]

A.1.14 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.

A.1.15 Column (3) in both tables look at electrification in a new light; instead of defining it at the level of the household, a dummy variable is now 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—suggesting that preferences and other unobserved

[27] 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.

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

household factors may sometimes lead to choice of both electricity and LPG—the fact that the link remains significant means that the measured impact of electrification on fuel choice cannot be ascribed solely to such unobserved household factors.

A.1.16 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 household choice could be driving the association between electrification and LPG use. The sample sizes decline, but not by very much, because in most of the communities surveyed in rural Brazil and urban India, there is somebody using electricity and LPG (not necessarily the same household, though). It is therefore not surprising that the results only change little.

A.1.17 Column (5) adds community fixed effects. They are basically a constant term for each community (or more exactly, primary sampling unit). On average, 12 households were surveyed per community in India, and 11 in Brazil. The fixed effects control for all factors that are constant within a community, including infrastructure, village average purchasing power, prices, and other geographical variation. Only the difference in LPG uptake between electrified and non-electrified households within a given village remains.[29] The impact of expenditures, education, and electrification are not altered. Unobserved community attributes jointly correlated with the included regressors and fuel use are therefore not driving the results.

Table A.1.5: Logit Results for LPG Use 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	

[29] This procedure 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.

Table A.1.5: Logit Results for LPG Use 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*
	(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)**
Household 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)**
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)**
Community access to electricity[1]			2.270		
			(5.89)**		
Constant	-12.562	-12.672	-13.624	-12.484	
	(60.16)**	(56.98)**	(30.82)**	(54.75)**	
State dummies added	Yes	Yes	Yes	yes	No
Pseudo R2	0.3950	0.3960	0.3854	0.3731	
Observations	48924	47684	47684	43364	39669

Table A.1.6: Logit Results for LPG Use 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)
Household 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: above secondary		-0.479	-0.516	-0.356	-0.028
		(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)
Community has access to electricity[1]			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	No
Pseudo R2	0.2203	0.2457	0.2030	0.2288	
Observations	1046	1070	1070	984	840

A.1.18 One comment that has been made with reference to the association between electrification and fuel choice is that, in India, households who get an LPG connection loose their quota of subsidized kerosene from the public distribution system (PDS). Since households that are not electrified have a more pressing need for kerosene to be used for lighting, it is conceivable that the desire to keep the PDS kerosene ration quota makes nonelectrified households reluctant to adopt LPG. Hence it is conceivable that results for India could be driven by this feature of the rationing system rather than a genuine, replicable effect of electrification. To test for this, the regression was repeated with only that part of the sample that did not consume any PDS kerosene. Households in this sub-sample supposedly do not worry greatly about losing their PDS kerosene ration quota. Results are largely as before. Specifically, the estimated impact of electrification does not decline and remains statistically significant.[30]

A.1.19 Summing up, the results reported earlier about fuel choice appear very robust to varying regression specifications. Specifically, a significant impact of electrification remains when household unobservables are accounted for by including electrification at the community level. The impact of electrification on fuel choice also holds up well when community and geographic factors are removed using fixed effects. It was not possible with the data at hand to control simultaneously for both household and community unobservables.

Multinomial Logit Analysis of Fuel Switching

A.1.20 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 nonsolid fuels—is set as the base (the omitted category against which the other outcomes are assessed).

A.1.21 Tables A.1.7 and A.1.8 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.

[30] The dummy for household electrified is estimated at 1.99 with a robust z-statistic of 15.6; sample size is 23,324.

Table A.1.7: 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 A.1.8: 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

A.1.22 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.

A.1.23 The results confirm that a number of variables are associated with 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 nonsolids. 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 nonsolid.

A.1.24 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 because of 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.

Appendix 2

Comparison of Data Sources and Statistics on Household Energy

A.2.1 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.

Energy Statistics

A.2.2 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, online version) are shown in Box A.2.1 below.

A.2.3 The published 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 A.2.1: 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)
Commercial energy production (kiloton of oil equivalent)
Commercial energy use (kg of oil equivalent per capita)
Commercial energy use (kiloton 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)

A.2.4 The Demographic and Health Surveys (DHS) have been undertaken in a number of developing countries by the company Macro International Inc. 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.

A.2.5 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?

A.2.6 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.

Household Fuel Use

A.2.7 Table A.2.1 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. Macro

International Inc. has provided this data specially to the World Bank.[31] Modern fuel use for cooking is here defined as LPG, natural gas, biogas, kerosene (for cooking), electricity (for cooking), or (in a few instances) 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.[32] The data on individual fuels for each country and sector underlying Table A.2.1 are reproduced in Table A.2.4: Distribution of women 15-49 by type of fuel used for cooking, by sector.

