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Energy Policies and Multitopic Household Surveys

Guidelines for Questionnaire Design in Living Standards Measurement Studies

Kyran O'Sullivan
Douglas F. Barnes

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Cover photo taken during household interview in Ngara District, Kagera region of Tanzania during Kagera Health and Development Survey 2004. Courtesy of Kathleen Beegle.

Doug Barnes and Kyran O'Sullivan are Senior Energy Specialists in the Energy and Water Department of the World Bank.

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Foreword

Accurate data on household energy use, combined with other data on household well-being (including consumption, income, health, and education), is essential to monitor progress in the household energy transition from traditional biomass fuels to modern fuels and electricity and to evaluate the effect of government energy policies on living conditions. Multitopic socioeconomic household surveys, such as the World Bank's Living Standards Measurement Study (LSMS), can provide data with which to make these measurements. Designers of LSMS and other multitopic household surveys can use these guidelines to help ensure that their surveys provide more extensive and reliable data on household energy use than they do at present. The guidelines highlight weaknesses in current LSMS surveys with respect to energy questions and discuss how such questions can be better formulated to yield more useful data for energy policy analysis. Household energy surveys implemented over the years offer lessons on which formulations of questions work best and provide the most consistent results. This experience has been drawn on to develop the prototype fuel and electricity modules contained in these guidelines. Indicators that may be constructed from the data are also discussed; in this regard, the present report contributes to international efforts to define energy indicators for sustainable development. These efforts include the publication *Energy Indicators for Sustainable Development: Guidelines and Methodologies* (IAEA 2005), which drew attention to using household surveys to provide data for constructing indicators.

It is anticipated that these guidelines will help LSMS designers incorporate energy modules of the type proposed herein into LSMS survey questionnaires. Over time, as more surveys containing these modules are implemented, more experience will be gained on which questions work best in particular country settings and which are most useful for policy analysis.

Jamal Saghir
Director, Energy and Water
Chair, Energy and Mining Sector Board

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CHAPTER 1

Introduction

Adequate and affordable supplies of electricity and modern fuels must be available to households if they are to have a good living standard. Safe, reliable, and good-quality energy services[1]—lighting, heating, cooking, and motive and mechanical power—are only available to households when they use electricity and modern fuels. In developing countries, however, some 2 billion people cook and heat their homes with wood or other traditional biomass; 1.6 billion people do not have electricity in their homes (World Bank 1996). For these people, obtaining energy is costly and time-consuming; and they may be denied the opportunity to earn income, read, and access information and entertainment.

Recognizing the role that energy services play in poverty reduction, governments everywhere wish to implement policies and make investments that will accelerate the transition from use of traditional fuels to modern fuels and electricity. As a consequence, policymakers increasingly seek empirical evidence of the relationship between investments made in energy infrastructure, the energy policies they implement, and welfare improvements at the household level.

Analysis using data on household energy use from Living Standards Measurement Study (LSMS) surveys can help policymakers to identify which households are affected by energy poverty and then design policies that will accelerate the household energy transition. For households that have already made the transition to using modern fuels and electricity, government policies in the sector will affect how much households pay and

1. Primary energy sources (crude oil, natural gas, coal, modern biomass and renewable energy) are transformed into fuels and electricity to provide households energy services. Modern biomass includes sustainable and safe use of biomass (e.g., biogas and wood used in improved cooking stoves).

consume. For example, regulatory policy for service providers may cause energy supply to improve or deteriorate, and energy price and tax adjustments will affect households' energy expenditure and consumption. Data from LSMS surveys can be used before a policy is implemented to construct hypotheses of the welfare changes that may occur. If data is available from two successive LSMS surveys (the first carried out before the policy intervention and the second after), the change in household welfare as a result of the intervention may be observed.

Energy services also affect household welfare through their role in the education and health status of household members. Literacy is much higher in households with electricity than in those without, and children in households that use modern cooking fuels are less likely to suffer acute respiratory disease than children in households that use biomass. Other effects on household welfare include time saving and increased productivity and income.

Potential Value of LSMS Surveys for Analysis of Household Energy Use

Unfortunately, data sets on which to base evaluation of energy services' role in contributing to these household welfare outcomes are in remarkably short supply. LSMS surveys offer one possible source of better information gathering on providing energy services to households in developing countries. If LSMS surveys, which already provide high-quality comprehensive data on many aspects of household welfare, could also provide better data on household energy use, the role of energy services in household welfare could be better understood. LSMS surveys with fuels and electricity modules containing questions on the fuels and electricity sources available to households, quantities consumed, and household cost and expenditures could be combined with other household socioeconomic characteristics and their relationships analyzed.

At present, household energy data collected through LSMS surveys is insufficient for extensive energy policy analysis. At the same time, specialized household energy surveys often are not designed for such analysis; they are seldom national in scope and do not cover the breadth of topics involving other sectors, which is the hallmark of LSMS surveys. Incorporating the proposed energy modules found in this report into future LSMS surveys will provide greater insight into the role energy services play in household welfare and thus will contribute to energy infrastructure planning and energy policy analysis so that they achieve the highest possible social and development impact.

Report Audience and Organization

These guidelines advise on how an LSMS or other multitopic household survey can be modified to improve its usefulness to the energy sector. Thus, the guidelines target two main audiences. The first are designers of LSMS and other multitopic household surveys who may not be familiar with the data needs of policy analysts working in the household energy sector. The second are energy policy analysts who wish to ensure that a planned multitopic household survey includes an adequate set of questions essential to their work.

This report begins by examining the characteristics and relative merits of LSMS and specialized household energy surveys. It then reviews the types of questions currently used in LSMS surveys, identifying important data gaps. Next, the issue of causality as it relates to energy services and development is examined. The report then turns to examples of the types of energy analysis that benefit from enhanced LSMS survey data. Prototype energy modules (accompanied by notes on each question contained in them) are presented. It is proposed that the few *ad hoc* questions on energy use currently found in LSMS surveys—which yield little information useful to policymakers—be replaced by the questions presented in the prototype modules. Mindful that LSMS surveys are already lengthy, expensive, and time-consuming, and that increased demands on the LSMS should be carefully considered, the additional questions in the proposed modules have been kept to a minimum while still being sufficient for the types of policy analysis that are most frequently conducted.

CHAPTER 2

Characteristics of LSMS Surveys and Specialized Household Energy Surveys

Since inception of the LSMS program in 1980 and piloting of the first surveys in Côte d'Ivoire and Peru in 1985, the World Bank LSMS surveys have been used for poverty analysis that underpins poverty reduction strategies in more than 50 countries. Integrated household surveys, similar in design to the LSMS, have also been developed and implemented in many countries.

LSMS surveys aim to provide a comprehensive picture of living standards. They are one of the most extensively used tools for measuring and monitoring household monetary and nonmonetary welfare (including income; expenditure; employment; migration; housing conditions; school enrollment; educational attainment; health status; nutrition; and use of transport, water, sanitation and energy services; Deaton 1997). Thus, government policymakers can use the LSMS survey data to determine living conditions of the poor and other disadvantaged groups. The data can be used to model economic behavior in order to design better policies or choose between alternative public investments. Such analysis enables one to assess the efficiency and efficacy of alternative policy designs and investments. For example, analysis of anthropometric data can be used to assess programs to reduce malnutrition or analyze health status used to evaluate immunization or HIV prevention.

Specialized household energy surveys, by contrast, are implemented to inform a particular energy policy or investment. For example, they are used to assess the efficiency and efficacy of fuel price subsidies or to establish baseline information for and monitor rural electrification programs.

The distinguishing characteristics of LSMS and specialized household energy surveys are important in explaining the rationale for advocating a greater depth of energy coverage in LSMS and other multitopic household surveys. To this end, it is also helpful to examine the relative strengths and weaknesses of such surveys from the perspective of energy policy analysts.

Characteristics of LSMS Surveys

LSMS surveys are both multitopic and multi-level (Grosh and Glewwe 2000; Grosh and Munoz 1996). They commonly use up to four survey instruments with which to examine a broad range of household welfare and behavioral factors, as follows:

Household questionnaire. This questionnaire collects detailed information on household members. It is composed of modules that focus on specific topics. The questionnaire always collects detailed information to measure household consumption, which is the best monetary indicator of household welfare. The household questionnaire typically includes modules on education, health, employment, migration, anthropometry, fertility, housing, agriculture, household enterprises, income, and savings and credit. Certain information (including employment, health, and education) is collected at the individual level. Frequently, the housing module covers information on fuels used for cooking and heating and electricity services available to the household.

Community characteristics questionnaire. This questionnaire gathers information on local conditions common to all households living in the same community. Like the household questionnaire, the community questionnaire contains modules on specific topics, including schools, health facilities, agricultural practices, and infrastructure (for example, roads, fuel sources, electricity, and water). The questionnaire asks key community leaders and groups about available services, economic activities, access to markets, and (more recently) social capital.

Price questionnaire. This questionnaire aims to gather information from market vendors on prevailing prices of commonly purchased items in shops and markets.

Facilities questionnaire. This questionnaire is administered to local service providers, such as schools and health clinics.

Characteristics of Specialized Household Energy Surveys

Specialized household energy surveys typically contain the following sections:

Core information. Whatever the purpose of a specialized household energy survey, information usually considered essential includes the fuel and electricity sources available to households, supply (for example, pricing, quality, and reliability) and demand (the quantities consumed) characteristics of these sources, the energy services households derive from the fuels and electricity sources they consume, and household expenditures on these fuels and electricity.

Initial cost of access. Because the cost of obtaining service (initial purchase of a liquefied petroleum gas [LPG] cylinder or electricity connection fee) is recognized as a significant barrier to access, specialized household energy surveys frequently collect this information, along with data on sources of financing that households use to defray these costs.

Alternatives to grid electricity. In developing countries, many urban areas often face unreliable grid-electricity supplies (they are available infrequently or subject to interruptions); in rural areas, electricity infrastructure may be lacking entirely. For these reasons, specialized household energy surveys often focus on alternatives to grid electricity. The surveys commonly investigate the use of diesel gensets, solar home photovoltaic (PV) systems, and car (storage) batteries. The questionnaire usually covers access to these energy sources and expenditures for acquiring and operating them.

Time use. In areas where biomass is used extensively for cooking or heating, specialized household energy surveys often contain large sections that investigate the time household members spend collecting biomass and tending cooking fires.

Energy end use. Specialized household energy surveys can investigate in detail the end uses of the energy sources consumed in order to quantify the benefits that households obtain from them. For example, to measure electric lighting's effects on rural households, one must know the number of lighting appliances customers used before and after electrification. For households without electricity, these appliances include non-electric equipment (for example, candles, simple kerosene wick lamps, regulated wick lamps [hurricane lanterns], and pressurized kerosene lamps). For households with electricity, they include incandescent, fluorescent, and compact fluorescent lamps. The questionnaire must collect data on the length of time each lamp is used during a typical day. With this information, researchers can compare electrified and non-electrified rural households with regard to price and quantity of lumen hours used. Households with electric lamps typically consume more than 20 times more lighting than households with kerosene lamps; however, the price per unit of light is substantially lower. Analysts can use such information to quantify the benefits of electric lighting for rural households, using methods involving willingness to pay.

Attitudes. Specialized household energy surveys often contain sections that explore household attitudes toward energy services. For example, households may have the option to connect to grid electricity service, but for various reasons choose not to. Respondents can be queried about the reasons for their choices. Their answers may reveal high up-front connection charges, side payments to utility providers, or inability to wire their houses internally for lack of qualified electricians or because of safety issues involving the materials used to construct their houses.

