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Energy Services for the World's Poor

The World Bank

ESMAP
Energy Sector Management Assistance Programme

Energy and Development Report 2000

The Energy and Development Report is an annual publication by the Energy Unit of the World Bank's Infrastructure Group and the Energy Sector Management Assistance Programme. The topic for this year's edition is energy and poverty alleviation.

Millions of households in the developing world still lack access to safe and reliable energy—and pay high prices for poor-quality substitutes. Addressing their needs poses a major challenge for developing country governments and for all other players in the energy sector—private firms, financiers, regulators, nongovernmental organizations, and multilateral and donor agencies.

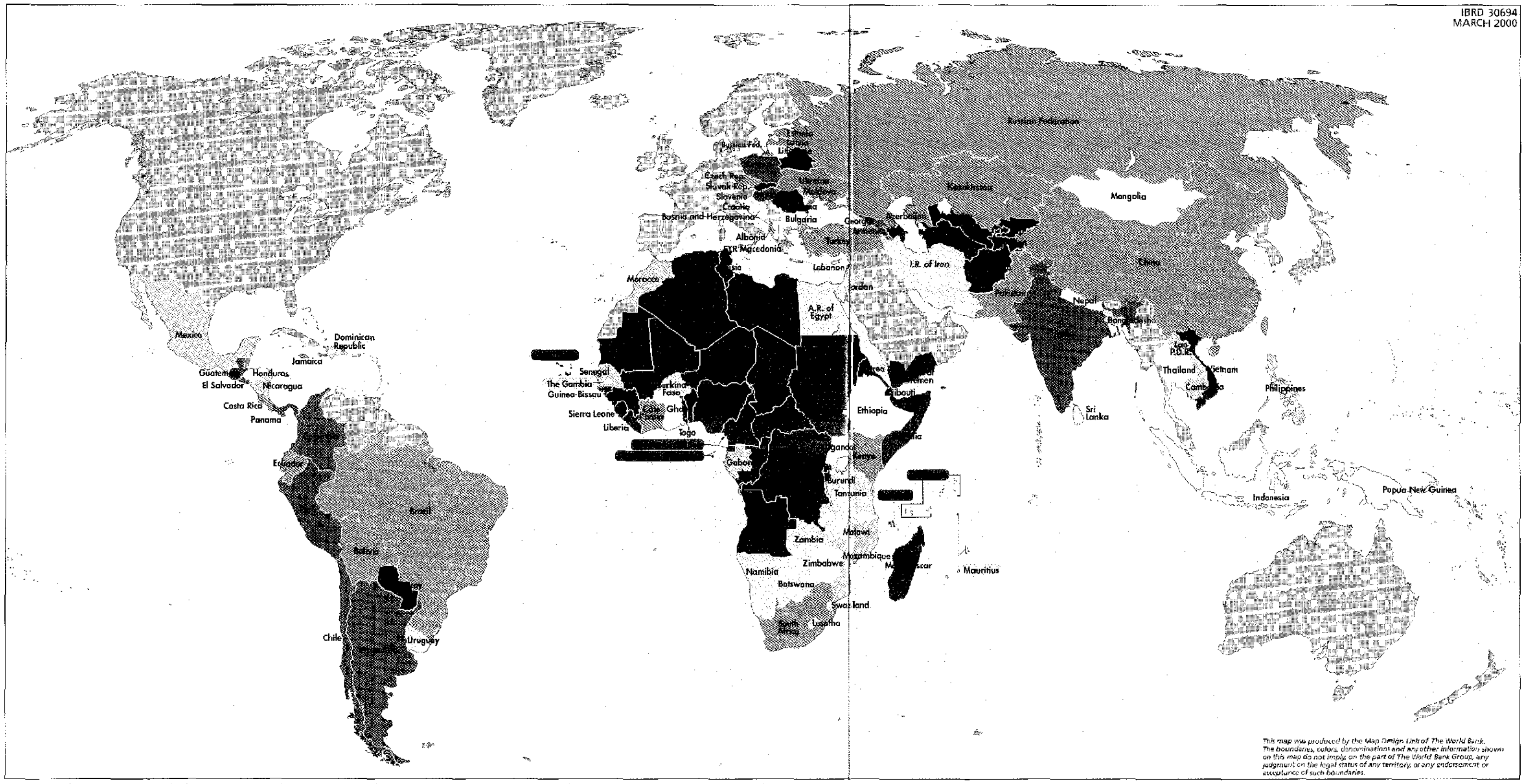
This report serves as a resource in this effort, bringing together survey papers and case studies that reflect the views and experience of authors from wide-ranging backgrounds. It focuses on three broad themes:

- **Understanding the challenge of expanding access to energy for low-income households and communities in developing countries.**
- **Facilitating technological and commercial innovations in serving the poor, through market structure and regulatory reform.**
- **Reducing financial, legal, regulatory, and tax barriers to better services for low-income households and areas.**

The report also reviews trends in private investment in the energy sector in 1990–99.

Map

Scorecard for power sector reform in developing countries, 1998



Source: Robert Bacon, "Global Energy Sector Reform in Developing Countries: A Scorecard" (ESMAP, Washington, D.C., 1999).

The World Bank surveyed power reform in 115 countries to see which of the following six reform steps had been taken:

- Corporatization.
- Laws permitting divestiture and unbundling.
- Regulations.
- Vertical and horizontal unbundling.
- Laws permitting concessions or greenfield investment.
- Privatization of existing assets.

Note that:

- The score does not indicate the quality of reform or the sequence of steps taken.
- For simplicity, success in one region counts as success for the country.
- Sectors under private ownership for 10 years are not considered part of the current reform movement and are omitted from the survey. (Other countries omitted from the survey include high-income countries, small economies, and countries that are not members of the World Bank.)

Number of reform steps taken

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- Countries not in survey

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ESMAP

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Energy Services for the World's Poor

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Foreword

How should a developing country government, concerned with tackling poverty among its citizens, think about its role in the energy sector? Do energy policies and projects have a positive role to play in alleviating poverty? If they do, what kinds of policies and projects are likely to have the most beneficial—and sustainable—impact? And where should energy sector policy advisers, similarly concerned with promoting development and improving the lot of the poor, focus their efforts?

These are the critical—and contentious—questions motivating this year's *Energy and Development Report.* They lie at the heart of the debate about how much emphasis development policies should place on growth and on attempts to directly improve the lot of the poorest. And they are central to debates about the potential of different sectoral interventions to improve both general economic well-being and the welfare of the poor. The chapters that follow offer no definitive answers, no magic bullets. But they do seek to cast light—and provoke debate—on the questions that must be answered to develop energy sector policies that play a positive and sustainable role in the battle against poverty.

James Bond
Chairman, Energy and Mining Sector Board
April 2000

Part 1

Energy services for the world's poor

Customer first

New tools

New rules

1 Reaching the poor in the age of energy reform

Penelope J. Brook and John Besant-Jones

Throughout the industrial era investments to expand and improve energy services have been a mainstay of economic and social development policy in emerging and industrial countries alike. By expanding access to reliable sources of energy—gas, electricity, petroleum products—for agriculture, industry, commerce, and households, governments have primed growth in productivity and output. But in recent years the focus of their interventions has shifted from investing public funds in large-scale energy projects to mobilizing private investment and adopting commercial standards through structural, regulatory, and ownership reforms. Whatever the approach, the link between energy and economic development remains indisputable (World Bank 1994).

The link between energy programs and poverty alleviation is less well understood—and more likely to provoke debate and soul-searching among energy specialists. That access to better and cheaper energy services improves the welfare of the poor seems obvious. But how can we identify the less direct effects of changes in the sector on the poor—particularly the effects of recent sectoral reforms? And how can we weigh the effects on the poor of pro-growth, pro-efficiency reforms against those of direct interventions aimed at improving the poor's access to modern energy for consumption and productive uses?

Hard data to answer these questions remain in remarkably short supply. And the time for preparing this report was too short to commission empirical work to address this deficit. (Several authors note useful directions for such research, however.) Instead, the report focuses on clarifying the following issues:

- What role access to efficient and sustainable energy services can play in strategies for reducing poverty, and what role liberalizing energy markets can play in improving this access.
- How programs for liberalizing energy markets can improve options for expanding access to energy services for the poor (supported by case studies).
- What the key challenges—and key energy policy instruments—are in strengthening support to the poor.

It is arguable that the poorest of the poor, who probably make up the majority of the estimated 2 billion people who lack access to modern energy, do not stand to benefit much from reforms targeted primarily at existing electricity and gas networks. Should governments maintain these growth-oriented sector policies, but focus more attention on social spending aimed at sharing their benefits more effectively with the poor? Are more thorough reforms needed instead, aimed at developing markets in a variety of energy services for households and communities beyond the reach of existing networks—and often at the margins of the cash economy? Or should more emphasis go to programs combining a variety of infrastructure services and community interventions, so as to reap synergies from both bundling infrastructure services and involving communities in service delivery? These questions will continue to stoke a healthy debate among energy and poverty specialists for some time. This report aims to provoke, and to cast light on, that debate.

Access to energy—and poverty alleviation

Poor households and communities typically rely on diverse sources of energy, using one fuel for heating, another for cooking or lighting, another for agricultural or other productive activities. Often the real (per unit) costs of these alternative energy sources are high relative to those of electricity or gas delivered through networks to wealthier households. Moreover, these energy sources often have high nonmonetary costs. When women and children spend many hours collecting firewood or dung for heating and cooking, for example, they have less time for education or for developing other productive activities. And the use of traditional energy sources can have serious health and environmental consequences.

In essence, meeting the needs of the poor for sustainable energy means finding technological and institutional innovations that lower the costs of obtaining and using energy services, and tailoring these services to the requirements of low-income households and communities. That requires some knowledge of how they currently obtain services—and of the nature of their demand for improved services (see chapter 2).

Energy services such as lighting, cooking, refrigeration, and power for electronics and motive force are provided most cheaply and conveniently, and with the least local pollution, when they are derived from electricity or gas delivered through networks. That is because the unit costs of energy from non-network sources are high relative to those of energy delivered through networks (see chapter 6). Moving from traditional to modern fuels can thus dramatically raise the effective incomes of low-income households.

But substantial barriers may prevent low-income households and communities from gaining access to modern energy services:

- Low-income households may be unable to fund the high costs of connecting to the networks (which run from US$50 for the simplest single-phase connection to hundreds of dollars for more conventional connections).
- The effective cost of access to electricity is increased by the additional cost of purchasing electric appliances and fittings (see chapter 2).
- Electricity and gas networks are costly to build and thus require high densities of energy demand to be viable. Since low-income areas have relatively low densities of energy demand, especially in rural areas, expanding networks to these areas is generally not viable without substantial subsidies (see chapter 5).
- Where no network exists, installing alternatives (such as a household photovoltaic cell) is costly (see chapter 11).
- Investments in nongrid technology are often quite lumpy, reducing options for incremental increases in the use of gas and electricity. Where photovoltaic systems are used, for example, the initial decision on the size of cell to be installed sets an upper limit on energy availability (see chapters 10 and 11).
- Sustainable improvement in energy services requires not just investing in technology, but also developing commercial mechanisms for handling the relationship between suppliers and customers—from billing and payments to responding to customer complaints. Traditional mechanisms for handling the interface with customers are often ill suited to poor households in informal settlements (which may, for example, lack a formal address) or small and dispersed rural communities (see chapter 6).
- Households' ability to commit to new connections and pay for service depends not only on the affordability of the service but also on access to credit. Financing can be a major barrier for households that operate at least in part outside the cash economy or lack traditional forms of collateral.
- In the transition economies of Europe and Central Asia low-income households that historically received highly subsidized energy services struggle to pay tariffs set closer to cost recovery levels (see chapters 3 and 8).

For policymakers wanting to improve services for the poor, the critical question is what kinds of policies and projects will be most successful—and most cost-effective—in knocking down these barriers. The more successful policies are in this, the less need there will be for subsidies to bridge the gap between service cost and households' ability to pay (see chapter 7).

The task for policymakers is not to pick winning technological and commercial innovations.

Has energy market reform helped the poor?

Intentionally or not, developing country energy policies often have elements likely to block or distort efforts to help the poor. Many traditional policies have been built on the implicit assumption that the demand characteristics of low-income energy users are similar to those of higher-income consumers. For example, it is presumed that all consumers will be best served by connections to conventional electricity grids providing twenty-four-hour access at standards approximating those in developed countries. So policies for expanding access have often centered on universal service obligations for incumbent or new utilities, accompanied by cross-subsidies ostensibly aimed at improving affordability for the poor but regressively favoring higher-income users, and exclusivity provisions protecting these otherwise unsustainable cross-subsidies. In addition, policies have emphasized network expansion, probably at the cost of non-network alternatives—if only because of monopolies granted to network owners unfamiliar with these alternatives.

The past decade has seen a revolution in energy policy in developed and developing countries. In a growing number of countries traditional public investment projects to reinforce and expand electricity and gas networks are being supplemented or replaced by sector reforms aimed at enhancing competition, reforming regulation, and securing a greater role for the private sector in financing and managing power generation and gas and, increasingly, distribution. The maps on the front and back inside covers show reform "scorecards" for the power and oil and gas sectors, based on a 1998 survey of 115 developing countries. This survey focused on six key reform steps in each sector—from commercialization and market restructuring to regulatory reform and privatization. The results show that the power sector in these countries is still dominated by state-owned monopolies. In the oil and gas sectors the maps show very low levels of reform in downstream oil and gas, which is often accompanied by heavily subsidized prices and untapped potential for markets in such petroleum fuels as liquefied petroleum gas (Bacon 1999).

But private sector involvement in energy has been increasing. Between 1990 and 1999 seventy-six developing countries introduced private participation in their electricity and gas sectors by awarding more than 700 projects and divestitures of shareholdings in electricity and gas enterprises. These transactions involved private investments totaling almost US$187 billion.[1] While middle-income developing countries have led this revolution, low-income countries also have been active participants (figures 1 and 2).

Despite the experience gained in energy reform, advances in generation technologies (conventional and nonconventional), and institutional and financial innovations in providing energy to low-income areas, the reforms have made little impact in improving energy services to the poor. They have focused on networks serving better-off users, generally neglecting institutional and market constraints to serving the poor.

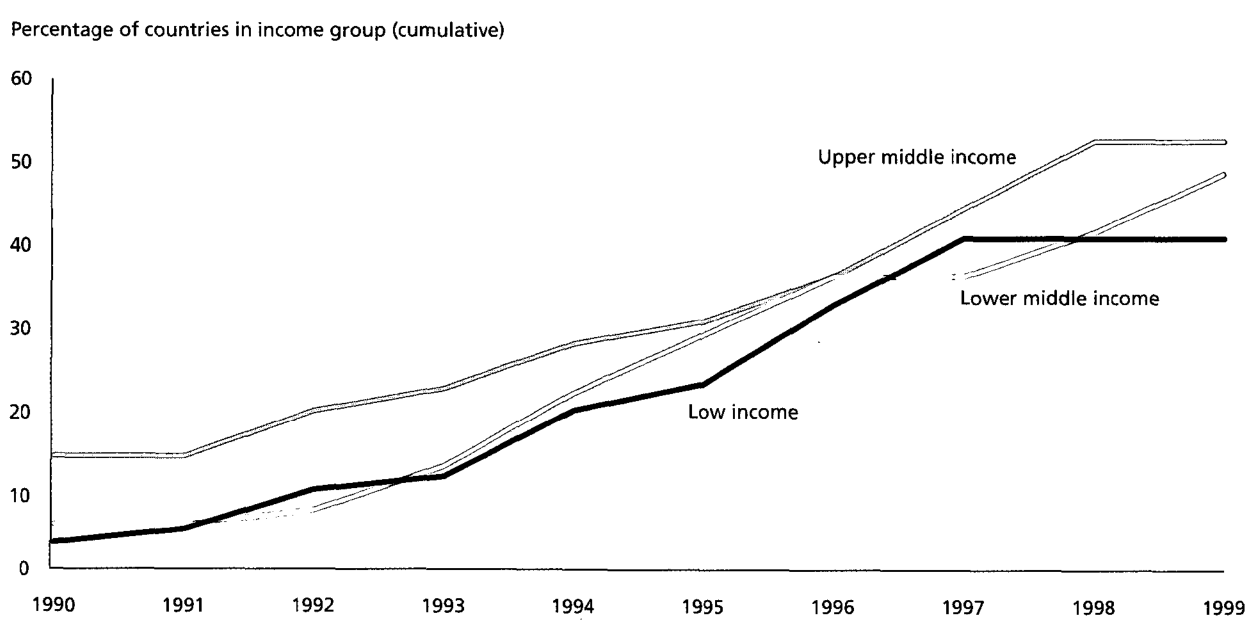
Policymakers reforming energy markets need to focus more on protecting and promoting the interests of the poor. In particular, they need to find ways of providing market and regulatory incentives that motivate private energy suppliers to extend access, improve service reliability, and help with payment difficulties. The record on this score from the privatization of electricity distribution in developing countries—predominantly in Latin America, for urban and periurban areas—is mixed. But the Latin American experience also shows that there is scope for helping the poor when electricity distribution is passed to the private sector (see chapters 9 and 10).

Energy policies for alleviating poverty

Across the energy sector, critical challenges remain: How to ensure that projects and policies intended to improve national welfare, particularly the welfare of the poor, achieve their aims? And how, in a sector characterized by both great diversity in services and complex links between service and poverty, to identify the kinds of interventions most likely to yield large and lasting benefits for the poor?

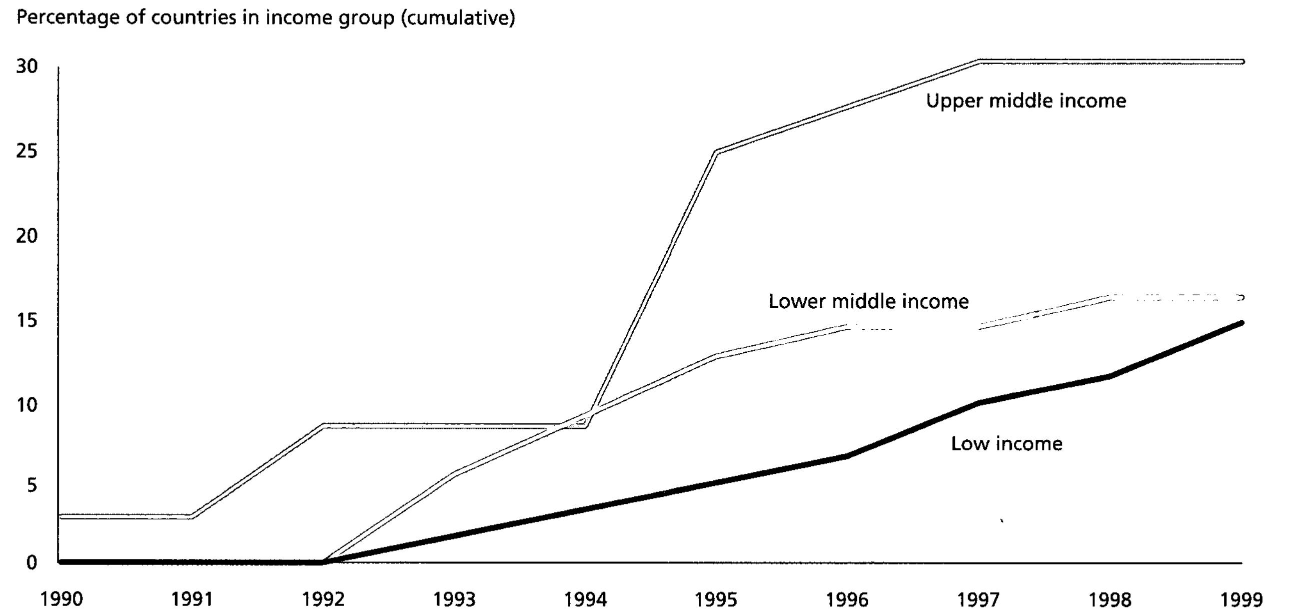
The task confronting policymakers is not to pick winning technological and commercial innovations (seldom an

Figure 1 **Developing countries with electricity projects involving private participation, 1990–99**



Note: Country groupings are based on the income categories defined in World Bank 1999.
Source: World Bank, PPI Project Database.

Figure 2 **Developing countries with gas projects involving private participation, 1990–99**



Note: Country groupings are based on the income categories defined in World Bank 1999. Gas projects include only transmission and distribution.
Source: World Bank, PPI Project Database.

area in which they have much comparative advantage), but to establish an environment with strong incentives for innovation in delivering energy services that meet the demands of users. New generation and distribution technologies and easily replicable models for community mobilization are essential to improving services for the poor, but will not develop in a hostile institutional environment.

The key tools at the disposal of governments as they try to open opportunities for "pro-poor" innovations are institutional ones (see chapter 12). They include choices about market structure and ownership (where and how competition and entry will be allowed and supported), regulation (what the prerequisites for, and mode of, regulatory intervention will be), and pricing (interventions in tariff structures, and fuel taxation). In efforts to help the poor enter the market for better energy services, tools are likely to include not only subsidy policy but also liberalization of financial markets to ease access to credit.

The chapters that follow focus both on policies for liberalizing energy markets and on policies and projects aimed directly at improving energy services for the poor—through subsidies and through investments in pilot or demonstration projects that increase market penetration for promising new technologies.

The report also provides resources for practitioners in energy and poverty: a review of developments in private financing of energy infrastructure in developing countries during the 1990s, a list of selected readings, and a list of World Bank Group contacts in the energy sector.

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Note

1. These data are from the World Bank's Private Participation in Infrastructure (PPI) Project Database. For more details on developments in the gas and electricity sectors, and on the database, see part 2.

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Customer first

2 Energy access, energy demand, and the information deficit

A Energy use around the world—evidence from household surveys

3 Better energy services, better energy sectors—and links with the poor

4 Measuring the impact of energy reform—practical options

2 Energy access, energy demand, and the information deficit

Alan Townsend

Message from the editors

Projects and policies that improve the poor's access to reliable, modern energy services can make an important difference to their welfare. But what is the starting point for improving access? And what kinds of improvements will poor households and communities value? To answer these questions requires some understanding of how they obtain and use energy services today, both for consumption and for productive activities. Also essential is an understanding of poor households' demand for better energy services—and their willingness to pay for them. Traditionally, data collection on these issues was weak—state monopoly providers had limited incentives and capacity to learn about their current and potential customers. More recently, policy advisers and donor agencies have worked to understand the poor's demand for services and to tailor projects to their preferences. But the data gap remains wide. A commonly cited figure for those lacking access to electricity is 2 billion people. As this chapter and its annex show, these people rely on highly varied energy sources—often incurring real costs far higher than those for equivalent energy from electricity networks. Improving energy services is not, of course, simply a matter of reaching 100 percent electrification. It means providing better options for moving to cleaner, safer, cheaper energy sources—and making energy markets more responsive to the needs and demands of households and communities. Evidence suggests that the poor are indeed often willing to pay for better energy services. Thus a major challenge is to open markets to identify and meet this demand.

A key theme of this report is that commercial energy markets, with proper design, can offer a broad range of sustainable and profitable energy services to low-income households. As described in the following chapter, sector specialists generally assume that the poor would be better off if they consumed more and better-quality energy services. In addition, there is a general expectation that, all things equal, they would choose to do so if given the chance, despite limited resources.

In practice, energy policymakers and those who advise them have access to relatively little consistent, reliable data on the poor's current energy consumption or demand for improved services. This does not, of course, imply that, at the household or community level, the poor are necessarily ill informed about the benefits of improved energy access or vague about their preferences and willingness to pay for improved services. What it does imply is that those shaping broad policy or developing government-sponsored projects in the sector are often poorly informed about the markets in which people actually access and use energy services—and risk making interventions that are inconsistent with local needs and preferences or, worse, actively thwart them.

Improving energy services for the poor will require greater attention on two fronts. First, policymakers and their advisers need to use such demand data as are available—within their own countries and abroad—to design projects that, at the least, do not close off energy options valued by the poor or distort incentives to supply and use better services. Second, they need to design policies and projects that elicit access and demand information more effectively. Here, the greatest gains are likely to come from policies that open up markets in energy services—and rely less on decisions by policymakers about who gets to buy what from whom. This chapter surveys the limited cross-country data available on demand for energy services by low-income households and discusses the implications for policymakers and energy suppliers. The accompanying annex draws on one of the more consistent cross-country data sets—based on the Living Standards Measurement Study (LSMS) surveys—to provide illustrative data on service coverage, choice of cooking fuel, and energy expenditures.

Policies and markets need to be designed to elicit information on access and demand.

A huge and diverse market

Poverty is generally measured on an individual basis,[1] but the key unit for energy infrastructure is the household. Low-income households represent a huge potential market for energy services. While poor households are disproportionately rural, huge numbers remain inadequately supplied with modern energy services even in cities and in the periurban areas surrounding major centers of the developing world. This problem is likely to increase as urbanization intensifies—current projections are that the majority of people in developing countries will be living in urban or periurban areas by 2020.

Worldwide, hundreds of millions of low-income households lack access to modern energy (electricity and petroleum products), but estimating the figure even within a few hundred million people is difficult. A common (though perhaps outdated) estimate is about 2 billion people, a third of the world's population.[2] Only by carefully compiling data from representative household surveys covering a large cross-section of the world's developing countries can we obtain a more accurate estimate. But for most countries such survey data do not yet exist.

Available cross-country survey data show that low-income households consume a mix of energy products for domestic and productive purposes (see annex to this chapter). As a whole they:

- Exhibit substantial variation in energy consumption patterns, depending on climate, local fuel resources, the economic history of their country, whether they are urban, rural, or periurban, and other factors. Households in many African countries consume little commercial energy compared with households in the countries of the former Soviet Union, for example, where the electricity infrastructure built in Soviet times still connects almost 100 percent of the population (though inadequate tariffs and chronic nonpayment of energy bills are eroding these systems' reliability).
- Consume a mix of energy that is suboptimal from economic, financial, health, and environmental perspectives.
- Consume less modern energy than they would be willing and able to use if supplies were commercially available at prices that are fair while still recovering costs.

Emerging trends at the household level have implications—not yet fully understood—for the way we might measure demand for and access to energy. Households in most developing countries are getting smaller and may have fewer wage earners, reflecting such factors as higher per capita incomes, smaller family sizes, greater access to education, and increasing urbanization. The people living in these smaller households are less likely to be poor and thus more likely to have disposable income to spend on modern energy. But the smaller households also mean that each new electricity connection may benefit fewer people than in the past. This has implications for the design of programs to increase access and may also make state enterprise–led connection strategies more unrealistic.[3]

Trends in energy mix and use

Low-income households use a diverse mix of fuels to meet their needs. While higher-income households tend toward commercial, high-value fuels such as electricity, diesel, and liquefied petroleum gas (LPG) for both domestic and productive uses, the poor tend to use more human and animal motive power for productive purposes and more biofuels (wood, dung, thatch, and straw residues) and candles for domestic purposes—consuming very little of efficient, commercial fuels (World Bank 1996). About a third of total energy use in developing countries comes from biofuels, most consumed by poor households (Afrene-Okese 1999). As incomes grow, households generally switch to electricity for lighting and fossil fuels for cooking—while in agriculture and industry, electricity and diesel engines replace human and animal motive power. In urban areas the transition to modern fuels is generally complete by the time per capita incomes reach around $1,000–1,500 (Barnes 2000).

Still, even for poor households, commercial energy is becoming a more important part of the mix for both consumption and productive purposes. Several factors lie behind this emerging pattern. First, the quality of energy from biofuels is low, and applications are limited. People who want to use good lights, radios, or appliances need commercial energy (including such sources as photovoltaic panels and batteries). Second, in heavily deforested areas and urban and periurban areas biofuels have become so scarce that they too have become commercialized. Once consumers pay cash for traditional fuels (or spend too much

Box 1 Government policies can block demand from low-income households

Several types of government policies can inadvertently limit access to energy services for the poor.

- *Long-term exclusive franchise arrangements.* Exclusive franchise agreements are motivated in part by the belief that the energy sector as a whole is a natural monopoly and, where private participation is introduced into the sector, in part by a perceived need to reduce investment risk by guaranteeing exclusivity in generation, transmission, distribution, and retailing. For those not yet connected, however, such agreements can block the development of alternative energy supply arrangements, especially if the franchise holder has a legal monopoly on distribution and retail in the entire country.

When combined with a uniform tariff policy, exclusivity arrangements are doubly damaging. In India, for example, the chronically poor financial situation of the state electricity boards is attributable mainly to the extremely low tariffs in rural areas. The low revenues undermine the utilities' ability to expand access not only in rural areas but also in urban areas. Their weak financial condition eventually leads to deterioration in maintenance of generating and network assets and declining quality of service for all customers.

- *Tariff, tax, and subsidy policies.* A government might adopt a uniform national tariff policy (differentiated across broad categories of users such as industrial, agricultural, and residential) expressly to protect rural customers. But such a policy can inhibit the extension of networks into rural areas. Rural customers often are willing to pay more than the uniform tariff for a reliable supply of electricity, but utilities may never offer them the choice because they have no incentive to do so. And in some countries—such as Pakistan—industrial and commercial customers are so overcharged that they evade payment and bypass the grid by installing their own generating equipment, which would be uneconomic if tariffs reflected costs. This shrinks the utility's revenue base and further erodes its financial position.

Import restrictions or taxes on energy products, often motivated by a desire to reduce dependence on particular fuels or on fuel imports, tend to raise the cost and reduce the availability of products. They may also have indirect effects. For example, taxing a high-quality fuel may increase the demand for lower-quality fuels, which will have price effects for the poor if supply is restricted. Thus a policy intended to raise revenue from the well-off can end up excluding the poor from consumption of a fuel.

- *Overspecification of technical and quality standards.* For historical reasons, developing countries often set technical standards in the electricity sector—covering everything from transmission and distribution grids to house wiring—at rich-country levels. That leads to high costs for electrification and increases the disincentive to expand network services. These high costs can be reduced appreciably by using design standards suitable for areas with low loads (World Bank 1996). Simplifying wiring codes and using load limiters (circuit breakers) rather than consumption-based meters for low levels of consumption can significantly reduce the costs not just of installation but also of billing and collection. Using cheaper poles and involving local labor in works and maintenance can also reduce connection and service costs.

Source: Powell and Starks 2000.

time gathering and preparing them), they are more likely to consider other commercial energy options.

Third, modern fuels have become cheaper in real terms. Despite a recent uptick in price, oil and gas are cheaper, in real terms, than they were before the first oil shock in 1973. Electricity prices have also fallen in real terms, because real price declines for fuel (including coal) have been accompanied by increased efficiency—so that more units of electricity are generated per unit of fuel—and because capital costs of many of the most important technologies have also fallen.[4]

These underlying cost drivers might be news to many consumers who have not yet felt their benefits. The problem is that poor government decisions—on pricing, taxation, competition, and other issues—have prevented many of the poor (as well as the better-off) from seeing the full benefits of the new commercial energy trends. Instead, mispricing has meant that consumers choose between no service and poor service—or pay higher prices in black markets or for do-it-yourself solutions (box 1).

End-use patterns are changing dramatically too (table 1). More households are investing in comfort (such as fans) and entertainment (especially television). Changes in consumption are driven by changes in preferences (for modern entertainment, for example), by big declines in prices for consumer electronic goods, and by the increasing energy efficiency of these goods.

Table 1 **Appliance ownership by households with electricity connections in four Indian states, 1980 and 1996** (percentage of households)

Appliance	1980	1996
Lights	100	100
Table fan	32	41
Ceiling fan	24	48
Transistor radio	47	31
Television	1	40
Tape recorder or record player	3	26
Refrigerator	1	9

Source: ESMAP 1999a.

While transistor radios—powered by expensive dry cell batteries—are less common than they were, televisions, tape recorders, and refrigerators have exploded in popularity and become increasingly affordable. Interestingly, consumers often embrace modern fuels for new uses—powering televisions, for example—while retaining traditional fuels for cooking and heating (see chapter 11). Modern fuels are also embraced for their business potential—from home sewing machines to video kiosks.

Spending levels

Not surprisingly, available cross-country data show that rich households spend more per month on electricity than do poorer ones (annex table A.8). But poor households often spend a higher share of their income, as in Bulgaria, Jamaica, Kazakhstan, Nepal, Pakistan, Panama, and South Africa.

Subsidy policy can skew these outcomes. Lifeline tariffs are commonly used in industrial countries to ensure that consumption at a basic level—for example, of the energy needed for good lighting in the evening—is available at low cost, while higher rates are charged for consumption above that level. Even these limited subsidies may have adverse incentive effects for making new connections to low-income households. Lifeline tariffs are still relatively rare in developing countries. More common in these countries is to subsidize entire classes of consumers, which typically benefits mostly middle- and upper-income households (because they tend to be connected more often and to use more power than poorer households). Even correcting for the effect of poor subsidy design and targeting, it would not be surprising to see poor households devoting a greater share of income to electricity, reflecting the high value they place on the service.