A.2.8 Various countries and years. In Table A.2.4 below. A couple of observations that look as if they might be errors are highlighted in Tables A.2.1 and A.2.4. The data are reproduced as received in tabulated form from the original source and it was not possible to for this report to go back to the original raw data to verify the tabulations. Such issues would obviously need to be addressed prior to any official use of this data.

A.2.9 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.

[31] 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.

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

Table A.2.1: 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
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 Macro International Inc. for the World Bank.

a: Modern cooking fuels include electricity, LPG, natural gas, kerosene, and gasoline (in a few cases).

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 because of an entry of "other fuels" that could not be allocated to either the modern or the solid category.

Note: Entries highlighted and marked with asterisk (*) appear implausible. Possible error in original source.

A.2.10 For a few countries it was possible to match the DHS fuel use data with other household surveys in order to compare the data. Table 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 three-year period between the two surveys.

Table A.2.2: 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 DHS			
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)				India 1999 DHS			
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

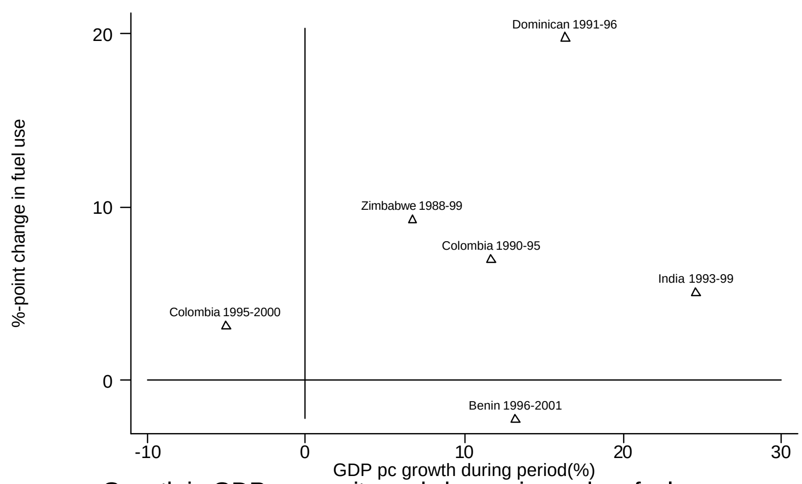
* The totals do not sum to 100 because of missing observations for some households on major cooking fuels.

A.2.11 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.

A.2.12 The six panel observations are summarized in Table A.2.3 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 A.2.1 plots for each country the percentage-point change in modern 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 A.2.4).

Figure A.2.1: Rate of Change of Fuel Use and of GDP per Capita in Panel Countries

Modern fuel use



Growth in GDP per capita and change in modern fuel use

A.2.13 Table A.2.3 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 growth elasticity of poverty. 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 as one would expect. Moreover, changes over time in fuel use can be documented so that it is feasible to adopt fuel use as a development target alongside other infrastructure and human development targets.

Table A.2.3: 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 A.2.4: 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*			*Rwanda 2000*		
	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	1.7	0.0	0.3
LPG, natural gas	19.2	1.2	4.4	0.3	0.0	0.1	0.2	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	0.1	0.0	0.0
Coal, lignite	0.0	0.0	0.0	74.7	6.6	18.0	2.2	0.2	0.5
Charcoal	27.0	4.1	8.1	14.3	92.3	79.3	59.4	2.7	12.5
Firewood, straw	52.1	94.4	87.0	0.0	0.0	0.0	36.3	96.9	86.4
Dung	0.0	0.0	0.0	0.0	0.0	0.0	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	0.1	0.0	0.2	0.0	0.0	0.1	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	2692	12658	15350	1206	6037	7243	1796	8617	10413

	Colombia 1990			*Colombia 1995*			*Colombia 2000*		
	Urban	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*
Type of cooking fuel									
Electricity	40.7	14.6	34.0	32.5	10.2	26.8	15.8	4.8	13.4
LPG, natural gas	0.0	0.0	0.0	59.1	20.8	49.4	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	38.2	12.4	31.6	1.3	2.0	1.5	0.7	0.5	0.7
Coal, lignite	1.4	3.6	2.0	0.7	2.4	1.1	0.0	0.0	0.0
Charcoal	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.7	0.8
Firewood, straw	5.1	62.2	19.7	2.6	61.9	17.6	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	9.8	3.6	8.2	3.8	2.9	3.6	1.2	0.6	1.1
Other	4.9	3.6	4.6	0.0	0.0	0.0	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	6310	2172	8482	8288	2822	11111	8941	2610	11552