Socioeconomic information of households. Specialized household energy surveys usually contain a limited set of questions on sources of income and expenditures for non-energy goods and services.[2] In addition, specialized household energy surveys usually collect cursory information on other household socioeconomic characteristics (for example, housing or level of educational attainment); however, they rarely contain extensive modules on such topics.

Other Distinguishing Features of Both Types of Surveys

Questionnaire design. Questionnaires of LSMS surveys and specialized household energy surveys are not static or uniform. Both types vary considerably by country and are customized

2. LSMS surveys, by contrast, aim at a comprehensive measure of household consumption; thus, they contain more reliable income and expenditure data, which is essential for distributional analysis.

to the identified analytical needs that make a survey necessary. Typically, a national energy ministry or energy utility commissions specialized household energy surveys and retains control over their questionnaire design. This control can ensure that sufficient questions are included to permit a detailed investigation of energy end use, time use, attitudes, initial cost of obtaining service, and other information important for energy policy. The design process should allow for adequate consultation with other sector ministries and research institutions in determining questionnaire content. In practice, however, such consultation is often *ad hoc.*

By contrast, design of LSMS survey questionnaires usually involves forming a committee chaired by the national planning or statistical agency; the committee typically includes members from sector ministries, civil society, research institutions, universities, and development agencies. It oversees questionnaire design through an iterative process. Because LSMS questionnaires can yield data useful for analysis of a great range of public-policy issues, many more modules and questions are usually proposed than can be accommodated—the length of the questionnaire must be limited to avoid respondent fatigue. Thus, it is important that energy specialists fully participate in the LSMS survey design process to ensure that essential, well-formulated energy questions are included.

Sample design. Both types of surveys are based on multi-stage stratified probability designs, using small sample sizes of 2,000–5,000 households to minimize non-sampling errors.[3] Their small size usually precludes disaggregating the results to small geographical areas. Domains of study (for example, urban/rural) are identified; within each, a stratified two-stage cluster design is used (clustering interviews helps to reduce cost). LSMS surveys are typically national in coverage, while specialized household energy surveys are often implemented in a particular region (for example, where a pilot rural electrification or improved stove program will be implemented).

Survey cost. LSMS surveys are significantly more expensive (US$0.5–1.5 million) than specialized household energy surveys (US$50,000–150,000). Cost factors include sample and questionnaire size, local per diem, and salaries. Collecting data on household energy use through a well-designed LSMS survey offers an extremely cost-effective opportunity.

Quality control. Extensive quality control is a hallmark of LSMS surveys. In terms of questionnaire design, quality control includes use of verbatim questions, explicit skip patterns, and translation of questions into respondents' languages. Survey modules provide the enumerator explicit suggestions for further probing. A custom-designed, data-entry program performs automated range and consistency checks within and across modules. Other quality-control features include enumerator training (typically four weeks), close field supervision, questionnaire pre-testing, piloting, and rigorous documenting of all survey stages. While specialized household energy surveys have adopted many of these features, their smaller budgets are a limitation that may sometimes compromise quality control.

3. However, for LSMS surveys, larger samples are not uncommon. For example, the 2001 Bosnia and Herzegovina LSMS Survey sampled 5,402 households, and the 1994 South Africa Integrated Household Survey covered about 9,000 households.

Because the LSMS surveys are much longer, two field visits at two-week intervals to each household are required to complete the household questionnaire. Between visits, data for the first half of the household questionnaire are entered and checked for errors. During the second visit, when the second half of the questionnaire is completed, these errors are corrected. For specialized household energy surveys, households are visited only once; thus there is no re-interviewing opportunity to correct for errors.

Existing and Missing Energy Questions in LSMS Surveys

In developing these guidelines, completed LSMS surveys were reviewed to determine what energy questions they contained. The review found that most surveys contained some energy questions. In the household questionnaire, energy questions centered mainly on fuel types used for cooking or lighting, along with types of household appliances. In the community questionnaire, energy questions typically focused on local pricing of various commodities, including energy.

However, for LSMS surveys, larger samples are not uncommon. For example, the 2001 Bosnia and Herzegovina LSMS Survey sampled 5,402 households, and the 1994 South Africa Integrated Household Survey covered about 9,000 households.

Household Questionnaires: What Energy Questions Do They Currently Contain?

The typical LSMS household survey instrument contains four types of energy questions that analysts can use to better understand household energy-use patterns. These relate to:

- electricity service providers,
- type of energy the household uses,
- expenditures on commercial fuels, and
- energy-using durable goods.

Electricity service providers. Nearly all LSMS household questionnaires ask households whether they have electricity service. This question is sometimes followed by another to determine the service provider (utility, self-generated, or other), as well as other questions on monthly household expenditures.

Type of energy the household uses. Questions regarding the types of energy households use ask respondents about their households' energy sources for various end uses (for example, "What is your principal source of lighting?" or "What is your primary fuel for cooking?"). In some cases, these questions may be followed by others regarding the secondary fuels used for such activities (Komives, Whittington, and Wu 2002). Since any household that has electricity uses it for lighting, the question on source of energy used for lighting can be used to determine whether the household has an electricity connection. In countries where space heating is common, respondents usually are asked such questions as "What is your primary fuel for space heating?" or "What is your main energy source for heating?"

Expenditures on commercial fuels. Questions on expenditures ask respondents how much money their households spent during the last week or month on listed non-food items, which often include a variety of fuels (for example, candles, batteries, bottled gas, kerosene, charcoal, and fuelwood). The responses reveal whether the household purchased a particular fuel and the monthly expenditures on it. Certain fuels are sometimes lumped together in ways that make it difficult to disaggregate expenditures on individual fuels.

Energy-using durable goods. Questions on durable goods present respondents a long list from which they are asked to indicate which goods their households own. The list typically includes electrical appliances (for example, fans and televisions) and cooking equipment (for example, stoves and hot plates). To enable a calculation of the flow of services from such durable goods, further questions on the age and present value of the item are asked.

Although most LSMS household surveys contain all four sets of questions, the level of sophistication varies widely. Some include only two questions with which to determine whether a household has an electricity connection and, if so, the level of monthly expenditure. Others include 10 or more questions to probe whether the household has a working electricity meter, whether it shares its bill with other households, household billing frequency, and number of hours of electricity service. Some instruments include small enterprise modules to collect information on the electricity households use for business or other productive purposes.

Some LSMS household questionnaires ask energy questions with regard to time use (Harvey and Taylor 2000). These questions involve how much time household members spend collecting fuelwood or other biomass fuels used for cooking and heating. The questions sometimes detail which household members do this type of work, where the fuel is collected, and the type of biomass stove used for cooking.

Community Questionnaires: What Energy Questions Do They Currently Contain?

In the LSMS community questionnaire, the most common energy-related questions involve availability and prices. They ask respondents about the availability and pricing of such fuels as charcoal, fuelwood, kerosene, LPG, candles, coal, and batteries. Some survey instruments include questions on the percentage of households in the community with electricity service or ask about the number of hours electricity service is usually available. A few ask how many years the community has had electricity service and whether electricity utility ownership is public or private.

LSMS Surveys: What Energy Questions Are Currently Missing?

Most LSMS surveys ask only about the main source of energy for a particular purpose. Because the survey permits only one answer, it is not possible to deduce which minor energy sources households use for lighting, cooking, and other end uses. Community questionnaires seldom include a comprehensive list of all energy sources when they ask which fuels are available in the community; thus, it is not possible to deduce which energy sources available in the community households choose not to use. To model the determinants of households' fuel-choice thoroughly, it is important to accurately characterize all of the available energy options that a household does not choose.

In addition, LSMS surveys typically lack sufficiently detailed questions on:

- pricing in order to accurately determine unit prices households pay for fuels and electricity (community questionnaires do not always include questions on prices of all the energy sources available in the community);
- connection fees;
- service quality and supply reliability from service providers and retail distributors;
- seasonal variation, as it relates to pricing and service reliability;
- household coping costs (e.g., how households behave during power outages or fuel shortages);
- quantities of fuels and electricity consumed;[4] and
- attitudes toward various energy sources (e.g., whether households perceive particular types of energy as relatively clean or polluting, convenient, expensive, or reliable).

Energy and Development Outcomes: The Issue of Causality

The issue of causality is a fundamental concern for development research. Causal models are needed to link improvements in energy infrastructure services with such desired outcomes as improved household health, education, or income. An analyst must know how a policy intervention will affect household decisions and, in turn, energy markets. The LSMS survey can be used to develop such causal models if better energy information is available.

However, the statistical and econometric work associated with using LSMS survey data on pricing and quantities can be challenging, and the socioeconomic information with which to estimate household demand functions may not be available. To identify the demand function, policy analysts must have access to variations in the price of fuel or electricity resulting from changing cost conditions. These may not be available because of unchanging, nationally uniform tariffs. Also, increasing block tariff structures pose difficulties because the marginal and average prices a household pays depend on its own decision about how much to use. At a minimum, estimating demand functions necessitates gathering data on the tariff structures applied to households in the LSMS survey sample.

In addition to estimating development outcomes (for example, improved health or educational attainment), causality is important in analyzing the costs and benefits of energy services. Most cost-benefit analysis is based on "with and without" or "before and after" comparisons, implying that the intervention is causally related to the change in status of an individual, household, business, or other social entity. Seriously evaluating the intervention's effect requires some type of control group. After the causal (or at least attributed) benefits are identified, the issue becomes how to measure them in order to compare them to the cost of the energy service.

4. Quantities of fuels consumed by the household must be back-calculated from data on household expenditures, using estimates of prices paid by households that sometimes are taken from a source other than the LSMS. In practice, this approach often proves problematic because information on the applicable tariff or price is not available or responses to the fuel expenditure questions are unreliable.

LSMS survey data can be used to estimate the benefits of infrastructure investments and policy interventions—and thereby help infrastructure analysts and task managers to appraise new projects—in three ways. The simplest method is to use data on the household costs of coping with unreliable services as a measure of the benefits of service quality improvement. The argument is that, if service quality is improved, households will experience economic benefits in the form of cost savings because they will no longer spend financial resources on coping with unreliable services.

The second method involves estimating a demand curve for a particular service based on price-quantity relationships derived from LSMS energy questions. In addition to its use in predicting behavioral changes in response to changes in pricing policy, this demand curve can be used to estimate welfare gains and losses using standard cost-benefit methods (Boardman and others 2001). With an estimated demand curve for a service such as electric lighting, it is possible to estimate the benefit for a rural household that switches from one lighting source to another. An example of this type of work was developed in the Philippines from a specialized household energy survey conducted in four regions geographically representative of that country.

In special circumstances, a third method may be used, whereby an energy or infrastructure analyst includes a "stated preference" module in the LSMS survey and directly queries respondents about their demand (willingness to pay) for improved energy services. For example, respondents could be asked if they would agree to a specified monthly increase in their monthly electricity bill in exchange for improved service reliability. Alternatively, choice modeling techniques might be used to explore the conditions under which a household would switch fuels for various uses. These techniques use survey techniques to value willingness to pay for levels and types of services (Mitchell and Carson 1988; Kopp, Schwarz, and Pommerehne 1997). The techniques were first pioneered to assess the value of such public goods as a clean environment. In this case, levels of pollution were described (sometimes aided by pictures for a given situation) to individuals to elicit their responses regarding how much they would pay to attain a clean environment. Stated preference techniques, such as the contingent valuation method (CVM) and choice modeling (CM), would probably not require the use of an entire LSMS survey sample. CM techniques in particular would require samples of only a few hundred households, not thousands as in many LSMS surveys (Haab and McConnell 2002; Bennett and Blamey 2001), so the questions could be administered to a subsample of a large sample survey.