Evidence of willingness and ability to pay

Low-income households consume a relatively small amount of energy, and that energy is of low quality. Per capita energy consumption in South Asia is only 2.6 percent—and that in Sub-Saharan Africa only 1.3 percent—of per capita consumption in the United States (World Bank 1996). For these supplies, survey and anecdotal evidence suggests, South Asians and Sub-Saharan Africans pay among the world's highest unit costs—and get some of the world's worst-quality energy.

Ugandans spend an estimated US$100 million a year—an incredible 1.5 percent of GDP—on dry cell batteries to power radios, flashlights, and other small items. The average Ugandan household spends an estimated US$72 a year on dry cell batteries, used in 94 percent of Ugandan households. The cost per unit of energy consumed works out to US$400 a kilowatt-hour. Ugandans may spend almost as much per year on kerosene for their lamps.

Car batteries, which cost about US$120 a year to operate, produce better-quality power at about US$3 a kilowatt-hour. More Ugandan households are powered by car batteries (around 5 percent) than by the integrated electricity network (around 4 percent; ESMAP 1999d). Not surprisingly, businesses and wealthier households in Uganda are enthusiastic buyers of diesel generators, which produce energy at about 19 cents a kilowatt-hour, or about three times the average (inadequate) tariff charged by the Uganda Electricity Board (UEB). Household tariffs normally range from 6 to 12 cents a kilowatt-hour. One result of chronic power shortages on the integrated network is that disadvantaged industries often have surplus captive capacity—perhaps equal to 20 percent of UEB's installed base—that cannot be sold to UEB or anyone else (Reinekka and Svensson 1999).

Uganda may be an extreme case, even for Africa. But evidence abounds that consumers in developing countries are willing to pay often extraordinarily high prices for reliable and predictable (if not always high-quality) energy. In the Lao People's Democratic Republic, one of the poorest countries in the world, surveys show that people will pay up to 10 percent of their income for energy services (ESMAP 1999c). Other survey data for developing countries indicate that for households with connections, electricity accounts for 1–8 percent of total consumption (see Afrane-Okese 1999 and the annex to this chapter). Among low-income households, median spending on electricity ranges from US$1 to US$12 a month. At the lower end of that range, mispricing and nonpayment are probably at least partially responsible for the low share of consumption spending devoted to electricity (as exemplified in almost every country in South Asia, Sub-Saharan Africa, and the former Soviet Union). Surveys also suggest that long-suffering customers of poorly performing utilities would be willing to pay more if the quality and reliability of power increased, but resent price increases when quality remains so poor.[5]

The flip side of this story: In too many cases the poor simply do not have the choice of consuming commercial energy. Governments must take the primary blame here—too many fail to follow policies that encourage rational pricing and competition in the energy services sector.

Better ways to measure demand

Most donor projects targeted at the poor now include some attempt to assess demand and willingness to pay at the design stage. However, there are serious problems in ensuring that such analysis elicits relevant information—or is linked effectively to project design. Difficulties in measuring demand for energy services, particularly among low-income households in developing countries, are well known. Survey questions may suffer from unrecognized biases. The answers too may suffer from biases, and they may not reflect actual demand responses. Selecting a representative sample is always difficult. And the analysis of the survey results is inevitably simplified to a point where conclusions may be less than useful (if not obvious).

Nowhere is the problem greater than in estimating the willingness of people to pay for commercial energy services. In many countries years of chronic undersupply, miserable quality, rampant theft of power or nonpayment, gross mispricing, and poor performance by state-owned monopoly suppliers have made willingness to pay even more difficult to assess. Moreover, baseline information on access and payments is generally in short supply in developing countries. State monopoly energy providers, facing only limited incentives to improve services, seldom gather reliable data on customer coverage, payments, and preferences. The only way to systematically reveal willingness to pay is to liberalize markets so that consumers can choose from a wider range of options with fewer distortions. But few developing country policymakers have fully embraced this solution. Most continue to view energy as a social good—and consumers as incapable of independent decisions about the mix of energy they will use.

We need to change the people who do the demand-side analysis.

Anecdotal evidence suggests that the biggest single hurdle for most households is up-front connection costs, which can range from as low as US$50 to well over US$1,000. This is true whether or not utility-provided electricity or gas is available. If it is not, most households theoretically could buy generators or photovoltaic installations, but may lack the credit or cash to do so. Potential customers have indicated in surveys (in many countries) and shown in practice (in a few) a willingness to take medium-term loans to fund up-front costs, repaying them as part of their bill over the first five years or so of service.

Variable costs—operations, maintenance, fuel—are less of a hurdle, although for a utility there are clearly some challenges here in building up both critical mass and the right mix in the customer base. Average monthly billing for some rural cooperatives in Bangladesh is in the range of US$2–3 per customer a month. Even where there is high density of demand, that level of average billing leaves little room for growth.

While the unmet demand of low-income households for commercial energy services is unquestionably large, it has limits. Even with perfect policies, some households will be unable or unwilling to pay for advanced energy solutions. Despite progress in reducing costs for both on-grid and off-grid technology, initial connection and monthly consumption charges can still present steep hurdles for low-income households. And government resources are unlikely to suffice to electrify low-income households at the same pace as higher-income consumers. Inevitably, tradeoffs will have to be made. But with a mix of good policy and effective communication, a government can sell a program that does not lead immediately to 100 percent electrification.

Conclusion

An understanding of current energy consumption by low-income households and communities, and of their preferences and willingness to pay for improved services, is an essential starting point for any energy project aimed at effectively and sustainably improving welfare. The monopolistic state suppliers that dominated energy sectors in the past were notoriously bad at gathering this kind of information. More recently, sector projects have come to place more emphasis on understanding demand, but available data remain spotty and survey methods are fraught with difficulties. Nevertheless, available survey and anecdotal evidence suggests that the poor represent a strong potential market for improved energy services.

How to make progress? We may know enough about demand on a global scale to be confident about one initial step: change the people who do the demand-side analysis. Fuel suppliers, equipment manufacturers, energy service companies, consumer groups (including user-owned energy suppliers), trade groups, and others need to be more involved in developing the energy services market for low-income households. But this can happen only if policymakers create an appropriate environment—and if state-owned enterprises either stop being part of the problem or disappear (through privatization or liquidation). Policymakers need to allow competition in the market for new customers and to provide mechanisms, including subsidies, to help potential customers pay for initial connections. And they can do much to lower transactions costs for communities, individuals, and private entities wishing to invest in infrastructure.

Policymakers need to make fewer decisions about who gets to buy what from whom. This implies a less controlled market—with its share of failures—in which a variety of institutions deliver a range of services. The result will reflect demand for energy services by the poor today—a market in which the solutions come from households, people make their own choices about fuels and their use, innovative energy service suppliers can prosper, and innovative consumers can increase the quality of their life and, potentially, their income.

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Notes

1. The standard definition of individual poverty is living on less than US$1 a day, adjusted for purchasing power parity. No distinction is made between rural and urban areas (or between monetized and only partially monetized settings).

2. Even this figure may understate the number without access, because some countries (India, for example) count all households in a village as being electrified if the village has one streetlight and one electric water pump.

3. In some countries, particularly in Africa, the growth in the number of households combined with the weak financial condition of local power companies has meant that the share of the population with access to electricity is actually decreasing. In Uganda a load forecast by Electricité de France indicated that doubling the number of household connections would increase the share of the population with access to electricity by less than 50 percent as a result of population growth and new household formation.

4. Capital costs for combined-cycle gas turbine power plants have been cut in half, to around US$400 per installed kilowatt, in less than ten years; efficiencies have gone up more than 10 percent; and delivered gas prices in most regional markets have fallen (see Electric Power Research Institute 1999).

5. Survey results from India and other countries are mixed on this issue and many others, indicating a need for basic education and communication about energy services and why they cannot simply be delivered for free (or at massively subsidized prices).

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Annex
Energy use around the world—evidence from household surveys

Kristin Komives, Dale Whittington, and Xùn Wu

This annex presents findings from a study of data sets from Living Standards Measurement Study (LSMS) surveys in fifteen developing countries around the world (box A.1). It reports results on electricity coverage, choice of cooking fuel, expenditures on electricity, and total energy expenditures. These results show:

- Cross-national differences. The countries in the sample are in Asia, Europe and Central Asia, Latin America and the Caribbean, and Sub-Saharan Africa, with surveys ranging from as recent as 1997 to as far back as 1988 (box A.2). The choice of countries in the study sample was based on data availability.
- Differences in household energy use and spending between rich and poor and by consumption levels.

Box A.1 Data notes

- The survey data allow study of household use of electricity for lighting and cooking. The study assumes that households that use electricity for neither lighting nor cooking do not have electricity.
- To identify the richest and poorest households, the study divided the households in each national sample into quintiles by per capita consumption. Consumption data are generally more accurate than household income data.
- The study adopted the urban-rural distinction made by the LSMS survey teams. The methodology used for distinguishing between urban and rural areas varies from country to country, but the cross-national findings nevertheless give a general sense of differences in energy use between urban and rural areas.
- To look at cross-national expenditure patterns, the study converted all expenditures to 1998 U.S. dollars using official exchange rates in the survey year. (Sector-specific purchasing power parity rates would have been preferable but were not available for the countries in the sample.)
- Because most LSMS surveys are not self-weighting, weights are needed in data analysis to correct for the effect of sample design and rates of nonresponse. For the preliminary results reported here, no weights have been used. The results are valid only for the survey population and cannot be extrapolated to the national level.

Box A.2 Countries in the study and the year of their survey

Asia	
Nepal	1996
Pakistan	1991
Vietnam	1993
Europe and Central Asia	
Albania[a]	1997
Bulgaria	1995
Kazakhstan	1996
Kyrgyz Republic	1993
Ukraine	1996
Latin America and the Caribbean	
Ecuador	1995
Jamaica	1997
Nicaragua	1993
Panama	1997
Sub-Saharan Africa	
Côte d'Ivoire	1988
Ghana	1989
South Africa	1993

a. The survey sample does not include Tirana.

Table A.1 **Electricity coverage varies widely across countries**

Country	Percentage of households with electricity
Côte d'Ivoire	40.8
Ghana	23.8
South Africa	51.2
Ecuador	88.3
Jamaica	77.7
Nicaragua	66.5
Panama	73.2
Nepal	25.8
Pakistan	76.5
Vietnam	48.6
Albania	100.0
Bulgaria	100.0
Kazakhstan	99.7
Kyrgyz Republic	99.5
Ukraine	99.7

Source: LSMS surveys.

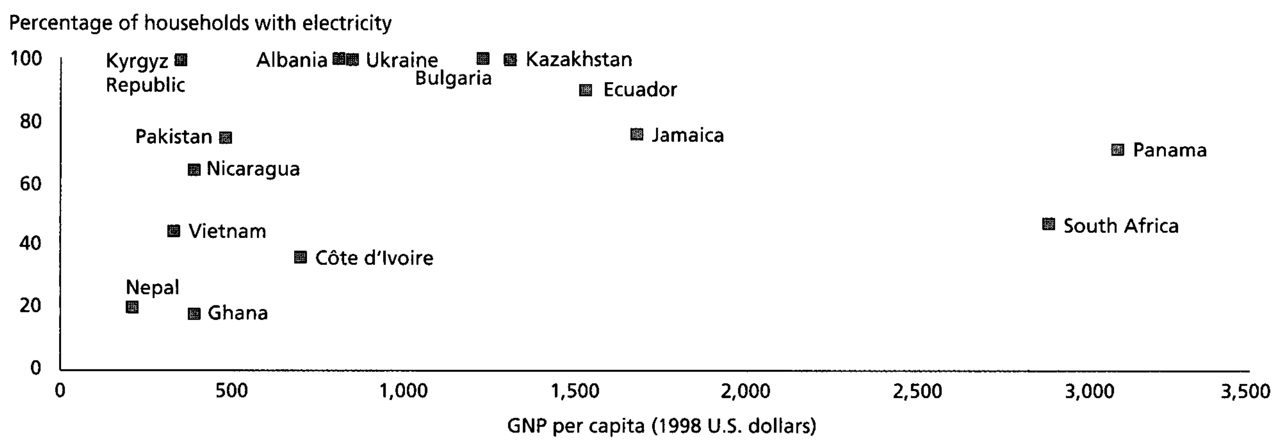
- Differences between urban and rural areas.
- Differences in coverage between electricity and other infrastructure services.

The surveys

Many countries undertake household surveys using some form of the LSMS survey. Developed by the World Bank in 1980, LSMS surveys have been adopted (with minor variations) in more than twenty developing countries. They are one of the most popular tools used by policymakers for measuring living standards and poverty and for designing government policies and evaluating social programs (see Deaton 1997 for an in-depth analysis of the potential uses of the LSMS data sets). LSMS surveys include questions on such utility services as water, electricity, and telecommunications, making them the only source of data for reliable cross-national comparisons combining information on energy use and broader socioeconomic characteristics of households.

LSMS surveys offer a unique opportunity for comparing infrastructure across countries using roughly similar data and for studying household well-being in detail. But they also have some gaps. The surveys are not done each year, so some results are outdated. Surveys rarely collect information on the infrastructure services available to households or on the quality of the service they receive. They gather information on household expenditures on such services, but not on use levels or unit prices. The surveys ask similar questions on infrastructure across countries, but the categories of answers usually differ. Thus some detail is lost in cross-country comparisons.

Figure A.1 **Weak relationship between GNP per capita and electricity use**



Note: GNP per capita data are from the World Bank's World Development Indicators database and are calculated using the World Bank Atlas method.
Source: LSMS surveys.

Moreover, it is difficult to make causal inferences (for example, why households use certain services) using cross-sectional data. For some countries panel data sets are available with survey information from several years. But these are exceptions, and cross-national comparisons using panel data generally are not possible.

Household electricity coverage

This section shows electricity coverage by country, by per capita GNP, for rural and urban areas, and by consumption quintile.

- *Coverage by country.* Households in Europe and Central Asia are by far the most likely to use electricity—more than 99 percent of sample households in Albania, Bulgaria, Kazakhstan, the Kyrgyz Republic, and Ukraine reported having electricity (table A.1). Fewer than half of households in Nepal and Vietnam used electricity at the time of the surveys. Households in Latin America and the Caribbean fall in between: 66–88 percent of households in Nicaragua, Panama, Jamaica, and Ecuador reported having electricity.
- *Coverage by GNP per capita.* The surveys show some tendency for electricity use to rise with per capita GNP, but this relationship is weak (figure A.1). Panama and South Africa are outliers, with lower electricity coverage than might be expected at their income levels. Countries in Europe and Central Asia have more extensive coverage than countries with similar per capita GNP in other regions.
- *Coverage in urban and rural areas.* Electricity use is generally much higher in urban than in rural areas (table A.2). In all countries except those in Africa the urban areas have electricity coverage of more than 85 percent. But electricity use in rural areas varies dramatically among countries. In Europe and Central Asia virtually all rural households report using electricity. By contrast, Ghana has only 4.3 percent coverage in rural areas.
- *Coverage for the richest and poorest quintiles.* The countries of Europe and Central Asia boast the smallest difference in electricity coverage between the richest and the poorest households in the sample population (table A.3). Virtually

Table A.2 **Electricity use in rural areas differs dramatically across countries**

Country	Percentage of households with electricity: Rural	Urban
Côte d'Ivoire	12.7	73.1
Ghana	4.3	61.7
South Africa	27.2	74.6
Ecuador	74.8	97.4
Jamaica	69.3	86.1
Nicaragua	33.1	92.3
Panama	48.7	98.1
Nepal	8.9	88.6
Pakistan	58.3	94.6
Vietnam	38.8	87.9
Albania	99.9	100.0
Bulgaria	100.0	99.9
Kazakhstan	99.5	99.9
Kyrgyz Republic	99.5	99.5
Ukraine	99.8	99.7

Source: LSMS surveys.

Table A.3

Disparities between rich and poor in electricity use are often great

Country	1998 GNP per capita (1998 U.S. dollars)	Percentage of households with electricity: Poorest quintile	Richest quintile
Côte d'Ivoire	700	11.0	71.0
Ghana	390	7.2	43.1
South Africa	2,880	13.0	94.6
Ecuador	1,530	77.9	97.5
Jamaica	1,680	55.4	94.0
Nicaragua	390	28.4	93.1
Panama	3,080	23.0	97.1
Nepal	210	3.7	75.0
Pakistan	480	59.8	89.6
Vietnam	330	27.4	76.3
Albania	810	100.0	100.0
Bulgaria	1,230	100.0	100.0
Kazakhstan	1,310	99.7	100.0
Kyrgyz Republic	350	99.0	100.0
Ukraine	850	99.7	99.7

Note: GNP per capita data are from the World Bank's World Development Indicators database and are calculated using the World Bank Atlas method.
Source: LSMS surveys.

everyone—rich and poor—has electricity. In most other countries in the sample the richest households are much more likely to use electricity than are the poorest.

○ *Coverage for all quintiles.* Are the differences related to household consumption levels? The survey data show that electricity use rises with consumption within countries, but not necessarily across countries (figure A.2). Quintiles with roughly similar levels of consumption (but from different countries) can have very different levels of electricity coverage. In Latin America and the Caribbean, for example, coverage for the quintile with a median consumption of about US$200 is roughly 55 percent in Jamaica and 75 percent in Nicaragua. Similarly, in Sub-Saharan Africa the quintile with consumption of US$150 has coverage of more than 40 percent in Ghana, but less than 15 percent in Côte d'Ivoire and South Africa. In both regions it appears that whether a household falls in the richest or poorest fifth of households in its country is more important than its absolute consumption level in determining whether it uses electricity.

Cooking fuels—basic or modern?

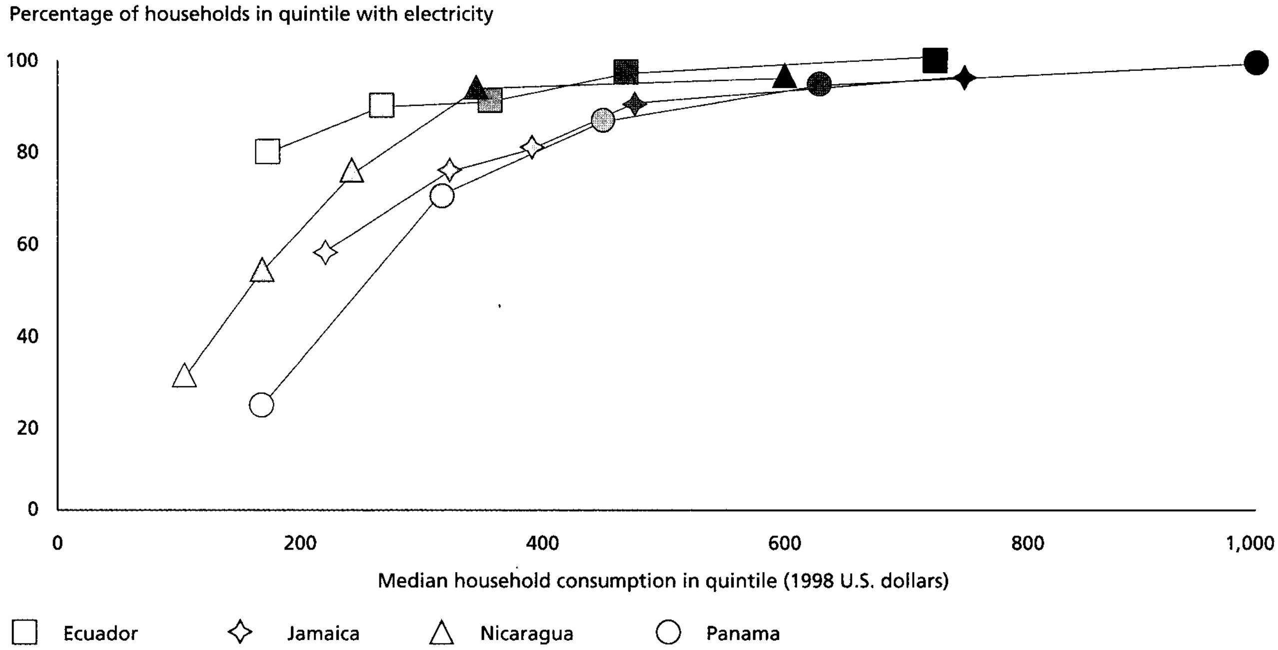
Households use energy for many different purposes and often choose different energy sources for each. Most households with electricity connections, for example, do not use electricity for cooking.

Cooking fuels can be grouped into three categories: *advanced* (electricity and bottled or natural gas), *intermediate* (kerosene and charcoal), and *basic* (wood, dung, thatch, and straw). Information on the use of advanced and basic cooking solutions was available for eight countries in the sample.

These eight countries fall naturally into two groups: those in which most of the population uses wood, dung, thatch, or straw as cooking fuel, and those in which this is not the case. Unlike electricity use, the choice of cooking fuel appears to be correlated with GNP per capita. The

Figure A.2 **Relative consumption is more important than absolute consumption in determining electricity use**

. . . in Latin America and the Caribbean . . .



. . . in Sub-Saharan Africa . . .

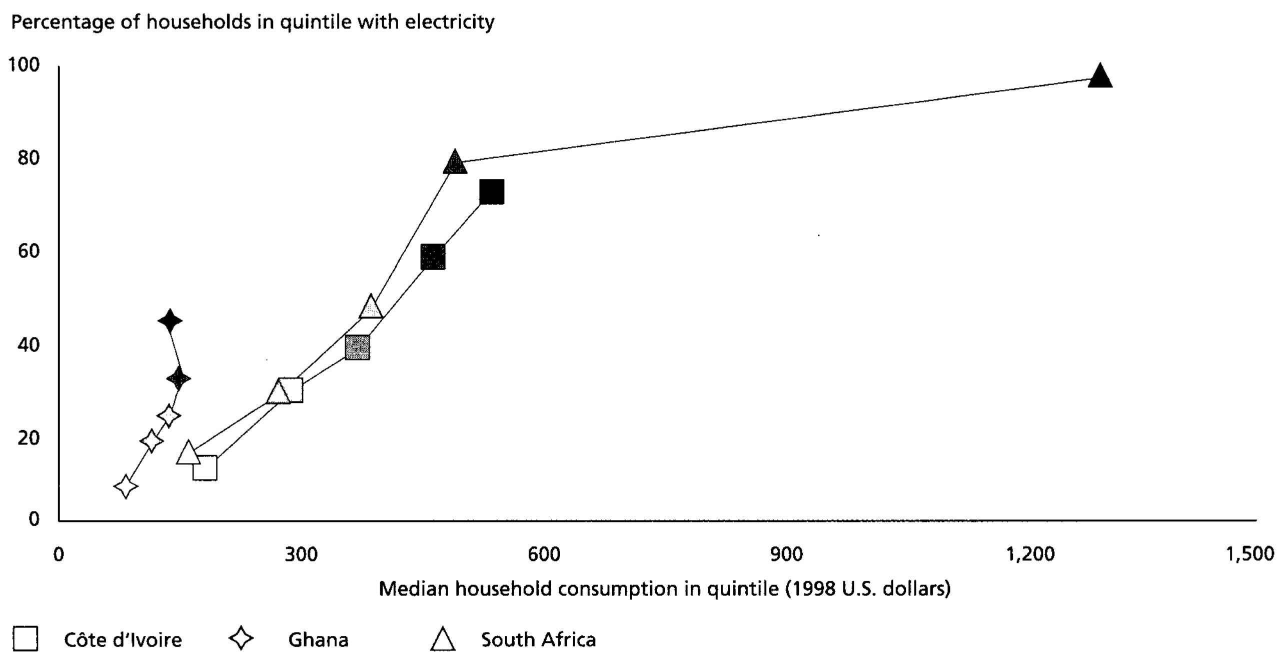
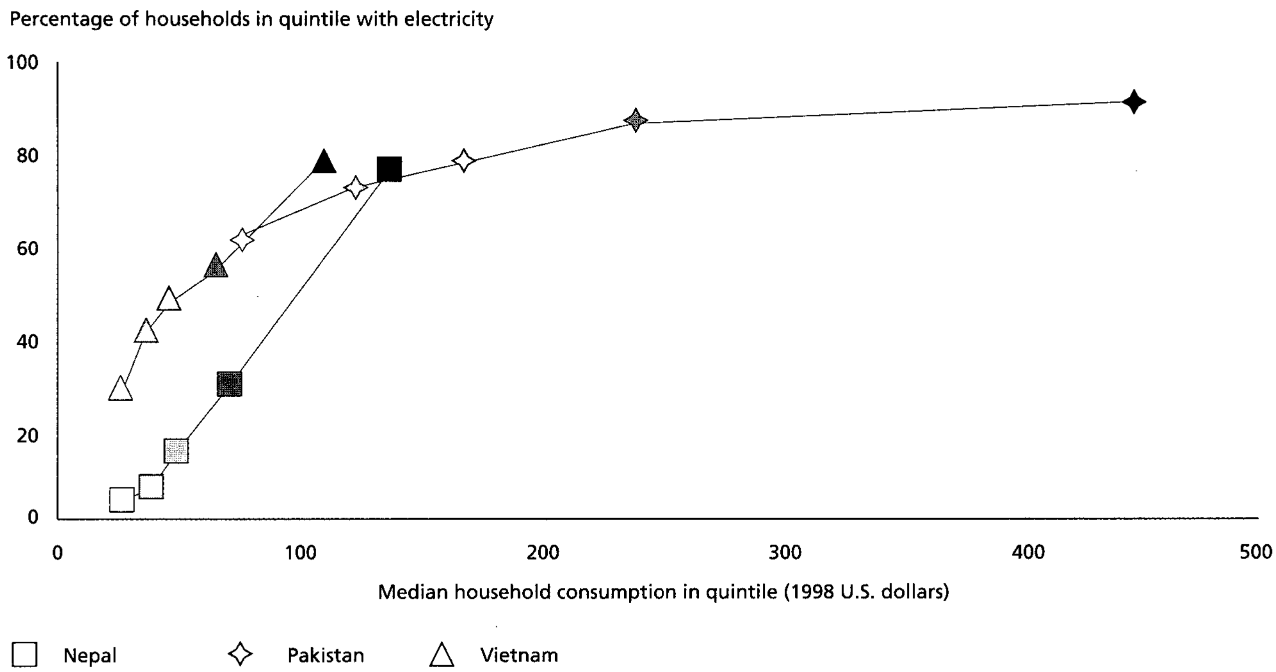


Figure A.2 **Relative consumption is more important than absolute consumption in determining electricity use (continued)**

. . . and in Asia



Note: The progression in the shapes from light to dark shades indicates the progression from the poorest to richest quintile. The richest quintile in Ghana has higher per capita consumption but lower median household consumption than the second quintile because the richest households are on average much smaller.
Source: LSMS surveys.

countries in the first group—Côte d'Ivoire, Nepal, Nicaragua, and Vietnam—are all low-income economies, as classified by per capita GNP. The second group consists of lower-middle-income and upper-middle-income economies: Bulgaria, Ecuador, Panama, and South Africa.

In only two countries in this second group—Bulgaria and South Africa—do large numbers of households use electricity for cooking (table A.4). In Ecuador and Panama most households use gas or kerosene for cooking.

In the four low-income economies almost no households in rural areas and in the poorest quintile use advanced cooking fuels (tables A.5 and A.6). Virtually all these households use wood, dung, thatch, or straw for cooking. Even urban households and those in the richest quintile are unlikely to use advanced fuels. Most use an intermediate fuel, and many use basic fuels. Only in Nicaragua do more than half the households in the richest quintile use an advanced fuel for cooking.

In the four wealthier countries, by contrast, very few urban or rich households use basic fuels for cooking. Fuel use by rural and poor households varies more among these countries.

Spending on electricity services

The LSMS data sets do not include information on electricity rates, but they do have information on monthly electricity spending. This information reveals what share of household consumption goes to electricity services.

- *Monthly consumption devoted to electricity.* Among households paying an electricity bill, the median share of consumption devoted to electricity services is less than 4 percent for all countries (table A.7). The median monthly electricity bill for most countries falls within the range US$1.10–6.00 (in 1998 dollars). The exceptions are Côte d'Ivoire, Jamaica, Panama, and South Africa, all with median bills of more than US$15.00 a month.
- *Electricity spending by the poorest and richest.* As might be expected, the poorest households have lower electricity bills on average than do the richest (table A.8). In some countries the difference is quite small, but in most cases the richest households spend on average three to six times as much on electricity each month.

Although rich households have higher bills, in nine of thirteen countries the households in the poorest quintile

Table A.4 Households' choice of cooking fuel is correlated with per capita GNP (percent)

Country	1998 GNP per capita (1998 U.S. dollars)	Advanced fuels: Electricity	Advanced fuels: Bottled or natural gas	Basic fuels
Low income				
Côte d'Ivoire	700	0.0	7.4	68.1
Nepal	210	0.2	3.7	83.7
Nicaragua	390	2.1	18.8	74.8
Vietnam	330	0.7	0.0	88.7
Middle income				
Bulgaria	1,230	75.6	6.8	.. [a]
Ecuador	1,530	0.9	.. [b]	14.7
Panama	3,080	0.5	.. [b]	26.5
South Africa	2,880	42.5	2.8	27.9

.. Not available.
Note: Basic fuels are wood, dung, thatch, and straw.
a. Wood, dung, thatch, and straw are not included as a separate category in the Bulgarian LSMS survey. Nonetheless, the share of households using these fuels is clearly small: only 17.65 percent reported using a fuel other than electricity or natural or bottled gas.
b. The survey does not distinguish between kerosene (an intermediate fuel) and bottled or natural gas.
Source: LSMS surveys.

Table A.5 Most households use basic fuels for cooking except in the urban areas of wealthier countries (percent)

Country	Rural households: Advanced fuels	Rural households: Basic fuels	Urban households: Advanced fuels	Urban households: Basic fuels
Low income				
Côte d'Ivoire	0.6	98.3	15.8	35.3
Nepal	0.2	97.5	17.2	32.4
Nicaragua	2.1	96.9	35.2	58.0
Vietnam	0.1	96.5	3.4	57.3
Middle income				
Bulgaria	55.8	..	95.5	..
Ecuador	..	31.6	..	3.0
Panama	..	50.6	..	1.8
South Africa	19.7	54.4	70.8	2.0

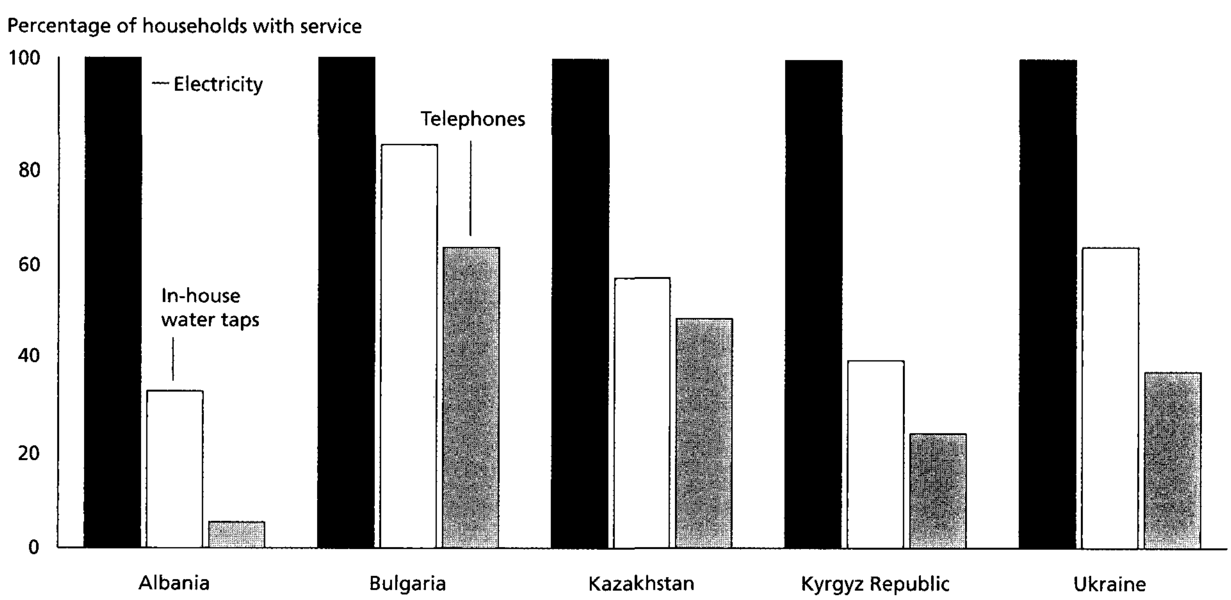
.. Not available.
Note: Advanced fuels are electricity and natural gas. Basic fuels are wood, dung, thatch, and straw.
Source: LSMS surveys.

Table A.6 **Virtually none of the poor in countries with low per capita GNP use advanced fuels for cooking** (percentage of households)

	Poorest quintile		Richest quintile	
Country	**Advanced fuels**	**Basic fuels**	**Advanced fuels**	**Basic fuels**
Low income				
Côte d'Ivoire	0.0	99.4	27.2	27.2
Nepal	0.0	98.5	18.7	38.9
Nicaragua	0.6	98.6	54.4	40.4
Vietnam	0.0	99.0	3.4	64.4
Middle income				
Bulgaria	69.3	..	90.2	..
Ecuador	..	32.9	..	3.4
Panama	..	77.1	..	2.3
South Africa	5.2	68.5	93.2	0.4

.. Not available.
Note: Advanced fuels are electricity and natural gas. Basic fuels are wood, dung, thatch, and straw.
Source: LSMS surveys.

