# 4 Measuring the impact of energy reform—practical options

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**Message from the editors**

**As described in the previous chapter, government interventions in energy markets have many effects on the poor. But there has been little measurement of these effects, making it hard to know exactly what the effects of a project have been, and hard to compare those of different interventions. This could be rectified by building impact indicators into energy projects at the design phase—and doing so consistently and systematically, across countries and over time. This chapter discusses the development of suitable indicators. First, agreement is needed on workable definitions of poverty and what would constitute welfare improvements for the poor. Then there must be explicit hypotheses on how specific elements of energy projects, individually or together, affect the poor. Finally, the indicators must be based on data that can realistically be collected in real-life low-income communities, in real-life developing countries.**



Following a decade of energy sector reforms in many developing countries, people are increasingly questioning how much these reforms have benefited the poor. That question has proved difficult to answer, in part because of the lack of a framework for thinking about the issue and in part because of a shortage of suitable data.

This chapter proposes a methodology for measuring the impact of interventions in the energy sector on the welfare of poor households. Here, energy sector interventions refer to any measure that significantly affects the cost, quality, and conditions of access to energy services, whether wholesale sector reform or a small investment project. These interventions include restructuring, privatization, and liberalization of traditional electric and natural gas utilities. They also include policy decisions affecting the availability and relative prices of alternative energy sources, both traditional biomass and commercial fuels—perhaps of more immediate relevance to poor households.

The aim of this methodology is not only to make it easier to answer questions about how energy sector interventions have affected the poor. It is also to help focus attention on poverty issues before interventions are made, encouraging the adoption of pro-poor features in the design.

The proposed approach has two stages. The first is to provide a set of welfare indicators sufficiently broad to capture the kinds of energy issues likely to concern poor households. The second is to calculate the value of these indicators for poor households before and after the intervention to gauge its effect on their welfare. The process depends critically on the availability of data sets that combine information about energy use with indicators of poverty (Gomez-Lobo, Foster, and Halpern 1999; Lovei and others 2000).

Measuring the welfare impact of energy sector interventions on the *poor* is not quite the same as measuring the impact on *poverty*. For example, an energy pricing reform might reduce the cost of electricity to poor households, directly increasing their welfare. The same price change might indirectly take some of these households out of poverty—by releasing women and children from the time-consuming task of gathering traditional fuel, or by raising productivity in household chores or in the operation of home-based microenterprises. Though measurable in principle, this ultimate effect is much harder to gauge with any reliability (Chong and Hentschel 1999). In particular, it is difficult to attribute changes in poverty to one intervention rather than another. Thus the more modest objective of examining how energy sector interventions directly benefit the poor is probably also more useful for impact evaluation.

### Stylized facts about energy and poverty

A good place to begin is with a brief review of some stylized facts on energy consumption and poverty (Albouy and Nadifi 1999). The energy literature has traditionally been dominated by a theory of transition in which households gradually ascend an "energy ladder." The ladder begins with traditional biomass fuels (firewood and charcoal), moves through modern commercial fuels (kerosene and liquefied petroleum gas, or LPG), and culminates with electricity. The ascent of this ladder, though not fully understood, is thought to be associated with rising income and increasing urbanization.

But the empirical work on energy and poverty has found that reality is more complex than this simple transitional theory suggests. At any given time households tend to rely on a range of fuels that typically encompass at least two of the steps on the energy ladder (Barnes and Qian 1992; Hosier and Kipondya 1993; ESMAP 1994; Eberhard and van Horen 1995). There are several possible explanations for this. One is that unreliable supplies require households to rely on diverse sources of energy. Another is that different energy sources are more cost-effective in some uses than in others, so it may make economic sense to use electricity for lighting but LPG for cooking, for example.