To date, the household energy sector has rarely used stated preference methods. Experience using these methods in other sectors in developing countries suggests they can be used successfully in the household energy sector. However, this does not imply that such work is easy or straightforward. Indeed, many applications of stated preference methods in both developing and developed countries have not provided policymakers reliable information. Generally, the problems have involved unsophisticated sampling and questions that ask respondents how much they are willing to pay for various levels of energy service. People generally know the national prices for electricity and other fuels and thus are often reluctant to express their willingness to pay much higher prices in fear that the hypothetical situation posed by the question will become a reality. Sophisticated sampling techniques and well-crafted questions are necessary to ensure reliable information (Whittington 1998, 2002).

A possible alternative to these techniques requires the availability of high-quality, cross-sectoral information with which to develop models of household demand for specific fuel types.[5] Using this approach, household demand models can potentially explain household fuel choices, as well as the quantities of each fuel type used as a function of fuel prices, household income, and other socioeconomic factors. Panel data from repeated LSMS surveys are particularly useful in evaluating the effects of policy interventions over time. However, one should not underestimate the complexity involved in formulating and estimating such household demand models in the energy sector.

5. This is possible with LSMS surveys.

CHAPTER 3

Importance of LSMS Survey Data for Energy Policy Analysis

Worldwide, as many as 2.4 billion poor people live in households that have yet to make the energy transition. The traditional fuels poor people use come at a high cost in time and labor. Hundreds of millions of people—mainly women and children—spend several hours daily gathering wood for cooking. Because of these demands on their time and energy, women and children are denied opportunities to improve their quality of life.

Household transitions to cleaner, more efficient, and more productive energy uses can dramatically affect the quality of life of people in developing countries. Cooking with LPG instead of biomass and using efficient wood stoves with chimneys instead of open fires reduce indoor air pollution, a major cause of respiratory illness. Irrigating using electric motors and diesel engines instead of traditional methods that use animal and human power can increase agricultural productivity. Using electric lighting rather than kerosene lamps encourages evening reading and school attendance. In addition, electricity supply enables households to engage in income-generating activities.

Household Energy Transitions

A significant body of literature on household energy transitions has focused on how households ascend what has been called an energy ladder (Barnes 1990; Leach 1986). At the bottom of the ladder, many people use low-grade biomass fuels (for example, straw, dung, and wood) in inefficient and unhealthful ways. At intermediate points along the ladder, they turn to commercial fuels (for example, charcoal, coal, and kerosene), finally switching to cleaner and more convenient fuels (for example, LPG and electricity) that can significantly improve their quality of life.

This model theorizes that households switch from low-grade fuels to ones higher up the ladder in incremental steps. The main factors determining the type and level of fuel-switching include income, price, and urbanization (Barnes, Krutilla, and Hyde 2005). For example, high levels of household income make fuels higher up the energy ladder more affordable. Similarly, as small settlements grow into large cities, fuelwood becomes scarcer while commercial fuels become more readily available as a result of improved economies of scale in infrastructure development and fuel distribution. In short, this simple model views the household energy transition as a smoothly sequenced evolution from fuelwood to charcoal and kerosene and ultimately to LPG and electricity.

Transitional Pathways

More recent empirical studies have found that households retain a portfolio of fuel options; that is, at any given time, they are likely to consume a range of fuels along the energy ladder (Barnes and Qian 1992; Dewees 1989; Hosier and Kipondya 1993). These findings have led researchers to propose more nuanced models of the household energy transition to explain the variety of transitional pathways encountered. Reliability of supply is just one of the factors thought to play a role. Another is the cost of energy forms for various uses. Energy sources have different levels of cost effectiveness and substitutability for the energy services that households require (for example, heating, cooking, lighting, and motive power). Degree of convenience, level of safety, and amount of pollution emitted into the home associated with the various energy sources may also be key factors affecting household choices and levels of consumption. For example, it is not unusual for households to use charcoal to prepare tea or coffee early in the morning and use fuelwood to prepare a stew cooked over several hours, which is eaten later in the day. It has been found that even well-off households use fuelwood to bake certain types of bread and meats because of the taste it imparts.

Lower-income households, which rely more on traditional fuels than do higher-income households, are disproportionately burdened by the costs (both monetary and non-monetary) of household energy use. Poor households are more vulnerable to price increases and volatility and unreliable energy supply. High start-up costs also present a significant obstacle for poor households.

Greater focus on the energy service or utility that the various energy sources provide in various end-use applications is also important for government policies that encourage the household energy transition to cleaner and more efficient energy use. For example, improved fuelwood stoves (for example, stoves fitted with chimneys that are more efficient than traditional threestone cooking fires) reduce the amount of firewood needed to prepare a meal and levels of indoor smoke (Wallmo and Jacobson 1998; Barnes and others 1993). Similarly, pressurized lanterns are safer than simple kerosene wick lamps and produce more light output per unit of fuel used.

Indicators to Measure the Energy Transition

Indicators constructed from LSMS survey data sets—access, consumption, pricing, and reliability, and levels of household pollution—can be used to diagnose and track the household energy transition. The indicators and their variables are described below, and the questions in the prototype modules that may be used to construct the indicators are noted.

Access Indicators

The reasons why a particular household lacks access to a modern fuel or electricity involve either a supply-side failure (the community where the household lives lacks a local distribution network) or a demand-side failure (the household chooses not to use the available service because it is too expensive, culturally unfamiliar, or otherwise inappropriate). Because the policy implications of these failures vary so greatly, access indicators should differentiate between the two situations.

Access ratio. This indicator refers to the percentage of all households that currently use a specific fuel or electricity. It does not discriminate between demand-and supply-side explanations for any shortfall in access [Question F01, Fuel Sources Module; Question E01, Electricity Sources Module].

Availability ratio. This indicator refers to the percentage of all households for whom a particular fuel or electricity service is available, regardless of whether they use it. The indicator captures the extent to which electricity service or a particular fuel supply has reached all areas of a country, and hence the extent to which households have the option of using the particular fuel or electricity source [Question C11, Electricity and Fuels in the Community Module].

Usage ratio. This indicator refers to the percentage of households in communities where the fuel or electricity is available that choose to use it [Question F01 and F11, Fuel Sources Module; Question E01, Electricity Sources Module; Question C11, Electricity and Fuels in the Community Module].

Appliance use. Several appliance-use indicators may be calculated. The stock of electrical appliances may be used as a proxy measure of household economic well-being (similar to the ways in which housing building materials and housing type are used). In addition, a proxy indicator of indoor air pollution is the percentage of households using biomass fuels for cooking that own an efficient wood stove fitted with a chimney that extracts smoke to the exterior of the dwelling. Another proxy indicator is the percentage of all households that use electric stoves or LPG burners and stoves [Question A04, Durable Goods (Light Bulbs and Appliances) Module; Question F01 and F11, Fuel Sources Module].

Consumption Indicators

Consumption indicators provide policymakers a picture of the relative importance of various fuels and their household end uses.

Gross energy consumption. This indicator is the total energy content of fuels and electricity that a household purchases. To calculate gross energy consumption, one must convert the quantity of each of the fuels purchased by the household into a common unit (such as kilojoules) for the purposes of aggregation (Appendix). Low values of gross energy consumption may indicate that households cannot afford to consume sufficient energy to meet basic needs of cooking, lighting, and heating. Conversely, high values may indicate that some energy forms are underpriced, causing wasteful use [Questions F02, F03, F04, F12, F13 and F14, Fuel Sources Module; Questions E03, Electricity Sources Module].

Net energy consumption. This indicator is an adjustment to the gross energy consumption variable, reflecting the efficiency factors of various fuels in different end uses. It is therefore a measure of the useful energy obtained by the household in end-use application. To calculate net energy consumption from gross energy consumption, one must disaggregate gross energy consumption by end-use activity, identify the appliance associated with each end-use activity, and scale down the gross energy consumption for each activity by the efficiency factor for the corresponding fuel and associated appliance (Appendix) [Questions F02, F03, F04, F12, F13 and F14, Fuel Sources Module; Question E03, Electricity Sources Module; Question A04, Durable Goods (Light Bulbs and Appliances) Module].

Price Indicators

Because LSMS and other multitopic household surveys can be used to collect information on prices paid, quantities used, and expenditures for all fuels used by a specific household, various price indicators can be calculated. High values or rapid changes in these indicators may signal an affordability problem among certain groups. Analysis of variations in fuel prices may reveal the presence of spatial monopolies. Price indicators include unit price, mean-weighted unit price, energy expenditure, and start-up costs.

Unit price. This indicator is the market price of each fuel and of electricity per unit purchased. The unit prices may vary geographically and may be an indicator of local monopolies or fuel scarcity [Questions F05, F06, F15 and F16, Fuel Sources Module; Questions E03 and E05, Electricity Sources Module].

Mean-weighted unit price. The household's average gross unit price of energy is the average of the unit prices for each fuel purchased by the household, weighted by the share of that fuel in the household's overall gross energy consumption [Questions F05, F06, F15 and F16, Fuel Sources Module; Questions E03 and E05, Electricity Sources Module].

Energy expenditure. This indicator is the price of each fuel, multiplied by the quantity consumed. When summed for all energy sources, one can estimate the aggregate household energy expenditures as a percentage of household expenditure or income [Questions F04, F06, F14 and F16, Fuel Sources Module; Question E05, Electricity Sources Module].

Start-up costs. This indicator represents the investment costs involved in securing access to an energy source (for example, electricity connection charges or cost of an initial cylinder of LPG). Connection costs can be expressed as a percentage of a poor household's monthly income [Question C06 (for electricity connection charge only), Electricity and Fuels in the Community Module].

Reliability Indicators

Reliability ratio. This indicator is the average percentage of time for a given period (usually a month) that any given fuel or electricity is available for use [Questions C03 and C04, Electricity and Fuels in the Community Module].

Reliability perception. This indicator refers to gauging perceptions on the relative availability and scarcity of various fuel and electricity sources [Question C11, Electricity and Fuels in the Community Module].

Pollution Indicators (Measurement of Indoor Air Pollution)

In India, a recent pilot study that tested an inexpensive air pollution monitor found it accurate and easy to use (Balakrishna and others 2005). If LSMS surveys can use this direct way of estimating indoor air pollution, it may be possible to construct indicators that combine concentrations of air pollutants with the various types of cooking fuels that households use.

Using LSMS Surveys for Energy Policy Analysis

LSMS surveys can be used to understand the relationships between use of energy services and household welfare; these analysis, in turn, can be used to adjust energy policies. For example, LSMS surveys can be used to investigate associations between use of biomass fuels and incidence of acute respiratory infection (ARI), with consequences for public health policy. LSMS data can also be used to estimate prices paid and expenditures incurred, with implications for energy pricing policy. It can also help to establish the household benefits of rural electrification, which can inform rural electrification policy. This section outlines these types of analysis.

Biomass Fuel Use and Acute Respiratory Infection

Exposure to smoke from the burning of traditional solid fuels (for example, fuelwood) for cooking and heating increases the risk of disease, most notably acute lower respiratory infection (ARI), in both children and adults (Smith and Mehta 2003; Kammen 2001; WHO 2002).[6] Women and children are disproportionately affected, in part, because of women's primary role in food preparation and child care, which exposes them to indoor air pollution.

Using data from a 2000 LSMS survey in Guatemala, Table 1 illustrates the association of fuel use and respiratory illness (Ahmed and others 2005). Incidence is less in households that use mainly LPG and that have a separate kitchen. By contrast, incidence is higher among households that use fuelwood only and that lack a separate kitchen.