Figure A.3 **In Europe and Central Asia more households use electricity than have in-house water taps and telephones**



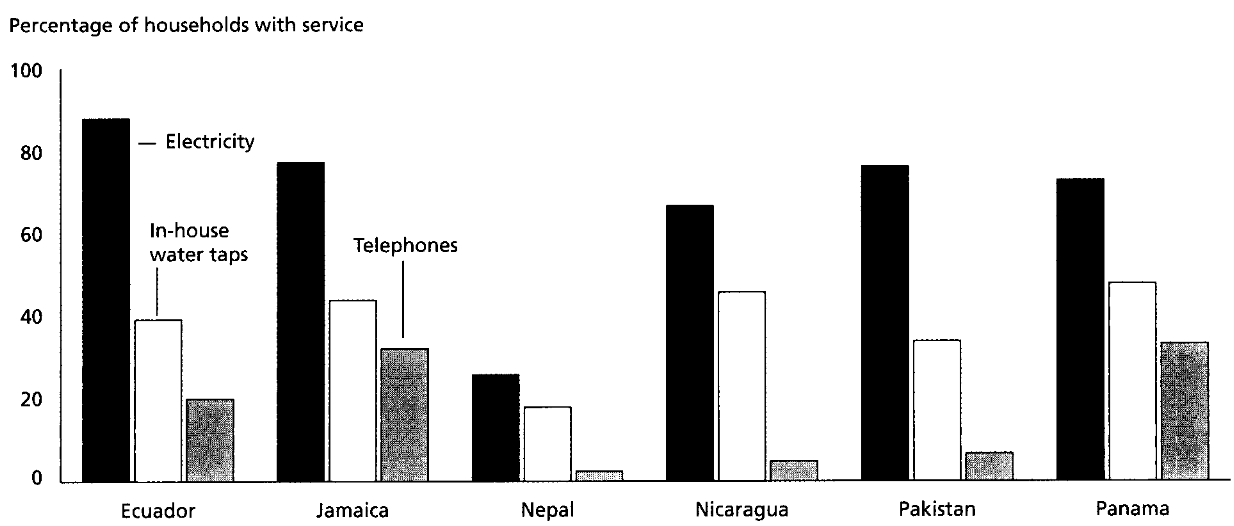
Source: LSMS surveys.

Table A.7 Median spending on electricity is less than 4 percent of household consumption in all countries

Country	Median monthly electricity bill (1998 U.S. dollars)	Electricity bill as percentage of consumption
Côte d'Ivoire	15.00	2.8
Ghana	1.40	0.9
South Africa	25.90	3.8
Ecuador	2.90	0.8
Jamaica	17.20	3.7
Nicaragua	6.00	2.0
Panama	16.20	2.7
Nepal	1.80	1.7
Pakistan	2.50	1.7
Vietnam	1.10	2.0
Albania	4.00	2.3
Bulgaria	4.00	2.5
Kazakhstan	3.90	1.8

Source: LSMS surveys.

Figure A.4 Electricity use is also more widespread than in-house water taps and telephones in Latin America and Asia



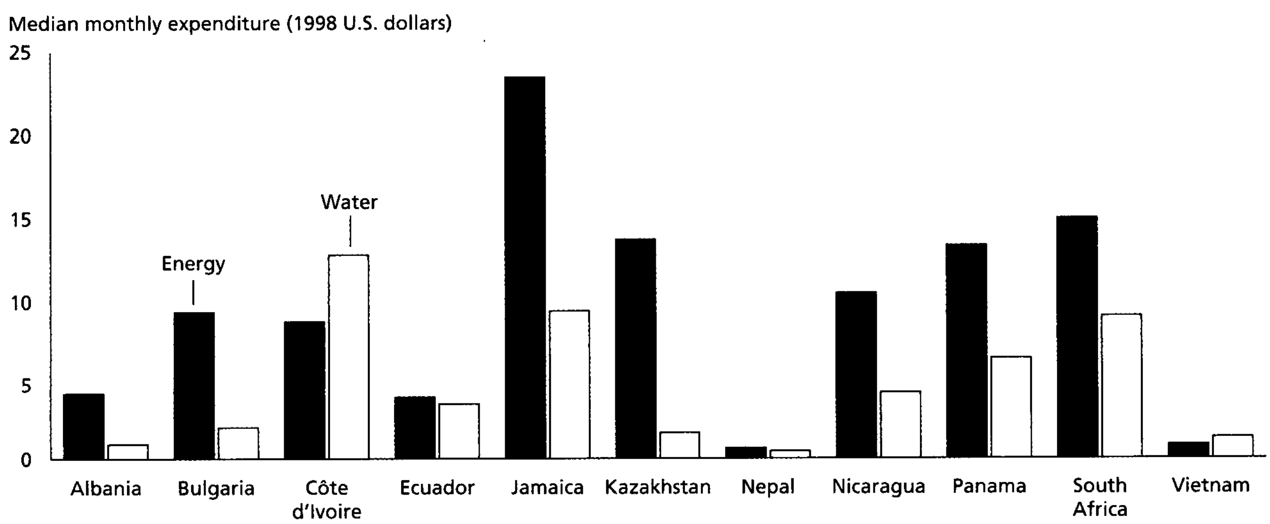
Source: LSMS surveys.

Table A.8 The poorest households devote a greater share of consumption to electricity than the richest do

	Median monthly electricity bill (1998 U.S. dollars)		Electricity bill as percentage of consumption	
Country	**Poorest quintile**	**Richest quintile**	**Poorest quintile**	**Richest quintile**
Côte d'Ivoire	7.78	23.71	2.3	3.0
Ghana	1.07	1.46	1.2	0.9
South Africa	6.90	44.50	3.9	3.6
Ecuador	1.67	7.09	1.0	0.8
Jamaica	11.47	19.40	5.0	2.6
Nicaragua	2.41	14.44	2.2	2.4
Panama	5.42	24.24	2.9	2.4
Nepal	0.91	2.93	2.9	1.7
Pakistan	1.75	5.28	2.5	1.2
Vietnam	0.53	2.57	1.9	2.2
Albania	2.48	8.94	2.0	3.0
Bulgaria	3.18	5.09	3.4	1.9
Kazakhstan	3.51	3.86	3.1	1.0

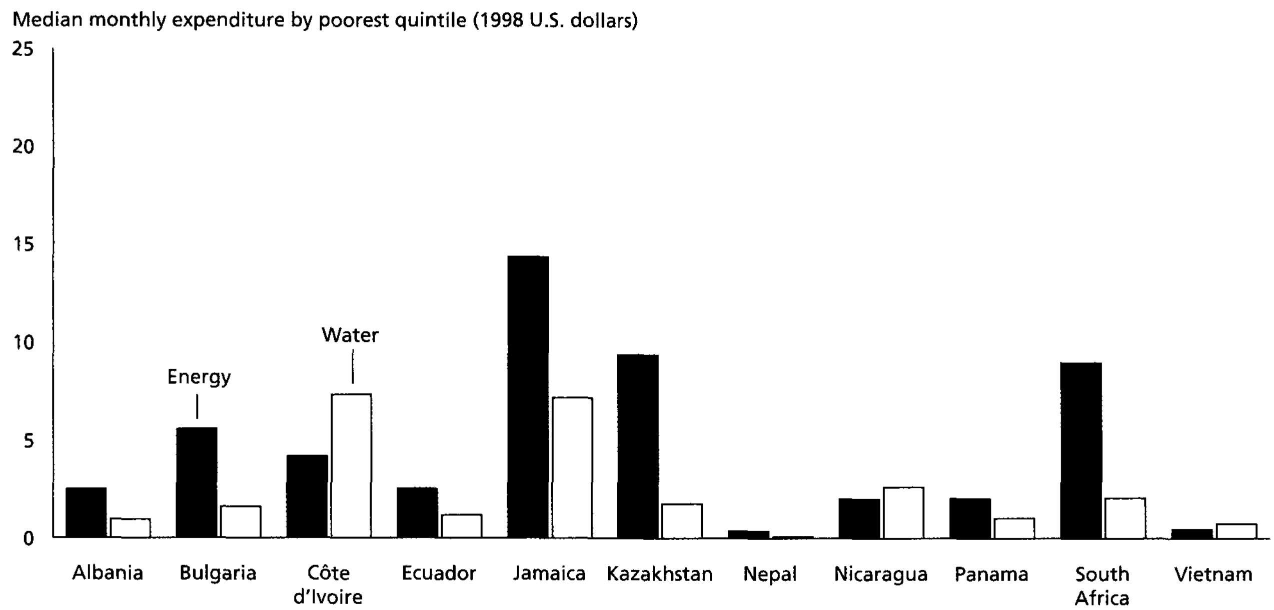
Source: LSMS surveys.

Figure A.5 In most countries households at all consumption levels spend more on energy than on water



Note: Energy spending is the sum of spending on electricity and other fuels for household use. Automobile fuel is not included.
Source: LSMS surveys.

Figure A.6 **The poorest quintile also generally spends more on energy than on water**



Note: Energy spending is the sum of spending on electricity and other fuels for household use. Automobile fuel is not included.
Source: LSMS surveys.

devote on average a larger share of household consumption to electricity. This share ranges from 1 to 5 percent for households in the poorest quintile, and from 0.8 to 3.6 percent for those in the richest.

Comparing energy with other infrastructure services

More households use electricity than have in-house water taps or telephones in countries in Europe and Central Asia and in other countries in the sample for which data on all three sectors are available (figures A.3 and A.4).

Because each national survey asks about spending on a slightly different group of fuels, comparisons of total energy expenditures within a country (for example, between richest and poorest) are more reliable than cross-national comparisons. In general, households spend more on energy than on water, if they pay for water at all (figure A.5). Although those in the poorest quintile spend less on average than the population as a whole, the patterns of expenditure for these two groups are generally similar (figure A.6).

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3 Better energy services, better energy sectors—and links with the poor

Catherine Waddams Price

Message from the editors

Governments around the world see energy projects and policies as key parts of their strategies for growth and development. Traditionally, governments have relied heavily on direct investment of public funds—through public providers—to expand energy capacity and access. More recently, a growing number have refocused their energy policies, opening the sector to new players and looking to the private sector to finance improvements in services. How do these interventions affect the poor? What are the links between better access to energy services—and better services—for households and communities and household welfare? What does more to improve the welfare of the poorest—growth-oriented sectoral policies or access-oriented policies? And what does the shift in focus from public investment to reform mean for the poor? Knowing the answers to these questions is critical for governments wanting to ensure that their sectoral interventions at least cause no harm to the poor and, more optimistically, can systematically improve their welfare. Current answers to these questions rest on a mix of economic reasoning and rich anecdotal evidence. But hard data to support rigorous answers remain in short supply—a major challenge for the sector.

Energy policies have a key role in the development and growth strategies of governments. Ready access to reliable, reasonably priced energy—particularly by industry, agriculture, and the commercial sector—is an important catalyst for growth. For households, better energy services can boost welfare—for example, by reducing time spent collecting biomass fuels for cooking or heating purposes or by boosting the productivity and income of household businesses. Accordingly, in many developing countries we see projects aimed at increasing the capacity of the modern energy sector to contribute to productivity, growth, and economic opportunity alongside projects that are more narrowly focused on expanding access to improved energy services for low-income or geographically dispersed communities. Traditionally, projects of both kinds relied heavily on direct investments in system expansion. More recently, governments have focused more attention on the institutional framework that supports investments and service delivery—and moved to reform this framework in the hope of enhancing operational efficiency and more efficiently mobilizing finance for system expansion and improvement.

To understand how these interventions affect the poor, we need some appreciation of the links between improved access to energy services—or better-quality services—at the household and community level and household welfare. We need some means of assessing the relative roles of growth-oriented sectoral policies and access-oriented policies in improving the welfare of the poorest. And we need some means of gauging the effect on the poor of a shift from policies centered on investment to policies centered on reform.

In general, there is broad agreement, supported by a degree of anecdotal evidence, on the direction of links between energy and poverty alleviation. But hard data on the absolute or relative magnitude of the welfare impacts of different kinds of sectoral interventions are in very short supply. Accordingly, this chapter is restricted to discussing broad directions, rather than precise measures, of impact. Similarly, while arguments about the likely effect of sectoral reform on the poor are reasonably well developed, relatively little evidence is yet available to cast light on these arguments or on the aspects of reform most likely to make a difference to the poor. Redressing this data gap is a clear

Table 1

Potential effects of improved energy services in alleviating poverty

Direct effects on well-being	Direct effects on health	Direct effects on education	Direct effects on economic opportunities for the poor	Trickle-down effect of increased productivity	Fiscal space (coupled with pro-poor policies)
Improved access to lighting, heat, and refrigeration	Improved indoor air quality through cleaner fuel	Improved access to lighting, allowing more time to study	Easier establishment and greater productivity of businesses that employ the poor	Easier establishment and greater productivity of businesses in general (including through positive impact on the environment)	Smaller fiscal burden and higher fiscal returns from more efficient services
Savings in time and effort (due to reduced need to gather biomass and other fuels)	Reduced fire hazard	Savings in time and effort, releasing time and energy to channel to education	Creation of employment in infrastructure service delivery		More benefits to the poor if government spending is effectively channeled to welfare-enhancing services
Improved access to information (through radio, television, and telecommunications)	Improved quality of health services (through better lighting, equipment, and refrigeration)		Improved health and education and savings in time and effort, increasing individual productivity		Higher fiscal returns associated with higher growth, coupled with pro-poor policies
	Easier establishment of health centers				
	Better education				

priority for those in the sector concerned with improving the impact of sector policies on the poor.

Improving access and broadening choice: the direct welfare effects

An underlying objective of many energy sector projects is to give low-income households and communities in rural and periurban areas better access to modern fuels—to allow them to shift from biomass fuels to kerosene or gas for cooking, to put electric lighting in a school or power a refrigerator in a community health clinic, or to access electricity for lighting or to power equipment for household businesses. Interventions of these kinds are expected to have important and direct effects on the welfare of the poor (table 1). They may enable households to use more energy services, either because they provide them access for the first time or because they reduce prices. Greater use of energy services may deliver other benefits, particularly better health and education and, as a result, improved access to and productivity in the labor market. Better service is also likely to reduce both the monetary and the nonmonetary costs of obtaining supply.

Households consume energy because of the services of light, power, and heat that it provides. Energy sources differ in their efficiency in meeting these needs—and in their capacity to do so—and also in their positive and negative side-effects. For some uses, substitution is possible. Heat, light, and motive power can come from different sources, and the choice of source affects several aspects of household welfare. Food may be cooked over a fire of wood or dung, on an improved stove fueled by biomass, or on a stove fueled by kerosene, liquefied petroleum gas (LPG), or electricity. But both traditional (fuelwood, dung) and intermediate (kerosene) fuels impose health costs on users through the adverse effects of smoke and emissions on respiration and through fire hazard. In India recent estimates attribute about 400,000 premature deaths a year to indoor air pollution. Firewood and other biomass fuels are also time consuming to collect—accounting on average for 20 percent of rural women's work time.

Lighting may come from candles, a kerosene lamp, or an electric bulb. But the relative brightness of electric light may open a range of possibilities that are constrained where households and communities must rely on candles or kerosene—lighting a schoolroom or health clinic at night, for example. A plow may be pushed by a person or pulled by an animal—or pulled by a tractor powered by a petroleum product. A water pump may be worked by hand, or by a kerosene or diesel generator. In each case service is likely to be more effective with modern fuels such as gas, electricity, or petroleum products, in part because they are usually used with more modern and efficient equipment.

Other uses are less amenable to substitution. Refrigeration—with potential benefits ranging from increased options for household production to the capacity for vaccine storage in health clinics—depends on some access to gas or electricity. Access to modern communications—particularly the Internet—depends on access to electricity.

Electric light opens new opportunities—lighting a school or a health clinic at night, for example.

Users generally face tradeoffs between monetary and time costs as they progress from traditional to intermediate to modern fuels. Fuelwood may be the cheapest in monetary terms, but can be very time consuming to collect; as supplies become sparse, both the time costs to the collectors and the scarcity costs to the economy increase. Intermediate fuels are generally more expensive than traditional fuels but cheaper to access than modern fuels. (Here, an important factor shaping household choice is likely to be the cost of connecting to a service. Intermediate fuels often have higher unit costs than, say, electricity or gas, but lower up-front access costs.) Moving from one type of fuel to another also often entails investment in new equipment. But the time and energy saved in collecting fuel can be converted into better health and more time for education and for other productive activity, increasing earning potential as well as providing direct benefits. The value of this time and energy depends on the opportunities available. (There is some evidence that the welfare effects of access to energy are disproportionately boosted where other infrastructure services are also present. In rural Peru, for example, recent surveys show that bundling water, sanitation, electricity, and education services has major welfare benefits—and that adding the fourth service has a development impact seven times that of adding the second. See Barnes 2000.)

Greater access to energy can be only beneficial, in the broadest sense, because it increases choice (if households do not wish to take advantage of greater choice, they are at least no worse off than before). In some circumstances, however, a new source of energy may lead to improvements for the community as a whole but result in exclusion for those who do not participate. For example, access to electricity for a small subset of households may enable these households to increase their productivity and wealth and to take advantage of improved opportunities through access to the Internet. There may therefore be an issue of "relative" as well as "absolute" access.

Hard data on the magnitude of the direct welfare impacts described here are in short supply—though anecdotal evidence is persuasive (see, for example, Albouy and Nadifi 1999). In the following chapter Vivien Foster sets out some options for remedying this data gap by clarifying indicators of poverty impact and building relevant indicators of service improvement and welfare enhancement into energy projects.

Direct impacts: the role of prices

The way in which the energy sector is regulated and prices are set has important implications for access—both direct (affecting the affordability of access) and indirect (affecting the possibility of access).

Obstacles to access may be financial rather than physical. Electricity connection fees between US$80 and US$300 are common. Once households are connected, however, electricity is usually cheaper than kerosene (Albouy and Nadifi 1999), and it also has nonfinancial benefits. Many low-income households lack access to the credit they would need to raise the connection fee, even where the financial benefits alone would warrant this investment. Worldwide, capital markets generally fail low-income groups.

Once households gain access to energy, consumption depends on affordability. The pricing of fuels is crucial in determining the amount consumed (if any) and the share of income this absorbs. Because many countries have subsidized some fuels in the past, reforms commonly include removing or restructuring these subsidies and thus affect the prices charged.

Energy consumption and income are positively related, but while energy spending rises with income, it generally does so less than proportionately—an important distinction in analyzing the link between energy services and poverty. Consumption levels off as income increases, with the poor spending 10–20 percent of their income on energy, and the rich about 2 percent (Albouy and Nadifi 1999). In some countries this larger burden for the poor is exacerbated by a higher average cost of fuel for low-income families, reflecting either fuel mix or tariff structure (table 2). The relationship between income and energy expenditure might seem to offer a route for subsidy, but in fact it contains a paradox, because the relationship is imperfect. Moreover, difficulties in access may mean that the poor receive none of the subsidy because they consume none of the product.

Energy pricing also has environmental implications—but adjusting prices to reflect environmental externalities more accurately may have adverse effects on the poor. Both fuelwood and hydrocarbon fuels are in limited supply, and their market price may not include their scarcity value. Burning them produces emissions that affect the global climate, and this too is generally not reflected in the price. Any adjustment in prices to more accurately reflect these environmental costs will hit the poor particularly hard because fuel absorbs such a large part of their income and because they lack the funds to invest in energy-saving devices or alternative fuels or appliances. Fuel markets are interdependent in the sense that taxes or subsidies in some will have a "knock-on" effect on others. Directing environmental taxes to electricity, on the basis that it is consumed by the better-off, will raise the price of intermediate and traditional fuels too and thus also affect poorer households.

Regulatory interventions can also affect the availability of services. For example, energy pricing structures may—inadvertently—create barriers to the extension of improved service options to low-income households and communities. Regulators may face a tradeoff between short-term protection of vulnerable groups through price constraints—which will discourage entry by restricting potential profits—and the long-term benefits from competitive entry. Institutional barriers may block incentives for providing access in an appropriate form or may lead to prohibitively high prices for access. That raises questions of obligatory service and universal service obligation, discussed below.

The choice of regulatory regime also shapes incentives relating to the extent and nature of service expansion. For example, a system that rewards capital expenditure (such as any based on rate of return on assets) will push providers to supply centralized generation and transmission networks, when it might be more cost-effective to install distributed generation with much smaller local distribution systems (Jechoutek 1999).

Indirect effects of improved energy services

So far, discussion has focused on the direct effects on welfare of improving access to energy services, and barriers that may stand in the way of such improvements. Improved energy services will also generally produce improvements in the economy as a whole, with benefits for the poor both as members of society and as consumers. Such indirect benefits arise from two sources: improved efficiency of the sector and the economy, which increases total wealth, and, through cuts in subsidies, the release of more funds for other activities. (The effect of subsidy reform on the poor may be mixed if prereform subsidies were well targeted to them—but this is seldom the case in developing countries; see chapter 7.)

Table 2 Fuel use in forty-five cities, by ease of access to electricity

Access to electricity in city	Average monthly household income (U.S. dollars)	Average population (thousands)	Wood	Charcoal	Kerosene	LPG	Electricity
Percentage of households using fuel[a]							
Very difficult	33	23	56.4	73.4	57.6	26.6	21.1
Difficult	67	174	72.3	33.5	65.2	21.8	42.8
Easy	62	514	24.1	62.7	50.4	21.6	47.7
Very easy	77	1,153	22.1	34.5	42.6	47.8	90.5
Fuel use (kilograms oil equivalent per capita per month)							
Very difficult	33	23	1.31	10.09	0.35	1.49	0.24
Difficult	67	174	7.27	2.54	0.46	0.91	1.24
Easy	62	514	2.83	7.20	1.10	0.50	2.00
Very easy	77	1,153	1.71	1.75	1.75	2.00	2.79

Note: The data are from household surveys conducted in twelve developing countries in various years from 1984 to 1993.
a. Shares sum to more than 100 percent because households may use more than one fuel.
Source: Energy Sector Management Assistance Programme (ESMAP) household surveys.

The first set of benefits is likely to be more important in the longer term, especially when the dynamic effects of technological development are included.

Directing environmental taxes to electricity will raise the price of intermediate and traditional fuels too.

As noted above, better energy services may result in better provision of local facilities, such as health centers, schools, and adult education facilities. They are also likely to have a positive effect on other infrastructure, such as transport (both roads and vehicles), and on local commercial activity. Increased economic activity can also be expected at the regional and national levels. Cuts in subsidies will provide fiscal "headroom," and improved efficiency will expand the tax base and reduce demands on the budget. But how will these benefits be distributed within the community? Here again, hard data with which to answer these questions are in short supply.

Potential beneficiaries can be divided into three groups: those who benefit directly from the increased wealth, perhaps through employment; those who benefit from the use of improved facilities available to all (infrastructure, broadcasting, and education and health services, if universally provided); and those who benefit from targeted subsidies (through income effects or through better access to subsidized products and services). Distribution of the benefits generally depends both on political infrastructure and on markets.

Reforms to improve the performance of the energy sector will not necessarily benefit the poor, at least in the short run. For example, if new commercial enterprises require a particular education level, it may be the middle classes rather than the poor who can take advantage of new employment opportunities. Direct intervention in the market to introduce a "bias toward the poor" may create new distortions, sacrifice some of the efficiency benefits, and prove difficult to target.

Distributional effects of reform

Traditionally, in both developed and developing countries, the supply of energy services has been the prerogative of state-owned monopolies. Often these monopolies had specific targets for extending access to particular groups—for example, through rural electrification programs. But cost inefficiency and poor targeting have generally led to poor results—both in overall sector performance and in progress in expanding service coverage. Many energy sectors have developed inefficiently, in part because operators had few incentives to minimize costs or optimize investment—and in part because they have been distorted by past redistributional programs, targeting the poor or other groups.

Energy reforms are generally driven by a desire to improve the efficiency and reduce the cost of energy supplies. If the reforms succeed in reducing costs, a "high-level" distributional question arises: How should these benefits be shared between producers and consumers? The answer will affect the size of the total gains.

"Reform" is not a monolithic concept. Different governments have taken different approaches, both in the extent of reform and in the rules that they establish to guide service providers. In general, there is a choice between high-powered incentive schemes, usually involving private ownership (or at least the right to retain any savings) so as to maximize suppliers' incentive to reduce costs, and regulatory schemes in which cost savings are passed on to or shared with consumers, much like traditional cost-of-service regulation. While schemes that pass on savings to consumers are seen as fairer in the short term, they are often the very structures that have given rise to excessive costs in the past. Regulation can strike a compromise between incentives and fairness—for example, by imposing average price caps that are reviewed from time to time. But its effectiveness depends on the ability of the regulatory authority to monitor and enforce price limits. Regulation also needs to be politically acceptable. In the United Kingdom, which pioneered incentive regulation, the regulator's monitoring performance has been controversial. Most of the early gains from reform accrued to new owners, not consumers. As a result the Labour government is introducing reforms to improve the distribution of benefits.

The level of prices is only one aspect of the pricing problem; rebalancing prices within the overall limit is also an issue. Reforms that introduce incentives based on profit maximization by suppliers may well lead them to raise prices or withdraw from markets that they had previously served. This may be efficient, but it could also be distributionally regressive, especially if low-income consumers are less price responsive than richer consumers. Evidence on the relative price elasticity of different income groups is mixed. Barnes and others (1998) found that demand from low-income households was more price responsive than that from richer households in many developing countries, but Nesbakken (1999) found the reverse for Norway. Any regressive effect from rebalancing in order to maximize profits will be in addition to that of removing any previous subsidy.

Competition reduces the scope for cross-subsidy between consumer groups. Forcing the incumbent to keep prices below a profitable level for a particular target group of consumers will hamper its competitiveness elsewhere and probably leave it supplying mainly the protected group of consumers. That was the early experience in U.K. residential energy markets, where incumbents retain a large share of high-cost, low-income consumers. The regulator faces a difficult choice between protecting these consumer groups through controlled prices in the short term, making them unattractive to entrants, and allowing them the longer-term benefits of competition by letting prices rise. The United Kingdom has a well-developed tax and benefit system, but the government is reluctant to use it explicitly for correcting the distributional effects of market reform.

One approach to the distributional effects of different access and pricing arrangements is to impose some obligation to supply. Chisari and Estache (1999) distinguish between obligatory service, which obliges the supplier to offer the service to all consumers in a particular area or category, and universal service obligation, which additionally requires that the service be offered on terms affordable to all. The second condition is clearly much more onerous. Reviewing the effect of such a condition in the Argentine reforms, Chisari and Estache found mixed results. Some low-income households benefited, while others migrated away from areas of formal jurisdictional control to avoid the increased cost of housing and utilities.

The impact of reform on the poor: practical experience

Some general conclusions about the effects of energy reforms on the poor can be drawn from reforms already instituted. In the United Kingdom the privatization and reorganization of the gas and electricity industries reduced costs, but the savings were not extensively shared with consumers (see, for example, Newbery and Pollitt 1997). And the introduction of competition has led to price differentiation among consumers. While the reforms provided some benefit to all consumers through lower prices, the greatest benefits went to shareholders and richer consumers (Waddams Price and Hancock 1998).

Chisari, Estache, and Romero (1997) analyze the distributional effects of utility reform in Argentina using a model that takes account of both consumer and investment expenditure patterns and the effects on incomes of changes in returns to capital and labor. They distinguish effective regulation (in which gains are diffused throughout the economy) from ineffective regulation (in which gains are retained by shareholders), but do not fully incorporate the disincentive effect of sharing on the size of achievable gains. They conclude that with effective regulation the overall distributional effect is progressive, while with ineffective regulation gains are smaller but much more evenly spread. In a later report, also based on the Argentine experience, Chisari and Estache (1999) point to the need to recognize the poor's limited access to credit and to the importance of coordinating regulatory, employment, and social policy and tailoring assistance programs for low-income or high-cost groups.

Price reform in Hungary did not worsen the distribution of income, indicating that the subsidies had been poorly targeted in the first place.

Other studies have also looked at the effect of potential price changes on households. Freund and Wallich (1995) show that subsidizing energy prices in Poland helps the rich much more than the poor, and recommend introducing prices that more accurately reflect costs and providing cash relief for the poor through social assistance or, failing that, a well-targeted and limited lifeline price for low consumption levels. In República Bolivariana de Venezuela Gutierrez (1995) concludes that prereform subsidies benefit the richest half of households and makes similar recommendations for mitigating the effects of reform on the poor. This study considers energy reform in a broad context, recognizing that low-income households would face increases in food, housing, and transport costs as well as energy prices. In this case general income support—rather than targeted energy subsidies—seems particularly apt. Newbery (1995) found that price reform in Hungary did not worsen the distribution of income, indicating that prereform subsidies had been poorly targeted.

Conclusion

Governments have traditionally used the energy sector for a variety of social ends—including ostensible efforts to alleviate poverty. However, the instruments used often resulted in poor sectoral performance and a truncated capacity either to expand improved services directly to the poor or to promote productivity improvements that could translate into better opportunities for the poor. The reforms that have been implemented in developed and developing countries are intended to remedy this poor performance. The effectiveness of their targeting mechanisms aimed at helping low-income households has varied considerably; whether the poor lose from the reform of such mechanisms depends in part on whether they benefited from them in the first place.

Most analysts agree that the best way to protect the poor is to raise their incomes—subsidizing particular goods and services introduces distortions in both consumption and investment, which is likely to harm the entire economy in the long term. But increasing incomes is itself fraught with risk, including new distortions in the labor market, a larger budgetary burden, and the failure of targeted assistance to reach those in need. In these circumstances it becomes crucial to consider "second best" policies, including the role of energy in the welfare of the poor.

Most reform programs face a tradeoff between increasing efficiency and protecting the poor. For example, proposed reforms in Russia in 1998 to fully recover the costs of providing housing and utilities would have increased the share of households spending more than 20 percent of their budgets on these items from less than an eighth to more than half (World Bank 1999). In analyzing different subsidy schemes in Central and Eastern Europe, Lovei and others (2000) show a clear choice between pricing distortion and effective coverage. The appropriate tradeoff in each country depends on the relative size of each problem and the availability of other means to alleviate the impact of reforms on the poor. Policymakers also face choices between the speed of reform and the impact on those previously receiving subsidies, with important consequences for both the social impact and the political sustainability of the reform.

Assessing the impact of energy reform on the poor and identifying ways to mitigate any possible harm requires information that remains unavailable for many countries. How are prices related to costs? Who gains from any cross-subsidies, and what efficiency losses do these cross-subsidies incur? If the potential efficiency gains justify reform, who is likely to lose as a result of physical or financial barriers to access to supplies? How will any price changes affect access and demand levels? Should the losers be protected and, if so, should the protection be transitional or permanent? What mechanism for targeting assistance is most likely to be effective in helping those who need it while distorting consumer prices and long-term investment decisions as little as possible?

In chapter 4 Vivien Foster explains a methodology for identifying both the effect of reforms on the poor and the appropriate policy responses, and details the information required. Every country undertaking reform needs information on energy costs and demand patterns to identify who is likely to be adversely affected by reforms, whether they need assistance, and what the most effective ways are to reach them without jeopardizing the potential gains of the reforms.

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4 Measuring the impact of energy reform—practical options

Vivien Foster

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. *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. *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 • Efficiency factors by fuel	• Unit cost by fuel	• Per capita subsistence threshold • Household expenditure by fuel • 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 • 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 • Efficiency factors by fuel	• Unit cost by fuel	• Capital cost of household energy use • Household expenditure by fuel		• Capital cost of household energy use
Economic burden	• Per capita subsistence threshold • Efficiency factors by fuel	• Unit cost by fuel	• Per capita subsistence threshold • Household expenditure by fuel • 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

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

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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New tools

5 Key drivers of improved access—service through networks

Stephen Powell and Mary Starks

Message from the editors

Unless energy can be produced and delivered more cheaply, it will stay beyond the reach of many of the poor. For energy delivered through networks, the costs that matter are not only the unit energy costs, but the costs of extending the network—into an urban slum, for example, or to a rural town. Extending a network can be very expensive—a major barrier to access for poor households and small or isolated communities. A central goal of the reform of electricity and gas networks, now occurring in an increasing number of developed and developing countries, is to provide incentives to reduce the costs of producing energy and getting it to consumers. New technologies in electricity are drastically reducing costs. But transmission costs are still a major hurdle to expanding networks in isolated or lightly populated areas. As a result it is the urban poor who stand the greatest chance of benefiting from network reform. For the rural poor, alternative solutions are required.

Electricity reform is based on the premise that market mechanisms supply electricity much more efficiently than central planning can.[1] But how will the poor, who have the least purchasing power, fare in a competitive electricity market? Will those without access continue to be denied it as electricity supply changes from a public service to a profit-seeking business? And will the poor who have access suddenly find it unaffordable?

One response to these general concerns is that a well-functioning power sector is crucial to macroeconomic stability and growth. It is precisely because poorly run, state-owned electric utilities have been such an impediment to growth that so many countries are trying to reform them. For those who believe that the best way to make the poor richer is to make everybody richer, that is how electricity reform helps the poor.