	Dominican 1991			*Dominican 1996*			*Sudan 1990*		
	Urban	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*
Type of cooking fuel									
Electricity	0.1	0.1	0.1	0.0	0.0	0.0	1.3	0.2	0.6
LPG, natural gas	83.0	25.6	64.8	96.1	63.6*	85.2*	12.5	0.6	5
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
Kerosene	0.0	0.1	0.1	0.0	0.2	0.1	0	0	0
Coal, lignite	14.6	21.3	16.7	2.8	6.9	4.2	0	0	0
Charcoal	0.0	0.0	0.0	0.0	0.0	0.0	72.6	32.1	47.1
Firewood, straw	2.3	52.9	18.3	0.9	29.2	10.4	9.9	65.7	44.9
Dung	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	0	0	0
Other	0.0	0.0	0.0	0.2	0.1	0.1	3.7	1.4	2.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100	100	100
Number of women	4958	2296	7254	5554	2780	8334	2180	3679	5859

	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

Note: Entries highlighted and marked with asterisk (*) look odd. Possible error.

Household Electricity Coverage

A.2.14 Information on the rate of electrification of households in different countries is available from DHS surveys. The column headed “DHS surveys” in Table A.2.5 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 A.2.5: 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	1999/2000
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.

A.2.15 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 most household surveys. Hence, it appears feasible to compile 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.

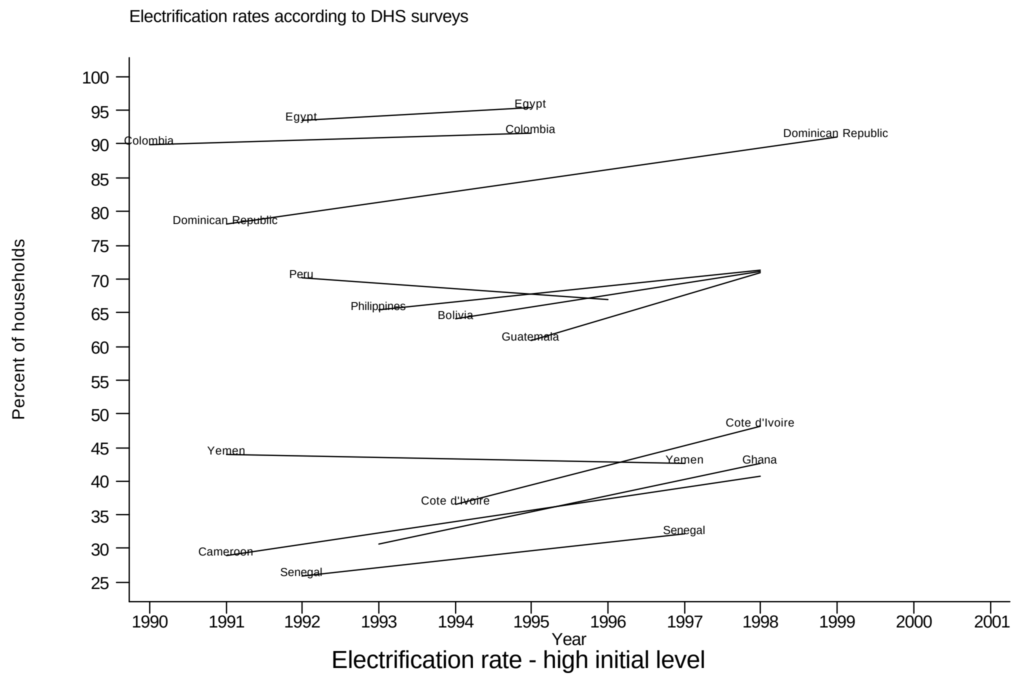
A.2.16 Summing up, if a development agency wants to measure household access to electricity (regardless of type, legality, quality) a survey-based measure arguably is the best approach. If, instead, a development agency wants to assess progress by official utilities in electrifying a developing country 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).

A.2.17 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: 22 panel observations are available.