A 1999 study, based on information from the fourth Zimbabwe Demographic and Health Survey, illustrates analysis that can be performed to assess the effects of cooking fuel type on ARI (Mishra 2003). In this study, control variables, identified in the research literature as covariates of ARI, included age of child, sex of child, birth order of child, nutritional status of child, mother's age at childbirth, mother's education in completed years of schooling, mother's religion, household standard of living, and region of residence.[7] Information on fuel types was used to group households into three categories (Table 2).

The results show that the unadjusted odds of having suffered from ARI are almost twice as high among children who live in households using high-pollution biomass fuels than among those living in households using low-pollution LPG/natural gas or electricity for cooking. After adjusting for the nine above-mentioned socioeconomic variables, children in households using wood, dung, or straw for cooking were more than twice as likely to have suffered from ARI as those in households using LPG/natural gas or electricity.

The mechanism by which cooking smoke can increase risk of ARI is not fully understood. Disentangling the causal associations with income, ventilation, kitchen-use patterns,

6. For a comprehensive review of studies on indoor air pollution and ARI, see Smith and others (2000).
7. Typical socioeconomic variables for which LSMS survey data is collected.

Table 1. Respiratory Symptoms in Children, by Fuel and Cooking Space, Guatemala (2000)

	Fuel			
Children with respiratory illness	Fuelwood only	Mix of fuelwood, LPG, and other	Clean only (mainly LPG)	Total
Percentage	48	46	40	47
Total no. cases	3,631	1,769	649	6,049

	Fuel and room for cooking					
	Biomass, no kitchen	Mixed, no kitchen	Biomass, kitchen	Mixed, kitchen	LPG, kitchen	Total
Percentage	50	53	47	43	42	47
Total no. cases	1,167	661	2,314	1,069	841	6,052

Source: 2000 LSMS (Ahmed and others 2005).

Table 2. ARI Prevalence among Children under Five Years of Age, Zimbabwe (1999)

Cooking fuel type (pollution level)*	Percent of sample	ARI prevalence
High	66.1	17.9
Medium	10.6	15.0
Low	23.3	10.1

*High = wood, dung, or straw; medium = kerosene or charcoal; low = electricity or LPG.
Source: Mishra (2003).

exposure times, location of kitchen, and other factors remains the subject of much experimental research, including carefully designed epidemiological studies. Nevertheless, it is clear that LSMS studies can be used to investigate associations between household fuel-use patterns and ARI, and all cooking fuels consumed by the household must be accurately measured.

Energy Prices and Household Expenditure

The questions set out in the fuels and electricity prototype modules in this report are designed to obtain accurate data on household use, quantities consumed, and prices paid. LSMS data sets that provide good-quality data on these variables can be useful in analyzing the effect of price changes on household welfare. A specialized household energy survey conducted in Yemen in 2003 used such questions, illustrating the types of analysis possible using such data.

Tables 3 summarizes, for each income decile, the percent of households reporting kerosene use and their average consumption and expenditure on kerosene purchases. What varies by income decile is not the quantity of kerosene used, but the percentage of households using kerosene. Thus, for example, 92 percent of households in the lowest decile and 57 percent in highest decile use kerosene. Rural households are more likely than

Table 3. Kerosene Use by Income Decile in Yemen (2003)

Income decile	Households reporting use (percent)			Consumption (liters per month)			Expenditure (YR per month)		
	Urban	Rural	All	Urban	Rural	All	Urban	Rural	All
1	79	94	92	8	10	10	282	394	386
2	66	93	89	10	11	11	368	446	436
3	50	85	80	10	11	11	313	433	422
4	56	90	83	6	11	11	233	475	442
5	52	86	79	6	9	8	268	367	354
6	46	80	71	7	10	9	259	397	374
7	52	80	72	9	11	11	360	415	404
8	40	74	64	8	11	10	304	418	398
9	27	71	57	7	11	10	230	377	354
10	35	68	57	7	11	10	303	406	384
Average	46	83	75	8	10	10	297	414	397

Source: World Bank (2005).

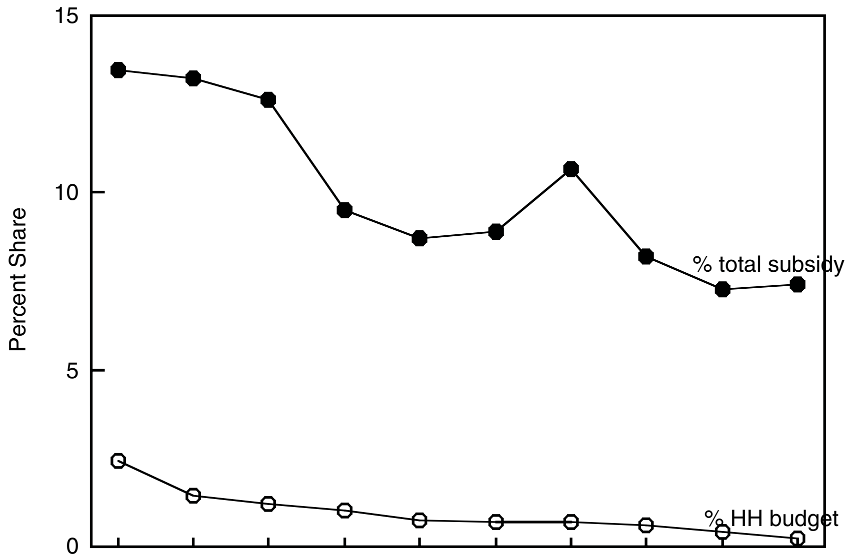
urban households to use kerosene (83 percent compared to 46 percent on average across all income deciles) reflecting, in part, easier access to LPG in urban areas (survey questions on LPG access confirm this finding).

Because kerosene is essential to the poor for cooking and lighting, many countries subsidize kerosene prices with the policy objective of protecting the poor. The rationale is that the poor should not have to pay the full cost of the fuel. However, subsidized kerosene prices have implications for public finances since the difference between the economic and subsidized price must be absorbed by the budget. Thus, policymakers would like to know who benefits from the subsidy and, if the subsidy were reduced, what the reduction in benefits would be. Analysis using the Yemen data illustrates one method of calculating the distribution of benefits.

In Yemen, the economic price of kerosene is its international price (the cif price at the port of Aden), plus distribution costs and taxes. Since the 2003 ex-distributor price (17 rials per liter) was substantially below that year's economic price (40 rials per liter), the difference represents the subsidy consumers received. Because the total quantity of kerosene consumed by each income decile is known, it is straightforward to calculate the distribution of the total amount of the subsidy. As Figure 1 shows, the poorest decile receives 13 percent of the total subsidy, while the richest receives 7 percent. The poverty rate in Yemen in 2003 was about 40 percent, meaning that 52 percent of the total subsidy goes to the non-poor. Using the data, it is also possible to estimate how removing the subsidy affects household expenditure. Figure 1 shows the increase in expenditure as a percent of total household budget. The subsidy is equivalent to 2.5 percent of the total expenditure of the poorest households, but only 0.2 percent of the richest.[8]

8. The calculation assumed no fuel switching and a price elasticity of –0.2.

Figure 1. Share of Total Subsidy Received and Share of Subsidy in Household Budget, By Income Decile



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● % total subsidy	13%	13%	13%	9%	9%	9%	11%	8%	7%	7%
⊖ % HH budget	2.5%	1.4%	1.2%	1.0%	0.8%	0.7%	0.7%	0.6%	0.4%	0.2%

Source: World Bank (2005).

Rural Electrification and Development

Rural electrification can transform rural people's lives in several major ways. Electrification of households can directly improve household welfare. Electricity for such productive uses as irrigation or rural enterprises can boost incomes. Electrification of rural health clinics, schools, and local government offices facilitates the delivery of public services.

For newly electrified households, the predominant use is lighting (Barkat and others 2002; Barnes and Floor 1996; Denton 1979). Numerous studies have found a correlation between electricity used in rural households and the amount of time adults read and children study (Barnes 1988; World Bank 2002, 2004). The probable reason is that kerosene lamps and candles, the usual alternative to electricity in rural households, provide inadequate light for reading (Nieuwenhout, Van de Rijt, and Wiggelinkhuizen 1998). The significantly higher levels of lighting that electric lamps provide enable comfortable reading, which can potentially improve education and school attendance (Khandker, Lavy, and Filmer 1994; Khandker 1996; Gordon 1997).

After lighting, household priority uses of electricity include televisions, fans, and other household appliances (Sathaye and Tyler 1991; World Bank 2002; Saunders and others 1975). Television, increasingly found in electrified rural households, is an important source of entertainment and information.

Households with electricity may experience time savings if they no longer must travel to battery-charging stations in a nearby town. Rural electrification can potentially support improvements in rural productivity through the use of electric pumps for irrigation and small electrical appliances in rural businesses (Ranganathan and Ramanayya 1998; World Bank 2002; Cabraal, Barnes, and Agarwal 2005; World Bank 1994).

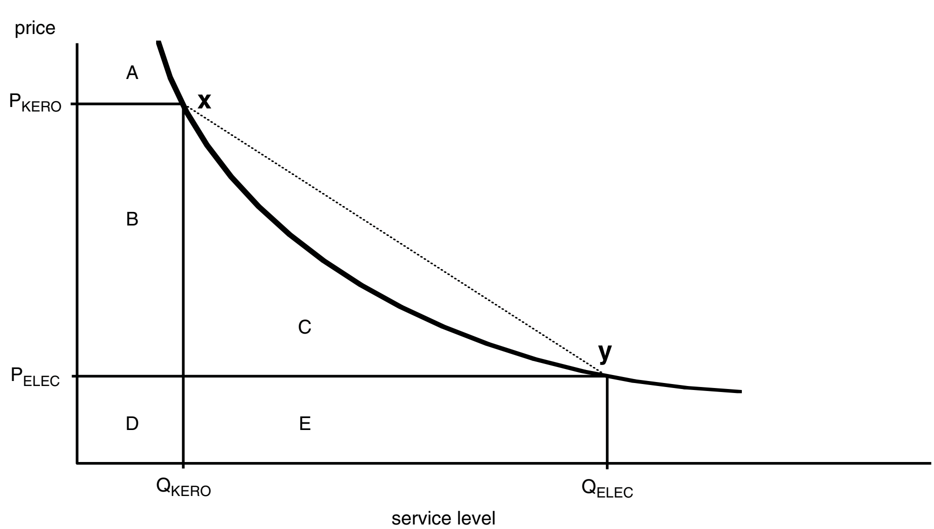
The improvements that electrification brings are amplified when accompanied by complementary investments, such as infrastructure (USAID 1983). A 1999 study in Peru found that providing a combination of infrastructure services—such as electricity, water, sanitation, and telephones—has a greater effect on poverty reduction

Willingness To Pay for Lighting

2002 study in the Philippines used survey data to develop a method for estimating the household benefits of electrification in monetary terms (World Bank 2002). Increasingly, rural electrification projects use this method to establish their economic returns. This section describes the theoretical framework for estimating the benefits of electric lighting using the willingness-to-pay method, along with a practical way to calculate the benefits. The results of applying the method in three recent World Bank rural electrification projects are also provided.

Consumer surplus—the difference between what the household pays for lighting service and the maximum amount it would be willing to pay—is the measure used to gauge the household benefits of electrification. Willingness to pay is based on the actual demand for a service, such as lighting. Based on the willingness-to-pay method, the monetary benefit to a household is the area under the demand curve, as shown in Figure 2. The only way to estimate such a demand curve is through a household survey that quantifies the amount of fuels and electricity consumed for lighting. This information is combined with information on the lighting service obtained from the various lighting devices the household uses. For the sake of simplicity, this example assumes that, before

Figure 2. Demand Curve for Lighting



Source: World Bank (2002).

electrification, the household only uses kerosene in kerosene lamps for lighting (in addition to kerosene, various other lighting sources, such as candles and dry-cell batteries, are usually used).