However, this chapter concentrates on the microeconomic effects: whether reform will make electricity cheaper for the poor who already have access to it, and provide it to those who do not. It analyzes the fundamental costs of generating electricity and distributing it through a grid to rural and poor populations. It describes how electricity reform and technological developments have reduced these costs in recent years and discusses institutional arrangements to ensure that lower costs are passed to customers. It examines whether reform will increase access to electricity for poor households and comments on policies to further the interests of the poor in the context of electricity reform.

Generating and selling electricity: what it costs

The provision of electricity through a grid involves four functions:

- *Generation:* converting primary energy into electricity.
- *Transmission:* the high-voltage, long-distance transport of electricity.
- *Distribution:* the low-voltage transport of electricity from the high-voltage system to the user.
- *Supply:* the selling of electricity to users—metering, billing, and so on.

This chapter's main concern is with reform of the transmission and distribution systems—"the grid"—but it also discusses the innovations in electricity generation that made reform possible.

Box 1 summarizes the cost characteristics of the four functions.

It has been estimated that in England and Wales generation accounts for about 65 percent of the total cost of electricity, transmission 10 percent, distribution 20 percent, and supply 5 percent (Newbery and Green 1996). These proportions vary in different systems. In particular, the start-up

Box 1 Cost characteristics of electricity provision

Generation

The costs comprise fixed capital costs and variable operational costs including fuel. Because each type of plant has a different balance between fixed and variable costs, for each type the optimal size—giving the maximum economies of scale—is different.

Transmission

Transmission costs cover building and maintaining the transmission system and operating it (dispatching plant and maintaining voltage and frequency within predetermined limits).

The cost of building and maintaining the system depends on physical factors such as its size and the terrain. The cost of extending it depends on the expected peak demand, but once the grid is built, the cost is sunk and so does not vary with the number of users or the volume of electricity transmitted. The high fixed costs make it unprofitable for more than one transmission system to compete in an area.

Furthermore, the technicalities of minute-to-minute balancing of supply and demand together with the high cost of system failure mean that the natural monopoly extends over the whole integrated system.

Distribution

As for transmission, the high fixed (and low variable) costs depend primarily on the physical coverage of the system (both distance and terrain) and the level of local peak demand.

However, because the operating function is much simpler (it does not involve generator dispatch), the economies of scale are not as great. A country that supports only one transmission system can support a number of (non-overlapping) distribution systems.

Supply

Many supply costs, such as bad debts and the costs of payment collection, vary with the number of customers. These costs are disproportionately high for low-income households, which are more likely to experience payment difficulties and suffer disconnection.

But some supply costs are fixed: once supply has been extended to a village, the extra cost of reading another meter in that village is low.

Supply costs vary with the distance of customers from the nearest demand center. The more remote and dispersed the customers, the more expensive it is to administer meter reading and bill collection centrally.

costs of a grid are high and fixed, which means that grids have big economies of scale, in terms of both the number of households connected and the amount of energy transmitted. Thus for grid systems in developing countries, one might expect transmission and distribution costs to be a greater proportion of the total.

There are two key points here. First, physical factors make the fixed costs of transmission and distribution particularly high for grid extensions to remote rural populations. The population density in rural areas is typically low, which means that the fixed costs are shared among relatively few people.

Second, the poor tend to have very low demand for electricity, which means that the average cost per unit consumed will be high because the fixed costs are divided among few units. Furthermore, for the rural poor, this demand tends to be concentrated at peak times (mainly in the evenings as people switch on lights). Since the fixed costs of transmission and distribution depend in part on peak demand, this demand pattern results in still higher costs for poor rural populations.

These points are illustrated in table 1, which gives indicative figures for the relative distribution costs of connecting different numbers of rural households at different distances from the transmission system. The central column shows the unit costs of distribution. The right-hand column shows the unit costs including generation and high-voltage transmission.

As the demand for electricity increases, the fixed costs can be spread. In developing countries, however, it takes time for demand to grow once access is provided: people have to wire their houses and buy electrical appliances before they start to buy electricity. Demand for electricity entails both a switch (not necessarily complete) from other fuels for cooking, heating, and lighting and new demand for electrical appliances such as televisions. Over time, as incomes rise, loads will increase, and load factors will also rise as people buy appliances with constant loads such as

Table 1

Effects of line length and consumption levels on the relative costs of electrification in Indonesia (U.S. cents per kilowatt-hour)

Cost component	Unit cost by component	Total unit cost
Generation and transmission	10	
Medium-voltage extension and low-voltage distribution		
3-kilometer spur line, 20 households	45	55
3-kilometer spur line, 50 households	20	30
1-kilometer spur line, 20 households	15	25
1-kilometer spur line, 50 households	7	17

Note: These costs are indicative averages for most developing countries with relatively flat terrain. A few countries are now adopting new, lower-cost network designs.
Source: World Bank 1996, p. 50.

refrigerators. However, this progression is difficult to predict and therefore the returns to investment in extension of electricity grids to rural and poor people are uncertain.

To summarize, providing access to electricity for low-income households—in particular the extension of the grid to rural areas—depends critically on the balance between the fixed and variable costs of transmission and distribution. The fundamental cost characteristics of grid provision do not favor the provision of access to rural and poor populations. Can reform make any difference?

Buying electricity: why it is getting cheaper

The recent wave of electricity reform was facilitated by innovations in technology.

Generation

Until the 1980s the electricity industry was viewed as a unified natural monopoly that produced and delivered electricity. For decades economies of scale had increased in electricity generation, reinforcing the view that it was a natural monopoly.

In the 1980s improvements in turbine technology were imported from the space program and materials science and the price of gas fell (in part because of gas market liberalization in developed economies). This had a radical effect on the economics of generation: the fixed cost of installing a combined-cycle gas turbine (CCGT) plant in the early 1990s in the United Kingdom was around US$600–650 per kilowatt, compared with US$750–800 for oil-fired plant, US$900–1,200 for coal plant, and US$2,250 for nuclear. Falling gas prices reduced the variable costs as well.[2]

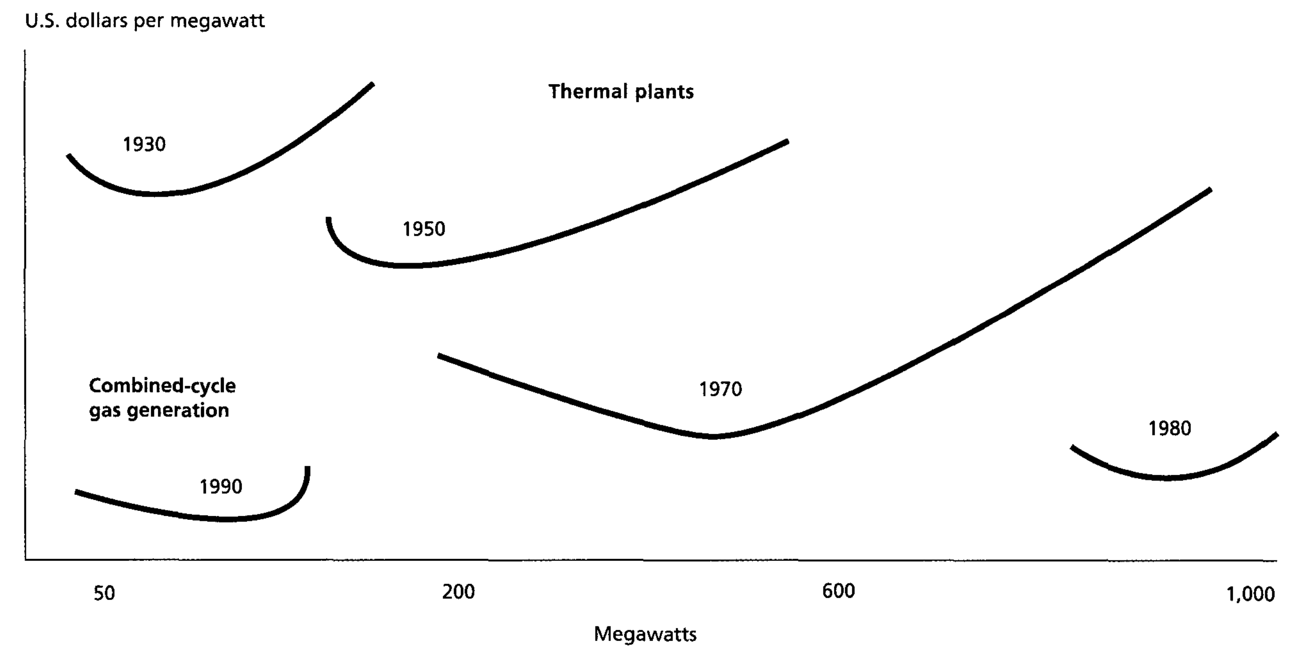
Combined-cycle gas generating units of 50–100 megawatts could by the 1990s be built and run economically—at one-tenth the size of the thermal plants (1,000 megawatts or more) of the 1980s (figure 1). This meant two things. First, generation could be a competitive activity even in relatively small electricity systems. Second, developers other than the state monopoly utility began to want to build power plant—large industrial users as well as independent power producers (IPPs).

Competition and private participation have had further effects on costs. Rather than buying equipment from a favored national supplier, as state-owned monopoly generators had done, new entrants import it if that means lower cost. In turn, this has increased competition between equipment manufacturers, and thermal efficiency has increased, further pushing unit costs down. The thermal efficiency of CCGT stations is now nearly 60 percent (compared with 30 percent or more for other thermal stations), and the cost of installing the latest CCGT technology is now about US$375–450 per kilowatt.[3]

Thus generation market reform should cut costs and reduce prices for customers. Following the introduction of competition in generation and the establishment of a bulk power market in Argentina, bulk electricity prices have fallen fairly consistently (figure 2).

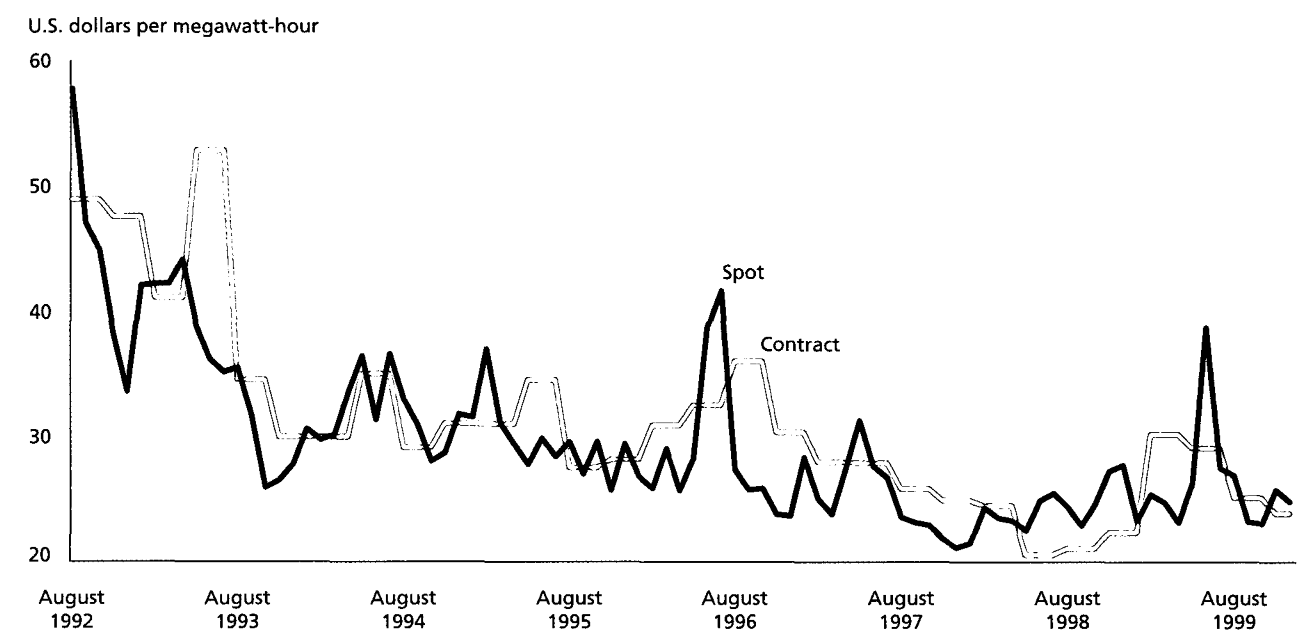
In other cases there have been difficulties, however. In England and Wales, for example, anticipated reductions in bulk electricity prices failed to materialize after competition was introduced and the bulk power market established, even though primary fuel prices were falling (figure 3). This has been blamed on the manipulation of bulk power prices by the larger generators. In other words, competition was not fully functioning. Trading arrangements intended to eliminate such behavior are planned.

Figure 1 **Cost curves showing optimal plant size, 1930–90**



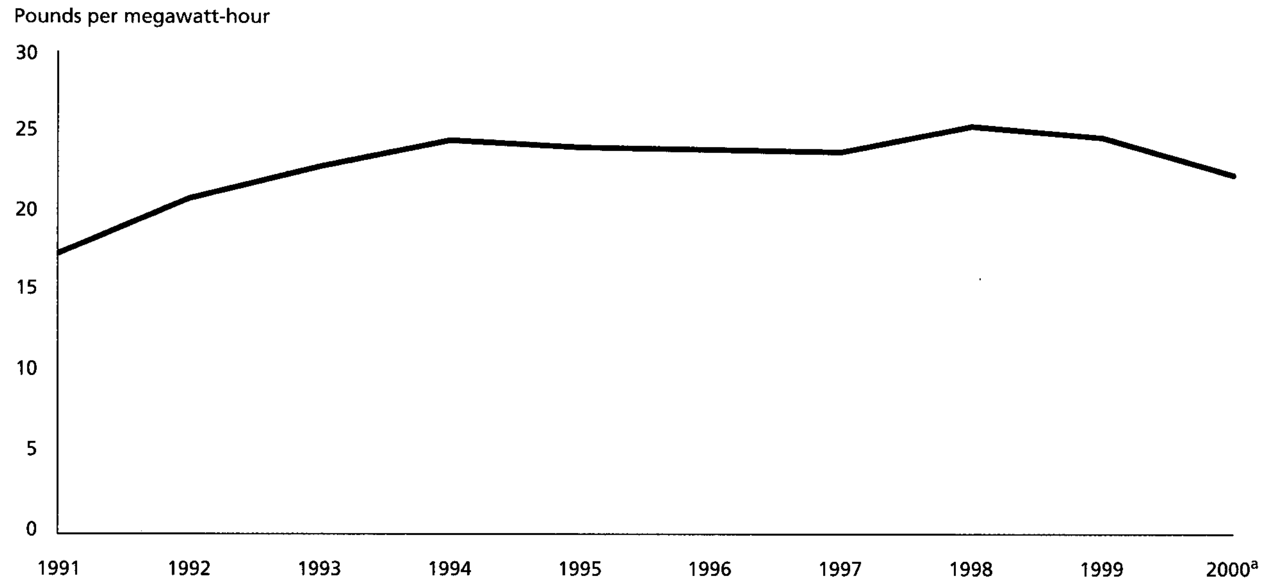
Source: Hunt and Shuttleworth 1996.

Figure 2 **Bulk electricity prices in Argentina, 1992–99**



Source: CAMMESA 2000.

Figure 3 **Average annual demand-weighted Electricity Pool of England and Wales purchase price, 1991–2000**



Note: The years refer to fiscal years, ending in March.
a. Average for April to October 1999.
Source: Electricity Pool of England and Wales 2000.

Some developing countries have also had difficulties in harnessing the full benefits of IPPs. A key question in generation reform is how to set up a bulk power market that delivers the benefits of reduced costs while still attracting private investors. Offering long-term power purchase agreements to IPPs attracts investors, but the greater the security (in terms of guaranteed purchase volumes and prices) offered by the contract, the less sharp the incentive for cost reduction and the less scope for the power purchasing agency to adjust its purchasing to achieve least-cost dispatch.[4]

To ensure that the full benefits of competitive generation reach customers, it is necessary to introduce competition in supply. If supply is provided through the local monopoly distribution company, customers cannot shop around for cheaper electricity. The monopoly distribution company can shop around, but has no incentive to do so as it can pass on generation costs to its captive customers. However, competitive suppliers will need to purchase power as cheaply as possible, thus ensuring that lower generation costs are passed to retail customers.

Transmission and distribution

Having recognized that the electricity industry comprises a number of distinct functions, governments have begun to separate transmission, distribution, and supply.

While transmission and distribution have in many cases been separated, and distribution split among a number of companies, both functions retain their natural monopoly characteristics in any one area because of their high fixed costs. However, the introduction of private participation through competitive tendering for concessions (to identify the least-cost provider) has captured many benefits in terms of lower costs.

Increased competition in the equipment markets has reduced the price of many of the fixed cost components. Installation has also proved cheaper when done by private contractors rather than utility employees.[5]

More generally, the private sector is simply more efficient as a consequence of its profit seeking. For example, when private distribution began in Buenos Aires there was a dramatic reduction in theft. Since theft was particularly prevalent in slum areas, this reduction in theft cut the difference between the cost of supplying these areas and the electricity tariff and enabled the distributor to supply slum areas with reduced subsidies (Albouy and Nadifi 1999).

Equipment costs can also be reduced by relaxing equipment specifications and adopting international standards. In the United Kingdom, for example, over the past five years the cost of electric plant in real terms has fallen by 10–15 percent (Fairbairn 2000).

However, transmission and distribution remain local or national monopolies. This means, first, that incentives to reduce costs are not as sharp as they would be under competition (although the profit motive supplies some incentive), and second, that savings that are made will not be freely passed to consumers. Therefore, where these monopolies are privately owned, regulation is necessary.

Incentive-based regulation, such as the CPI–X price cap methodology, involves a balance between giving utilities the incentive to reduce costs and ensuring that cost reductions are passed to the consumer. The utility keeps some of the savings, but must pass the rest to the consumer.[6] In the United Kingdom incentive-based regulation has been broadly successful in reducing prices to domestic consumers, even though bulk prices have not fallen (figure 4).

Supply

The potential for competition in supply, which, with relatively low fixed costs, is not a natural monopoly, has been recognized and is being acted on in many countries (partial opening of the market to supply competition is a requirement of the European Union directive on the single market for electricity, for example). As a result of competition, in the United Kingdom the cost of meters has fallen by 39 percent over the past five years.

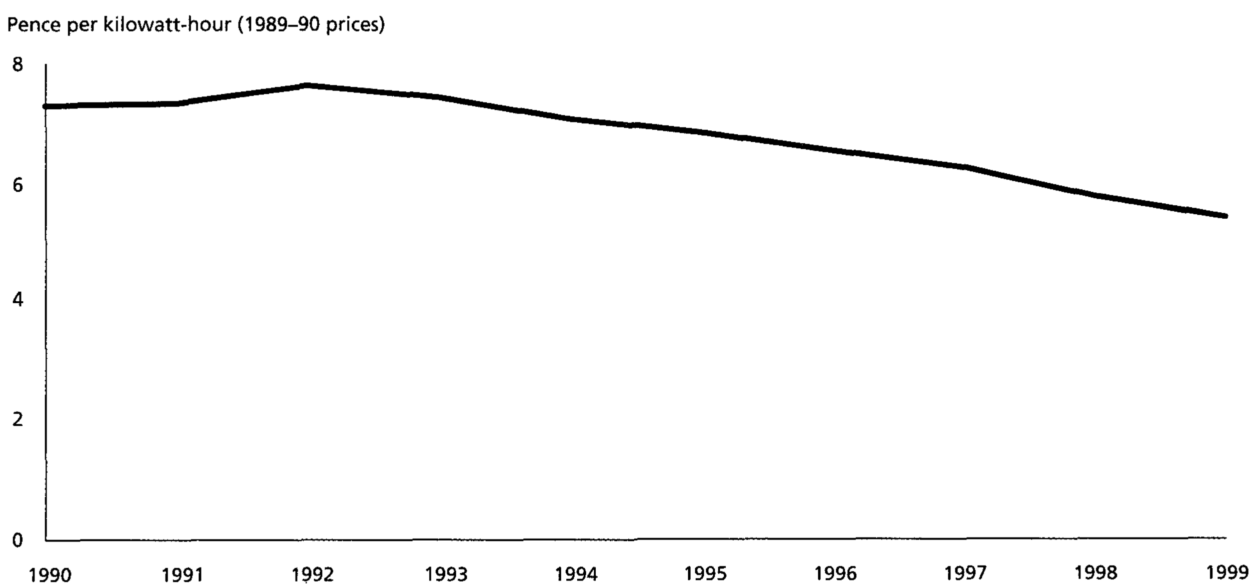
However, competition in supply is so far confined largely to more developed markets, where companies can offer a number of supply services (such as electricity and gas) together and can differentiate themselves by service quality and brand. In developing countries the costs of supply can be reduced in other ways, notably through increased local involvement. Employing someone to read meters in a village is cheaper if that person does not have to travel a long distance from the nearest town. Local participation in bill collection and maintenance can also be effective. For example, in Bangladesh locally managed cooperatives buy power from the grid and distribute it locally. They have a better record on billing, maintenance, and reducing losses than that of the main power utility in charge of urban distribution (World Bank 1996).

Electricity for the poor: does cheaper mean better?

Cheaper generation has reduced the total cost of providing electricity. That should mean lower prices for the poor who are already served by a grid. Reductions in the fixed costs of transmission and distribution equipment, and innovations to reduce the costs of supplying remote areas, improve the prospects that grids will be extended to rural areas.

However, there are two important caveats. First, for the poor to benefit, lower production costs must be passed on as

Figure 4 Electricity price for standard domestic tariff customers in the United Kingdom, 1990–99



Note: The years refer to fiscal years, ending in March.
Source: U.K. Department of Trade, Statistical Office 1999.

lower prices. In many developing countries tariffs have risen following reform as subsidies have been withdrawn (despite cost reductions). In many respects this benefits the poor,[7] but it does make access to electricity less affordable. One solution is to direct electricity subsidies much more precisely to the poor, for example, through the introduction of lifeline tariffs.[8] More generally, the design of the tariff system is crucial in determining how the benefits of electricity reform (in terms of lower costs) are distributed among different customer classes. If electricity reform is to benefit the poor, tariff policy must be designed with their needs in mind.

Second, the fixed costs of transmission and distribution equipment have not fallen enough to make it profitable to extend the grid to all areas. Given the huge difference between cost of supply and (socially or politically) acceptable tariffs for some rural populations, extensions of the grid to these people must be subsidized if they are to happen at all. There are two ways in which this can happen: within the utility by cross-subsidy from profitable customers (under an obligation to extend service) or with subsidies from outside the utility, for example, from a rural electrification fund.

Conclusion

Reform of grid-based electricity provision will not revolutionize access by the poor. The cost structure of grid provision, so unfavorable to extending access to rural populations, is not fundamentally altered by electricity reform. However, reform unambiguously moves the overall level of costs in the right direction. At the margin, cost reductions imply both increased affordability of grid services and increased viability of grid extensions. As long as the introduction of competition and profit-seeking private participation is combined with regulation and tariff design that is sensitive to the needs of the poor, electricity reform is a positive step.

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Notes

1. Reform of grid-based energy services has concentrated on the generation and distribution of electricity. Electricity networks are far more extensive than gas networks in most parts of the developing world and reform of gas networks has been less widespread. This chapter therefore discusses electricity reform, although many of the important points apply to both industries, given the parallels in terms of network economics.

2. Although the widespread adoption of CCGT as the new technology of choice was linked to the fall in the price of gas, the technology can run on diesel. This discussion therefore also applies to countries with no access to gas.

3. The cost estimates are from Richard Fairbairn of PB Power Ltd.

4. For a more detailed discussion of this issue see Bacon 1995.

5. This is one reason why employment in the electricity industry has fallen dramatically following reform. This is a controversial social effect of reform and one that has direct implications for the poor. However, the subject is beyond the scope of this chapter.

6. CPI–X achieves this by fixing allowed prices for a given period, during which the utility can retain the profits arising from any cost reduction. At the end of this period the price cap is reviewed to ensure that over the long term the benefits are passed to consumers.

7. Since energy subsidies are a larger proportion of GDP in many developing countries and benefit the well-off more than the poor (because the well-off use more energy, particularly electricity), reductions in subsidies will tend to benefit the poor in fiscal terms, particularly if the funds are redirected toward social policies. For further discussion of energy subsidies see World Bank 1996 and International Energy Agency 1999.

8. Lifeline tariffs essentially involve subsidizing electricity only at the very low levels of consumption typical of poor households. The subsidies apply to very small amounts of electricity and do not cost too much. This policy has been successful in Thailand; see Tuntivate and Barnes 1997.

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6 Key drivers of improved access—off-grid service

Eduardo Villagran

Message from the editors

For the foreseeable future the prospects of better energy services for many of the poor will depend not on the wholesale expansion of electricity and gas networks, but on finding better, cheaper off-grid energy sources. In rural areas and city slums ways must be found to bring down the costs of cleaner, more reliable fuels and the costs of doing business in supplying and serving poor communities. Poor communities and households need help in making informed choices between energy services and may have to take collective action to secure them. Financing hurdles for consumers on the margins of the cash economy must also be overcome. Both technological and commercial innovations are needed—to bring down the costs of producing energy and of financing and managing services. While there are many promising developments, the costs of implementing innovative off-grid projects remain high, and the challenges of scaling up are daunting. In this context, two government roles are likely to be critical. First, reforms are needed not only in energy networks but in the broader energy markets on which many of the poor rely. Second, the use of subsidies must be improved in ways that encourage innovation.

What would a well-developed market for off-grid energy services look like? It would offer an array of energy solutions to meet (mostly rural) consumers' needs—standalone photovoltaic systems, battery charging stations, minigrids powered by sun or wind, and isolated systems based on diesel, hydropower, and biomass. It would supply natural gas, propane, and kerosene for heat and refrigeration, and diesel and gasoline for productive uses. Households and entrepreneurs would have access to accurate, easily grasped information on products. Local shops would sell replacement parts and services. Vendors and developers would have access to accurate, current data on customers and their location, organizations, grids, solar radiation, rivers, topography, and wind speed and direction. They would have simple, robust analytical tools for selecting technologies. Prices would be set freely, and vendors would be able to use financing mechanisms to spread capital costs over much of the useful life of their investments. Energy goods and services would become commodities bought and sold at the local store, and governments and donors would have flexible means for supporting consumers' choices through subsidies and other assistance.

Nowhere have such markets yet been created—with organizations operating on a level playing field and collectively driving the process of electrification. Decisions on off-grid provision are still largely dominated by governments, donors, and nongovernmental organizations (NGOs). But there has been much experimentation with methods of delivering off-grid service, particularly in the electricity sector (the primary focus of this chapter). These experiments cast light on the key factors that could drive service improvements in rural areas in the future: technological advances that reduce costs and increase ease of use and maintenance of small-scale electricity systems by households and communities; organizational innovations that help communities choose, implement, and maintain improved systems; and innovations in financing—with or without the aid of subsidies—that help poor households over the hurdle of high capital costs for new services. This chapter describes some of these innovations, and the role they could play in extending access to electricity beyond the reach of grids.

The off-grid market in the post-privatization era

Electricity sector restructuring tends to center on existing grid distribution systems, their electricity supply, and the rights and obligations of their customers. Any effects on actual or potential off-grid customers—who would use different technologies, supplied by new market players—tend to be accidental. In reality, opportunities for improving services through market reforms are not restricted to the grid-based part of the energy sector. Off-grid, too, there is potential for reforms to spur innovation in the design, delivery, and financing of energy services.

The central planning-type approach by governments and donors to technology selection does not work.

Off-grid markets pose serious challenges. Distance from existing lines, dispersion of potential customers, and low energy consumption make access to electricity service through grid extensions more difficult, regardless of who owns distribution utilities. Private utilities will not build unprofitable lines unless explicit subsidies (or embedded cross-subsidies) more than compensate for any financial loss over the life of the project.

That being the case, reform programs should include improved access to electricity service for potential customers, regardless of their location with respect to the grid, in a way that is consistent with a more competitive market structure, private participation, and independent regulation. The challenge is to understand the limits of grid expansion—particularly when initial investment may be focused on rehabilitation rather than network build-out—and to ensure an incentive structure and demand drivers that will allow alternative suppliers to compete to serve the unconnected.

This goal raises some difficult questions for the policy designers who will have to structure markets that lead to the right solutions, perhaps including subsidies:

- What technology is most appropriate for bringing electricity service to a given population? What are the costs and benefits of the options, and how should the choice among them be made?
- If the electricity service differs in quantity and quality from grid electricity, how does this affect consumer satisfaction? How does it affect the demand for electricity and for other energy sources?
- A distribution utility, with professional management, may not be involved in delivering off-grid electricity service. Who is going to introduce, operate, maintain, and repay the costs of the institutions and technologies for service provision?
- Off-grid electricity sources tend to have much higher capital costs than grid service. How are these to be financed, given the limits of short-term credit and the low incomes of most who live off-grid? Many off-grid electricity sources have a long useful life, but their installation must be amortized over much shorter terms.

Technology drivers

By contrast with grid-based supply, the technology options off-grid are highly varied—in generation technique, in cost characteristics, and in the kind and quality of electricity service delivered. As noted, governments and donors still make most decisions about which off-grid technologies to use. Their decisions are generally based on four main criteria:

- *Kilowatt-hour per kilometer of line.* Consumption density is used as a criterion for deciding whether to build a line. The decision threshold must be adjusted to reflect prevailing net revenues and line construction costs.
- *Distance from the line.* Where density, consumption, and construction costs are similar, planners use distance from the line as a rule of thumb.
- *Least cost.* Some algorithms estimate the cost of providing a kilowatt-hour to consumers using different technologies under different conditions. Tables have been prepared comparing line extensions with diesel systems for varying distances from the grid and different numbers of customers, for example. While useful, these tables need to be continually updated. Moreover, they tend to ignore differences in quality between off-grid sources and fail to take full account of the potential benefits from each source.
- *Highest net economic benefit.* Estimates of net economic benefit take into account quality differences between energy sources and compare their potential benefits. But they must be prepared for every project by qualified personnel and are expensive.

In practice, the most basic rule of thumb in rural electrification is to try to make the off-grid market as small as possible. If governments, NGOs, and donors can put a community on the grid, they try to do so. The cost per customer ranges from US$250 upward. At US$10,000 per kilometer of line, a village of fifty users 3 kilometers from the grid will begin hitting the "photovoltaic ceiling," about US$650 per customer (including installation and some training). At 5 kilometers, a village that size should seriously consider the photovoltaic option. If the wind blows hard—say 8 meters a second—it might consider windpower, but the right conditions are rare.

Small hydropower plants pose unique difficulties. Their energy production is determined by turbine size (and water flow, of course). Say 50 kilowatts are installed to serve a village of 200 people. First the line must be built from the plant to the village. Then the minigrid must be installed. But the real problem is that demand peaks at 7:00 p.m., when almost all 50 kilowatts are used, but at 3:00 a.m. the demand falls to 10 kilowatts or less and stays that way until the noon peak. As a result the plant capacity factor is extremely low, maybe 30 percent, but all 50 kilowatts must be paid for, at about US$1,500 per kilowatt plus the grid and the line—this could be as high as US$600 per user or as low as US$250. Then the community grows and needs an expansion, or demand increases and another unit has to be added. Small hydro plants are a rigid option. Still, when conditions are right, they are a possibility.

Photovoltaic costs seem to have leveled off, casting doubt on the long-term potential of this market premised on continual cost reductions. Still, many experiments are under way (see chapter 11). One is to use smaller panels, say 35 rather than 55 watts, to reduce the cost. Other ways to cut costs are to make batteries smaller and to omit controllers, unnecessary for occasional use though risky for the longevity of the battery. Another option is to pair off customers, for example, having some charge their batteries at their neighbor's on alternate days. But the essential condition is very low consumption, no more than a couple of lights and a radio. These are more organizational arrangements than technical drivers, but a smaller, less expensive panel, a fuse-type control, and a smaller battery could certainly lower the photovoltaic ceiling in some cases, perhaps to US$450 for a 55-watt system. (There is some regional variation in prices and in average system sizes.)

By contrast, there is no apparent way to make wind or hydro systems any cheaper, though connecting them to the grid opens new possibilities.

The central planning–type approach by governments and donors to technology selection does not work in most places. Customers and service suppliers are not consulted in any meaningful way, there is no strong sense of ownership of projects, and users lack an understanding of the true costs of supply. As indicated below, the government should allow customers and service companies to make the technology decisions, while it assumes a facilitating role. They may continue to use the same selection methodologies or they may devise new ones. The key change required is that providers and consumers decide.