All this means that any indicators measuring the welfare impact of energy sector interventions on the poor need to consider a household's full range of energy sources rather than focusing on a single source. Many of the traditional indicators tend to concentrate narrowly on electricity—for example, measuring the number of household connections or the share of household spending on electricity. This overlooks the fact that interventions affecting the prices and availability of different fuels may affect the welfare of poor households just as much as electricity sector reforms, if not more so, even after households obtain an electricity connection. The following section broadens some of the traditional electricity-based indicators of welfare to encompass the full range of fuels used by households.

### Indicators of the welfare impact

To choose an appropriate set of indicators also requires a working definition of human welfare as it relates to interventions in the energy sector. Consistent with the literature, this section takes three different perspectives on human welfare—basic needs, monetary, and nonmonetary (Lok-Dessallien 1999).

For many of the indicators discussed here, it will often be necessary to calculate the shares of total household energy consumption represented by different energy sources. In doing so, it is essential to take into account that different types of fuel have different efficiency factors, ranging from 10 percent for fuelwood to 65 percent for electricity (Leach and Gowen 1987). *Effective energy consumption* refers to the energy actually consumed by the household—after efficiency factors have been taken into account—rather than the energy purchased by the household.

#### Basic needs

According to one traditional view, welfare relates to people's ability to satisfy their most basic material needs. While intuitively appealing, this view involves subjectivity in defining a basic need (Hicks 1998). For the energy sector, it raises two questions: To what extent can energy be regarded as a basic need? And how should a basic energy need be defined?

While policymakers have sometimes defined an electricity connection as a basic need (box 1), this view conflicts with households' tendency to use a wide range of fuels even when electricity is available. A more plausible definition of a basic energy need would be reliable access to one or more sources of energy.

The most basic indicator of access is *coverage* of energy services. This indicator is widely used for electricity infrastructure, but less so for other energy sources, where it is potentially just as useful. Access to traditional biomass and modern commercial fuels is by no means universal, but may be limited by local environmental factors and deficiencies in commercial distribution networks (Barnes and Qian 1992). In addition to looking at coverage rates for different energy sources, it may be helpful to sum the number of types of energy to which each household has access, keeping in mind that access covers fuel sources that a household may choose not to use.

The basic coverage indicator says nothing about the reliability of the service, however. A household may have an electricity connection but receive the service only a few hours each day. Access to other types of fuel may be similarly intermittent and uncertain. A *reliability index* could be constructed by asking poor households what share of the time they are

**Box 1 Energy in the basic needs approach**

Many Latin American countries have traditionally measured poverty using multidimensional indexes of unsatisfied basic needs. The indexes vary from country to country, but generally include measures of sanitation, housing quality, and educational attainment. A recent survey in Latin America found that among thirteen countries, only three—Bolivia, Panama, and Peru—had indexes that included an electricity connection as a basic need (Hicks 1998).

able to obtain energy from a particular source. This information can be aggregated across fuel sources by taking a weighted average of the reliability score for each energy source, with the weights corresponding to the share of each energy source in the household's effective consumption.

A more indirect—but less information-intensive—way of gauging reliability is to use a *consumption concentration index* to capture the extent to which households have to rely on a diversity of fuels. Concentration indexes can be calculated as the sum of the squares of the shares of different energy sources in a household's effective energy consumption. But such indexes should be interpreted with caution because fuel diversity may simply indicate that different fuel sources are more cost-effective in different uses, rather than reflecting reliability problems.

### Monetary

The standard economic view is that the purchasing power of the household (whether measured by income or consumption) provides the best overall indicator of welfare. Energy sector interventions might affect economic measures of well-being in several ways. The most direct way is by reducing (or perhaps increasing) the cost of satisfying energy requirements and thereby increasing (or reducing) the purchasing power of a given household income. Households might respond to the increase in purchasing power by using more energy or expanding their consumption of other goods, leading either way to an improvement in economic welfare.

A traditional monetary indicator of welfare, widely used in the electricity sector, is the share of household income (or expenditure) devoted to energy. A large share is taken to imply an unacceptable economic burden of meeting energy requirements.