Before a household obtains electricity from the national or local grid, it uses kerosene or another form of energy for lighting. Thus, before electrification, the quantity of lighting services (kilolumen hours [klm-hr] per month consumed) is Q_{KERO}, at the price P_{KERO}. Thus, total household expenditure on lighting is $Q_{KERO} \times P_{KERO}$, which equals area B + D. When a household obtains electricity service, its demand for lighting changes to Q_{ELEC} at price P_{ELEC}.

Total willingness to pay for the service at level Q_{KERO} is the total area under the demand curve to that level of consumption; that is, area A + B + D. This is the total benefit to the consumer. However, the cost is area B + D, and therefore the net benefit or consumer surplus is the difference between the two, namely area A.

After electrification, the level of service (in the case of lighting, the number of lumen-hours) typically increases substantially; consumption increases from Q_{KERO} to Q_{ELEC}, but the price paid for the electrified service also falls from P_{KERO} to P_{ELEC}. Now the household's expenditure for electricity is $P_{ELEC} \times Q_{ELEC}$, which equals area D + E.

At this level of consumption, the total area under the demand curve to Q_{ELEC}—that is, the total benefit—is now area A + B + C + D + E. Therefore, the net benefit or consumer surplus, after subtracting the cost or D + E, equals A + B + C. Thus, it follows that the net economic benefit of electrification is the increase in consumer surplus, or area B + C. Areas B and D can be calculated using survey data on prices and quantities of kerosene used for lighting. The types of kerosene lanterns that households use may also be known from the LSMS survey (Durable Goods [Light Bulbs and Appliances] Module) or can be otherwise determined. The service obtained—expressed as klm-hr per month—can be obtained by multiplying lamp light output by the number of hours per month that lamps owned by the household are used.[9]

Similarly, area E is calculated by multiplying the total cost of electricity used for lighting by the service obtained. To calculate the service obtained by the households, one must acquire information on the number of electric lamps the household uses, their rating, and hours of usage per month. Manufacturer information on light output from various types of light bulbs can then be used to calculate Q_{ELEC} (klm-hr per month)[10]

The shape of the demand curve cannot be determined when only two demand points (for lighting obtained using kerosene and electricity) are known. In the absence of empirical data for intermediate points along the demand curve (for lighting obtained using dry-cell batteries, diesel gensets, or car batteries), assumptions on the shape of the curve between points x and y are critical to calculate area C; in such a case, a standard functional specification with a constant elasticity may be used.

9. A simple kerosene lamp may provide up to 40 lumens and a hurricane lamp 10–100 lumens, depending on the type of wick and lamp. A kerosene mantle lamp may provide approximately 400 lumens. Actual values vary and should be obtained from experimental data.

10. Approximate light output of a 40-W incandescent lamp is 400 lumens, 630 lumens for a 60-W incandescent lamp, 600 lumens for a 15-W fluorescent lamp, and 900 lumens for a 16-W compact fluorescent lamp (CFL).

Table 4. Willingness-to-pay Results from Three Projects

	Project country		
Factor	**Bolivia**	**Lao PDR**	**Peru**
Q_{KERO} (klm-hr per month)	7	20	4.6
Q_{ELEC} (klm-hr per month)	90	435	363
P_{KERO} ($ per klm-hr)	0.48	0.195	0.57
P_{ELEC} ($ per klm-hr)	0.04	0.003	0.01
Elasticity	–1.03	–1.74	–1.08
B (US$)	3.08	3.84	2.58
C (US$)	5.56	6.05	9.95
D (US$)	0.28	0.06	0.05
E (US$)	3.32	1.25	3.58
Total willingness to pay (per household per month)	12.24	11.20	16.16

Sources: World Bank project appraisal documents: ERTIC Project PAD (Bolivia data), 2003; Second Southern Provinces Rural Electrification Project (Lao PRD data), 2004; Peru Rural Electrification Project (Peru data), 2005.

Since its development using survey data from the Philippines, this method has been applied in economic analysis of several World Bank projects. Table 4 summarizes survey results from three projects. These calculations used data from specialized household energy surveys; however, similar calculations could be made using data from LSMS surveys that incorporate the questions presented in the prototype modules.

These household benefits are for lighting alone, and they are well above the cost of electricity service. As is well known, households can derive an array of other benefits from electricity, including entertainment, food preservation, and comfort from fans.

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Electricity and Education: Results from India and Nicaragua

As pointed out above, the benefits of electrification include time saving, increased productivity, and improved health and education outcomes. Thus, the willingness-to-pay measure for lighting represents only a portion of the benefits. The Philippines study described above is one of the few to have estimated the education and time-saving benefits of electrification in monetary terms. When it estimated the combined effect of electricity and education on income, it found that wage earners in households with electricity can expect to earn $37–47 more per month than their counterparts without electricity. This amount represents about 25 percent of a typical household's monthly income in the survey areas.

Data from the LSMS and specialized household energy surveys can provide some evidence of the association between electrification and education, even if falling short of estimating monetary values of the benefits (Table 5).

Table 5. Electricity and Education Links in India and Nicaragua

India Specialized Household Energy Survey, 1996				
	Family literacy (%)		Women reading in the last 24 hours (%)	
Income decile	With electricity	Without electricity	With electricity	Without electricity
Lowest	48.2	7.7	29.9	4.1
Middle	57.3	14.1	46.3	2.1
Highest	64.4	26.5	39.0	2.2

Nicaragua LSMS Survey, 1998				
	Household literacy (%)		Children enrolled in school (%)	
Region	With electricity	Without electricity	With electricity	Without electricity
Atlantic	74	46	77	40
Central	74	50	77	46
Pacific	77	62	73	62
Total	73	53	72	50

Sources: Kulkarni and Barnes (2005); World Bank (2002).

The 1996 India survey found that, in households without electricity, virtually no women read, regardless of income class. By contrast, in households with electricity, literacy was much higher, regardless of income class. Findings from the 1998 Nicaragua LSMS survey were similar. Electricity in the home was highly correlated with school attendance and family literacy. Obviously, these correlations constructed from survey data do not establish causality; nevertheless, the findings are compelling and are consistent with those in other countries. The implication is that this could be an important research area for future LSMS surveys with better energy questions.

CHAPTER 4

The Way Forward

The purpose of these guidelines is to design a set of energy questions for use in LSMS surveys that, while not as extensive as those in the specialized household energy surveys, could still provide sufficient information with which to improve analysis of household energy use.

It is proposed that the few *ad hoc* questions on energy use currently found in LSMS surveys—which yield little information useful to policymakers—be replaced by the questions presented in the prototype energy modules that follow. The rationale for including these particular questions is based on the review of the key policy issues that household data can inform and an assessment of the feasibility of including such questions in LSMS surveys. The format of the proposed modules is similar to that often used in current LSMS surveys in order to facilitate their adoption.

Formulation of the questions presented in the prototype modules draws on experience from recent LSMS and specialized household energy surveys. The notes provided point out commonly encountered problems and how they may be overcome. The notes caution that the questions must be customized to the particular country for which a survey is designed, taking into account its unique circumstances of fuel and electricity availability and use.

The prototype modules presented below have been designed for insertion in an LSMS survey as stand-alone modules. Since the questions in each prototype module complement each other, their potential to yield the greatest amount of data on household energy use will be realized if they are kept whole. However, because of the necessity to limit the number of modules, LSMS survey designers may not always be able to insert stand-alone modules. Instead, the electricity and fuels questions on access, consumption, prices, costs, and end use in the prototype modules may be integrated into another module, such as the Housing Module, and questions on time spent collecting fuels into the Time Use and Labor Module.

Questions in the Durable Goods (Light Bulbs and Appliances) Module may be integrated into the LSMS Durable Goods Module. It should be kept in mind that, in addition to the question "Does your household own [item]?," the essential complementary questions (in order to estimate a monetary value of the benefits of energy use) are "How many [items] do you own?" and "How many hours during the last week did you use the [items]?"

For best results, it is recommended that all of the questions in the prototype modules be included.

Fuel Sources Module

The purpose of the Fuel Sources Module is to collect information on household access, consumption, and payment for all the fuels used (Figure 3). Those household members that pay for or collect fuels are usually the best-informed respondents.

The list of household fuels in this module is indicative (Table 6). The LSMS survey designer may need to delete fuels that are not available in the country for which the LSMS is being designed and add others. The survey designer should recall that fuel shortages or price advantages of one fuel over another can induce fuel substitution. For example, if LPG is subsidized and gasoline is not, households can have their car fuel systems adapted to use LPG instead of gasoline.

Notes on Fuel Sources Prototype Module

F01 and F11: During the last 30 days, has your household used [for each fuel]?
These questions establish which energy sources the household uses. It is important to collect information about all fuels used by the household, not simply those most frequently used, as households tend to use a portfolio of fuels. Design of the module ensures that enumerators will first determine which fuels and electricity sources households use. Only after establishing which fuels households have used in the last 30 days and which electricity sources are available to them will the enumerator ask the follow-up questions for each fuel and electricity source.

F02 and F12: What is the typical unit of measure [for each fuel]?
Sometimes atypical units are collected (for example, large tree limbs in the case of firewood). The enumerator will have to adjust these for a commonly used unit. Instructions should be given to the enumerators to make notes of all such cases.

F03: What is the approximate weight or volume of a typical unit of [for each fuel]?
F13: What is the approximate weight or volume of a typical unit of [for each fuel]?
Accurate measurement of the units in which energy is consumed is critical to data quality. The complexity of accurately capturing this information varies substantially across fuels. Some are measured in formal scientific units (for example, liters in the case of kerosene or kilograms for LPG). However, respondents may think more in terms of the cylinders or bottles in which the fuel is sold rather than the scientific units they represent. For example, kerosene is often sold in several sizes of plastic bottles, and respondents may not know their volumetric content. It is important to develop appropriate prompting strategies so that the enumerator can establish which sizes the household uses and ensure that the correct weight is entered.