Technology meets demand—learning to live with what you have

Technology selection should mesh with willingness to pay and service requirements. Off-grid electricity—except that from twenty-four-hour diesel systems and overdimensioned hydroelectric or biomass plants—differs from grid electricity in that consumption must be actively adjusted to the supply:

- Some systems provide service for only a few hours a day and thus would not allow refrigeration and other continuous or off-peak electricity uses. Households and businesses would use kerosene or propane for cooking, and fossil fuels to power productive equipment.
- A mini-hydro plant either supplies insufficient power to meet peak demand or has excess capacity off peak. So consumers must ration their electricity or develop uses for off-peak supply to ease the financial burden.
- Wind- or solar-powered minigrids require an expensive bank of batteries, which puts a financial cap on the system's capacity. Electricity service is often limited to fluorescent lights, radio, and television, and mechanisms are needed to prevent excessive consumption by any users.
- Photovoltaic systems give users the service provided by one or two batteries of 6 or 12 volts, 110–115 amperes. That limits uses to basic lighting and some electronic equipment.

Electricity differs in quality from other types of energy. Small amounts are enough to power a radio, a television, sound equipment, and, in some cases, even a cellular phone and a laptop computer. Because other energy sources cannot substitute for electricity in these uses, its economic benefit is higher than in cooking, heating, and pumping water, for example (Villagran and Orozco 1988).

Consumers with grid electricity have "the benefit of opportunity," the convenience of instant, unlimited availability. But consumers with access to very limited amounts of energy from such off-grid sources as photovoltaic panels or wind-powered battery charging stations are forced to rationalize their use of electricity, using it where it tends to generate higher relative benefits. The amounts of electricity supplied by these sources are so small, however, that the tradeoffs between competing uses are often painful.

A variety of energy sources can be used to meet off-grid communities' energy needs. Lighting and some electronics might be powered by photovoltaic systems, while refrigeration and cooking depend on propane or kerosene. Markets for alternative energy sources such as propane and kerosene can be stimulated in parallel with limited-supply electricity sources. In many countries the development of such markets is blocked by government interventions to subsidize prices and control quantities (box 1).

Organizational drivers meet demand—choice in implementation, operation, and maintenance

Whether a rural community or household gets an energy service well targeted to its needs and preferences depends not only on the availability of suitable technology, but also on the presence of institutional arrangements that provide

Box 1

Developing the market for liquefied petroleum gas

The global supply of liquefied petroleum gas (LPG) is about 120 million tons a year, or 3.3 million barrels a day. (The global oil supply exceeds 75 million barrels a day.) The LPG supply chain—from the relatively concentrated production sector to the highly fragmented distribution sector—grosses more than US$50 billion a year.

LPG is a blend of hydrocarbons heavier than natural gas but lighter than refined oil products such as gasoline and kerosene. Typically, it is a blend of propane and butane that is gaseous at normal pressure but liquid when modest pressure is applied. About 80 percent of the world's LPG is sold in the familiar metal cylinders—in most emerging markets it is referred to simply as "bottled gas."

LPG is a by-product of two very different oil and gas production processes. Oil companies and state-owned enterprises account for about half the sales of LPG to final customers, and independent marketers—often very small businesses—for the other half. This fragmentation has resulted in a lack of standard business practices. So customers cannot always be sure that the LPG bottle they buy has been properly filled, contains LPG with the right energy content, and is not defective.

In developing countries, where LPG is in most demand as a cooking fuel, the market faces two main challenges. First, both the sale and consumption of LPG requires special infrastructure. Consumers must invest about US$20 to buy the cylinder, a significant outlay for many households. Governments need to assess whether this up-front cost shuts some households out of the market, and how they could ease this initial transaction.

Second, because LPG is perceived as largely a household fuel, most governments subsidize its price and control quantities. The resulting market distortion tends to reduce the availability of LPG. When governments try to maintain different prices for different classes of consumers, they magnify this distortion. And because world LPG prices track world oil prices, government attempts to regulate LPG prices often impose large fiscal burdens.

To realize the full promise of LPG, governments should:

- Deregulate oil product and LPG prices, to relieve themselves of potentially huge fiscal burdens and allow a real market to develop.
- Pay more attention to standards and business practices, so that consumers perceive the LPG market as fair, safe, and reliable.
- Alter the business environment in ways that allow LPG supply, marketing, and services to flourish. A strong market would inspire a shift in the business strategy of the big LPG producers—from regarding LPG as a nuisance to seeking to market the product as a value added service.

Source: Manley 2000.

incentives for technological innovation and for tailoring technologies to local circumstances. In theory, an electric utility, like any other company, would use whatever technologies are available to serve as many customers in its territory as possible. In practice, distribution utilities are largely run by line builders and consider solutions other than grid extension expensive and unreliable.

Competition for the market to connect new customers might encourage distribution utilities to become more innovative in the service delivery options they offer. That requires a market structure that allows open entry—a free-for-all to hook up new customers. Regulation would focus on simple rules (open licensing procedures, standards) and on minimizing transactions costs (through provision of standardized documents, tariff and business models, and access to information).

Such a market would probably give rise to new organizations, competing for their share of the off-grid electricity service market. In this complex, largely undeveloped market new organizations would be shaped by the effective demands of consumers and the actions of governments and donors. Where the market is better developed, with more—and wealthier and more educated—customers, stronger, more sustainable service providers would probably flourish. In the early stages of market development in poorer, illiterate regions, there is a risk that unscrupulous suppliers might make a killing by selling expensive systems that work for only a short time. This early phase would call for increased consumer education.

A range of organizations now offer off-grid electricity service.

Photovoltaic service companies

Some private companies and NGOs supply, install, and maintain photovoltaic systems in exchange for a periodic payment. Most are heavily subsidized by governments and donors. It is expensive to inspect and maintain small, dispersed systems and collect payments from their users. But the arrangements used allow the companies to amortize the panels over a period closer in length to their expected useful life, which is supposed to be thirty to forty years, rather than five or ten. In Guadeloupe and Martinique, for example, a French energy company, TOTAL Energy, supplies photovoltaic systems with one, two, or three panels, depending on demand, and charges users per kilowatt-hour. Customers use a prepaid card to purchase the number of kilowatt-hours they want, buying another card when they have used them up. In a sense, they are purchasing metered electricity. (In other photovoltaic mini-grids used elsewhere, fuses are used to limit energy use by any one customer.) TOTAL Energy grids remain heavily subsidized by the French government. It is hard to see how the company, charging US$5 a month, could cover its interest payments, much less any operating and maintenance costs, so it is not yet clear whether this concept is ready to fly.

Most off-grid systems have a long life, their initial cost is high, but finance is only short term.

Village committees

A model being used in many countries for stand-alone photovoltaic, mini-hydro, and even diesel systems—with mixed success—starts out with a village committee lobbying for access to electricity service for its community. Once a system is in place the committee operates and maintains it, collects payments or replacement charges, amortizes credits, and procures replacement parts. Committees are rarely formal legal entities, have idiosyncratic decisionmaking methods, and own no assets. Sometimes they lack the authority to enforce their decisions and are subject to pressure from influential citizens, especially relating to payments. Their members—ordinary citizens—may be poor administrators. And some users of the service may be unwilling or unable to participate. But committees are easy and inexpensive to organize and run, they tend to be legitimate representatives of their communities, and they can work even if not all users participate.

Local vendor representatives

Some photovoltaic vendors use local agents to perform basic maintenance and encourage adequate battery replacement. These agents also troubleshoot and give advice. Although their fees add to the cost of the systems, they provide a local presence and a better understanding of local needs and problems. With subsidies and assistance from the German government, photovoltaic system vendors in Senegal operate through local electricians, who sell, install, and maintain systems. A sizable, private, largely unregulated photovoltaic industry has developed in Kenya (see chapter 11).

Rural electric cooperatives

Cooperatives are typically developed to operate and maintain larger systems, especially isolated mini-hydroelectric or diesel-based systems. They require a willing attitude among most of the users and intensive organizational development and training. Their capitalization systems may not be flexible enough to reflect their members' willingness and capacity to contribute. But they provide a formal legal structure, have well-defined administrative and accounting procedures, tend to be self-regulating, and use democratic decisionmaking.

Cooperatives have not worked everywhere. But the international experience suggests that they can thrive where government policy explicitly carves out a niche for them (and does not allow incumbent utilities to discriminate against them) and people have the willingness to cooperate.

Rural energy corporations

Rural energy corporations are private companies formed to own and operate large isolated systems based on diesel or mini-hydroelectric plants. They range from a few partners to broad-based corporations. Compared with other rural energy organizations, they are more expensive to develop and require greater managerial sophistication and more centralized decisionmaking. But they have a formal legal structure, well-defined administrative and accounting procedures, and flexible capitalization mechanisms.

The Roatan Electric Company in Honduras, a broad-based corporation formed by 95 percent of the system's 5,000 users, has owned and operated a 6-megawatt diesel system since 1992. This small utility needed significant technical assistance and capital subsidies from the government to get started. But it is now sustainable—thanks largely to the wealth and managerial acumen of its customers and the skilled support of the many diesel operators and mechanics who work on Roatan's 300-boat fishing fleet.

The financing problem

While most off-grid systems have a long life, their initial capital cost is high and they can usually be financed only over short terms.

Countries are exploring several solutions to this dual financing problem. Two broad, and potentially complementary, approaches are possible. One is to subsidize service provision in some way (for more on subsidy design, see chapter 7). The second is to facilitate the extension of credit for new services through the finance market or through financing options offered by the service provider.

Subsidizing capital costs

Often governments subsidize the capital cost of systems, sometimes at 100 percent. A variant is to subsidize terms and rates for the financing of systems, which requires a continuous injection of funds. In another scheme, the off-grid utility concept, a private corporation sells the service provided by home photovoltaic systems for a monthly fee, which may be subsidized. Yet another option is to require a sizable down payment, but this can put the service out of reach for much of the rural population.

While rural households usually spend US$3–10 a month on alternative energy sources, some high-income rural households are willing to pay as much as US$50 a month. It is possible to "skim off" the market and serve these high-income users, even though they are few and far between. But solving their electrification problems may not do much for the problems of the majority.

In principle, subsidies to make service more accessible to users should be one-shot deals, not long-term support. Dependencies have a way of perpetuating themselves. The question is how to quantify and allocate subsidies.

The best and most common criterion for allocating subsidies is minimum subsidy per user. This criterion promotes both least-cost technology and maximum leverage. It is also best to have a ceiling on subsidies given by the project's economic net present value. While in theory a criterion of maximum net economic benefit has the most merit, in reality engineering cost estimation is much easier. And since the benefits of the first few kilowatt-hours—lights, a radio, a television—are similar for all technologies, least cost is an adequate criterion in small rural systems.

The mechanism for giving out subsidies through the market system must be founded on clear guidelines on who can benefit and how. It should be as open as possible so that anybody can apply for a subsidy—a utility wishing to serve some of its customers using photovoltaics, an individual user, a vendor, an association, a committee, or a developer. The process should be decentralized, open, and competitive.

In a competitive system the agents requesting the lowest subsidy per customer, including any organizational development and training, would be selected. In a system of pure competition the identification of customers, the selection of technology, and the process for setting prices would all be left to the market (the buyers and sellers), and the potential customers with greater willingness to pay and lower costs would get connected first. This system encourages innovation and participation. But it will inevitably have implications for regional development and poverty. These will need to be addressed in ways that do not undermine innovation and participation.

The subsidy mechanism should be open so that anyone can apply—a utility, a customer, a vendor, a community, or a developer.

Improving financing terms

Most subsidy schemes focus on the absolute level of capital costs involved in implementing either off- or on-grid systems and on their affordability to customers. But the term of available financing for these systems may also be a problem. Small hydroelectric plants should last for fifty years, photovoltaic panels for thirty to forty, and wind generation systems for at least thirty, but commercial financing is available for ten to fifteen years—at around 12 percent at best—to large photovoltaic developers. That contrasts sharply with the forty-year terms and 2 percent interest rates applied by the Rural Electrification Administration to develop rural grids in the United States.

Some thought has been given to creating guarantee funds for the residual value after a more conventional financing term has expired. By way of illustration, assume that most rural users can pay about US$5 a month. With 12 percent financing, the repayment period for a photovoltaic system costing US$500 would be a little more than twenty-six years, a term at which money is rarely available. After fifteen years, a more reasonable term, only about US$120 would be amortized and the rest would have to be refinanced. A guarantee fund would allow developers and vendors to get credit at normal terms and rates but with low amortization payments. At the end of the term there would still be a significant residual value to be refinanced. The fund would guarantee this residual value from the start, allowing financial institutions to secure the loans. Developers and vendors, who tend to analyze projects on a cash flow basis, could pass the savings in capital costs along to the consumers.

A level playing field for financial and technical assistance—some options

Governments and donors must develop a mechanism for making subsidies and assistance broadly accessible. This could range from a small agency, much like a bank, that gives away money with the same care and responsibility that a commercial bank uses in making loans, to a more hands-on type of organization such as the U.S. Rural Electrification Administration. To work properly, such a mechanism needs:

- *A broad universe of projects to choose from.* With many diverse projects, a funding agency can select those projects with the best demand profile and organizational makeup and an adequate willingness and capacity to pay. As the market develops, projects to reach more marginal users will become increasingly feasible. To speed market development, each agency would disseminate information on its programs through all appropriate means (directly, through radio and television broadcasts, and by brochures, posters, and newspapers). While the agency could maintain a master database, it is the market—made up of individuals, communities, and companies—that would identify most projects.
- *A technology selection methodology.* The agency should identify, develop, and publicize tools for selecting technologies so that project developers can use them too and governments and donors can ensure that their resources are allocated optimally.[1] Even if the agency provides tools, the selection should be left to the market.
- *Appropriate system designs.* System designs must meet the customer's functional requirements—no more, no less. There must be functional requirements or design parameters for all major off-grid technologies so that subsidizers know that least cost is being attempted without sacrificing quality. Standards need to be appropriate and flexible (such standards may generate controversy, similar to the sensitivities associated with "appropriate technology"). And customers need to have some up-front choice, so that they understand the price-quality tradeoff in advance.
- *Technical support.* Training and organizational development must be part of the initial investment package. For home photovoltaic systems the bidding specifications must include training in how to use and maintain the systems. For a mini-hydro system they must include organizational development to be provided by a third party—an NGO or a community development group—under contract. Even if the organizational development program takes six months, its full cost must be included up front, as part of the initial investment package, and its financing provided for by the financial package, including any subsidy. The program should include training on how to operate, maintain, and replace systems and how to charge for services in a way that is affordable.
- *Competitive procurement of goods and services.* Free and open competition among equipment and service providers, under appropriate bidding terms and conditions, provides another opportunity for minimizing costs. Fair competition requires comparing apples with apples, so in addition to design and construction parameters, standard bidding documents for different technologies are often desirable. Fair competition should not mean a purchasing agency, merely facilitation. The Internet opens new possibilities for communities and developers to effect efficient purchases.
- *Reporting and follow-up.* Front-end subsidies create the least dependency and permit the least bureaucracy. But some believe that most problems surface down the line, requiring intensive follow-up to make sure that systems are being used and maintained appropriately. Can off-grid customers demand unlimited, reliable service at the flick of a switch in exchange for paying their bills on time? That depends on what market agents are willing and able to do at a certain site and point in time. Remote, poor, illiterate, and neglected households will continue to risk their savings on what they find in their limited markets. Subsidizers must take this into account when choosing follow-up strategies. At the very least, feedback reports will minimize future mistakes.

Conclusion

The key drivers of improved access to off-grid electricity service have all shifted the emphasis from a centralized toward a decentralized approach. Successful off-grid energy projects must understand and address, at the local level, the nature of the demand and its interaction with:

- The local energy source.
- The local operating organization.
- All possible project development actors, beginning with the communities and including community-level and other development programs.
- Other market agents, such as local vendors and electricians.
- Other energy suppliers.

Off-grid therefore means more than off-grid electricity supply. It means an expanded role for users, a diversity of organizational models, a greater reliance on local organizations, and a greater knowledge of both the energy supply in the broadest sense and the energy demand at the site. Planners, facilitators, and financiers all benefit from direct exposure to local conditions. The nature of the problem and the possible solutions are best defined at the site.

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Note

1. See Deloitte Touche Tohmatsu Emerging Markets and NRECA International 1998 for a discussion of technology selection methods based on net economic benefit.

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7 The role of energy subsidies

Douglas F. Barnes and Jonathan Halpern

Message from the editors

A first priority of energy policies aimed at alleviating poverty must be to bring down the costs of safe, clean, reliable energy services. Chapters 5 and 6 discuss some promising trends in that direction, but low-income households must clear another high hurdle before they become energy consumers—the initial cost. They must pay to have gas or electricity connected, or buy a photovoltaic cell or LPG cylinder, and then buy the appliances that will run on the energy. Subsidies are thus likely to remain a key part of pro-poor energy policies in developing countries for some time. Traditional ways of delivering subsidies, particularly cross-subsidization of consumption, often fail to help the poor. They are also less sustainable—and make little sense—once governments begin liberalizing energy markets. The challenge for governments is to find better ways of delivering subsidies—going back to basics on the questions of whom to subsidize, which aspects of cost to subsidize and by how much, and how to deliver these subsidies. A "good" subsidy scheme is one that enhances access for the poor while sustaining incentives for efficient delivery and consumption. But that is not sufficient: the subsidy scheme must also be practicable within the financial and human resource constraints of the government.

A remarkable number of people in developing countries have gained access to electricity during the past twenty-five years—more than 1 billion. Still, about 2 billion people do not have access to electricity. An equal number rely on biomass energy for cooking. It remains the case that high-income households have electricity, and the world's poorest, mostly rural households do not. For petroleum products and other "modern" fuels, the scenario is similar. The rich have access and the poor do not. The poor also often spend a significant amount of their time collecting fuel for their household needs or spend a large percentage of their income on energy.

Limited access, a high percentage of income spent on energy, and significant amounts of time spent collecting biomass fuel for cooking all have been cited as reasons for providing energy subsidies to encourage the poorest households to use high-quality fuels. The problem is that while such subsidies can be beneficial, they can also be harmful, inefficient, and in some cases detrimental to the poor.

The modern fuels being used by households in developing countries include electricity, liquefied petroleum gas (LPG), and kerosene.[1] The supplies of these fuels are often irregular, and policies on their use in various countries range from taxation to subsidies. Many development assistance programs have been directed toward making the supplies of these fuels more regular, reliable, and efficient. Unfortunately, their efforts often do not take into consideration those who do not have access to such services. Attempts to subsidize energy have led to problems as well. Many energy subsidies intended for the poor are appropriated by middle- and high-income groups.

This chapter explores the case for subsidies to promote the use of energy that enhances the quality of life of the poor or reduces their expenditures on energy and to encourage businesses to serve poor and rural populations.

Why subsidize energy?

At the sectoral level energy is a commodity that is bought and sold through markets. There are often many private energy companies competing intensely in such markets. Why subsidize energy? If the goal is to improve the living standards of the poor, there may be other ways to do so. Energy is but one component of a household's basic basket of consumption, which includes food, water, shelter, clothing, and education. There may be better ways to increase the welfare of poor people than through energy subsidies. For example, the poor could be provided with income transfers so that they can choose the best solutions for themselves.

A simple answer to this question is that energy should not be subsidized. In an ideal world the poor could adopt whatever form of energy suits their needs and ability to pay. But reality is more complicated. The poor often have difficulty in gaining access to quality energy services, and businesses have a hard time justifying the initial high costs of serving them. Moreover, most developing countries lack the social service infrastructure required to effectively manage income-based transfer programs.

Many studies show that the poor are often willing to pay for higher-quality energy services, but are deterred from obtaining service by high access costs or nonavailability of service.

If modern energy is available to the poor, which may be the case in urban areas, the high costs of initiating energy services or taxes on fuels may pose a constraint on their ability to adopt higher-quality fuels. Energy service businesses may have weak incentives to provide access to quality energy services to the poor, mainly because of the low population densities, which make it costly to serve remote locations, and the low incomes of the poor, who often use little energy compared with wealthier households. Thus the main barriers to service may be access costs, the ability to pay for access, and related government policies, such as import restrictions and tax policies.

Access barriers are common for both electricity and LPG. In some countries close to the full thirty-year life-cycle cost of electricity service must be paid up front by consumers, amounting to more than US$600 as a connection fee. This is obviously beyond the means of poor households. Similarly, for LPG in most countries people must apply and pay fees for service, pay a deposit for LPG bottles, and pay in advance for their contents. This limits the ability of the poor to obtain such energy services, even though they may be able to afford the monthly energy service expenses. The poor do not have cash reserves for such fees or lump-sum purchases.

The use of modern energy sources such as electricity, kerosene, and LPG is clearly desired by many rural and poor people. They want electricity for lighting, as this allows them to extend the day and read in the evening (Barnes 1988). And children can study longer, which will raise education levels (Bose 1993; Domdom, Abiad, and Pasimio 1999; Khandker 1996). Electricity service makes this possible because of the high quality of light; typically an electric lightbulb gives off about 200 times as much light as a kerosene lamp (van der Plas and de Graff 1988; Nieuwenhout, van der Rijt, and Wiggelinkhuizen 1998). In urban Java (Indonesia) families using electricity have lower lighting expenditures and receive on average six times as much light as households using kerosene (ESMAP 1990; Fitzgerald, Barnes, and McGranahan 1990).

For cooking, the urban poor often pay more for wood or charcoal than they would for LPG, once the end-use efficiencies of the fuels are taken into account (Alam, Sathaye, and Barnes 1998; ESMAP 1999; Barnes, Krutilla, and Hyde 1999). Thus subsidizing access may assist them in lowering their expenditures on energy for cooking—and in avoiding all the problems of indoor air pollution. Recent evidence from India indicates that indoor air pollution may be responsible for more than 400,000 premature deaths a year (Smith 1999, 1987).

Subsidies to private firms should encourage access, not cover operating costs.

In sum, the benefits of access justify some form of energy subsidy. The welfare gain will often be much higher than the long-term costs involved in providing electricity service. But the up-front investments by private or even public businesses to reach low-income customers cannot justify the resulting small revenue flows, especially for energy businesses with short-term profit goals. Moreover, the poor cannot afford to pay these long-term costs at the initiation of service or over a short period. As a consequence these businesses have little incentive to market energy services to poor segments of the population. A subsidy can be used to assist poor households in obtaining higher-quality energy services—either some form of direct subsidy to the poor or, where service networks are nonexistent, incentives to businesses to develop such service networks. However, energy subsidies should be directed at encouraging access to services rather than helping to cover the operating costs of providing the services.

Some typical subsidy problems

The goal of most subsidy programs is to promote some "social good," such as improving the quality of life of a group of people or redistributing income to less fortunate groups. Subsidies should be directly targeted to the intended beneficiaries and no others. They should minimize market distortions. Subsidies also can be justifiably used to promote the development of the market for new products or services.

In practice, it is difficult to efficiently achieve these multiple objectives. Moreover, subsidies are the grist of politics. Subsidies have often been:

- Implicit, such as nonpayment of electricity bills.
- Untargeted, such as a subsidy for energy used by all.

In Yemen the lifeline rate was set at a consumption level that includes more than 75 percent of the population.

- Indiscriminate, such as a subsidy for a quantity well above that needed by poor or rural populations.
- Complex or difficult to administer to the targeted group.
- Overly restrictive with respect to the end use or technology, depriving users of choice.

Mistargeting of subsidies grows as different interest groups attempt to capture them. For example, Indonesia has had a policy of subsidizing kerosene to encourage its use by the poor for cooking. Although the policy has accomplished its goal, as many low-income households are cooking with kerosene, there are also many free riders—middle- and high-income people who take advantage of the subsidy (ESMAP 1990). In Ecuador subsidized kerosene was diverted to the transport sector and much of it never reached the poor, especially in rural areas (ESMAP 1994). In the first case the subsidy, while reaching the poor, was not well targeted (errors of inclusion). In the second case the design of the subsidy introduced distortions in the energy market, and many of the intended beneficiaries never benefited from the subsidy (errors of exclusion).

In some cases subsidies appropriate for the poor are not properly dimensioned. One such case is the misuse of lifeline rates in the electricity sector. A lifeline rate is a cross-subsidy that enables the poor who use minimal services to pay a lower price than wealthier households using higher levels of service. Lifeline rates can be a well-targeted subsidy for the poor, particularly where they are already connected to the grid, because the poor generally can afford to use very little electricity, mainly for lighting and televisions. But the welfare benefit of the uses can be quite high, justifying the cross-subsidy. In many countries, however, the lifeline is set very high. In Yemen the lifeline was set at 200 kilowatt-hours a month, a consumption level that includes most of the population. Thus even conceptually sound subsidies can be misapplied, with the result that those who are ready and willing to pay higher prices for electricity receive more benefits than the poorer households.

Subsidies meant to encourage the development of an activity often outlive their usefulness and eventually begin to cause problems for society. Take an example from India. In the early stages of the green revolution the government decided that it was a good idea to encourage irrigation. The new seed varieties to increase crop yields required a reliable source of water. As a consequence, when electricity was introduced in rural areas, the agricultural electricity price was set very low. After a time this practice was not really necessary, as the productivity gains from the new varieties far exceeded the cost of electricity for agricultural pumping along with other inputs needed to increase crop production. But the subsidies were not phased out over time after the rural market for electricity developed.

The farmers lobby has not only been successful in keeping the existing subsidies in place, but in some states has persuaded politicians to provide farmers free electricity. The farmers with electricity service not only get free or nearly free electricity, but also keep the profits from increasing agricultural production. As a consequence the state electricity boards have been severely decapitalized and cannot finance the necessary investments to maintain reliability and extend service.

The subsidy decision: who, what, how, and how much

Subsidies should be assessed by their relative *efficacy, sector efficiency,* and *cost-effectiveness.* Efficacy means that the subsidy reaches those for whom it is intended, the poor (minimizing errors of inclusion and exclusion). Sector efficiency means that the subsidy is structured in such a way that it encourages provision of service at least cost. This is one aspect that needs to be addressed more thoroughly in energy sector restructuring work, which often does not consider access issues, particularly in remote rural areas. Cost-effectiveness means that the subsidy achieves social goals at the lowest program cost while providing incentives to businesses to serve poor and rural populations. To achieve these three goals, decisions must be made on the subsidy's target group, on its form and its level, on the eligibility criteria for the subsidy, and on how to finance it.

Whom to subsidize

Those without access to higher-quality energy services generally are rural households and the poor. In the case of electricity the share of the population without service varies significantly among countries, but generally it is the poorest third. Thus in most cases the target group for the subsidy should be those without service. Households that already have service generally are the better-off. In practice, many households that have electricity service have benefited from past subsidies.

In the case of oil-based products many households purchase kerosene in small quantities, but it is almost impossible to purchase subsidized LPG in comparable amounts because the bottles are still relatively large. Therefore, the poor may have access to kerosene at very high prices because of the small quantities that they purchase, and have difficulty getting LPG because of the large purchases and service initiation fees involved.

What to subsidize

For disadvantaged groups without service, it would be reasonable to subsidize service access itself. As noted, the poor, especially those in urban areas, spend a significant amount of their income on low-quality energy services. Subsidizing some of the access barriers that they face can encourage them to climb the energy ladder to better services. For example, the electricity connection fee for poor households can be kept low by providing a partial subsidy for the capital cost of the connection and rolling the rest of the cost into monthly bills. An example of such a subsidy program is Chile's rural electrification program (see chapter 9). This program encourages businesses to serve rural populations by subsidizing the costs of connections for poor consumers.

The Chilean case involves the expansion of service by existing businesses. An even greater challenge is to provide electricity access to remote populations when businesses are weak or nonexistent, as is the case in the renewable energy industry. Various models for promoting renewable energy systems, such as household photovoltaic systems, are being tried through both World Bank lending and Global Environment Facility grants. They involve providing subsidies to retailers, communities, concessionaires, and service providers to encourage them to serve remote populations. Such models are producing varied results (Martinot, Cabraal, and Mathur 2000).

For the case of LPG, the initial service fees could be reduced and smaller bottles developed to lower the initial costs of service.

How to subsidize

The choice of instrument and implementation mechanism is a significant determinant of the efficiency and efficacy of a subsidy in improving the welfare of the poor. In general, fuel, or supply-side, subsidies perform poorly. The reason for this has already been touched on in the discussion of the kerosene subsidies in Indonesia. Although implementing such a program is not difficult, fuel subsidies generally reduce business incentives to expand services and are badly targeted.

India has used a 25 percent fuel subsidy for LPG for cooking for many years (see Alam, Sathaye, and Barnes 1998). Unlike Indonesia, India has had to import LPG to meet consumer demand. To keep the subsidies under control, India has limited imports of LPG and limited retailers to distributing LPG in urban areas. Even today there are long waiting lists of urban households for the subsidized LPG. As a consequence these subsidies go mainly to the well-off and middle class.

Fuel subsidies generally reduce business incentives to expand services and are badly targeted.

Subsidies for access to different types of energy can be justified if they are well targeted and if they reduce business costs in a rural service territory. For example, it can be quite costly to extend electricity to one household in a village, especially given the low electricity consumption of rural households. But if service initiation costs are low, perhaps 100 households would be encouraged to take a connection and start paying monthly or bimonthly electricity bills. While a business could not make any profit serving one household, it probably could serving 100. As long as all business operating costs are covered, there will be an incentive to serve the rural customers. In Costa Rica the distribution company recognized that people often wait until after the grid comes to their village to obtain a connection. Late adopters of electricity know that the cost of connecting their household will be lower than that for the initial users. The electricity cooperatives therefore developed an initiation fee schedule to promote demand for service. This fee was based on an "average" penetration level in the village, and they charged all customers the same fee regardless of whether they were an early or late adopter. In addition, the government subsidized some of the capital costs of line extensions. Even so, the distribution company constantly generated losses during the first five years of the cooperative electrification program because of new line expansion (Foley 1997).

How much to subsidize

There is a fine line between subsidies that encourage service provision and those that encourage only the purchase of equipment. This is an especially important problem for renewable energy, since most of the costs of service are the capital costs of the systems themselves. Consider an example from Peru, where a village without electricity was selected to receive household photovoltaic systems. The systems involved 100 percent subsidies. After several years a return visit to the village revealed that many households had sold their systems. The subsidy level should be pitched to provide relief to poor households and to create business incentives to serve the poor over the long term.

There is a fine line between subsidies that encourage service provision and those that encourage only the purchase of equipment.

Decisions on the size of subsidies should follow some general principles. Subsidies should provide an incentive to extend service to households that would not otherwise get it. They should stimulate new business without being an end in themselves. They should provide a benefit to the rural and poor populations, but should not create a disincentive to provide energy service after the equipment is installed in the households.

In the Asunto Valley in Bolivia installation of a free micro-hydro system actually caused the local distribution company to lose money because of the increased costs associated with adding the capacity (ESMAP 1991). Many of the photovoltaic programs in India encouraged manufacturers to produce for the government subsidy rather than for the market. The appropriate balance is to provide enough subsidy to enable poor and rural households to afford access to the service while not destroying business incentives to serve them.

Assessing subsidy mechanisms

The design and implementation of subsidies should not be viewed as a static process. As noted, subsidies should be efficacious, efficient, and cost-effective (table 1). They can come in many different sizes and shapes, depending on the country's institutional endowment and on government policies, and they can be financed in different ways. Sources of subsidy may include cross-subsidies between user groups for network companies, subsidized interest rates on loans, equity investment by a government to promote service expansion, low bulk tariff rates for distribution companies expanding service, taxes earmarked for a subsidy fund, and government budgetary contributions.

To be cost-effective, efficient, and useful for rural and poor people, energy subsidies should have two main goals. The first is to assist the poor in gaining access to higher-quality energy services, which points toward having a subsidy that helps lower front-end costs for poor consumers. The second is to provide business incentives to serve rural and poor consumers who would not otherwise be served, without significantly distorting energy markets and without having the government as the major customer for equipment. A key activity that the government can and should be involved in is providing technical assistance in the form of information, research, and advice to communities on energy options.

In general, supply-side subsidies should be avoided because they are not well targeted and because they cause distortions in the energy market. But there have been exceptions where the distortions inherent in such subsidies have not unduly undermined service provision or the financial viability of the businesses involved. One example of an approach that struck a balance between subsidies for service expansion and business incentives to serve rural populations involved the successful rural electrification program in Thailand (Tuntivate and Barnes 1997). In Thailand all electricity companies were required by law to be financially profitable. The company responsible for expanding rural service was the Provincial Electricity Authority. To compensate for its service expansion costs, the company was permitted to purchase electricity from the power company at a lower price than the company serving Bangkok paid. In addition, after studying consumer load patterns, the company established a pricing structure that involved a demand subsidy in the form of a minimum tariff and discrete blocks with higher charges for larger users. The minimum tariff is a kind of lifeline rate. The Provincial Electricity Authority remains financially viable because of the many measures it took to keep costs low. But the subsidy was also important for expanding electricity to more than 90 percent of the population in Thailand.

Little empirical work has been done to identify the effectiveness of efforts to reach rural and poor households with energy services, with or without subsidies. To design

Table 1 **Assessing alternative energy subsidy mechanisms for the poor**

Subsidy mechanism	Sector efficiency	Efficacy	Cost-effectiveness
Subsidy directed to service provider (supply side)			
Subsidy for bulk power supply	☐	☐	☑
Direct operating subsidy	☐	☐	☑
Capital subsidy	☐	☐	☑
Financing subsidy	☐	☐	☑
Subsidy directed to consumer (demand side)			
Direct connection subsidy to non-service provider	☑	☑	☐
Connection subsidy through service provider	☑	☑	☑
Credit for new connection	☑	☑	☐
Direct consumption subsidy to low power users (lifeline rate)	☐	☑	☑
Cross-subsidy to low power users (lifeline rate)	☐	☑	☑
Consumption subsidy for all consumers	☐	☐	☐

effective energy subsidies requires a better understanding of the populations they serve. To clearly identify the impact of assistance for rural and poor households, the service companies or governments should be completing market assessments, consumer surveys, and studies on willingness to pay for services.