Although relatively simple to calculate, this indicator compounds several different effects, complicating its interpretation. For example, a large share of energy expenditure could be due to high consumption (reflecting large household size, high levels of discretionary use, or low efficiency of use), high unit prices of energy, or exceptionally low income. Each explanation carries very different policy implications.

Perhaps a more useful way of thinking about the affordability of energy is to examine whether households are able to purchase enough energy to meet subsistence requirements. The subsistence threshold would need to be externally defined, based on what would be required to perform basic functions such as lighting, cooking, and (depending on climate) heating.[1] And it should be expressed in per capita terms to take into account differences in household size.[2]

An *affordability index* could then be defined as the share of households whose effective energy consumption per capita exceeds the subsistence threshold. The same information could also be expressed as the ratio of each household's effective energy consumption per capita to the subsistence threshold.

To complement the affordability index, fuel costs and fuel subsidies could be tracked over time to see how energy pricing policies affect the rich and the poor. This exercise gives rise to two more indicators: the *average fuel cost* per effective unit of energy consumption (total household energy expenditure divided by total effective energy consumption) and the *average subsidy* per effective unit of consumption (calculated by weighting the unit subsidy on each type of fuel by the share of that fuel in each household's total effective energy consumption).

An important drawback of the average fuel cost measure is that it overlooks the costs of complementary capital investments (such as lightbulbs and stoves) required to use the fuel productively. This can create a misleading impression, since some energy sources have low fuel costs but high capital costs, and others the opposite. To the extent that poor households are credit constrained, high capital costs may prevent them from taking advantage of fuels with overall lower costs. An *average total cost* per effective unit of energy consumption can be estimated by adding the amortized capital costs of the durables used for cooking, lighting, and heating, as a study of cooking fuels in Tanzania did (box 2). This study also shows how the incidence of subsidies varies across different types of fuel in Tanzania.

To produce a more informative measure of economic burden, some of the types of information described above could be combined. For example, it might be interesting to track how the cost of subsistence-level per capita consumption changes as a percentage of per capita income (or expenditure), or how the total subsidy received at a subsistence level of consumption changes as a percentage of household income (or expenditure). These measures hold consumption constant at a level thought to represent a basic requirement and thus avoid confounding quantity and price effects.

### Nonmonetary

In recent years there has been a trend toward complementing economic measures of deprivation with nonmonetary measures to obtain a multidimensional view of human well-being, particularly by tracking health and education indicators.

There is some evidence that interventions in the energy sector could have direct effects on health and even education outcomes. In households relying on traditional fuels, indoor air pollution may cause respiratory illness, and paraffin poisoning of children and serious burns have also been documented (box 3). Although the link between energy and education has yet not been studied in depth, recent findings suggest that electric lighting significantly increases the time poor children are able to spend reading and studying (Domdom, Abiad, and Pasimio 1999).

**Box 2**

## Cost of meeting energy requirements for cooking in Dar es Salaam, Tanzania

A study of the costs of using alternative cooking fuels in Dar es Salaam, Tanzania, is interesting because it compares alternative measures of unit costs (Hosier and Kipondya 1993). The first comparison is between the financial and economic costs of different fuels, where the economic cost adjusts for the distortionary effect of subsidies and duties and also takes into account the foreign exchange component of imported fuels. The financial and economic costs differ substantially, particularly for electricity, which is heavily subsidized.

The second comparison is between the capital and operating costs of using different fuels. The ranking of fuels from most to least expensive is very different for capital and operating costs. The capital costs range widely, with electricity being by far the most expensive. Summing the economic cost of a notional cooking budget of 320 megajoules a month with the associated capital cost yields the total financial and economic costs. While electricity is the cheapest cooking fuel in terms of financial cost, it becomes the most expensive in terms of economic cost.