Specific fuels present their unique challenges. For example, the weight contained in LPG cylinders can differ markedly from that marked on the cylinders. Using LSMS survey

Figure 3A. Fuel Sources (biomas and candles)—Prototype Module

ID CODE	FUEL SOURCES	F01 During the last 30 days, has your household used […]? Ask question F01 for each source first. Then >> to questions F02 - F10 for each question for which the response to F01 was "yes" [1]. Yes...1 No...2>>Next Item	F02 What is the typical unit of measure for […]? BIOMASS Piece ......1 Bundle ..2 Stack ......3 Bag ....4 Sack ......5 CANDLE Small......6 Medium..7 Large ....8 OTHER..14	F03 What is the approximate weight of a typical unit of[…]? Use decimals.	F04 How many units of […] has your household used in the last 30 days? (include both purchased and collected units). Use decimals.	F05 How many of these units of […] did your household purchase during the last 30 days? Use decimals. If not puchased >>F08	F06 What is the typical price your household pays per unit of […]?	F07 What was the total cost of all the units of […] that your household purchased in the last 30 days?	F08 How much time did all members of your household spend collecting […] in the last 30 days? Include roundtrip travel time.		F09 What is the one-way distance members of your household typically travel to collect […]?	F10 What percentage of […] was used for the following purposes? Enter 9999 for no use; 1, 2, 3, or 4 [1=25% 2=50% 3=75% 4=100%]				
		Code	Unit	Kilograms	Number	Number	Amount	Amount	Hours Men	Women	Kilometers	Lighting	Cooking	Space Heating	Hot Water Heating	Other
	Agricultural Residue															
	Dung															
	Firewood															
	Other traditional biomass															
	Charcoal & Coal															
	Candles															

Figure 3B. Fuel Sources (gaseous and liquid fules)—Prototype Module

ID CODE	FUEL SOURCES	F11 During the last 30 days, has your household used [...]? Ask question F11 for each source first. Then >> to questions F12 - F19 for each question for which the response to F01 was "yes" [1]. Yes...1 No...2>>Next Item	F12 What is the typical unit of measure for [...]? LPG 12kg ......9 16kg ....10 LIQUID FUELS Litres ....11 Bottles..12 Jugs ....13 OTHER..14	F13 What is the approximate weight or volume of a typical unit of[...]? Use decimals.	F14 How many units of [...] has your household used in the last 30 days? Use decimals.	F15 How many of these units of [...] did your household purchase during the last 30 days? Use decimals. If not puchased>> F18	F16 What is the typical price your household pays per unit of [...]?	F17 What was the total cost of all the units of [...] that your household purchased in the last 30 days?	F18 What is the one-way distance members of your household typically travel to purchase [...]?	F19 What percentage of [...] was used for the following purposes? Enter 9999 for no use; 1, 2, 3, or 4 [1=25% 2=50% 3=75% 4=100%]						
		Code	Unit	Liters	Number	Number	Amount	Amount	Kilometers	Lighting	Cooking	Space Heating	Hot Water Heating	Irrigation	Transport	Other
	LPG															
	Kerosene															
	Gasoline															
	Diesel															
	Natural Gas															

Table 6. Fuels and Their Common Household Uses

Fuel	Household use
Firewood, animal dung, and other biomass	Cooking and hot-water heating
Charcoal	Cooking and hot-water heating
Candles	Lighting
Kerosene	Lighting (wick and hurricane lamps) and cooking
Biogas	Cooking
Liquefied petroleum gas (LPG)	Cooking and lighting (less often)
Diesel	Lighting (wick and hurricane lamps) and electricity (diesel generators)
Gasoline	Transport (motor bikes and cars)
District heating	Space heating
Natural gas	Cooking and space heating

data, the analyst (not the field enumerator) will need to establish the average net weight of LPG cylinders sold. Biomass fuels present the most difficult case in that they tend to be sold or collected in measures—that is, bags of charcoal, bundles of firewood, or cakes of dung—for which only approximate conversion to scientific units may be possible. It is therefore essential to begin the questionnaire design process with a detailed understanding of the units in which fuels are measured and sold in local markets, as well as a method for converting these into scientific units. For example, in certain countries, it is not unusual for charcoal to be sold in discarded fertilizer bags. It is not difficult to establish an average weight for the amount of charcoal contained in these bags.

F04 and F14: How many units of [for each fuel] has your household used in the last 30 days?

These questions record the household's physical consumption of each fuel during the last 30 days. Different fuels tend to have distinct time cycles for purchase and consumption, which make accurate responses problematic. Households tend to make frequent purchases of certain fuels, such as kerosene. They purchase these in small quantities and consume them entirely within days or weeks.

Households (especially poor ones) tend to make less frequent purchases of such fuels as LPG, which may be available only in 11-kg cylinders. The household may consume a single cylinder over a period longer than 30 days. The difficulty is to accurately estimate what fraction of the 11-kg cylinder the household consumed over the last 30-day period. As pointed out above, seasonality can be an important factor in fuel consumption. Consumption of fuels for space heating peaks during cold seasons. Religious festivals and harvests are often a factor that causes increased consumption of transport and cooking fuels. Thus, local habits for obtaining fuels should be considered during the questionnaire design stage so that the choice of time period can be adapted as needed and appropriate prompting strategies can be developed for the interview.

In deciding whether to specify the last 30 days or another time period for this question, as well as for Questions F05, F07, F15 and F17, the survey designer should take into account the particular country's energy-use patterns and whether it has marked seasonal variations of use. If households have marked seasonal variations in fuels consumption, it may be necessary to ask an additional question on the household's average consumption per month.

F05 and F15: How many of these units of [for each fuel] did your household purchase in the last 30 days?
F06 and F16: What is the typical price your household pays per unit of [for each fuel]?
F07 and F17: What was the total cost of all the units of [for each fuel] that your household purchased in the last 30 days?
Questions F05, F06, F07, F15, F16 and F17 are used to record the household's expenditure on each fuel source during the last 30 days. Expenditure is calculated by multiplying the number of units purchased (F05 or F15) by the price paid (F06 or F16). The result of this calculation should be consistent with the response to Questions F07 and F17. If the results are not consistent, the analyst must decide which is more reliable. The answers are straightforward for fuels purchased frequently in cash. However, as noted above, some fuels may be purchased less frequently than once per month, making it harder for households to estimate monthly expenditure.

F08: How much time did all members of your household spend collecting [for each biomass fuel] in the last 30 days? Include time spent purchasing and collecting, as well as round-trip travel.
This question identifies the extent to which households pay for different fuels in terms of the time they expend collecting them. This question is expected to be relevant primarily for traditional biomass fuels, including dung and fuelwood. However, it may sometimes be relevant for other fuels (for example, car batteries, which may need to be taken to the nearest town for recharging). This question, combined with other LSMS survey information, can be used to explore which types of activities are curtailed by households who engage in wood collection. Identity of the household members involved in fuel collection is important because it affects the way in which the time dedicated to this activity is valued. Depending on the context, it may be important to distinguish not only between men and women and adults and children, but also adults that earn income outside the household and children in and out of school. Households members may combine time spent collecting or purchasing fuels with other tasks. Local habits for obtaining fuels should be considered during the questionnaire design stage so that the question can be adapted as needed.

F09: What is the one-way distance members of your household typically travel to collect [for each biomass fuel]?
F18: What is the one-way distance members of your household typically travel to purchase for each liquid fuel]?
These questions record the distance a household travels to reach the place where each type of energy is collected or purchased. One should note that it may be difficult to obtain accurate distance estimates from respondents. Research addressing this issue and the relative merits of asking for "time to source" is being undertaken and may be helpful to review. Some objective testing of this measure prior to conducting a survey is recommended.

F10 and F19: What percentage of [for each fuel] was used for the following purposes?
These questions document the uses to which each fuel is put. The end-use categories are country-specific; thus, the module must be carefully reviewed so that it is adapted to the particular country. For example, if the country's use of fuels for space heating is negligi-

ble, that end-use category can be removed from the questionnaire. In-country testing may be needed to determine if the percentages can be left open or if set categories (1 = 25%, 2 = 50%, 3 = 75%, and 4 = 100%) are needed.

Electricity Sources Modules (Grid and Off-grid)

The Electricity Sources (Grid) Module (Figure 4a) pertains to electricity the household obtains from a utility (for example, grid electricity), community system (for example, mini- and micro-hydro systems), or neighbor or relative (informal connections to a neighbor or relative's grid supply or genset). The purpose of this module is to collect all relevant information on electricity access, consumption, payment, and uses, bearing in mind that households may rely on a variety of sources. The household member that pays for electricity purchases is usually the best-informed respondent.

E01 and E06: Does your household have electricity from [for each electricity source]?
This question is asked first for all possible electricity sources (Box 1). Only after answering for all possible sources does the interviewer ask Question E02 (for grid, genset, and micro-hydro sources). If the household obtains no electricity from the grid, the interviewer will move on to Question E07 (for off-grid sources). Households may have access to grid electricity from a utility without being utility customers if they obtain electricity illegally (unofficial grid connection) or informally (by wiring up to a neighbor's system). The module somewhat artificially distinguishes between utility customers and non-customers by treating grid electricity in the latter case as a distinct electricity source. The appropriate expression for these types of arrangements must be determined by taking local conditions into account. If the grid supply is particularly unreliable, the household may have both grid and non-grid sources, with the latter used as a back-up system. Question E01 also clarifies the name of the electric utility that supplies the household so that it is possible to later verify the tariffs and charges faced by the household. The names of all available formal electricity service providers should be listed on the printed questionnaire. The question should therefore be adapted to local circumstances to ensure that this information is obtained.

Notes on Electricity Sources (Grid) Prototype Module

E02: What is electricity used for in your home?
List up to five in order of importance. The end-use categories are country-specific and must be reviewed carefully when the module is adapted for use in any particular country. For example, if there is negligible electricity use for space heating, hot-water heating, or cooking in the country, these end-use categories can be removed from the questionnaire. Because substitution of electricity with fuels for certain applications may involve important policy issues, design of this question and the corresponding one in the fuels sources module (F10) may need to be considered together (for example, policymakers want to discourage use of electricity for cooking [because it causes demand to spike during evening hours, making it impossible for the utility to match the demand load during that time] and promote substitution by LPG or natural gas). Information obtained through the Durable Goods (Light Bulbs and Appliances) Module will complement and serve to validate the information obtained with this question.

Figure 4a. Electricity Sources (Grid) Prototype Module

ID CODE	ELECTRICITY SOURCES Now I would like to ask you about your source(s) of electricity. First I will ask you questions about your electricity usage from grid sources.	E01 Does your household have electricity from […]? Ask question E01 for each source first. Then >> to questions E02 - E05 for each question for which the response to E01 was "yes" [1]. Yes...1 No...2>>E06	E02 What is electricity used for in your home? List up to five in order of importance. Lighting ....1 TV/Radio ....2 Fans....3 Refrigeration ....4 Cooking....5 Hot Water Heating (for washing/bathing)....6 Water Pumping (not incl. Irrigation) ....7 Irrigation ....8 Space Heating ....9 Other Small Appliances ....10 1st Use Code	2nd Use Code	3rd Use Code	4th Use Code	5th Use Code	E03 How much electricity did the household <u>consume</u> from […] during 30 days of the last billing period? Calculate from bill. If bill unavailable, leave blank. Kilowatt hours (kWh)	E04 What is the basis for the electricity charges that you pay for […]? Utility Meter ....1 Pay Neighbor....2 Included in Rent ....3 Don't Pay ....4 Other....5	E05 How much did the household pay for 30 days of electricity use? Calculate from bill. If bill unavailable, ask respondent to estimate. Amount Calculated from bill	Estimated
	GRID ELECTRICITY [Name]: from a Public Company, Municipal Corporation,Etc. [Household is a Utility Customer]										
	GRID ELECTRICITY from Neighbor or Relative [Household is <u>not</u> a Utility Customer]										
	GENSET ELECTRICITY from Neighbor or Relative										
	MICRO-HYDRO from Community										

Figure 4b. Electricity Sources (Off-grid) Prototype Module

ID CODE	ELECTRICITY SOURCES (Continued) Now I would like to ask you about your source(s) of electricity . First I will ask you questions about your electricity usage from grid sources.	E06 Does your household have electricity from […]? Ask question E06 for each source first. Then >> to questions E07 - E011 for each question for which the response to E06 was "yes" [1]. Yes...1 No...2	E07 What is electricity used for in your home? List up to five. Lighting ....1 TV/Radio ....2 Fans ....3 Refrigerator ....4 Other (Specify) ....5 1st Use Code	2nd Use Code	3rd Use Code	4th Use Code	5th Use Code	E08 How much did you pay for your […]? purchase cost of system if obtained for free: code 9999 Amount	E09 How did you pay for this […]? Cash Purchase ....1 Lease ....2 Credit ....3 Other 4	E10 How much did you pay to oper - ate your […] in the last 30 days? Amount	E11 What is the rating of your […]?
	SOLAR (PV) HOME SYSTEM										Watt peak (Wp)
	STORAGE (CAR) BATTERY									Battery charging cost for last 30 Days	Volts / Amp Hours
	GENSET (PERSONAL)									Fuel cost for last 30 Days	kW
	DRY CELL BATTERIES									Cost of all dry cell batteries used in last 30 Days	

	E12 Do you use electricity in your household for home business purposes? Yes...1 No...2

Box 1. Potential Electricity Sources for Household Use

- Car (storage) batteries
- Household-owned electric generator (genset)
- Electric generator owned by neighbor
- Electricity from privately-owned, mini-grid or village/community grid
- Electricity from national, regional, or town grid
- Pico- and micro-hydro electric generator
- Solar (photovoltaic) home system (SHS)

E03: How much electricity did the household consume from [for each electricity source] during 30 days of the last billing period?
For formal metered connections to grid electricity, consumption is recorded on the monthly bill received by the customer. If possible, the household should be asked to show the enumerator the bill. If the norms of confidentiality permit, it may be desirable to record the household's customer number so that its consumption record can be matched with that of the customer database. When the bill cannot be shown by the respondent (or when the household has a pre-payment meter and does not receive a bill), it is unlikely that respondents can answer this question accurately. Therefore, when the bill is unavailable, this box should be left blank. During analysis of the data set, the quantity of electricity consumed may be inferred by applying the charges detailed in the published tariff schedule to the reported monthly expenditure (response to Question E06).