Conclusion

There is no justification for subsidies to the large commercial businesses that dominate the energy sector or to industries that provide services mostly to better-off households in developing countries. But under some circumstances it is reasonable to use subsidies to promote access to energy for the poorest households, which now must get by with such fuels as dung and straw for cooking, and candles and kerosene for lighting.

Each subsidy mechanism has strengths and weaknesses. Supply-side subsidies such as the kerosene subsidy in Indonesia have poor targeting characteristics and provide weak incentives for efficient service delivery. But the explicit administrative costs of managing such subsidies are low. Where governments have ample resources to spend on service expansion and efficiency considerations are of low priority, supply-side subsidy schemes may work, but at a very high cost to the country.

Demand-side subsidies have better targeting properties and, in the case of subsidized connection costs, provide better incentives for efficient service delivery. Subsidies for connections financed by budgetary transfers provide better incentives to expand coverage than cross-subsidies or any of the supply-side subsidies, since this mechanism permits the provider to generate more revenue for each new connection extended to the target population. The downside of these sorts of demand-side subsidies is that they generally require an administrative and institutional superstructure to identify and verify target beneficiaries independent of the service provider. Doing this effectively often carries a high cost relative to the total subsidy program costs.

Energy subsidies have become unpopular among policy advisers. But subsidies should not be rejected out of hand. Instead, they should be more carefully designed to maximize their impact on the poor. But even well-designed subsidies are only one among many factors involved in successfully reaching poor populations with quality energy services. Others include setting up effective institutional structures for markets, dealing with the tendency of politicians to steer subsidy programs away from the poor to their constituencies, and developing pricing policies that permit businesses to recover costs for energy services.

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Note

1. For cooking, modern fuels would include LPG, kerosene, and the use of biomass in improved stoves. For lighting, modern energy refers to the use of electricity, which is significantly more efficient than burning kerosene or other petroleum products.

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8 The costs of corruption for the poor

Laszlo Lovei and Alastair McKechnie

Message from the editors

In recent years the fight against corruption has assumed a key place in development policy, as a way of strengthening economic growth and helping civil society and democracy to function. Corruption not only stifles growth. It also perpetuates or deepens inequality, as the few amass power and wealth at the expense of the many. The energy sector lends itself to corrupt practices. This is a result both of its traditional institutional arrangements—dominated by state monopolies controlling oil, gas, or electricity—and of the sheer amount of cash it can generate. Corruption in energy takes many forms, from petty corruption in meter reading and billing to grand corruption in the allocation of lucrative monopolies. These practices differ in scale but contribute to the same results—weak operational and financial performance and, for the poor in particular, declining service quality or reduced chances of ever accessing network services. The answer to corruption is continuing reform, to reduce the incentive and potential to capture monopoly rents and to increase the transparency of public and private transactions, regulatory structures, and decisionmaking processes.

The energy sector, with its complex mix of public and private actors and often enshrined centers of monopoly power, is prone to corruption. This sector generates substantial cash transactions compared with other infrastructure sectors, not only in both small and large capital-intensive investments but also in revenues, which tend to be higher than those for such services as water and sanitation or use of roads. With considerable monopoly rents at stake (from meter reading up to project award) and, in many countries, long histories of weak monitoring, low transparency, and inadequate civil service pay, opportunities and incentives for illicit gain are rife.

While there is little hard evidence on the incidence and costs of corruption within or across countries or sectors, there is little disagreement that these costs can be high. For example, evidence from case studies suggests that illegal payoffs can lower the quality of public works projects, and increase their costs by as much as 30–50 percent (Rose-Ackerman 1996). And there is reason to believe that the costs of corruption are disproportionately borne by the poor—that corruption is not only inefficient, but also inequitable. Understanding how corruption manifests itself in the energy sector—and how this affects the poor—can thus make a valuable contribution to the identification and design of sector programs aimed at improving the well-being of the poor.

This chapter looks at some common manifestations of corruption in developing country energy sectors, drawing examples from Europe and Central Asia and from South Asia. (The choice of these regions as sources of examples is not intended to imply that corruption of these forms is unique to these regions or more prevalent there than elsewhere.) It looks at why the presence of corruption should matter to policymakers concerned with improving the lot of the poor—and then discusses steps that governments might take to reduce the incidence of corruption and its costs to the poor.

Common forms of corruption

For ease of discussion, some common forms of corruption can be grouped into categories according to the level of the public officials involved:

- Petty corruption, such as bribes paid to or demanded by meter readers or safety inspectors.
- Corruption by company managers and mid-level bureaucrats, such as side payments associated with energy purchase or sale contracts or debt instruments.

- Grand corruption, such as lucrative monopolies granted in return for political campaign contributions and the personal enrichment of political leaders.

Corruption characterizes both traditional and modern society and governance. Traditional society in some regions is characterized by patron-client relationships, complex interrelations of patronage and protection that require financial resources for the exercise of power and impose financial burdens for protection. In South Asia, for example, these relationships are reinforced by the vestiges of traditional social stratification, hierarchy, and deference.

This is not to suggest that certain cultures are inherently corrupt, but that the old social organization provides incentives for rent seeking. Development involves the transformation of such societies so as to empower the poor and provide legal constraints on the exercise of power. In countries where governments change through elections, the political ideologies of parties have converged since the end of the cold war and government is being seen more as acquisition of the spoils of office. If government brings rewards, elections have become costlier as information channels proliferate through new technologies (satellite television). These trends have resulted in election finance scandals in industrial countries, and anecdotal evidence suggests that politicians in new democracies are also pressed to acquire illicit sources of campaign funding.

Petty corruption

Petty corruption is most prevalent at the interface with customers and is one of the reasons for the low payment collection rates reported by many gas, electricity, and district heating companies in developing countries. For example, the state-owned Baku Electricity Company in Azerbaijan reported a household payment collection rate of 12 percent in the second half of 1999, despite employing 1,000 meter readers and payment collectors. Only part of the payments collected were officially recorded, but consumers did not seem to mind, since the meter readers in return reduced their reported consumption by 50 percent. The indifference of the consumers was replaced by anger, however, when the low payment collection rate repeatedly led to electricity blackouts due to the lack of fuel at power stations.

In Bangladesh revenues are collected for only 55 percent of the power generated. By one estimate, about half the total system losses of the Bangladesh Power Development Board (BPDB) and Dhaka Electricity Supply Authority (DESA) are accounted for by mismanagement and petty corruption surrounding electricity metering. Hard facts are difficult to come by, but anecdotal evidence from electricity consumers and articles in the local press suggest pervasive corruption by some power sector employees. A recent survey by the Bangladesh chapter of Transparency International revealed that public utility employees were regarded as the most corrupt officials after the police and lower judiciary. Meter readers frequently delegate the actual task of meter reading to informal operators and focus their own efforts on developing a business in illegal connections.

The aggregate impact of "petty corruption" may be far from petty.

In Pakistan nontechnical losses arising from electricity theft were reduced significantly when the army took over electricity distribution in 1999. While there were many illegal connections by low-income households, the Pakistani army found that significant quantities of electricity were stolen by high-income households, industry, and large commercial establishments such as shopping malls. In India surveys sponsored by the World Bank as part of load management and agricultural electricity studies have shown that 20–30 percent of electricity attributed to unmetered agricultural consumption is stolen by users in other sectors.

The aggregate impact of "petty corruption" may be far from petty. In Bangladesh the losses of the BPDB and DESA amount to more than US$100 million each year. Petty corruption in South Asia is often well organized. Trade unions protect corrupt workers, politicians protect the unions, and accompanying this protection is a stream of stolen revenues from the meter readers to unions to politicians.

Corrupt management practices

Corrupt management practices may involve both cash and noncash transactions. Noncash transactions, a key feature of the Soviet economic system, have remained widespread and provide fertile ground for such practices in the former Soviet Union. Exchanging electricity (for fuel) and gas and coal (for electricity and industrial production) at artificially inflated rates is one method of generating private gains.

Another practice is the issuance of promissory notes by electricity companies with restrictions on circulation, duration, and eligibility. These notes are immediately discounted heavily on the market and can be purchased for a fraction of their face value. The electricity company officials who certify that the circulation of the note followed a permissible path and that the holder of the note is entitled to redeem it in full for electricity or fuel are able to use their position to extract bribes.

A third example is from the coal industry in Russia and Ukraine. Anecdotal evidence suggests that unrecorded coal production illegally sold for the benefit of individual mine managers is a widespread phenomenon, involving local industrial customers, the rail transport system, and port authorities.

> Grand corruption is seldom as visible as its two lesser cousins.

All these practices may result in an increase of 20–30 percent in costs and a reduction of similar size in revenues for gas, coal, and electricity companies, aggravating their already precarious financial positions.

Certain government regulations in the former Soviet Union create particularly strong incentives for collusion between public officials and private company managers. The allocation of oil export pipeline capacity in Russia, where part of the capacity is reserved to be allocated on a discretionary basis, seems to be a typical example. The difference between the domestic and export prices of crude oil is US$80 a ton, so access to export capacity translates into large economic benefits. Therefore, the limits imposed on petroleum product exports—ostensibly to ensure adequate domestic supplies—coupled with the discretionary exemptions, provide an opportunity to generate significant private (and personal) gains.

In the South Asian power sector cash transactions, some paid overseas in foreign currency, appear to be a more common manifestation of corruption at the managerial level than noncash transactions. Corruption appears more common in unsolicited bids, supplier's credits, and crash program–type procurement initiatives where there is little or no competition among suppliers, the definition of what is being procured is negotiable, and reputable firms may be reluctant to participate. Even where competitive bidding processes are used, side payments may be made to ensure favorable bid specifications, terms, and conditions, and favorable bid evaluations or endorsements. Side payments may also facilitate the issuance of work orders, the opening of letters of credit, and all stages of project implementation carried out by contractors and consultants, such as processing payments and obtaining permits.

Jobs where rents can be collected are themselves subject to corrupt processes. Patrons in government or management award such jobs to their clients, who are expected to transfer back some of their illicit gains. Such jobs may even require up-front payments by the new employee. Being able to "transfer" employees from low-paid jobs without potential for illicit gain to low-paid jobs that benefit from corruption bestows power on the manager or politician. It is also common for politicians to reward their supporters or cronies by using their influence to award rent-collecting jobs in public enterprises.

Grand corruption

Grand corruption is seldom as visible as its two lesser cousins. A notable exception occurred in Ukraine, where a former prime minister personally granted exclusive rights to a gas trader that was reportedly controlled by him and his associates. The trader imported gas from Russia at a price of US$50 per thousand cubic meters and sold it to captive industrial consumers for US$80. When the prime minister, who used the financial wealth generated by this lucrative monopoly to establish a political party, was fired, the wholesale gas market was liberalized.

The gas trader quickly lost most of its customers, but remained the holder of several hundred million dollars of debt to the Russian gas company RAO Gazprom for gas received but not paid for. RAO Gazprom, arguing that the private trader's privileges were granted by a cabinet resolution, has reportedly succeeded in transferring the liability for unpaid gas bills to the Ukraine government. Following the temporary liberalization of the gas market, the owner of another private gas trading company was appointed to head a newly created vertically integrated national oil and gas company (Naftogaz) and given exclusive rights to sell gas imported from Russia to the 300 largest industrial companies in Ukraine.

An example of an environment that creates opportunity for the abuse of high office comes from the Russian coal sector. One of the most heavily subsidized industries in Russia, coal mining continues to command a particularly high degree of political influence. As recently as 1994 the drain of coal subsidies on the federal budget was enormous. In that year almost US$2.8 billion was spent on direct subsidies to the sector, representing more than 1 percent of GDP. Until late 1997 control of these subsidies was the prerogative of RosUgol, the national coal monopoly (in fact, operating as a ministry of coal mining). Allocation, distribution, and use of these budget funds were highly nontransparent, with no effective monitoring arrangements. Audits of 1996–97 coal subsidies ordered by the first deputy prime minister and the Duma found that significant sums of money had either been disbursed to the wrong recipients or used for the wrong purposes. The Russian government responded with a series of far-reaching measures to improve the transparency of and accountability for subsidies to the coal sector.

Corruption and the poor

The kinds of corrupt activity described above differ in the nature and magnitude of their implications for the poor.

In petty corruption in electricity or gas systems, both parties (the meter reader and the household) may benefit from striking a "deal." In the short run—especially in the countries of the former Soviet Union, where almost all households are connected—there is nothing particularly antipoor in this. But in countries in South Asia the poor may be too vulnerable to resist the rapacity of the coalition of corrupt utility employees and their protectors, who may use physical force to enforce their regime. In such countries poor consumers may not benefit much from the diversion of utility revenues.

In the long run, however, inadequate revenue collection and other corrupt practices tend to lead to deteriorating service. This hurts the poor more than others since less politically influential (typically less affluent) neighborhoods suffer more blackouts and supply interruptions. In Azerbaijan, for example, gas supply has been permanently suspended except on the peninsula where Baku, the capital city, is located. Many households and district heating systems in the country, dependent on gas, found themselves (literally) in the cold. The recent residential electricity blackouts have been scheduled for the peak morning and evening hours outside the capital city, while curtailments in Baku have been scheduled for the hours when people are typically at work or asleep.

In Bangladesh, where voltage in distribution networks is unstable, observers in rural villages have noticed lightbulbs lasting only a few days because of voltage surges. A low-income rural household might spend as much on lightbulbs as on electricity. (A Bank-funded survey revealed that power outages in Bangladesh cost about US$1 billion a year and reduce GDP growth by about half a percentage point.) Diversion of utility revenues had become such a problem in Pakistan that in 1999 the government mobilized the army to supervise meter reading and billing. The scale of theft surprised the authorities, especially the extent to which the affluent benefited; industries, shopping centers, and large residences accounted for a large share of the stolen electricity.

Where the great majority of poor households lack connections—as is the case in most developing countries—the costs of petty corruption are likely to fall disproportionately on the poor. Large power sector losses due to theft have been a major cause of the bankruptcy of Indian state electricity boards—negative equity is not uncommon. These losses mean that little funding is left for expansion of networks to improve access—in South Asia less than half of households have electricity service. Losses also put a strain on state budgets, through major expenditures on subsidies for electricity boards. This fiscal drag lowers the growth of state GDP and crowds out other expenditures, particularly for education and health.

Similarly, in Bangladesh subsidies from the government budget amount to more than US$100 million a year, more than expenditure on health. The beneficiaries of the subsidies are the relatively affluent 16 percent of households that have electricity service. The poor lose from the budget subsidies to the power sector in two ways: lower rates of economic growth and less social expenditure from which they would benefit directly.

> In Pakistan industries, shopping centers, and large residences accounted for a large share of the stolen electricity.

Corrupt management practices typically lead to increases in supply costs, which in turn result in increased tariffs or, alternatively, mounting financial losses leading to reduced service. Increased tariffs badly hurt the less affluent (but still connected) households, since their budgets are tighter and they may have to give up other essentials (such as health care or education), while middle- and high-income families may just sacrifice luxuries. In other words, the problem is not that there is an antipoor bias in the tariff increase, but that the tariff increase may hurt the poor more than others. For the poor who are not connected, the higher tariffs (plus higher connection costs) resulting from corrupt management practices may create a higher barrier to access to the service than for the nonpoor. The alternative scenario—unchanged tariffs but mounting financial losses leading to service reductions—has a clear antipoor bias when service reductions are spread unevenly across the country, as illustrated above.

Grand corruption typically has the least direct impact on the poor. It leads to higher energy costs for industrial entities or reduced budgetary revenues from export and natural resource taxes. Most of the money paid in bribes is in foreign currency that never crosses the border. Excess costs of projects and concessions are funded by the country through electricity tariffs and foreign borrowing, and the illicit funds flow to the foreign accounts of government officials. The diversion of these funds harms economic growth, reducing employment opportunities, and also tends to reduce the resources for social programs, including assistance to the poor. The diversion of coal industry subsidies in Russia could have had a more direct impact on some poor families, since it might have contributed to the delays in the payment of disability and unemployment benefits.

Reducing the costs of corruption

Governments can take various steps to reduce the scope for corruption—most involving privatization, competition, more transparent rules, and more disclosure.

> In Bangladesh annual power subsidies exceeded government spending on health—benefiting the more affluent 16 percent who have service.

Petty corruption

In the utility sector an interim solution to petty corruption in bill collection is to hire a private collection agency or to sign a management contract with a private party to run part or all of the distribution company. Contracts of this kind normally include collection targets and stipulate sanctions for failure to meet these targets, including contract termination. The few management contracts implemented so far in Europe and Central Asia have led to noticeable improvements in collection rates, but have still fallen short of producing a cash flow that would ensure the long-term financial viability of the energy companies. Contracting out billing and collections has been less successful in South Asia, where powerful vested interests such as trade unions have undermined private participation that does not give the private sector full control of the utility.

The final solution is to sell the distribution company to strategic investors with a proven track record and a long-term interest in the business. Doing this, however, requires considerable time, technical expertise, and political commitment. Assisting clients with the privatization of their distribution companies is probably the single most important building block of the World Bank's strategy to promote reforms in the energy sector. In Europe and Central Asia the Bank is actively engaged in the privatization process in Armenia, Georgia, Moldova, Poland, and Ukraine and is also promoting privatization and management contracts in Albania, Azerbaijan, Bulgaria, Estonia, Kazakhstan, Latvia, Lithuania, Romania, and Russia. In South Asia the Bank has supported the privatization of four distribution companies in the Indian state of Orissa, achieved in 1999 after an earlier attempt at a management contract failed. Other Indian states—Andhra Pradesh, Haryana, Karnataka, Rajasthan, and Uttar Pradesh—have sought Bank assistance in utility restructuring and privatization, as have Pakistan and Sri Lanka.

Corrupt management practices

Corrupt practices involving noncash transactions can be targeted through an economywide reduction of the share of barters, offsets, and other noncash payment mechanisms. In addition, they can be reduced by reforms in the energy sector that include:

- Adoption of transparent market rules.
- Reduction in the scope and applicability of emergency provisions.
- Establishment of independent system operators with a multilevel governance structure to reduce the influence of any single individual.
- Establishment of independent regulatory bodies to oversee market operations.

The track record so far is mixed. It appears that these safeguards work less effectively in environments where the bulk of the sector is still publicly owned. The recommended sale of gas and electricity distributors, producers, and generators to strategic investors is expected to further reduce the possibility for "foul play" by public officials and politically motivated employment policies that support corruption.

In the oil sector in Russia the World Bank has proposed transparent procedures for allocating crude oil pipeline capacity that would include a market-based component such as an auction, an audit of Transneft (the pipeline operator), and the elimination of product export restrictions (except for delinquent taxpayers). However, the government has so far resisted these proposals. In the coal sector the Bank made progress in privatizing coal mines a condition for releasing a slice of financing in its sectoral adjustment operation.

To the extent that privatization exposes producers to the incentives and discipline of the market, it serves as a natural counterbalance to corruption among company managers, who for the first time are answerable to private owners with an interest in protecting and increasing the value of their assets. This aspect of the restructuring program tends to encounter resistance at all levels of government and from the labor unions.

Bangladesh has been able to minimize corrupt practices in the rural electrification sector through a combination of public participation from below and financial discipline from above. The sector is organized into cooperatives with boards of directors elected by their customers. A well-managed rural electrification board channels donor funds to the cooperatives conditional upon their performance and has the right to dismiss incompetent or corrupt managers.

Corrupt utilities are inevitably bankrupt utilities unable to extend service to those without it.

Rural cooperatives charge higher tariffs than BPDB and DESA and have succeeded in recovering revenues for about 95 percent of electricity billed, a much higher level than for BPDB and DESA. When rural cooperatives have taken over towns previously supplied by BPDB and replaced BPDB workers with their own staff, they have achieved huge reductions in losses and increases in collections. Cooperatives have developed management practices to reduce theft, such as not allowing staff to be meter readers for more than three years and staffing billing departments with women, who have a better reputation for integrity in these jobs than men do. Empowering the poor to demand better service has seldom been tried in the power sector, yet holds promise for the future.

Grand corruption

As with lesser forms of corruption, grand corruption is likely to be tackled most effectively by highly transparent reform programs that involve disaggregating and divesting former state monopolies and creating independent and reasonably transparent regulatory and monitoring mechanisms.

For the gas sector in Ukraine recommendations have included the following:

- Gas imports and marketing to industrial consumers should be liberalized.
- The government should not guarantee payments to RAO Gazprom.
- Regular gas auctions should be held to produce a transparent (cash) price signal.
- The functions of the electricity regulator should be expanded to include the downstream gas industry as well.
- The operation of gas transmission and dispatch should be transferred to a strategic investor through outright privatization or a concession or management contract.

Progress with the first three items has been mixed, the fourth item has been implemented, but no progress has been made so far in privatizing or concessioning transmission.

In the Russian coal sector several remedial measures have been taken:

- Dissolving RosUgol.
- Transferring all subsidy management functions to the appropriate agencies.
- Establishing earmarked federal treasury accounts for all subsidy categories and recipients.
- Putting in place mechanisms that ensure that individual entitlements go directly to individuals, and not through coal companies, as previously.
- Setting clear priorities for subsidy disbursements to mitigate the social impact of restructuring.

Experience with the new system shows a marked improvement in the management of coal sector subsidies. Flows of funds through the earmarked accounts are strictly monitored by the treasury, whose local offices release funds only upon presentation of documentary evidence testifying to the completion of the works for which the funds have been transferred. In addition, social surveys of laidoff miners have confirmed that subsidies disbursed for their social protection have been delivered to the intended recipients. Present efforts to further strengthen the multifaceted subsidy management system focus on discouraging the widespread practice of noncompetitive procurement of goods (such as the expensive equipment needed for environmental mitigation works at and around closed mines), which leads to wasteful use of public funds and is rife with potential for corruption.

Bangladesh has been successful in awarding independent power producer contracts through transparent international competitive bidding based on the price of electricity supplied. This has resulted in prices of less than US$0.03 a kilowatt-hour, roughly half the price of directly negotiated deals in such countries as Indonesia and Pakistan.

Conclusion

Corruption in the energy sector is antipoor. It slows economic growth and diverts public funds away from social expenditures that would directly benefit the poor. Corrupt utilities are inevitably bankrupt utilities unable to extend service to those without it, usually the poorer segments of society.

Transparency in the energy sector can be improved by first privatizing electricity distribution, where most theft takes place. In some social and political settings other forms of private participation might work, such as contracting out meter reading and billing, leasing distribution utilities, or offering concessions. Encouraging electricity customers and those without supply to find a voice and articulate their frustration with inadequate service merits more attention by reformers. Ideas that could be piloted include surveying public opinion, organizing focus groups, using the mass media, forming partnerships with nongovernmental organizations, and giving customers a say through cooperatives, reconstruction of utility boards, and participation in regulatory hearings.

As countries become more concerned about governance, they are likely to direct attention to reducing corruption in the energy sector, where there is huge potential for diversion of public revenues, rent collecting by corrupt employees, and large-scale graft related to the award of major contracts. Many industrial countries that today preach against the sins of corruption were themselves noted for corrupt administration during the past two centuries. Better-educated citizens are likely to demand higher standards of governance. It was instructive in January 2000 to see a workers' strike against power reforms in the Indian state of Uttar Pradesh fail after the public, frustrated by poor service and abuse by employees, refused to support the strikers. The social transformation that underlies development will create pressures for better governance. But the imperative of attacking poverty requires that the World Bank Group and others that support energy development assist countries in eliminating corruption in the energy sector.

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9 A case study on subsidizing rural electrification in Chile

Alejandro Jadresic

Message from the editors

Reform of the energy sector and reform of subsidies ideally go hand in hand. Structural, ownership, and regulatory reforms aimed at making services more efficient should lead to rethinking of both the level of subsidy and the delivery mechanism. Chile, one of the earliest and most thorough energy reformers, has also been one of the more innovative in restructuring its subsidy schemes. It has seen electrification as a key measure in alleviating poverty in rural areas—in 1992 about 47 percent of its rural population had no access to electricity. Its rural electrification program includes subsidies designed to be consistent with the broad principles of energy reform—decentralization of decisions to the regional and community level, competition (between technologies as well as suppliers), and a requirement that all partners in the process—users and private companies as well as the state—contribute to the financing of expansion projects. The short-term result: an increase in rural electrification of about 50 percent in the first five years of the program.

In Chile in the early 1990s, nearly 240,000 rural households—more than 1 million people, or almost half the rural population—had no access to any source of electricity (figure 1). By contrast, 97 percent of urban households had electricity supply. The lack of access was concentrated in a few regions where most of the rural population lives (figure 2). It affected mainly lower-income families, since the wealthier could usually afford to install generators or pay for extension of the distribution grid.

To increase rural access to electricity, Chile launched a rural electrification program in 1994. Like many rural electrification projects, the program has had to address these challenges: how to ensure sustainability, how to avoid politicization and corruption of the process (and subsidy delivery mechanisms), how to develop ways to deliver service to isolated communities, and how to involve the private sector.

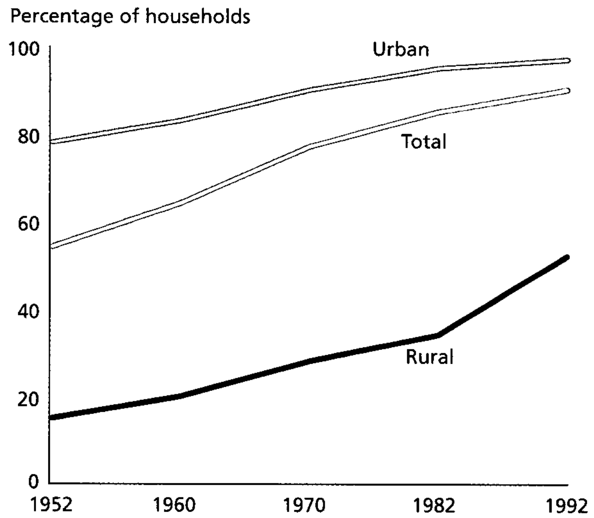
The program set up a special fund to competitively allocate a one-time direct subsidy to private electricity distribution companies to cover part of their investment costs in rural electrification projects. Operating costs have to be financed with tariff charges set by the regulatory authority. Bids are conducted annually. To apply for a subsidy, companies present their projects to the regional governments, which allocate the funds to those scoring best on several objective criteria: cost-benefit analysis, amount of investment covered by the companies, and social impact. The central government allocates the subsidy funds to the regions on the basis of two criteria: how much progress a region made in rural electrification in the previous year and how many households still lack electricity. Regional governments also allocate their own resources to the program.

The program, which is expected to run until 2004, has made significant headway in achieving its goals. It has increased the coverage of electricity systems in rural areas from 53 percent in 1992 to 76 percent at the end of 1999, exceeding the 75 percent target set for 2000. The program has promoted social equity and improved the living conditions of the poor. And it has shown that it is possible to create market incentives that lead to efficient private solutions to rural electrification—an important lesson at a time that so many developing countries are reforming their power markets and privatizing their state-owned electric utilities.

Institutional background

Rural electrification in Chile had traditionally been the province of state-owned power companies, which followed centrally developed plans and relied on subsidies from the central government or cross-subsidies from tariffs set above

Figure 1 **Electricity coverage in Chile, 1952–92**



Source: Chilean National Statistics Institute, census data.

cost in urban areas. Lack of funding and more pressing priorities had resulted in slow progress.

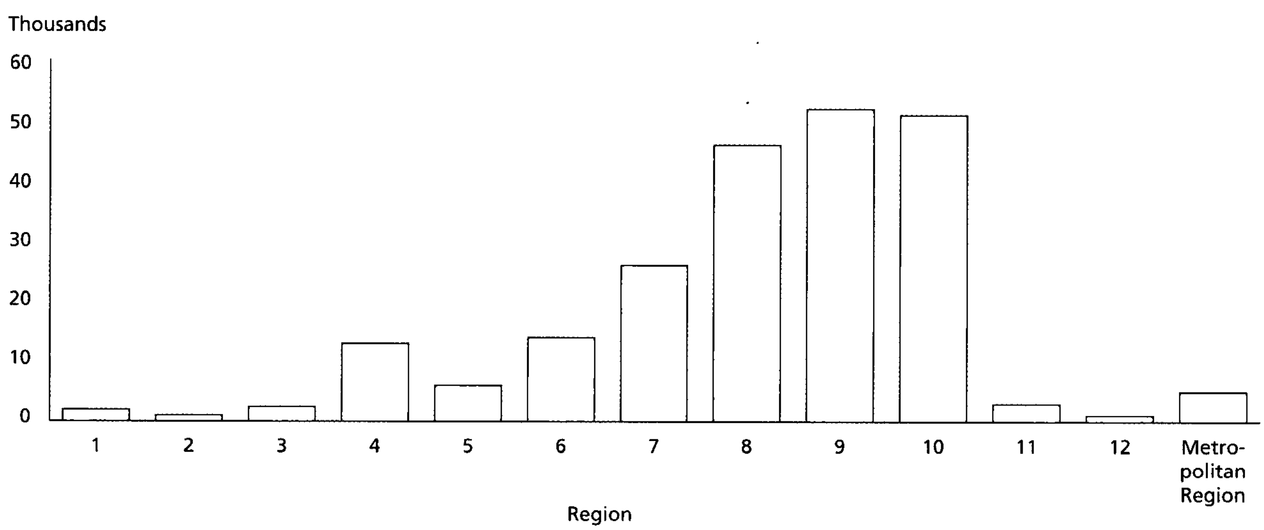
In the 1980s important changes in the administrative organization of the country and in the electricity industry called a halt to the scheme. Chile liberalized its markets, privatized state-owned electricity companies, and allowed the private sector the key role in investment. Before selling the electricity companies, the state split them into generation and transmission companies and distribution utilities. The distribution utilities were divided according to the areas in which they operated, but no exclusive distribution rights were granted. The National Energy Commission (Comisión Nacional de Energía, CNE) was created as the main policymaking and regulatory body. A new electricity law established free entry and competition in generation, a nonexclusive concession system for distribution, and a pricing scheme based on marginal costs, with generation charges reviewed every six months and distribution charges every four years (Jadresic 1997b).

The national government had traditionally been highly centralized, which tended to concentrate decisionmaking and wealth in the capital and the main cities and to promote rural-urban migration. To counter these forces, in the 1970s the country was organized into twelve regions and a metropolitan area for the capital, Santiago. The new regional governments acquired growing decisionmaking rights in such matters as allocating the state investment budget among projects and designing and implementing regional development programs. The role of the central government increasingly became to define national policies, design policy tools, and provide investment funds to the regional governments (Jadresic 1996).

The principles of the program's design

The designers of the rural electrification program set out to devise a scheme that would promote private investment,

Figure 2 **Rural dwellings lacking electricity by region in Chile, 1992**



Source: Chilean National Statistics Institute, 1992 census data.

stimulate competition, and take into account the structural reforms in the power industry and the decentralization of the national administration. They built the program around four central principles.

Decentralized decisionmaking

To ensure appropriate technology choices, promote local commitment and sustainability, and fit the new decentralized structure, the program designers decided that the regional governments would identify needs, choose the solutions, and participate in the decisions on the allocation of central funds. To involve local communities, the program would require that projects be requested by organizations rather than individuals. But the central government would provide economic resources and technical assistance and help to coordinate the institutions involved in the program. It would also provide the criteria and tools for evaluating projects to ensure coherent decisions and efficient allocation of investment resources.

It is possible to create market incentives that lead to efficient private solutions.

Joint financing

To ensure sustainability, all participants—the state, the electricity companies, and the users—would contribute to the funding of investment projects. The state's participation was needed because rural electrification projects usually are unprofitable for electric utilities, as a result of low electricity consumption, the distance from distribution centers, and the dispersion of dwellings. But state subsidies would be allocated only to projects with a positive social return. The state's contribution, delivered through the special fund, would also cover expenditures related to managing the overall program.

The state would not own or operate any facility built under the rural electrification program—that would be the role of private investors. The aim was to make rural electrification projects an attractive business opportunity for electric utilities. Companies would be required to invest their own resources to increase their commitment to the success of projects. Users would contribute both at the investment phase of projects—to increase their commitment to projects and to help extend the resources for rural electrification—and during the operation of projects—to support adequate service and maintenance.

Competition

To reduce the risk of politicization, minimize project costs, and encourage innovation, competition would be used at as many levels and stages as possible: among projects proposed by different rural communities, among distribution companies interested in supplying these communities, and among regions requesting funds from the central government. In the first two cases decisions on the allocation of investment funds would be made at the regional level, and in the third case by the central government.