**Box table 2 Financial and economic costs of cooking fuels in Dar es Salaam, 1990**
(Tanzanian shillings)

| | Fuel cost (per effective megajoule) | | Amortized monthly appliance cost | Total monthly cost of 320 megajoules | |
|---|---|---|---|---|---|
| Fuel | Financial | Economic | | Financial[a] | Economic[b] |
| Firewood | 3.94 | 5.27 | n.a. | 1,259.35 | 1,686.40 |
| Charcoal (traditional) | 3.59 | 5.64 | 22.22 | 1,169.81 | 1,827.02 |
| Charcoal (improved) | 2.39 | 3.76 | 125.00 | 890.06 | 1,328.20 |
| Kerosene | 5.24 | 9.13 | 33.33 | 1,709.52 | 2,954.93 |
| LPG | 3.17 | 4.49 | 208.33 | 1,224.21 | 1,645.13 |
| Electricity | 0.62 | 10.38 | 458.33 | 657.99 | 3,779.93 |

n.a. Not applicable.
a. Financial cost is financial fuel cost of 320 megajoules plus monthly amortized appliance cost.
b. Economic cost is economic fuel cost of 320 megajoules plus monthly amortized appliance cost.
*Source:* Hosier and Kipondya 1993.

Where health and education effects are important, two types of indicators could be used to measure them. The first type aims to measure the *exposure levels* of poor households, in terms of indoor air pollutants inhaled or hours of reading (the second being somewhat harder to capture). The second type of indicator tries to capture the *consequences of these exposures*, such as the incidence of respiratory illnesses in poor communities or the rate of grade completion among school-age children. With the indicators of consequences, while theoretically of greater interest, it becomes more difficult to isolate the effects of the energy sector intervention from those of other factors that might also influence health and educational attainment.

### Summary of indicators

Among the indicators for measuring the impact of energy sector reforms on household welfare, the access and affordability indicators will be relevant in most cases, while the broader health and education indicators may be of more interest in some cases than in others. Calculating all the indicators in all cases may be neither feasible nor desirable. To aid selection, the most essential—and easily calculated—of the indicators are noted in table 1.

### Combining energy and poverty information

All the indicators discussed above provide general information on the welfare impact of energy sector interventions on any household. To say something about the welfare impact on the poor, it is necessary to calculate the indicators separately for the poor and the nonpoor. But which is more useful for this type of analysis, an absolute or relative concept of economic poverty?

Many countries have developed poverty lines, typically based on the cost of acquiring a basic basket of food and nonfood requirements (Ravallion 1998; Lanjouw 1999). International benchmark poverty lines also exist, such as the $1 a day and $2 a day lines adopted by the World Bank for extreme poverty and poverty. Poverty lines allow absolute judgments about which households are poor and which are not, and thus analysis of how energy sector reforms affect these two groups.

But constructing poverty lines is far from straightforward because of the difficulties of establishing the basic basket of goods. Moreover, dividing the population into the two broad categories of poor and nonpoor may conceal important gradations within each group. Perhaps a richer approach is to classify households according to their relative position in the overall distribution of income (or consumption), by dividing the population into income (or consumption) quintiles or deciles. Separate welfare indicators can then be calculated for each quintile or decile.

This approach also allows an assessment of the equity of interventions in the energy sector, by examining how benefits are distributed across income groups. The analytical tools for measuring inequality are already well developed in the income distribution literature (Cowell 1995). Standard measures such as the Gini coefficient can be readily adapted to the energy sector, giving rise to concentration coefficients that measure the extent to which distribution of services departs from an equitable benchmark (Kakwani 1986).[3] Although widely used in analyzing public expenditure programs, these analytical tools have rarely been applied to the energy sector. Box 4 describes an interesting exception.

**Box 3** **Health effects of different energy sources in South Africa**

A recent study reviewed the empirical evidence on the health and wider social impacts of different energy sources in South Africa (Eberhard and van Horen 1995). Examining small-scale research projects that measured the intake of particulates among children, the study concluded that children living in urban homes relying on coal inhale more than five times the daily limit recommended by the U.S. Environmental Protection Agency. Children living in rural homes relying on fuelwood inhale more than nine times the limit.