E04: What is the basis for the electricity charges that you pay for [for each electricity source]?
Households that live in rented accommodations may not be utility customers. Instead, they may pay for electricity as part of their monthly rental; some households may not pay at all. Households that share a meter may pay a neighbor. It is important to record this information as it can help interpret the information provided on the amount the household paid for electricity (response to Question E06).

E05: How much did the household pay for 30 days of electricity use from [for each electricity source]?
Ideally, the answer to this question can be obtained from the utility bill, which the enumerator should ask to see. In some countries, it may be possible and useful to record the household's customer number so that time-series information on the household's consumption can be obtained from the utility's database. The amount charged to the household is determined by applying the tariff schedule, which may have fixed charges; variable generation, transmission, and distribution charges; and taxes and fees. The total amount of the bill (inclusive of all charges) should be recorded. If it is not possible to view the bill, the respondent should be asked to estimate this amount. As noted above, information on the quantity of electricity consumed may have to be inferred from payment information; thus, it is key to obtain accurate information in response to this question. Households that share a meter may also share the bill (for billing purposes, one household is

recorded as the customer in the utility's billing system; this customer receives the bill, but other households connected to the meter share payment). The question may need to be adapted to take account of this.

Notes on Electricity Sources (Off-grid) Prototype Module

The Electricity Sources (Off-grid) Module refers to electricity sources that the household does not share with neighbors, such as its own genset, car (storage) battery, or solar (PV) home system (Figure 4b).

E06: See notes for Question E01 in the Electricity Sources (Grid) Module.
E07: What is electricity used for in your home?
This question is similar to Question E02 in the Electricity Sources (Grid) Module. However, since gensets, dry cell batteries, car (storage) batteries, and solar home systems (SHSs) usually have sufficient capacity only to power lights, televisions, radios, and other appliances, the list of possible end uses is not as extensive. As before, the end-use categories are country-specific and must be reviewed carefully when the module is adapted for use in any particular country.

E08: How much did you pay for your [for each electricity source]?
Answers to this question can help establish a household's willingness to pay for grid electricity, which is useful in planning electrification programs.

E09: How did you pay for this [. . .]?
Answers to this question can help gauge the effectiveness of efforts to establish credit facilities and SHS dealer networks.

E10: How much did you pay to operate your [for each electricity source] in the last 30 days?
This question is relevant for car batteries, dry cell batteries, and gensets but not for SHSs (the cost of replacing the battery every few years is the greatest running cost).

E11: What is the rating of your [for each electricity source]?
For solar panels, the quantity of electricity consumption can be directly inferred from system capacity. For diesel generation, it can be inferred from system capacity and the monthly expenditure on diesel (Appendix).

E12: Do you use electricity in your household for home business purposes?
As part of collecting basic information on household characteristics, LSMS surveys usually contain a question that asks if the household has a home business and other questions that probe the nature of a household's home business. Thus, it may be unnecessary to ask this question in the electricity module. If the household has a home-based business, electricity consumption will often be much greater than otherwise expected.

Durable Goods (Light Bulbs and Appliances) Module

The purpose of the Durable Goods (Light Bulbs and Appliances) Module (Figure 5) is to determine the uses of electricity (to complement and validate the information obtained

Figure 5. Durable Goods (Light Bulbs and Appliances) Prototype Module

LIGHTBULBS

ID CODE	A01 Does your household own [item]? No...2 (>>A04)	A02 How many [items] do you own?	A03 How many hours during the last week did you use the [items]?
		Number	Hours
Incandescent light bulbs			
25 Watt			
50 Watt			
75 Watt			
Fluorescent tubes			
10W Straight			
20W Straight			
22W Circular			
32W Circular			
Energy saving bulbs (CFLs)			
12 Watt			
18 Watt			
20 Watt			

APPLIANCES

ID CODE	A04 How many of the following items does your household own?	A05 How many years ago did you acquire the [item]?	A06 According to current prices, what do you think you could get if you sold it?	A07 What is the average wattage rating of the appliance?	A08 How many hours during the last week did you use the [items]?
	Number	Number	Amount	Wattage	Hours
Electricity Appliances					
Radio					
TV (B&W)					
TV (Color)					
Video/DVD					
Fan					
Electric iron					
Refrigerator					
Electric hot plate or stove					
Domestic water pump					
Hot water geyser					
Electric pump for irrigation					
Appliance (Specify)					
Lighting & Cooking Appliances					
Kerosene lamp (wick)					
Pressurized (Petromax) lamp					
Improved cooking stove					
LPG burner or stove					

through Question E03 above). The electricity can be from any source (grid electricity, own or neighbor's genset, solar [PV] home system, and car [storage] battery are the most common sources). Household members that are most often in the household are usually the best-informed respondents. Information on appliance use provides insights into the household's priority uses of electricity service and can also be used to calculate monetary estimates of the benefits of electrification. The quantity of electricity consumed by the various appliances is calculated as follows: watt rating of appliance × hours of use per day × 30 days/1,000 = kWh consumed per month. The light output from the various classes of light bulbs is calculated as follows: efficiency rate of light bulb (lumen/watt) × hours of use per month = light output (klm per month).

Notes on Durable Goods (Light Bulbs and Appliances) Prototype Module

A01: Does your household own [for each class of light bulb]?
The wattage can usually be read from manufacturer markings on the light bulb. The listed classes of light bulbs should be those that are available locally. The list should be comprehensive, and not limited to the most common classes of light bulbs owned by households. Otherwise, it will not be possible to construct a complete picture of electricity use for lighting.

A02: How many [for each class of light bulb] do you own?
The enumerator should enter the number of all light bulbs in each class owned by the household. Experience with this question in specialized energy surveys has obtained reasonably good results. Poor households usually can readily answer this question and those below. Respondents in non-poor households with many light bulbs and appliances experience greater difficulty in accurately answering this question.

A03: How many hours during the last week did you use the [items]?
The enumerator should enter the sum of hours of use for all light bulbs in the same class. Thus, if the household owns two 25-W light bulbs, one of which is used 14 hours per week and the other 28, the enumerator should enter 42.

A04: How many of the following items does your household own? [for each appliance]?
The items listed in the module should be adapted to include appliances that are locally available. The list should be comprehensive and not just list the most common appliances owned by households. Local names of appliances (for example, type of kerosene lamp or improved wood stove) should be used. One should note that these questions have been integrated into the standard module on durable goods for an LSMS survey. The list of items should contain all durable goods for which the LSMS requires data, plus any specific items relevant to the energy needs (such as energy-efficient mud stoves). For all items for which electricity is used, the two additional questions on wattage (A06 and A07, respectively) will be needed.

A05: How many years ago did you acquire the [item]?
Household preferences for electricity use may be inferred from the answers to this question.

A06: According to current prices, what do you think you could get if you sold it?
It is standard in household surveys to establish the market value of household assets.

A07: What is the average wattage rating of the [for each appliance]?
Manufacturer markings that include the rating are usually affixed to the appliance. However, it may be difficult to read some markings if they are worn or otherwise illegible or affixed to an inaccessible part of the appliance. Training should enable enumerators to readily identify the ratings of the most common brands or types of appliances, such as locally available televisions and radios. Information on these ratings must be collected and provided to the enumerators during training.

A08: How many hours during the last week did you use the [for each appliance]?
This question establishes the number of hours of appliance use. In terms of televisions and radios, this question differs from those that ask households how many hours they watch television or listen to the radio.

Electricity and Fuels in the Community Module

The Electricity and Fuels in the Community Module is designed to collect data on items common to a cluster of households interviewed; it does not refer to a community in any administrative sense. These questions provide a snapshot of the choice set of energy sources available at the community level (Figure 6).

Notes on Electricity and Fuels in the Community Prototype Module

C01: Is electricity available in this community?
Answers to this question help interpret individual household responses to Question E01 ("Does your household have electricity from?") in the electricity sources module.

C02: What is the main source of electricity in this community? (Which source of electricity is available to the most households in this community?)
Depending on local circumstances, the questionnaire should be adapted to collect information on the name of the provider, wherever a formal company is involved, to provide a means of verifying information about the price of services.

C03: On average, how many hours a day is electricity available from [service provider]?
Questions C03 and C04 establish the reliability of electricity supply in the community.

C04: How many times in the last 30 days did electricity from [. . .] fail for more than 15 minutes?
Load shedding (electricity blackouts) may affect only part of the community. During design, blackout patterns should be considered so that the question can be adapted accordingly.

C05: In what year did [electricity source] become available to this community?
This question makes it possible to reconstruct the historical diffusion of electricity services across communities in the country, even in the absence of a long series of household surveys over time. If the electricity sources module also asks when the household obtained electricity service, it will be possible to examine the historical diffusion of coverage within communities.

Figure 6. Electricity and Fuels in the Community Prototype Module

ID CODE	C01 Is grid electricity available in this community? Yes...1 No...2 (>>C07)	C02 What is the main source of electricity in this community? (i.e. Which source of electricity is available to the most households in this community?) STATE UTILITY [Name] ....1 MUNICIPAL UTILITY [Name] ....2 COOPERATIVE ....3 PRIVATE COMPANY [Name] ....3 OTHER (Specify) 5

ID CODE	ELECTRICITY SOURCES: Complete C03 - C06 for the source of electricity that is used most in this community.	C03 On average, how many hours a day is electricity available from […]	C04 How many times in the last 30 days did electricity from […] fail for more than 15 minutes?	C05 In what year did […] become available to this community?	C06 How much is the one-time connection cost fee for […]?	C07 Is LPG available in this community? Yes...1 No...2 (>>C09)	C08 How much is the one-time cost for an initial LPG cylinder?
		Hours/Day	Number	Year	Amount		Amount
	(Response from C02)						

ID CODE	ELECTRICITY SOURCE: Complete C09 for each facility/ business.	C09 Does this community have the […] listed? Yes...1 No...2 (>>C011)	C10 What type of electricity source does the […] use? NONE.........1 GRID ....2 GENSET........3 OTHER 4
	Hospital/ health clinic		
	Post office		
	School		
	Community center		
	Local government offices		
	Flour mill/ grain milling		
	Bakery		
	Furniture making		
	Grocery shop		
	Barber shop		
	Other (specify)		

ID CODE	HOUSEHOLD ENERGY SOURCES: Complete C11 - C14 for each energy source.	C11 In your opinion, is […] readily available in this community? Yes...1 No...2	C12 In your opinion, is […] expensive in this community? Yes...1 No...2	C13 In your opinion, does the use of […] cause health problems? Yes...1 No...2	C14 Is using […] safe in this community? Yes...1 No...2
	Grid electricity				
	Firewood				
	Charcoal & coal				
	LPG				
	Natural gas				
	Kerosene				
	Diesel				
	Other (specify)				

C06: How much is the one-time, connection-cost fee for [electricity source]?
The cost of gaining access to electricity service varies by country location. For any particular community, connection cost is a function of the community's distance from the existing grid, population density, and other demographic factors. The cost per household may vary between US$400 and $1,000. Subsidies can defray the cost for individual households. Repayment of the hookup fee may be spread over several months (or in some cases, over several harvests), and it may be important to capture this information.