The rules for deciding among competing projects would be transparent and stable and established by the central government. They would consider the average cost required to provide a certain quality of service, the local electricity needs, and the sustainability of proposed solutions. Priority would be given to zones showing the capacity to implement the program. Zones with high poverty and low community involvement—where sustainability is more likely to be a problem (particularly where self-generation is used)—would initially require more institutional assistance.

Appropriate technologies

For solutions to rural electrification needs, the program would consider not only extension of the existing distribution grids but also other technological alternatives. These alternatives, mainly for self-generation in isolated communities, could include:

- Photovoltaic solutions for isolated rural dwellings.
- Hybrid systems that reduce fossil fuel dependence and operating costs.
- Small hydroelectric power stations, independent or combined with other energy sources.
- Experimental solutions based on wind power and biomass systems, which would require a resource assessment program before being applied.

Evaluations of these alternatives would take account of minimum cost criteria and recognize that these solutions might not be the final ones. Electrification based on these technologies, along with other programs supporting rural development, could lead to greater and more concentrated electricity demand. In the medium and long term connection to the main grid might turn out to be the lowest-cost and most reliable solution. Self-generation could be just the first step (Chile, National Energy Commission 1997).

The program in action

The rural electrification program (Programa de Electrificación Rural, PER) was launched in November 1994 to carry out the new rural electrification policy. The CNE was to lead and coordinate the program. And the goals were set: supply electricity to 100 percent of electrifiable rural dwellings within ten years and reach 75 percent coverage by 2000 (Jadresic 1997a).

In 1995 the average state subsidy per rural dwelling amounted to US$1,080; in 1999 it reached US$1,510.

To reach 75 percent coverage by 2000, it was estimated that the state would have to invest about US$150 million, which would allow electrification of roughly 110,000 rural dwellings. This estimate covers subsidies from the special fund and resources allocated by regional governments. The private sector would have to invest a similar amount. Users would also have to contribute (Chile, National Energy Commission 1997).

The CNE prepared a planning and management model for the technical units of the regional governments that would lead the process. It also created methodological tools to ensure efficient allocation of the state subsidies, based on national and international experience. And it prepared preinvestment studies to generate initial project portfolios for each region.

The program is based on the idea that the technological solution should fit the needs. If technically and economically feasible, the first choice would be to provide service at the standards offered by the distribution grid (220 volts effective monophasic alternate voltage and 50 hertz frequency, with twenty-four-hour availability). But where the costs of this solution are too high, alternative technologies would be considered. To ensure sustainability in these cases, all costs over the life of the projects would be considered in the appraisal, as well as organizational schemes for operating and maintaining the projects (Chile, National Energy Commission 1997).

Management of the program

The central government's tasks of providing funds and technical assistance and coordinating the program are handled mainly by the CNE. The CNE has supplied technical, methodological, and organizational assistance in the preparation, analysis, and management of projects. It has signed work agreements with the governments of regions with the largest rural electrification deficits to create small regional technical units. It has played an important role in promoting the program at the national level and in the follow-up to the program. And the CNE has developed the norms allowing alternative energy sources in rural electrification and promoted experimental projects using these technologies.

Management of rural electrification projects

Communities in areas lacking electricity supply generally propose the rural electrification projects, supported by local distribution companies interested in providing the service. A community presents a project to its municipality, which then asks the distribution company to prepare a technical proposal, at no cost to the municipality, or contracts for this service with an independent consulting company. Once the proposal is prepared, the municipality lists the project in a publicly accessible register.

Using the prescribed criteria and tools, the regional planning agency evaluates the projects, analyzing their economic and financial costs and benefits and calculating the contribution of the company and the subsidy required. Only projects with a positive social return but a negative private return are considered for subsidies. This scheme allows a 10 percent real rate of return on investment, similar to that used for setting tariffs for the projects, over a thirty-year horizon (Chile, National Energy Commission 2000; *Diario El Mercurio* 2000).

After being analyzed, the projects are submitted to the head of the regional government in a portfolio of all those meeting the minimum requirements. The head of the regional government then presents a proposal to the regional council, which has to allocate the state funds among the projects taking into account the number of beneficiaries, the unit cost, and the financing needs. The regional government then allocates the funds to the companies that presented the projects selected.

Once a project has been implemented, the distribution company takes care of operation, management, and maintenance, recovering its costs through the tariffs charged consumers, which are set by the CNE.

Financing of the program

The responsibility for financing the projects is split up as follows:

- Users have to cover the costs of the in-house wiring, the electric meter, and the coupling to the grid. These expenditures, nearly 10 percent of the costs of each project, are initially financed by the distribution company and repaid by the users over time. Once the project is operating, the users have to pay the regulated tariffs.

- The distribution company is required to invest at least the amount calculated using a formula set by the government—to avoid such risks as goldplating. The company also must operate the projects once they are built.
- The state has to provide a subsidy for the investment costs that is no more than the (negative) net present value of the project, which in any case has to be smaller than the total investment.

Until 1994 rural electrification subsidies had been financed with resources that came from a central government fund. The fund was the main source of financing for the regional governments, which allocated its resources to many areas, including health, education, and infrastructure. Rural electrification therefore had to compete with many other needs.

To ensure that the rural electrification program could achieve its goals, a separate fund was created in 1995 to provide additional resources. The fund could be used to finance projects (grid extension or self-generation), feasibility studies, and preparation of project portfolios. To encourage regional governments to invest their own resources in rural electrification projects, it was decided that the special fund would be allocated among regions on the basis of their achievements in rural electrification in the previous year and the number of dwellings still lacking electricity.

Grants from international organizations have also been used in the program, especially for experimental projects based on self-generation systems using alternative energy sources (Chile, National Energy Commission 1999a).

Results

The rural electrification program has had a significant impact. It has not only greatly improved coverage but has also changed the way things are done in the field. It has shown that it is possible to achieve rural electrification—usually thought to be possible only by the state—in a competitive environment dominated by private companies, and that competition results in better use of resources and better results. The program has also helped to broaden the technologies used in these projects, though grid extension has been the predominant approach used. And by the end of 1999 the program had reached the coverage and investment goals originally set for 2000 (Chile, National Energy Commission 1999a).

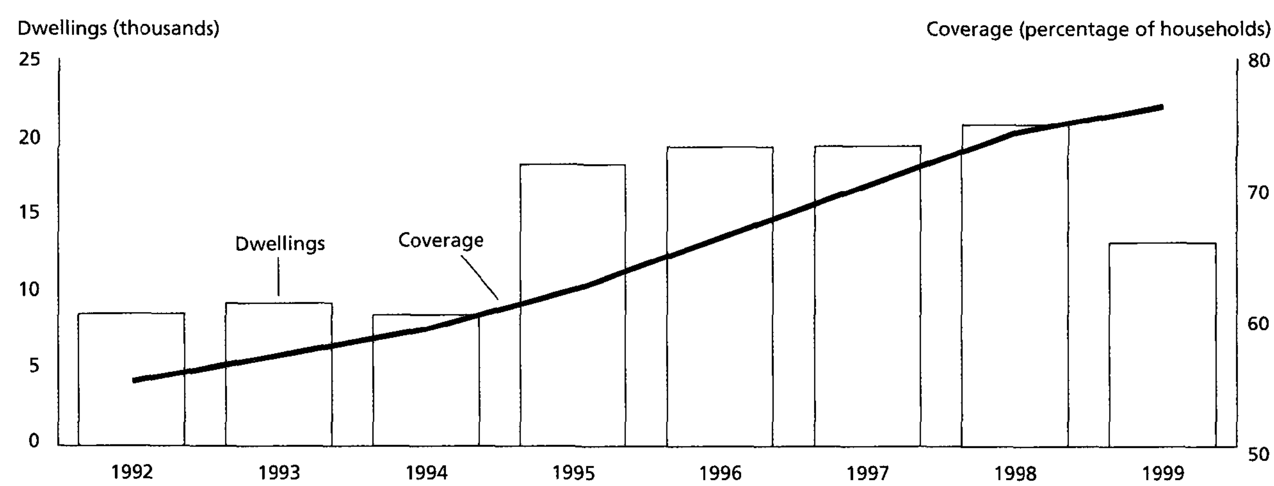
Coverage

The program has greatly increased the number of rural dwellings electrified each year as well as the coverage of the electricity system (figure 3). It has achieved the best results in the regions that started with the lowest coverage and that have the largest rural populations (see figures 2 and 4).

Investment

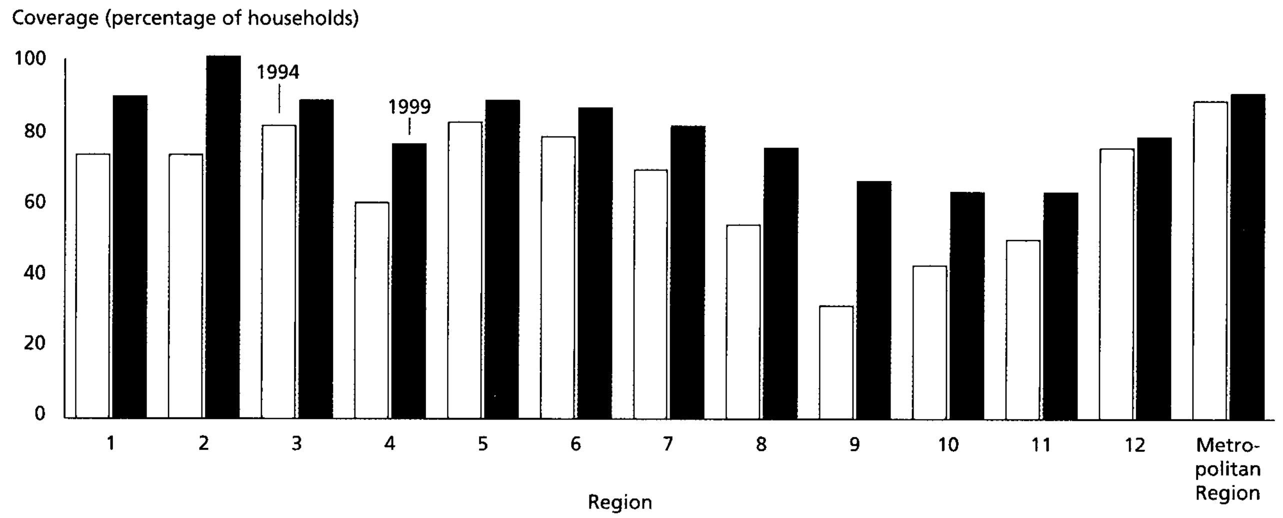
The state has contributed the most funding to the program, investing US$112 million in rural electrification in 1995–99, something less than what was estimated at the beginning of the program. That has meant more than doubling its average investment over the previous years. As the private sector has increased its investment in rural electrification, however, the state's share has declined—from 70 percent in 1992 to 61

Figure 3 **Rural dwellings obtaining electricity and rural electricity coverage in Chile, 1992–99**



Note: Data for 1999 are estimates.
Source: Chile, National Energy Commission 1999a.

Figure 4 **Increase in rural electricity coverage under the rural electrification program in Chile**



Note: Data for 1999 are as of September.
Source: Chile, National Energy Commission 1999a.

percent in 1999 (*Diario El Mercurio* 2000). Private investment in the program so far has totaled US$60 million.

Performance of participants

Users have participated in identifying and defining the projects—helping to establish the needs and priorities in each region—and in financing the investments. Companies have helped define the projects, invested resources, and undertaken the commercial risk, and continue to own and manage the installations. The most successful companies have created or strengthened special units for rural electrification.

Regional governments have managed the program well. They have promoted the program among communities, provided basic assistance in preparing the projects, decided which would be implemented, and allocated resources accordingly. They have also coordinated and monitored the implementation of the projects. Some regions—mainly those with the greatest needs and those in which rural electrification is more politically sensitive—have created special units for rural electrification, in some cases based on their experience in the field. Essential in involving regional authorities is the fact that success in the program has become a key political achievement.

The central government, primarily through the CNE as the program's coordinator, has ensured proper design and implementation of projects, clear rules (for example, for allocating funds), well-defined responsibilities, and incentives to promote efficient decisions—all essential for success.

Use of alternative technologies

Most of the projects have involved extension of the grid, a solution that usually means a lower cost per connected dwelling and a higher quality of service. But several projects have relied on alternative technologies, primarily one-house photovoltaic systems. These systems have been installed in isolated areas in the northern part of the country (for nearly 1,000 dwellings), which has some of the strongest solar radiation in the world. Micro wind, biomass, and hydropower generators have been used too, mainly in the southern part of the country. Wind and biomass technologies have been used in experimental projects and usually with technical assistance from international organizations, given the lack of experience with them in Chile and the need for further research on the availability and sustainability of these energy sources (Chile, National Energy Commission 1999a, 1999b).

The nonconventional technologies generally provide electricity at a higher cost and poorer quality (lower voltage, fewer hours of service). But they have been an attractive alternative where extending the grid is too costly because of the distance from the existing grid or the high dispersion of dwellings. Both these causes have increased the marginal cost of rural electrification in Chile. In 1995 the average state subsidy per dwelling amounted to US$1,080; in 1999 it reached US$1,510 (Chile, National Energy Commission 1999b).

This outcome is nevertheless consistent with the program's goal of maximizing rural electricity coverage within budget constraints, which mandates first implementing the projects with the highest impact per unit of investment. At the same time, however, it allows a growing role for nonconventional technologies in rural electrification projects, as improvements in these technologies reduce their costs and make them increasingly competitive with conventional solutions.

Given the lack of exclusive distribution rights, companies see rural electrification as a strategic move.

Role of markets

An innovative aspect of the program has been its promotion of rural electrification in a competitive environment dominated by private companies. It has successfully introduced competition at several levels: among communities, for financing for their projects; among distribution companies, for implementation of their projects; and among regions, for the funds provided by the central government.

The participation of private distribution companies has been critical to the program's success. From the companies' perspective, rural electrification is a long-term business and riskier than traditional distribution. Customer payments, even with generally low default rates, are usually small, while operating and maintenance costs are high compared with those for urban distribution. Companies expect consumption to increase gradually, as users realize the potential of electricity for income-generating activities (for example, for water pumps, cooling installations, and processing plants for agricultural, fishing, and forestry products). But given the lack of exclusive distribution rights, companies have seen participation in rural electrification as a strategic move to protect the existing distribution area and discourage entry by competitors.

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Note

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10 A case study on exclusive concessions for rural off-grid service in Argentina

Alvaro J. Covarrubias and Kilian Reiche

Message from the editors

Argentina, like Chile, has been a leader among developing countries in reforming and privatizing the production and delivery of energy services—and is also taking an activist approach, postreform, to expanding rural electrification. About 30 percent of rural Argentines lack electricity service. The government is piloting schemes to award concessions to electrify rural markets of between 3,000 and 25,000 customers, potentially using a variety of technological options. A key innovation in this case? To award concessions to the bidder requiring the lowest subsidy, with the objective of creating incentives to identify cost-effective technological and commercial solutions for supplying low-income customers. Argentina's initiative is in its early stages. But the initial evidence is that willingness and ability to pay fall well short of costs—suggesting that a major challenge for the future will be finding a sustainable source of financing for the subsidy.

Argentina is pioneering a new approach to provide electricity to the 1.4 million members of its rural population lacking basic service. Under this approach concessions will be granted to private bidders that require the lowest subsidy for serving a given area. The concessions will electrify rural markets of 3,000–25,000 consumers, using solar, wind, mini- and micro-hydropower, and other renewable energy technologies wherever they are the least-cost option.

A model concession contract applicable to all provinces has been designed to try to ensure that the concessionaire maximizes private investment and minimizes public subsidies. The concessions will not have an obligatory coverage target, but concessionaires will be required to provide service to consumers who ask for it. Once a concession is awarded, the concessionaire chooses the technologies best suited to meet the demand and willingness to pay of each village. The subsidy paid to the concessionaire and the customer is means-based and depends on the energy service level and chosen technology. Higher subsidies will be paid for renewable energy options. In the early years of the concessions, when subsidies are at their highest levels, the subsidies will be partially funded by donors. The subsidy can cover a share of the installation cost and, for the very poor, a share of the monthly tariff. But the subsidies will decline over the fifteen-year concession period.

The focus of this chapter is an off-grid concession being renegotiated in Jujuy province. This renegotiation is at the forefront of efforts to design effective subsidies and incentives to miminize them. Preparations for the Jujuy renegotiation got under way in 1999 and donor funding for project preparation and subsidies is scheduled to run until 2005. Beyond that date subsidy funding should decline to lower levels. Analytical work on market demand and ability to pay in Jujuy is complete and the amendment to the existing concession contract is due to be finalized by mid-2000. By 2005 all off-grid consumers in Jujuy who want service should have it.

Argentina's electricity policy

In the early 1990s the Argentine government unbundled and privatized its electricity generation and transmission sectors. Distribution companies, mostly owned by provincial governments, were privatized shortly afterwards. Privatization was done through concession contracts. Generation is competitive but distribution concessionaires receive exclusive coverage of their designated area. Any policies for rural electrification had to be compatible with this new pattern of ownership and market structure.

In 1995 the government of Argentina established a policy for the provision of off-grid electricity for lighting and social communications (radio and television) to the dispersed rural population and to provincial public services such as schools, health centers, and police stations. The federal Secretariat of Energy set up a program, Programa de Abastecimiento Eléctrico a la Población Rural de Argentina (PAEPRA), to promote electricity supply within six years to 314,000 rural households and 6,000 public services in sixteen provinces—all distant from power distribution grids. Wherever practical, PAEPRA was supposed to give preference to renewable energy systems for electricity production. PAEPRA's mandate was to articulate policy; the provincial governments were to fund the projects. In practice, and largely for political reasons, the provincial governments preferred grid extensions. Off-grid projects were starved of funds.

To help steer funding to off-grid projects, the World Bank is supporting a component concessioning project covering eight of these provinces over six years. The project, called Proyecto de Energía Renovable en el Mercado Eléctrico Rural (PERMER), aims to provide electricity to about 70,000 households and 1,100 public services. The project is expected to cost US$120 million. Funding will be allocated roughly as follows: the World Bank (US$30 million loan), the Global Environment Facility (US$10 million grant), Argentina's Electricity Development Fund for provincial projects (US$26 million), the concessionaires (US$44 million), and the customers (US$10 million).

PERMER has adopted the policy principles devised by the Secretariat of Energy for PAEPRA. In addition, to support PERMER, the Secretariat of Energy is preparing standards for electricity equipment based on renewable energy. It is training the staff of provincial regulatory bodies. It is improving databases on solar, wind, and mini-hydropower energy resources. And it is disseminating early implementation lessons through seminars and workshops. Within the project a number of tricky contract design decisions are still outstanding. How will concessionaires decide the least-cost solutions in "technology neutral" projects? How can the quality of off-grid energy service be assured and verified? How can system users be made to feel ownership—since the concessionaire will retain ownership of the electricity systems? How to ensure that enough capable bidders bid for a concession contract?

The case for rural concessions

The Argentine government decided to use concessions for rural electrification because of the country's successful experience in the 1990s with concessions for a range of infrastructure services, including energy, water, ports, roads, and railways. The main difference with the dealership approach used in many other countries is that the PERMER concessions are exclusive regulated monopolies, while dealerships allow open entry. Consequently, the selection and regulation of the concessionaire are vital to the success of the approach.

> Subsidies to the rural poor for off-grid electricity can cover only basic lighting and communications.

Relative to a competitive market with private dealers, the concession approach was favored because it:

- Creates a market with sufficient critical mass for commercially sustainable business by granting exclusive rights over a large geographic area.
- Attracts larger, better-organized private companies with their own sources of financing.
- Permits easier administration and regulation.
- Offers better chances of covering a large number of customers in a few years.
- Has good potential for reducing unit costs of equipment (through volume discounts), transactions, operations and maintenance (through economies of scale), and overhead.
- Ensures service to the consumer over a long period—the fifteen-year contract life of the concession (World Bank 1999a).

But concessions also pose greater implementation challenges in provincial areas where regulatory expertise is less developed. Under the PERMER contract, for example, both the concessionaire and the regulatory agency will need the knowledge and tools to find the least-cost solution for each village. Quality of service is also hard to monitor. Formal competitive bidding takes time and is costly. Negotiated contracts may be much quicker but may be less politically acceptable.

In the case of PERMER there is an additional complication in concession design. There are two groups of participating provinces: those where there are already distribution concessionaires covering both urban and rural areas, and those where there is no concessionaire and a new, separate rural concession must be bid. If there is an existing concessionaire that agrees to participate—as in Jujuy—its concession contract is renegotiated with the provincial government according to principles set by the federal government. If an existing concessionaire does not agree to participate, a new concession will be offered for competitive bidding.

Origins of the Jujuy concession

In 1995, just before its privatization, the Jujuy provincial-owned distribution utility was serving rural customers in nearly 1,200 households and nearly seventy public service buildings, as well as a larger, grid-connected market. The rural customers were connected to small, dispersed diesel generators and mini-hydropower, solar, and solar and wind systems. During the negotiations for the concession it became clear to the provincial government that bidders were much more interested in the grid business. So in 1996 the Jujuy provincial government split the concession in two and awarded them to two corporations: EJDESA for the grid-connected market and EJSEDSA for the off-grid (dispersed) market, EJSEDSA being a subsidiary of EJDESA.

The off-grid concession committed EJSEDSA to improving the off-grid rural system, to extending service to all rural households and public service buildings in Jujuy, and to exploring the possibility of providing electricity service for small productive activities. The rules for doing so were determined by PAEPRA. A market survey in 1996 found that about 6,000 households and 160 public service buildings (mainly rural schools) had no electricity service. EJSEDSA set an objective to extend electricity service to 600 rural households and public buildings a year, to complete about 4,500 over eight years.

Under the concession contract the provincial government was required to procure the equipment for the first 600 customers. However, the government did not buy the equipment, so in 1997–98 EJSEDSA limited its activity to connecting public buildings, mainly schools, and to maintaining existing systems. In 1999 EJSEDSA funded and

Table 1 **Distribution of income and spending on energy in Jujuy**

Monthly income category	Share of population (percent)	Monthly energy expenditure U.S. dollars	Monthly energy expenditure Share of income (percent)
Low income: less than US$150	42	9	> 6
Low to middle income: US$150–250	31	15	6–10
Middle to high income: US$250–400	17	18	5–7
High income: more than US$400	10	21	< 5

Source: PERMER.

Table 2 **Installation and lifetime costs of solar home systems in Jujuy** (U.S. dollars)

System size (peak watts)	Installation cost	Lifetime operations and maintenance cost	Lifetime battery cost	Lifetime total cost	Monthly recovery cost
50	764	390	216	1,370	16.8
70	1,074	390	299	1,763	23.1
100	1,347	390	418	2,155	26.7

Note: Assumes a 14 percent return on the concessionaire's investment and a fifteen-year life for solar systems, with batteries replaced every three years and operations and maintenance and controller replacement every seven years.
Source: PERMER.

installed photovoltaic systems in 556 rural households and 43 additional schools. It now serves 3,050 rural customers, 1,333 of whom have individual or collective photovoltaic systems.

To address the off-grid funding deficit, in 1998 the federal government proposed to the World Bank that the EJSEDSA off-grid electricity service be used as a pilot for the concession approach in the PERMER off-grid rural electrification project, using mainly photovoltaic systems. In 1999 Jujuy province confirmed to the national government its willingness to participate in PERMER and the interest of EJSEDSA.

Renegotiation in Jujuy

Considerable analytical work has been done under PERMER to assess consumers' ability to pay, set the correct tariff levels, estimate required subsidies, decide how subsidies will be paid, and design incentives to keep these subsidies to a minimum over time. This work will serve as a model for future PERMER concessions.

Matching service to income

Because of their low monthly income, most of Jujuy's rural residents can only afford to pay for small amounts of energy for lighting and communications. About 42 percent of households have a monthly income of less than US$150 and spend more than 6 percent of it (about US$9) on energy, in the form of kerosene, bottled gas, or batteries (table 1). Another 31 percent of households earn US$150–250 a month and spend about US$15 of it on energy. Those with higher incomes (US$250 or more a month) make up 27 percent of households and spend US$18–21 a month on energy.

Federal policy on subsidies for off-grid electricity for low-income populations requires that service be provided only for basic lighting and communications. Solar home systems appear to be the preferred technology in areas with high solar radiation, as in Jujuy province. Energy supplies with these systems cost an estimated US$17–27 a month (table 2)—considerably more than is now being spent by almost three-quarters of the rural population. Thus subsidies have been set so that rural consumers do not spend more than they now spend on energy.

To illustrate, a 100-peak-watt solar home system supplies about 7.5 kilowatt-hours a month. This system would allow a household to have four hours a day of light from two high-efficiency lightbulbs of 15 watts each, to listen to a 10-watt radio for three hours, to operate a 20-watt radio-cassette recorder for one hour, and to watch an 80-watt television set for one hour (table 3). For this service level a household with a monthly income of US$250 would require a monthly subsidy of about $12.

Table 3 **Service levels and customers' capacity to pay for solar home systems in Jujuy**

System size (peak watts)	Service level (kilowatt-hours a month)	Typical output: Lamps	Typical output: Radio	Typical output: Radio-cassette recorder	Typical output: Black and white television	Customers surveyed	Capacity to pay (U.S. dollars): Monthly tariff	Capacity to pay (U.S. dollars): Installation fee
50	3.75	2 of 11 watts 4 hours a day	10 watts 3.5 hours a day			361	3	50
70	5.25	2 of 11 watts 5 hours a day	10 watts 4 hours a day	20 watts 1 hour a day		516	5	80
100	7.50	2 of 15 watts 4 hours a day	10 watts 3 hours a day	20 watts 1 hour a day	80 watts 1 hour a day	688	10	100
150	11.25	1 of 15 watts 4 hours a day and 2 of 11 watts 4 hours a day	10 watts 3 hours a day	20 watts 1 hour a day	80 watts 2 hours a day	138	17	150
200	15.00	1 of 15 watts 4 hours a day and 2 of 11 watts 4 hours a day	10 watts 5 hours a day	20 watts 3 hours a day	80 watts 3 hours a day	17	25	200

Source: PERMER.

Designing tariffs for solar home systems

Under the terms of the concession, the provincial government regulates the tariff. Electricity tariffs based on economic and technical principles should generally recover investment and financing costs and operations, maintenance, and fuel costs, and deliver a profit to the provider. But the technical operation and cost structure of solar- or wind-based electricity service to off-grid customers differ substantially from those for grid-connected customers. For grid-connected customers, the electricity consumed is metered and tariff design takes into account the time of day, voltage level, and ways the electricity is consumed.[1] Off-grid electricity from a solar home system is not metered. The user pays for system size. Rural minigrids are somewhere in between, with energy and peak power limits.

The bidding documents indicate the tariff schedules with and without subsidies.

Fuel is not part of the life-cycle cost in solar home systems because the solar panel converts free solar energy into electricity. So, in this case the tariff design is based on the size of the solar panel and the storage battery—that is, on the cost of the initial investment. Thus the monthly tariff for a solar system recovers the initial investment and the net present value of operations and maintenance costs, including periodic replacement of the battery. In common with other technologies, the financial cost (annual interest rate) and the number of years over which the initial investment and operations and maintenance costs are recovered are also key ingredients in solar tariffs.

Setting subsidies for the rural poor

Three population segments are active in the market for electricity in dispersed rural areas. One segment has sufficient income to pay the full tariff, another needs financing to cover the high up-front cost, and the poorest segment needs a large subsidy because its income cannot even cover basic needs. Subsidies should be targeted to the latter two segments.

In Argentina the subsidy for rural electricity tariffs is based on household spending for lighting, radios, and the like in the absence of electricity or on household willingness to pay for electricity. Household spending on kerosene, candles, bottled gas, and dry batteries are a good indicator of the upper limit of electricity tariffs that households can afford. This baseline cost is assumed to be the rural poor's capacity to pay. From a social point of view, if the actual cost of providing electricity is higher than the baseline cost, the subsidy should fill the gap.

Households' willingness to pay for electricity is also a good indicator for defining the subsidy but—contrary to expectations—surveys have shown that willingness to pay is lower than capacity to pay. Households may believe that switching to electricity is worthwhile only if it lowers their energy spending, regardless of the other benefits that come with electricity. A lower willingness to pay may also be due to a lack of information on these benefits or the fact that regular monthly fees are harder to pay when income varies by season.

In PERMER the rules for collection and payment of subsidies to the rural poor for solar power services are relatively straightforward. The concessionaire will finance 40 percent of the installation cost of solar home systems, collect 10 percent from subsidized consumers, and collect the balance (as a subsidy to the consumer) from the provincial government. Two options can be considered for when to pay the subsidy. One is to pay the subsidy after the concessionaire has submitted proof of a system's purchase. The other is to pay the subsidy after the concessionaire has submitted proof of a system's installation. The first option reduces financial costs and assumes the concessionaire will install the system; otherwise the concessionaire will be fined or the contract revoked. The second option increases financial costs but provides an incentive for prompt installation. The option chosen is a matter for the province and the concessionaire to agree on.

The subsidy will gradually be reduced to account for expected cost reductions. Over time the monthly tariff to be paid by subsidized consumers recovers 40 percent of the installation cost plus operations and maintenance costs. In the case of the very poor, the concessionaire has to make arrangements with consumers for the payment of the 10 percent installation fee. In addition, the provincial government will subsidize part of the monthly tariff from the Tariff Compensation Fund, a fund that subsidizes electricity tariffs for low-income populations in the provinces. Low- and middle-income rural households are expected to receive subsidies of US$8–12 a month. High-income rural households will pay tariffs recovering the cost of service in full.

Providing incentives to minimize subsidies

A sustainable rural electrification market requires maximizing private investment while minimizing subsidies. The bidding process for PERMER is addressing this issue in several ways.

First, the regulatory agency calculates tariffs for off-grid electricity supplies by level of service—for example, 50, 70, 100, 150, or 200 peak watts for solar home systems. For this purpose the agency estimates costs based on indicative quotations and national and international experience. As noted, in PERMER it is assumed that the concessionaire will invest 40 percent and the household will pay 10 percent of the installation cost. The remaining 50 percent is the base subsidy. The bidding documents indicate the tariff schedules with and without subsidies.

Sustainability requires a certain, long-term source of financing for the subsidy.

Second, the concession is awarded to the most qualified bidder—based on technical, financial, and management criteria—offering the largest rebate to the unsubsidized tariff schedule. The rebate is applied to reduce the subsidy. The concession must be awarded through international competitive bidding following World Bank guidelines.

Third, where there is bidding for the concession contract, the concessionaire must procure (following its own procurement rules) and install solar home systems and obtain certification by the regulatory agency of having done so to receive payment of the consumer subsidy from the provincial government. Alternatively, the concessionaire can show evidence of purchase but incur fines or contract revocation if the equipment is not installed.

In Jujuy and all other PERMER provinces with an existing concessionaire, the tariff schedule and subsidy are fixed by the regulatory agency and the concessionaire must procure the equipment following World Bank guidelines. Any decrease (increase) in the cost of the equipment procured relative to the base cost used by the regulatory agency will be reflected in a decrease (increase) in the consumer subsidy to be collected by the concessionaire.

As noted, in PERMER the subsidy is being financed by the Electricity Development Fund, a World Bank loan, and a Global Environment Facility grant (the portion of this grant will be decreasing over time). Once the six years of project implementation have elapsed, only the Tariff Compensation Fund will finance the subsidy. The tariffs and subsidy will be reviewed every two years and revised if costs and market conditions have changed substantially. It is not clear yet how large that commitment will be.

Conclusion

If the poorest segments of the rural population are to be provided with basic electricity service, they need to be subsidized to close the gap between their capacity to pay for the service and the higher cost of providing it. The sustainability of such a solution requires a well-identified, long-term, sustainable source of financing for the subsidy, and the interest of private entrepreneurs in concessions of this sort.

Whether a concession system is the right choice for rural energy service delivery will depend on the institutional, social, and economic framework of a particular country or province. Several general issues remain to be studied during the implementation of PERMER, such as the relative advantages of monopolies and licenses and of bidding and negotiations, how to design a concession contract with a fair allocation of rights, obligations, and commercial risks among the concessionaire, the consumer, and the government, and the fair allocation of subsidy in the tariff design.

PERMER is expected to improve the quality of rural life in several ways. Electric lamps 200 times brighter than kerosene lamps will allow children to study in the evening and give adults the opportunity to extend income-generating work during evening hours. The cleanness of electric lamps will eliminate the health and safety hazards of using kerosene or candles for in-house illumination. Radio and television will improve access to national and worldwide information, reducing the isolation of rural residents and hence horizontal inequality in Argentina. Schools may provide better learning conditions by enabling the use of personal computers, the Internet, and satellite television for a wide range of programs.

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Note

1. Electricity tariffs for grid-connected customers at low-voltage levels during peak demand hours are higher than tariffs for customers connected at high-voltage levels during low demand hours.