A health survey conducted as part of the study revealed that children from coal-using homes are 190 percent more likely to develop lower respiratory illness (pneumonia, bronchitis, asthma) than children from electrified homes. Acute respiratory infections are the second most important cause of child mortality in South Africa.

A larger-scale health and safety survey of nonelectrified households in South Africa showed that about 6.5 percent had experienced (sometimes fatal) incidents of paraffin poisoning of children. Burns resulting from exposed flames in the household are the fourth most important cause of death for children in South Africa.

### Implementation issues

While conceptually straightforward, many of the proposed indicators are relatively data intensive. The availability of suitable data from existing sources and the cost of gathering additional data are likely to be the main constraints in applying this approach to assessing the welfare impact of energy sector interventions on the poor.

The ideal data set would have these three characteristics (Gomez-Lobo, Foster, and Halpern 1999):

- It would combine information on energy-related behavior with information on income or consumption.
- It would record such information both immediately before and some time after the energy sector intervention for the same households.
- It would contain information both for households that had been affected by the intervention and for a control group that had not been.

Under less than ideal circumstances—those that decisionmakers typically confront—there are shortcuts that may permit some approximation of the indicators.

#### Spanning the full range of data requirements

The data set should contain comprehensive information about both the energy-related decisions of the household (required to calculate the welfare indicators) and the poverty indicators required to examine the welfare impact on the poor. Only ten basic pieces of information are required to calculate all the indicators on access and affordability (table 2). (The health and education indicators are omitted from table 2 because they are much more complex and case specific.) Moreover, many are parametric (such as subsistence thresholds and unit costs) and can therefore be derived from external sources.

Perhaps the most critical input for these indicators is the effective household consumption for each of the fuels the household uses, from which household fuel shares can be derived. This information, rarely available in direct form, can generally be inferred from data on household expenditure on different fuels, by applying unit prices and efficiency factors to derive implicit levels of effective consumption. This approach does not capture consumption of traditional biomass fuels that households gather at no monetary cost, however, which may be a particularly important energy source for the poorest. This information can be obtained only through a special survey.

The most important source of information will be household surveys, such as the World Bank–inspired Living

**Table 1** **Summary of proposed welfare indicators**

| Indicator | Comments |
| --- | --- |
| **Basic needs** | |
| *Coverage index*[a] | |
| Whether or not a household has access to a particular energy source; may be aggregated to give the total number of energy sources available to each household. | The indicator does not take into account reliability of supply. |
| *Reliability index* | |
| Percentage of time on average that an energy source is available for use by a household; may be aggregated as a weighted average. | The indicator requires a subjective household assessment of reliability. |
| *Concentration index* | |
| The sum of the squares of the shares of different energy sources in a household's effective energy consumption. | Fuel diversity captures more than mere unreliability of fuel supply. |
| **Monetary** | |
| *Affordability index*[a] | |
| Percentage of households whose per capita effective energy consumption exceeds a subsistence threshold, or ratio of a household's per capita effective energy consumption to a subsistence threshold. | Determining the subsistence threshold often involves much subjectivity. |
| *Average fuel cost per effective unit of energy*[a] | |
| Total household energy expenditure divided by the household's total effective energy consumption. | The indicator fails to take into account the capital costs of using fuels. |
| *Average subsidy per effective unit of energy*[a] | |
| Average of the unit subsidy for each energy source weighted by the share of that energy source in the household's total effective energy consumption. | |
| *Average total cost per effective unit of energy* | |
| Total household energy expenditure, plus amortized capital cost of durables used for cooking, heating, and lighting, divided by the household's total effective energy consumption. | Calculating the amortized capital costs of durables for the full range of fuel uses is likely to be complicated. |
| *Economic burden* | |
| Average fuel cost per effective unit of energy multiplied by the subsistence threshold, divided by per capita income (or expenditure). | |
| **Nonmonetary** | |
| *Exposure rates* | |
| *Health:* Twenty-four-hour exposure rates to indoor air pollutants.<br>*Education:* Hours of reading by schoolchildren. | |
| *Incidence rates* | |
| *Health:* Proportion of households affected by energy-related incidents of ill health, such as respiratory illness, burns, and paraffin poisoning.<br>*Education:* Grade completion rates of schoolchildren. | It is difficult to isolate the impact of energy sector interventions on incidence rates, which may be affected by many other factors. |

a. Among the most essential indicators presented.