In addition, it may be useful to establish the start-up cost for other types of energy services, such as LPG (as it is necessary to purchase a cylinder to initiate fuel use) or car batteries (where the battery must be purchased initially). One should note that start-up costs do not refer to the cost of appliances that may be needed to use the fuel (for example, light bulbs, hurricane lamps, or stoves) since these are covered separately under the appliance inventory in the LSMS survey.

C07: Is LPG available in this community?
The module focuses on LPG access because of LPG's often critical role as a clean cooking fuel.

C08: How much is the one-time cost for an initial LPG cylinder?
This information is important because the cost of the initial cylinder is often key to the household's decision to make the transition from kerosene for cooking. This question will reveal if cost of LPG cylinders varies significantly between regions in a country, indicating some market failure in regions with high costs.

C09: Does this community have the [facility/business] listed?
C10: What type of energy source does the [facility/business] use?
Questions C09 and C10 are important because the delivery of services may depend on the facilities having electricity access.

C11: In your opinion, is [. . .] readily available in this community?
Questions C08-C11 are sample questions that can be used to investigate local opinions of energy pricing, safety, and health issues.

C12: In your opinion, is [. . .] expensive in this community?
Opinions of which fuels are expensive can provide valuable insights into community attitudes which may be markedly different in different regions of the country.

C13: In your opinion, does the use of [. . .] cause health problems?
"Health problems" imply burns that people suffer from cooking fires or use of kerosene lamps and cooking appliances. They may also imply a respondent's awareness of the health effects of indoor air pollution from use of biomass in cooking fires.

C14: Is using [. . .] safe in this community?
"Safe" may imply household accidents (for example, fires) associated with using kerosene or wood fires. In certain countries, LPG use is considered unsafe because damaged LPG bottles may be in circulation.

CHAPTER 5

Conclusion

One goal of these guidelines is to promote the use of the modules in forthcoming LSMS surveys and to monitor which questions work best in different country contexts. It is anticipated that countries preparing LSMS surveys will make use of these guidelines and may seek World Bank assistance in evaluating alternative energy module designs.

It is anticipated that data sets from these enhanced LSMS survey modules can be used to formulate indicators that analysts in the energy sector can use as key decision-making tools. Data monitoring can ensure that welfare changes are taken into account when new policy interventions are designed and that equity issues are addressed. For a program designed to reduce fuelwood consumption and indoor air pollution, LSMS data can monitor changes in consumption after households adopt improved charcoaling techniques and cook stoves. In addition, LSMS data can monitor whether the expected cost savings from the competitive procurement of petroleum products and the introduction of competition in the marketing of petroleum prices are passed on to households in the form of lower prices and increased reliability of supply. In terms of shifts in consumption, LSMS data can monitor changes in household behavior when fuel-price subsidies are removed or electricity-service charges raised, thereby gaining insight into the dynamics of the energy portfolios households maintain to minimize risk. Finally, LSMS data can monitor the extent to which various groups gain access to electricity and the effects that policy tools—such as lifeline rates, credit financing schemes, or improved design standards and technologies—have on household welfare.

Summing up, LSMS surveys containing better information on household energy use will provide important insights into the role that energy services play in household welfare and the policies that would be most effective in accelerating the household transition to use of modern fuels.

APPENDIX

Notes on Energy Appliances and Conversion Factors

Definitions

Car Battery. Commonly used in areas of developing countries without an electricity grid (motorcycle or lorry batteries are also used) to provide household electricity for lighting and to power televisions and radios. Recharging often occurs at battery-charging stations using grid electricity in the nearest grid-connected town. The amount of electricity per recharge depends on the size of the battery, depth of discharge, and efficiency of the charger. Wind generators, SHSs, or diesel generators can also be used to recharge batteries. The most common battery rating is ampere-hours; this unit of measurement for battery electrical storage capacity is obtained by multiplying a current flow in amperes by the time in hours of discharge. A battery that delivers 5 amperes for 20 hours delivers 100 ampere-hours. Since watts equal volts × amps, a 12-volt battery with a 400 amp-hour charge can deliver 12 × 400 or 4,800 watts for an hour or 4.8 kWh.

Horsepower. Unit for power or for measuring the rate of work; 1 horsepower equals 746 watts. Diesel generators used by households to generate electricity and diesel pumps used to pump water are often rated in horsepower.

Joule (J). Standard international (SI) unit of energy and heat; 1 joule equals 0.2389 calories.

Kilowatt hour (kWh). Work equals energy per time period; one kWh is equivalent to 1,000 watts (joules per second) over a 1-hour period; thus, 1 kilowatt hour equals 3.6×10^6 joules.

Lumen (lm). Quantity of light (luminous flux) emitted by a lamp. The quantity of light radiated or received for a period of 1 hour is a lumen-hour (lm hr). A 60 Watt incandescent lamp and a 12 Watt compact fluorescent lamp emit approximately the same amount of lumens (720 lm).

Peak Watt (Wp). Power output that a photovoltaic (PV) module produces at Standard Test Conditions (STC) of a module operating temperature of 25°C with an irradiance of 1,000 watts per square meter (usually attained at noon).

Power. Rate at which work is done (or rate at which heat released or energy converted). A light bulb of 100 watts, for example, draws 100 joules of electrical energy per second.

Solar Home System (SHS). System whose main components typically include a solar (PV) module, inverter, battery, and charge controller (sometimes known as a regulator). The PV module may range in size from 20 to 100 peak watts (Wp). SHSs with 400 Wp or more are necessary to operate a refrigerator and are not common in developing countries. A 50-Wp system can supply lighting and can power for a small television or radio for several hours per day and a 12 Wp system can operate a lamp or a radio for several hours per day.

Watt (W). Standard unit of measurement of electrical power; 1 watt equals 1 ampere of current flowing at 1 volt. Electric appliances (for example, radios, televisions, electric heating coils, and light bulbs) are rated in watts (W); a 60-W light bulb or a 60-W black-and-white television set operated 5 hours per day uses 9 kWh of electricity per month (60 watt × 5 hours × 30 days).

Conversion Equivalents

Units of mass
1 kilogram (kg) = 2.2046 pounds (lb)
1 pound (lb) = 0.454 kilograms (kg)

Units of volume
1 liter (l) = 0.2642 gallons (gal) (U.S.) = 0.22 gal (UK or imperial)
1 gallon (gal) (U.S.) = 0.8327 gal (UK) = 3.78528 liters (l)

Units of energy
1 megajoule (MJ) = 238.84 kilocalories (kcal) = 0.2777 kilowatt hours (kWh)
1 kilowatt hour (kWh) = 3.6 megajoules (MJ) = 860 kilocalories (kcal)

Cooking Efficiency

The term *useful energy* refers to work harnessed for the purpose of which the fuel is consumed. In the case of cooking, useful energy is the heat actually used for heating the food (transmitted to the food-cooking process). The annual amount of energy required for cooking varies with the type of food, fuel, and stove used and the specific cooking practices

Table A1. Typical Efficiencies at the Final Consumption Stage of Cooking

Fuel source	Energy content (MJ per kg)	Conversion efficiency (%)	Useful energy at final consumption stage of cooking (MJ per kg)	Approximate quantity of fuel necessary to provide 5 Gigajoules of useful energy for cooking (Kilograms)
LPG	45.5	60	27.3	180
Natural gas	38 MJ/M^3	60		219 M^3
Kerosene (pressure)	43.0	55	23.6	210
Kerosene (wick)	43.0	35	15.1	330
Biogas (60% methane)	22.8 MJ/M^3	60		365 M^3
Charcoal (efficient)	30.0	30	9.0	550
Charcoal (traditional)	30.0	20	6.0	830
Bituminous coal	22.5	25	5.6	880
Fuelwood (efficient), 15% moisture	16.0	25	4.0	1250
Fuelwood (traditional), 15% moisture	16.0	15	2.4	2000
Crop residue (straw, leaves, and grass), 5% moisture	13.5	12	1.6	3000
Dung, 15% moisture	14.5	12	1.7	2900

Sources: "Energy Statistics: A Manual for Developing Countries," Series F, No. 56, United Nations, New York, U.S. and authors estimates.

of a household (Millennium Project 2005). Diet is also a factor in energy needs. Cooking hard staples such as maize and potatoes requires more energy than cooking fish. The annual energy requirements for a family of five is about 5 gigajoules of useful energy (i.e. energy "into the pot"). Typically, households use a combination of fuels. Table A-1 provides a comparison of typical efficiencies of different fuels in cooking

Household Lighting Appliances

In developing countries, households in areas not served by grid electricity use a great variety of lighting appliances. Carbide (acetylene) lamps are simple lamps that produce and burn acetylene gas through the reaction of calcium carbide with water. Kerosene wick lamps are simple lamps consisting of a small receptacle for containing the kerosene and a wick (usually made of cotton). The lower half of the wick is dipped, absorbing the kerosene, while the top part extends out of the top of the receptacle. Instead of kerosene, diesel or animal fat are also used. A kerosene or gasoline mantle lamp has a fuel tank and a small pump to pressurize the kerosene. A burner sits atop the lamp, directly underneath of which is the mantle, which incandesces when heated by the gas flame. The most widely used gas lamps use cylinders of propane, butane, or a mixture thereof (LPG).

Table A2 compares characteristic values of various lamps. Performance varies considerably, depending on the luminous conditions in rooms and such behavioral patterns as adjusting the lamp setting, cleaning glass covers, replacing mantles, and polishing reflectors. In addition, characteristics of the same type of lamp (for example, kerosene lamps) vary by lamp size. Table A-3 compares characteristic values of various batteries.

Table A2. Comparison of Non-electric and Electric Lamps for Domestic Lighting in Developing Countries

		Output based on lumens per watt	
Lighting type	Light output (lumens)	klmh per kgOE	klmh per kWh
Non-electric			
Paraffin candle	11.8	2.33	0.20
Kerosene wick	11.4	1.15	0.10
Kerosene hurricane	32	1.92	0.16
Kerosene pressure	2,040	17.53	1.48
Incandescent (watts)			
25	230	109.12	9.20
40	430	127.50	10.75
50	580	137.58	11.60
60	730	144.30	12.17
100	1,280	151.80	12.80
Florescent (watts)			
10	600	711.63	60.00
20	1,200	711.63	60.00
40	1,613	478.27	40.33
Compact florescent			
Philips lamp (15-W)	894	706.88	59.60
Philips lamp (9-W)	369	486.28	41.00
Osram sol lamp (6.14-W)	240	463.60	39.09

Source: Nieuwenhout, Van de Rijt, and Wiggelinkhuizen (1998).

Table A3. Battery Electricity

	Rating	Storage capacity
Battery Type	Amp Hours (Ah)	Watt Hrs
High Quality D Cell (1.5 v)	7.5	11.25
Poor Quality D Cell (1.5 v)	3.5	5.25
Car battery (12 v)	60	720

Note: A battery can only discharge to 80 percent of capacity.

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