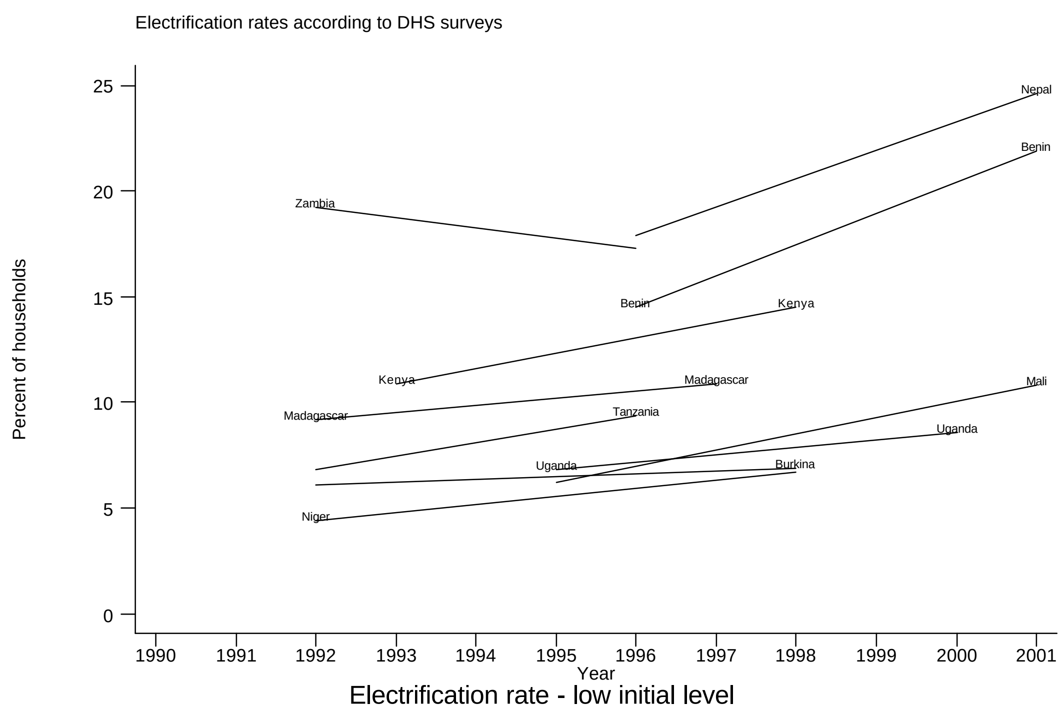
A.2.18 The change in the share of household with electricity over the panel period (the length of which differs but averages five years) varies from 12 to 3 percentage-points. The average rate of change is 2 percentage-points. This is to be compared to an average level of electrification in the panel sample of 38 percent. The progress by individual countries is shown in Figure A.2.2 (upper panel) for high and medium-electrification countries (above 25 percent connected) and for low-electrification countries in the lower panel.

Figure A.2.2: Electrification Progress Over Time

(a) Countries with middle-high initial levels of coverage



(b) Countries with low initial coverage



A.2.19 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 unconnected 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 unconnected areas—also affects the measured rate of electrification.

A.2.20 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.

Bibliography

Barnes, Douglas and Willem Floor. 1999. "Biomass energy and the poor in the developing countries." *Journal of International Affairs*, Fall, 53(1): 237-259.

Barnes, Douglas F., Kerry Krutilla, and William Hyde. 2002. *The Urban Energy Transition—Energy, Poverty, and the Environment: Two Decades of Research.* Forthcoming book volume.

Barnes, Douglas F. and Uu Qian. 1992. "Urban Interfuel Substitution, Energy Use and Equity in Developing Countries." *World Bank Industry And Energy Department Working Paper, Energy Series Paper 53*, Washington, DC.

Davis, Mark. 1998. "Rural Household Energy Consumption: the Effects of Access to Electricity—Evidence from South Africa." *Energy Policy*, 26(3): 207-217.

Deaton, Angus. 2001. *Comparing Prices and Poverty Rates in India, 1999-2000*. First draft. December 2001. Princeton University.

ESMAP. 2000. *Energy and Development Report 2000: Energy Services for the World's Poor.* Washington, DC.

ESMAP. 2001. *Sustainable Woodfuel Supplies from the Dry Tropical Woodlands.* ESMAP Technical Paper 13, June. Washington DC.

Foster, Vivien and Jean-Philippe Tre. Forthcoming. *Measuring the Impact of Energy Interventions on The Poor—An Illustration from Guatemala*.

Heltberg, Rasmus. 2003. *Guatemala: Household Fuel Use and Fuel Switching.* World Bank\ESMAP, ESMAP Technical Paper 036. June.

Heltberg, Rasmus. 2001. "Determinants and Impact of Local Institutions for Common Resource Management." *Environment and Development Economics*, vol. 6(2), p. 183-208.

Heltberg, Rasmus, Thomas Channing Arndt, and Nagothu Udays Sekhar. 2000. "Fuelwood Consumption and Forest Degradation: A Household Model for Domestic Energy Substitution in Rural India", *Land Economics*, May.

Hosier, R and W. Kipondya. 1993. "Urban Household Energy Use in Tanzania: Prices, Substitutes and Poverty." *Energy Policy* 21: 453-73, May.

IEA (International Energy Agency). 2002. *World Energy Outlook 2002*. Paris.

Leach, Gerald. 1992. "The Energy Transition." *Energy Policy*, February: 116-123.

Masera, Omar R., Barbara D. Saatkamp, and Daniel M. Kammen. 2000. "From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model." *World Development*, 28(12): 2083-2103.

WHO. 2002. *World Health Report 2002*. Geneva.