Box 4

## Inequality analysis of electricity connections in Colombia

A recent study applied inequality analysis to electricity connections in Colombia, looking at the change in electricity connection rates by income quintile between 1974 and 1992 (Vélez 1995). The concentration coefficients for these two years indicate that the distribution of electricity connections went from regressive (0.157) to virtually egalitarian (0.034). The reason is that the new connections during the intervening period were somewhat skewed toward lower-income households, as indicated by the slightly negative concentration coefficient of –0.031.

**Box table 4 Increase in electricity coverage by income quintile in Colombia, 1974–92**

| Income quintile | Electricity coverage rate (percent) | | Increase in coverage, 1974–92 | |
|---|---|---|---|---|
| | 1974 | 1992 | New connections (thousands) | Share of new connections (percent) |
| 1 (richest) | 91.3 | 98.0 | 750 | 17.4 |
| 2 | 73.5 | 96.0 | 849 | 19.7 |
| 3 | 61.7 | 93.4 | 897 | 20.8 |
| 4 | 49.1 | 90.4 | 943 | 21.9 |
| 5 (poorest) | 41.4 | 81.3 | 869 | 20.2 |
| Concentration coefficient | 0.157 | 0.034 | | –0.031 |

*Source:* Vélez 1995.

The study also looked at Colombia's complex system of cross-subsidies in electricity pricing, which are based on the characteristics of each neighborhood. Analyzing the incidence of these cross-subsidies across income quintiles, it found a slightly progressive pattern, indicated by a concentration coefficient of –0.033. And distinguishing between legal subsidies (those accruing to legitimate paying customers through the official tariff structure) and illegal subsidies (those accruing implicitly to households with nonpaying, clandestine connections), the study found that illegal subsidies are much more progressive, with a concentration coefficient of –0.301 compared with –0.016 for legal subsidies.



Standards Measurement Study surveys or the general income and expenditure surveys. These combine information on energy expenditure with information about household income and expenditure, from which absolute or relative indicators of poverty can be derived. In many cases household surveys complemented by external price and engineering parameters will be adequate for the analysis of the economic indicators of welfare.

For indicators of access special surveys may be required, since household surveys typically consider access only to electricity. In some cases it may be possible to "piggyback" on an existing household survey by incorporating additional questions on energy consumption.

Although household surveys increasingly record the detailed expenditure information needed for this type of analysis, many countries still lack such information. In these countries information on energy expenditures would have to be obtained from a special sector survey. Some countries may even lack reliable information on economic measures of poverty. An alternative that is sometimes available is the poverty map, which classifies areas as poor or not poor according to an index of economic or noneconomic poverty indicators. Where poverty maps are available, impact indicators can be calculated for a sample of households in the areas classified as poor.

### Obtaining data before and after the intervention

One of the main limitations of relying on existing household surveys is that their timing is unlikely to coincide exactly with the timing of the intervention. In some cases it may be possible to use a past household survey as the baseline for measuring impact, and then to repeat only the relevant sec-

## Table 2 Data required to calculate indicators, by potential source

| Indicator | Data sources: Engineering estimates | Price surveys | Household surveys | Electric utilities | Special surveys |
|---|---|---|---|---|---|
| Coverage index | | | • Household access by fuel | | • Household access by fuel |
| Reliability index | | | | • Reliability of access by fuel | • Reliability of access by fuel |
| Concentration index | • Efficiency factors by fuel | • Unit cost by fuel | • Household expenditure by fuel | | |
| Affordability index | • Per capita subsistence threshold<br>• Efficiency factors by fuel | • Unit cost by fuel | • Per capita subsistence threshold<br>• Household expenditure by fuel<br>• Household size | • Per capita subsistence threshold | |
| Average fuel cost per effective unit of energy | • Efficiency factors by fuel | • Unit cost by fuel | • Household expenditure by fuel | | |
| Average subsidy per effective unit of energy | • Efficiency factors by fuel | • Unit subsidy by fuel<br>• Unit cost by fuel | • Household expenditure by fuel | • Unit subsidy by fuel | |
| Average total cost per effective unit of energy | • Capital cost of household energy use<br>• Efficiency factors by fuel | • Unit cost by fuel | • Capital cost of household energy use<br>• Household expenditure by fuel | | • Capital cost of household energy use |
| Economic burden | • Per capita subsistence threshold<br>• Efficiency factors by fuel | • Unit cost by fuel | • Per capita subsistence threshold<br>• Household expenditure by fuel<br>• Household size | • Per capita subsistence threshold | |
| | | | | | |
| Poverty[a] | | | • Household income or expenditure | | |

a. Required in all cases to calculate indicators by income group.

tions of the survey on a subset of the original sample at a suitable time after the intervention.

Even where timing is fortuitous, longitudinal surveys (those following the same households over time) are still extremely rare in developing countries, so it is seldom possible to observe the same household before and after an intervention. But there are many statistical techniques that can be used to control for differences between households in the pre- and postintervention samples, ranging from matched pairs to multiple regression models (see Baker 1999 for a detailed discussion).

### Obtaining data on treatment and control groups

A data set containing information both on households affected by the intervention and on a control set of similar households not affected makes it possible to be sure that the impacts observed are not in fact attributable to differences in the pre- and postintervention samples or to extraneous influences on energy consumption behavior unrelated to the intervention (Baker 1999).

One possibility is to compare different regions of a country, some affected by the intervention and the others not. But where the intervention had a national reach, as is often the case, this option is unavailable. Moreover, constructing such a control on the basis of international comparators is likely to raise as many problems as it resolves.

To alleviate the problem of devising an adequate control, the indicators presented here tend to focus on outcomes directly linked to energy sector parameters (such as consumption decisions) and to avoid links with general levels of poverty (which may be sensitive to a wide range of decisions). Nevertheless, this problem is almost impossible to resolve entirely.

## Conclusion

This chapter began by arguing the need for a set of quantitative indicators for measuring the effect of interventions in the energy sector on the welfare of the poor. It developed three sets of indicators, covering access to energy services, their affordability, and effects on health and education outcomes.

This set of indicators produces a holistic view of energy consumption rather than focusing narrowly on the electricity sector, as has too often been done in the past. This approach is supported by empirical studies of energy and poverty, which find that the poor make limited use of electricity even after obtaining a household connection.

The major challenge in implementing this approach is the need for household-level information about both poverty and energy use. But the chapter suggests shortcuts for deriving the information at relatively low cost from existing data sources.

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**Notes**

1. Subsistence energy consumption can also be defined empirically rather than normatively. This can be done by looking at the actual energy consumption of a reference group believed to be living in a subsistence situation, for example, those whose total income or consumption lies close to the extreme poverty line.

2. Where there are significant proven scale economies in energy consumption at the household level, this could be reflected by reducing the weight attached to each marginal individual as household size increases.

3. The concentration coefficient ranges from +1 to –1, with positive values indicating a regressive distribution, negative values a progressive distribution, and a value of zero a perfectly equitable distribution. The formula for calculating the concentration coefficient is

$$\frac{2}{n}\sum_{i=1}^{n} ix_i - \left(1+\frac{1}{n}\right)$$

where $n$ is the total number of groupings of the income variable used (for example, ten deciles) and $x_i$ is the share of connections going to group $i$ (not to be confused with the connection rate for that group).

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