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11 A case study on private provision of photovoltaic systems in Kenya

Mark Hankins

Message from the editors

Fewer than 2 percent of Kenya's rural households have access to electricity from the grid. Efforts by the state monopoly to improve that figure by expanding the grid have had little effect, in part because the rural population is so sparse. Some rural households have turned to different suppliers with different technology—private companies providing photovoltaic systems. Since 1990, more than 2.5 megawatts of photovoltaic electricity have been sold in Kenya, mostly to households among the top 25 percent of rural income earners. The photovoltaic market has grown in stages as technological and commercial innovations have brought it within reach of lower-income users. Photovoltaic units have gradually become smaller and cheaper. Just as important, hire purchase and finance agencies have entered the market, enabling lower-income families to buy systems on credit. The government has largely taken a hands-off approach. That, combined with its liberalization of foreign exchange and import regimes, has allowed private entrepreneurship to flourish.

The Kenyan photovoltaic industry should be of interest to other developing countries—in Africa and elsewhere—because it provides a low-cost model for sustainable, private sector–based off-grid rural electrification (box 1). Some 120,000 solar photovoltaic systems for household use (lighting, radio, or television) have been sold in Kenya since 1990, and in 1992–98 the market grew by more than 20 percent a year. (In 1999 sales dropped as a result of a downturn in Kenya's economy.) Most buyers are rural, middle-class households that lack confidence that the power grid will be extended, are knowledgeable about photovoltaic system performance, and want to make existing battery systems less maintenance intensive. Local entrepreneurs have played a key role in the process by aggressively moving photovoltaic systems to market and by downsizing the product to the needs of the lower-income market.

This market has developed in an environment where rural grid electrification had been lagging population growth for years and less than 2 percent of Kenya's 3.7 million rural households have access to grid electricity (box 2). The monopoly utility Kenya Power and Light could not cost-effectively reach most rural customers, who are far from each other and existing distribution systems. By 1999 only about 61,500 households had been connected in the more than fifteen years of Kenya Power and Light's rural electrification program (figure 1). These households consume 153 gigawatt-hours, or 4 percent of the country's demand, in 135 schemes around the country. Even if the annual connection rate more than doubled from its current rate to 10,000 connections a year, it would take almost 400 years to connect the existing rural population. In response to the slow pace of grid expansion, and starting in the mid-1970s, a small portion of salaried rural Kenyans concluded that rural electrification efforts would not reach them and began looking for alternatives.

Three stages of market development

Between 1982 and 1999 the photovoltaic market grew into a US$6 million a year industry in three stages. In the first stage upper-middle-class rural innovators—as well as nongovernmental organizations (NGOs) working off-grid—installed complete photovoltaic systems that generated demand for the technology. In the second stage large numbers of rural people bought small photovoltaic panels and batteries, primarily to power televisions. In the third stage hire purchase and finance agencies began to offer systems, allowing far more rural Kenyans to buy them on credit.

Box 1 Solar home systems

Solar home systems are an increasingly important means of providing lighting in dispersed off-grid areas of developing countries. More than 600,000 solar home systems are installed in rural areas of the developing world, many of them in the Dominican Republic, India, Indonesia, Kenya, Morocco, the Philippines, and Zimbabwe.

These are the main components of solar home systems:

- *Solar cell modules,* which convert sunlight to electricity. Solar home systems use modules that produce between 12 and 60 watts.
- *Lead-acid batteries,* which store the energy collected during the day so that it can power lights, radios, and televisions at night and during cloudy weather. Specially made deep-discharge batteries are preferred. But many people use automotive batteries, which are cheap and readily available.
- *Charge controllers* (also called *regulators*), which manage the electric charge, protect batteries from damage, and show the status of the system.
- *Low-voltage direct current (DC) appliances.* Solar home systems use DC electricity and require efficient lights, radios, and televisions. Local assembly of DC fluorescent lamps is common where solar home systems are sold.
- *Accessories.* Module mounts, wiring and fuses, battery boxes, switches, and other common electrical accessories connect the components of a photovoltaic system. The accessories for alternate current (AC) systems can often be used in solar lighting systems.

Box 2 Demographic and economic indicators for Kenya

Population size	30.5 million
Growth rate	2.7 percent
Rural share	79 percent
GDP, 1999	US$9.6 billion
GDP growth, 1993–99	1.8 percent
Per capita income	US$296
Access to grid electricity, 1999	Less than 2 percent of rural population About 8 percent of total population
Exchange rate, January 2000	70 Kenyan shillings = 1 U.S. dollar

Source: Kenya, Central Bureau of Statistics 1999a, 1999b.

Stage 1: innovators and NGOs

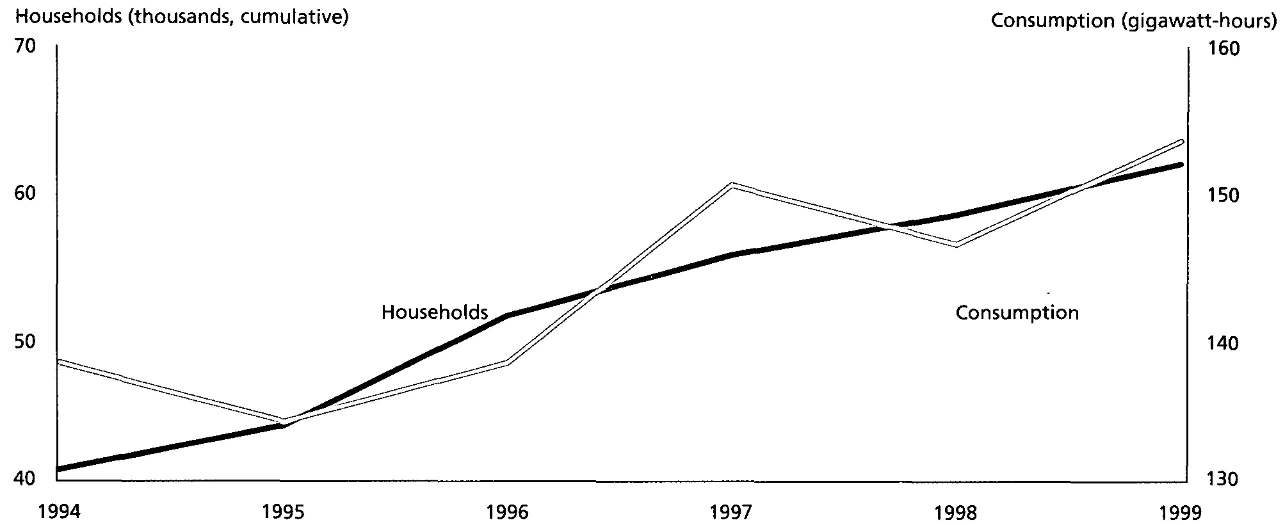
After a significant drop in the price of solar modules, donors and governments began turning to photovoltaic technology for remote power needs in East Africa. In 1982 photovoltaic-powered water pumps came into use in refugee camps in Ethiopia and Somalia. Lighting systems and vaccine refrigerators found applications in missions and clinics in Kenya, Tanzania, and Uganda. In addition, signaling and telecommunications became an immediate market for solar modules. These developments, virtually all donor or government led, initiated East African trade in photovoltaic systems, and Nairobi companies began to stock modules.

It did not take long for the rural market in Kenya to discover that, for lighting and television, photovoltaic systems are superior to generator sets. A small number of donor-initiated projects (church organizations, international NGOs, and small-scale bilateral aid projects) installed demonstration systems in off-grid schools and missions. For example, one project installed four photovoltaic systems in rural boarding schools. Within two years headmasters and scores of other community members had purchased systems for their households. After several initiatives trained rural photovoltaic agents to install and sell systems, local companies went after this household market.

In the early years well-engineered, complete systems were common, typically from 40 to 100 peak watts, with one battery powering five to ten lights and a black and white television. Marketing was easy. During the 1980s coffee boom, any off-grid coffee or tea farmer or businessperson with a permanent stone house was a candidate for a solar home system. Moreover, once a community leader had a photovoltaic lighting system, it did not take long for his middle-income neighbors to buy one too. And once the technology was known in a community, it became common for urban-based Kenyans with disposable income to purchase photovoltaic systems for their rural homes.

By the end of 1990 Kenya had more than 0.5 megawatt of installed photovoltaic capacity and at least 5,000 installed solar home systems. Although donors continued to purchase 20–40 percent of the photovoltaic equipment each year, they became far less important than the household market. Kenya

Figure 1 **Rural electrification in Kenya, 1994–99**



Note: The years refer to fiscal years.
Source: Kenya Power and Light, annual reports for fiscal 1996–99.

had nine importers of photovoltaic modules and scores of agents, mostly serving the Mt. Kenya cash-crop region.

Stage 2: mass-market, battery-based systems

Aggressive marketing quickly saturated the market for buyers of large solar home systems. Less than 0.5 percent of rural Kenyans can afford to spend US$1,000 or more for a 60-peak-watt solar home system, and by the early 1990s this market was quickly "creamed off."

Photovoltaic dealers realized that, as much as electric light was a priority, rural people also wanted television. The rapid mass-market growth of the photovoltaic industry had much to do with the expanded reach of the local television network. Among rural Africans there is a huge desire to be connected to the outside world and to be entertained. Since 1990, 5–10 percent of rural Kenyan families have bought small Chinese black and white televisions (Musinga and others 1997). In the early 1990s these televisions cost less than US$50 apiece. By the mid-1990s, 10 percent of local battery production—as many as 60,000 units a year—was being sold in the rural television and photovoltaic system market. (Tens of thousands of people use batteries to power televisions without photovoltaic modules.)

With the growth of the television market came smaller, cheaper, and incrementally purchased photovoltaic systems. Rural television buyers are cash-strapped and cannot make large cash outlays. After paying US$50 for a television and US$50 for a battery, most are not interested in a 60-peak-watt photovoltaic system that costs ten times that amount. Photovoltaic panels are still desirable, however, because they eliminate the need to carry a battery to and from a charging station.

Thus it is not surprising that interest soared in smaller, lower-cost photovoltaic modules once they became widely available. The modules were imported from Croatia, France, and Wales. In 1990 only 2,400 12-peak-watt modules were sold, at a retail price of about US$100 each. By 1998 more than 22,000 modules were selling each year, and the retail price had dropped to US$65.

Such small modules do not supply enough electricity to power a family's lighting demand. Still, more and more photovoltaic systems were being purchased a piece at a time, and vital system parts—such as charge regulators, which help protect batteries—were being left out. Yet the poor performance of smaller photovoltaic modules and systems did not slow sales (figure 2). The reason? Many consumers learn to conserve their modules' output by using the television and lights less. In addition, many purchase additional modules later when they can afford them.

Stage 3: financing mechanisms

Growing demand for photovoltaic systems inspired traders to look for ways to generate even higher sales. As noted, middle-class incomes are not high enough to cover the up-front costs of complete systems. But buying equipment incrementally is only a partial solution because it results in systems that are undersized, incomplete, and short-lived (due to battery failure).

Hire purchase of consumer goods—sewing machines, televisions, stereos, bicycles, sofas—has been common in Kenya for at least twenty years. Under this arrangement a wage employee signs up with a hire purchase company that automatically deducts monthly payments from his or her salary. Interest rates, which run 40 percent a year or more, are factored into the price. In 1996, after at least one failure to market photovoltaic products through hire purchase companies, a leading photovoltaic company tried to build sales through hire purchase agencies. The company offered attractive credit terms to hire purchase retailers and sought a wide base of agents. In 1998 the company sold more than 1,500 systems (and modules) on credit. Today at least four leading photovoltaic importers supply systems to hire purchase agents, and 15 percent of the solar home system business passes through hire purchase.

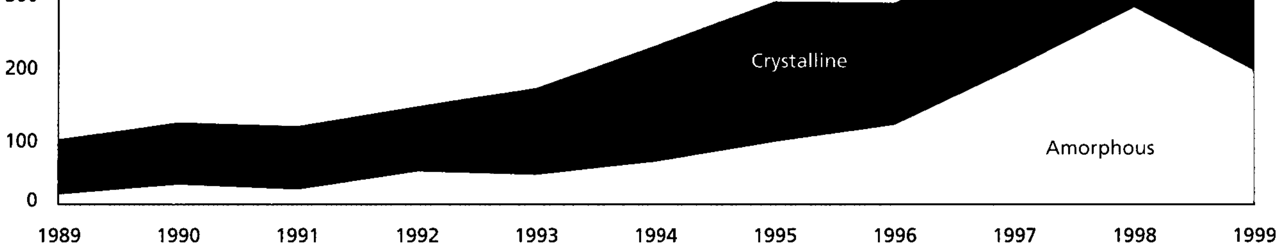
Traditional loans dedicated to solar home systems are still in the early stages, because banks and credit cooperatives are reluctant to enter the photovoltaic business. Certainly, thousands of salaried people have used loans from banks and cooperatives to buy photovoltaic systems. But these ordinary loans are not trackable as solar home system loans.

The World Bank, through the Energy Sector Management Assistance Programme, has tried to stimulate financing for photovoltaic systems. One project worked with two rural banks to develop loan lines dedicated to solar home systems. The demand for the loans was far greater than the supply, repayment rates were high, and installation quality was excellent. Bundling the systems and loans together into one program enabled loans to be priced much lower than regular commercial retail rates. As new products, however, solar home systems required a lot of extra staff time from the two banks. Still, the project underscored the need to educate financial institutions about the demand for and the value and viability of financed solar home systems. As a result of this and a new initiative by the International Finance Corporation, commercial banks and rural savings and credit cooperatives are now more aware of the demand for and viability of finance in providing basic electricity service to rural people through photovoltaic systems. Unfortunately, 1999 was a poor year for the Kenyan economy, undermining efforts to grow lending.

Market prospects

Since 1990 more than 2.5 megawatts of photovoltaic capacity have been sold in Kenya. More than 60 percent of these sales went into solar home systems. By 1999, 3–4 percent of the rural population had acquired a photovoltaic system, and at least 70 percent knew what such a system was. That same year the total photovoltaic market was about 480 peak kilowatts. Of this,

Figure 2 **Estimated photovoltaic sales in Kenya, 1989–99**



Note: Crystalline silicon solar cell modules are manufactured from ingots of very pure silicon. Amorphous solar cell modules are manufactured using a less expensive process. Some amorphous modules have quality problems, but most experts agree that they will eventually be the most common technology.
Source: Energy Alternatives Africa, annual surveys.

more than 250 peak kilowatts came from modules of 20 peak watts or less. This sustained and growing demand is a clear indication of the value rural people place on modern energy.

Data suggest that photovoltaic systems are being bought not by the elite, but mostly by upper-middle-class people—that is, the top quarter of rural income earners. According to a 1997 survey of 1,200 households, the total demand for solar home systems in rural Kenya is about 25 peak megawatts, and the effective demand is 14 peak megawatts (table 1). Market penetration is occurring at about 1 percent a year, and 5–10 percent of the total demand has been satisfied.

But when given a choice between a solar home system and grid power, rural Kenyans universally prefer the grid. If people even hear that electricity service will be supplied in an area, they will wait five years for grid power rather than buy photovoltaic systems. Grid electricity offers more appliance choices and lower costs. But most rural Kenyans do not have a choice. Between 1995 and 1999 the rural electrification program connected fewer than 21,000 households. During the same period more than 80,000 households bought solar modules.

Market players

Today's photovoltaic industry involves an increasing number of players:

- There are ten to twelve photovoltaic equipment importers, many of which have turnovers above US$500,000, and nearly all of which deal in other products related to photovoltaic power. For example, one major photovoltaic importer is a battery manufacturer, another is a television and appliance dealer, and another sells power electronics.
- There are hundreds of retailers—including appliance vendors, automotive parts suppliers, hire purchase agents, and a few dedicated "solar retailers"—selling to customers from urban and small town outlets.
- There is a small but active group of local manufacturers that assemble and sell system components, including 12Vdc (volts of direct current electricity) lights, cables, charge regulators, and batteries.

Consumer benefits

Surveys show that about 60 percent of buyers are satisfied with their photovoltaic systems, and 94 percent would recommend them to a friend (Hankins, Ochieng, and Scherpenzeel 1997).

A dealer's purchase price for a photovoltaic system can be as little as US$150 for a two-light, 12-peak-watt system with batteries and wires (without a charge regulator). In real terms prices for photovoltaic electricity have fallen over the past five years as a growing number of importing companies have increased competition (table 2).

Photovoltaic systems can save consumers more than US$8 a month over more traditional forms of energy, with 80 percent of the savings coming from lower kerosene and dry cell consumption (table 3). Thus a 10- to 15-peak-watt photovoltaic system will pay for itself within 1.5–2.0 years. The smallest systems—that is, 10–15 peak watts—offer the largest incremental savings. Incremental savings are much smaller for larger systems. These savings explain why many rural Kenyans buy small photovoltaic modules and batteries without charge regulators. The first solar home system that a Kenyan buys is likely to be lower quality and less economic. Still, the photovoltaic panel and battery set brings better energy services and cash savings immediately, even if it does not last as long as a well-designed system.

Photovoltaic electricity and 12-volt lead-acid batteries are vastly superior to kerosene and dry cells, mainly because they are more convenient. Electric light is much higher quality than that provided by a kerosene lamp: it provides far more lumens per dollar, it does not smoke, and it can be switched on and off at will (no need to light a lamp). Similarly, a 12-volt battery can run multiple appliances—a television, lights, and a radio—for much longer periods than can a

Table 1 **Breakdown of the demand for solar home systems in rural Kenya**

Type of system consumer could afford	Share of population (percent)	Average monthly energy expenditure (U.S. dollars)	Number of households (millions)
None	40	< 7.4	1.60
One light (5–12 peak watts)	34	7.5	1.36
Two to four lights (15–40 peak watts)	22	7.5–11.0	0.88
Five or more lights (> 40 peak watts)	3	> 11.0	0.12

Source: Musinga and others 1997.

Table 2

Cost and size of average consumer photovoltaic systems in Kenya, 1995–96

System size (watts)	1995 Cost (U.S. dollars)	1995 Watts used	1995 Installed cost per watt (U.S. dollars)	1996 Cost (U.S. dollars)	1996 Watts used	1996 Installed cost per watt (U.S. dollars)
< 16	227	12	18.9	217	12	18.1
16–25	453	22	20.6	399	21	19.0
26–45	734	40	18.4	643	41	15.7
> 45	958	67	14.3	839	56	15.0

Source: Hankins, Ochieng, and Scherpenzeel 1997.

dry cell. And as noted, adding a solar module to a battery system reduces the need to carry the battery back and forth for charging at a distant center. In addition, photovoltaic and battery systems are preferred to generator sets. Photovoltaic systems are cheaper and more convenient for typical rural needs. Even the smallest generator retails for more than US$500, not including installation. Used for four or five hours a day, such a set costs US$64 a month to fuel, plus maintenance. Moreover, to get light in the middle of the night, the household has to start up the machine. Solar systems provide households with round-the-clock electricity.

Still, even in Kenya it is doubtful that the poorest 40 percent of the population—which relies mostly on subsistence farming—would consider photovoltaic power a priority. In terms of megajoules, wood is by far the most important form of energy in East Africa. It is usually a collectable "free" resource. But burning wood does not provide acceptable lighting levels, and neither radios nor televisions can be powered by wood. Most rural Kenyans continue to use kerosene for lighting, dry cell batteries for radios (more than half of rural households own a radio or radio-cassette player; Musinga and others 1997), and wood for cooking. Families pay US$5–10 a month for kerosene and dry cells, while women and children tend to collect wood. Higher-income households use more kerosene and dry cells, while lower-income households limit their purchases to times when they have cash flow (after harvests, at the end of the month, and so on).

Government policy

The demand for electricity in Kenya is growing by about 6 percent a year. Energy policies are primarily targeted to

Table 3

Monthly savings reported by photovoltaic consumers in Kenya, by system size, 1996
(U.S. dollars)

Source of savings	1–15 watts	16–25 watts	26–45 watts	46–200 watts
Battery charging	1.71	1.45	1.75	1.42
Kerosene	2.93	3.87	5.64	6.78
Dry cells	3.89	3.75	5.02	4.24
Other	0.00	0.31	0.27	0.33
Total	8.55	9.40	12.65	12.76

Source: Hankins, Ochieng, and Scherpenzeel 1997.

meet the electric power industry and commercial fuel supplier needs, which have a direct bearing on Kenya's urban infrastructure. Through the 1997 Electric Power Act, Kenya liberalized the power sector and privatized the main power company, Kenya Power and Light—though the government still owns a controlling share. Kenya Power and Light now buys electricity from three new independent power producers, and more independent producers are preparing to enter the market. While Kenya Power and Light retains a monopoly on distribution, privatization has forced the utility to carefully scrutinize programs that are not cost-effective, including its rural program. It has limited generation capacity—about 800 megawatts in 1999—and has made urban and industrial customers a priority.

But the government's hands-off approach to the off-grid private sector has helped the photovoltaic industry flourish. Over the past five years the removal of import, price, and foreign exchange controls has opened markets to competition. The government has reduced duties on photovoltaic modules to 5 percent and removed the value added tax, lowering photovoltaic system prices to consumers by 15–20 percent. The Kenyan shilling is freely convertible. Moreover, after South Africa and Zimbabwe, Kenya has the continent's most thriving secondary capital market: debentures, mortgages, pensions, bonds, and stocks are traded widely. This environment has encouraged international photovoltaic suppliers to establish local bases in Kenya to serve the East African market—modules come to Kenyan vendors from Australia, Croatia, France, India, Japan, Russia, Spain, the United Kingdom, and the United States. The competition has led to more competitive pricing and a wide range of product selection. Still, photovoltaic prices are more competitive in Asian countries such as China and Indonesia.

A final benefit of the government's hands-off policy is that there have been no large projects or government tenders to distort the industry. In other countries (India, South Africa) large projects and unsustainable subsidies for photovoltaic equipment have undermined private sector activity, because big players move in and out of the market at will to take advantage of the handouts. In Kenya the market's commercial base has made it more sustainable.

Still, a number of policy-related hurdles remain:

- Conventional rural electrification equipment and photovoltaic modules are exempt from duties and value added taxes. But batteries, charge regulators, inverters, and efficient appliances are charged duties and value added taxes in excess of 35 percent of their price. (Kenyan manufacturers make more than 90 percent of the batteries used in local solar home systems, 30–50 percent of the lamps, and perhaps 10 percent of the charge regulators.) There is a need to level the playing field for electrification options.
- The industry suffers from erratic equipment and installation standards. Dealers undersize or leave out vital components to win contracts, and there is little incentive for proper engineering. Prevalent sales and installation practices undermine consumer confidence in photovoltaic equipment, especially larger systems. Although many people are satisfied with marginally functioning systems, others will not consider using photovoltaic systems because they view them as inferior. Consumers need to be made aware of what a well-designed system can do. Without consumer awareness, it is hard for companies to promote quality.
- The industry suffers a lack of trained technicians. Without systematic technician training, installation—and hence system quality—will remain poor.
- Financing for photovoltaic systems is the next frontier in making the technology more widely available and functional. Rural residents cannot afford to buy complete systems all at once. But Kenya has a strong rural credit tradition and hire purchase movement and this is fertile ground for more experimentation.

Conclusion

Kenya's experience should be replicable in other countries facing similar conditions. Key among these are:

- Low grid coverage.
- Adequate rural incomes (there is a well-developed middle class) and a large number of rural people who want lights and power for their televisions (television broadcasting reaches deep into rural areas).
- A strong entrepreneurial class. Many components of photovoltaic systems—including batteries, lights, and cables—were already sold by traders before the industry took off. This made it easier for small-scale traders to enter the market. A good flow of customer feedback to importers, wholesalers, and retailers of photovoltaic products has developed. This has helped the industry to respond to new customer demand for smaller, lower-cost systems. And the modular nature of photovoltaic technology has allowed customers to add a module when their energy needs require and budget permits.
- A relatively progressive financial sector that has (albeit slowly) incorporated photovoltaic equipment into its consumer goods portfolio, based on firm demand, not donor projects or government subsidies.

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Note

The Energy Sector Management Assistance Programme has provided about US$500,000 in recent years to analyze the development of the photovoltaic market in Kenya and to test-market equipment.

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New rules

12

Better energy services for the poor

12 Better energy services for the poor

Penelope J. Brook and Warrick P. Smith

Governments around the world—rich and poor alike—confront the challenge of ensuring that their people have access to clean, efficient, reliable, and affordable energy services. This challenge is particularly acute for developing countries and for low-income households and communities where density, distance, and resource availability raise costs above local ability or willingness to pay.

There is a rich body of experience with different policy responses to this problem. But do current approaches take sufficient account of the new opportunities arising from rapid changes in technology and economic thinking? This chapter outlines those opportunities, explores some of the new directions open to policymakers, and considers some of the implementation challenges.

New opportunities

Energy policies and projects have traditionally focused on large capital investments in the generation and transmission of electricity, gas, and petroleum products, often through monolithic state-owned enterprises. Improving the welfare of the poor was rarely an explicit objective. To the extent that it was explicit, two outcomes were expected:

- Higher productivity and growth—as a result of increased access to modern, reliable energy sources by cities, towns, and businesses. This benefit was expected to trickle down to the poor through better earnings prospects.
- Improved community and household access to reliable energy services (particularly electricity and gas) through grid extension and expanded generation capacity.

Results were often disappointing. Repeated investments in poorly operated systems, perennially short of cash because of below-cost tariffs and chronic inefficiencies and system losses, often failed to increase access or productivity in developing countries. And the poor typically bore the brunt of these failures—suffering unreliable access when connected to energy networks and often facing high costs for alternative energy sources while waiting for access, whether to gas or electricity networks or to improved distribution systems for kerosene, liquefied petroleum gas (LPG), or other petroleum-based fuels.

Much has changed as policymakers have learned more about the causes of these failures and pushed for more effective and sustainable energy policies. Recent experience—initially in industrial countries but increasingly in developing countries—shows that energy supply through networks can be made competitive. This creates opportunities for expanding services and cutting costs both on and off networks. In addition, new technologies have created opportunities for lower-cost, smaller-scale generation that lends itself to more competition in networks (see chapter 5) and to a broader range of supply options off-grid (see chapter 6). Technology has also profoundly changed the options for managing the transmission of power and gas across grids, increasing consumers' chances of accessing cheaper, more reliable energy. And the pace of technological progress shows no signs of abating.

For most goods and services it is now accepted that the best way to respond to consumer needs and preferences, and to spur innovation, is to allow provision by a range of service providers that compete in terms of price and quality. For much of the 20th century energy services were believed to be an exception to this proposition because they were viewed as a natural monopoly and because governments relied on monopolistic provision (whether state owned or private) to deliver cross-subsidies between users and to pursue other social objectives. But reinforced by technological developments, economic thinking on energy policy is changing fast. Ideas on managing monopolies have shifted to options for facilitating competition and mobilizing the private sector to develop, finance, and implement new and better ways of meeting consumer needs. This evolution has big implications for policymakers.

New directions

Policymakers have promising new options for meeting the energy needs of the poor. Attention should focus on four areas of policy action.

Rethinking monopoly

The past preoccupation with monopolies needs to shift to take advantage of opportunities for competition in energy provision. This has two major implications:

> The best way to respond to consumer needs is to allow a range of providers that compete on price and quality.

- Exclusivity arrangements traditionally granted to energy providers need to be scrutinized with increasing caution. For example, distribution networks for power, gas, and other fuels might be privatized without exclusive service areas (especially in service areas that include unconnected households). And off-grid solutions—such as contracts for rural electrification through solar, wind-powered, or micro-hydropower schemes—can be designed to allow entry by providers offering alternative technologies, lower prices, or both.
- Energy markets should be restructured to facilitate entry and competition, including in the distribution and retailing of services. Options to be considered include:
  - Separating distribution functions from transmission and generation functions in electricity and gas, to facilitate competitive entry and service expansion by local distributors.
  - Separating retailing from distribution functions to facilitate price and service competition in low-income communities.
  - Allowing multiple players, small and large, in the construction and operation of secondary and tertiary networks (for grid-based services).
  - Allowing multiple players in projects to expand services to rural areas.

Getting prices right

Traditional approaches to energy pricing often involve deep distortions. For example, uniform national electricity and gas tariffs that are set below the full costs of supply make these sectors dependent on public subsidies that are rarely sustainable. But even in sectors that are financially self-sufficient, cross-subsidies between categories of users rarely help the poor (who lack access to network services) and in fact create financial disincentives to serve low-income households. In addition, cross-subsidies rest on monopolistic supply arrangements and so preclude more dynamic, competitive approaches.

Elsewhere in the energy sector, taxes on fuels such as petroleum, kerosene, and LPG often limit the extension of markets for these fuels to low-income communities, or distort incentives for their use. In addressing these shortcomings, policymakers should focus on three issues:

- To the maximum extent possible, energy prices should reflect the full costs of supply. In addition to promoting the efficient use of a scarce resource, this approach gives service providers an incentive to respond to all categories of consumers—including those in remote or difficult to serve areas.
- Where subsidies are considered necessary or desirable, there is a need to rethink their structure, financing, and delivery. Traditional cross-subsidies that depend on monopolistic provision will be difficult to reconcile with market liberalization. Subsidies should be clearly targeted to the intended beneficiaries and delivered in a manner consistent with competitive provision. For example, budget-funded subsidies might be delivered to targeted households through a welfare-type system, as in many sectors in Chile. In societies with less developed social safety nets, it should be possible to award subsidies to suppliers based on the number of new households they connect and serve, creating strong incentives for service expansion without erecting or sustaining monopolies—subsidizing connections, not consumption.
- Tax arrangements need to take into account their impact on energy markets. For example, fuel taxes often distort the relative prices of alternative energy sources or remove certain fuels from markets accessible to low-income households or communities.

Adapting regulatory approaches

Power and gas regulation has traditionally focused on closely supervising monopolistic suppliers, including through detailed price and quality rules. This function has been seen as the preserve of central regulatory bodies, whether housed in a ministry or operating independently. This approach needs to be reconsidered in three important respects:

- Intensive regulation needs to be limited to residual elements of monopoly power—for example, in network distribution systems and possibly at the interface between trunk transmission networks and distributors or retailers. Much less control should be exercised over interactions between essentially competitive market players—including new local providers active in small-scale retailing of electricity, gas, and other fuels and in the installation and maintenance of diesel generators, LPG distribution points, micro-hydropower systems, or photovoltaic cells.

- Regulations on service quality standards need to be scrutinized. While there may be an ongoing need to address public safety and other concerns, standards are often set at levels that unnecessarily increase costs and so block expansion of services to low-income households. For example, technical standards for system construction (such as standards for the construction of transmission lines) are often set at industrial country levels, leading to high startup costs and creating a disincentive to expand both network and off-grid services. At the household level, simplifying wiring codes and using load limiters rather than consumption-based meters for low levels of consumption could reduce installation, billing, and collection costs.
- Regulatory processes need to change. Reflecting the changes in energy markets, more efforts need to be made to facilitate participation by low-income consumers and their representatives. There are also opportunities to mobilize communities (and nongovernmental organizations) in monitoring small-scale energy retailers and service providers in periurban slums and small rural towns.

Looking beyond the energy sector

Energy policymakers have tended to stay within their bailiwick, rarely venturing into broader policy issues that affect the affordability of energy services. The new approach requires policymakers to take a more holistic view of the factors affecting energy supply to low-income households and communities. For example:

- Low-income households often have trouble accessing credit to finance new connections and equipment. Recent decades have seen the emergence of promising private solutions to this problem—including term payment arrangements extended by service providers, finance extended by local microcredit agencies, and community savings schemes. While there is debate on the scope and nature of government action appropriate to support such schemes, finance and banking laws should not erect unnecessary barriers to the development of financing arrangements targeted at the poor.
- Many regulations make it more difficult for suppliers to offer a service or for households to sign up for it, or otherwise increase the costs of energy services. These include building codes that define construction standards for electricity or gas connections, land use and physical planning laws and regulations that prohibit the extension of services into informal neighborhoods, rules and processes for clarifying land tenure and ensuring land security, and prerequisites for legal recognition of community-based organizations that could intermediate between service providers and local households. Taxes, import restrictions, and other interventions may also increase the costs of equipment used in serving low-income households and communities. Just as sound energy policies contribute broadly to most other productive activities in the economy, sound microeconomic policies are vital for sustainable improvements in energy services.

Regulatory processes need to change—with more participation by low-income consumers.

A more holistic approach to policymaking would create the potential for technological and commercial innovations that bring better services within the reach of the poor—and for removing or reducing barriers to service for low-income households and communities. Some new policies would require new interventions—such as revised regulatory and subsidy arrangements. Others would require reforming interventions that inadvertently impede the improvement of services for the poor. Most focus on reshaping the institutions that determine the nature and cost of energy services delivered—rather than on adjusting the actual delivery of these services.

The new policy approaches do not mean that the government has no role to play in financing energy investments. But they do mean that public investments need to be much more carefully designed, and made in a way that facilitates rather than crowds out or restricts private competitive responses. In many cases public resources may be best channeled through transparent subsidies rather than through existing monopolies.

From theory to practice

Change is always difficult—whether on the relatively modest scale of making poor communities more active players in decisions on how to improve their energy services, or on the grander political scale of reformulating energy policies to enable competition and entry. Very often, those who stand to gain from such changes—and this applies above all to the poor—have less political voice, or a less concentrated political voice, than those who risk losses.

The policy approaches outlined above are no exception to this rule. In particular, they threaten the loss or erosion of various kinds of monopoly power (and accompanying opportunities for corruption)—by removing or reducing exclusive service prerogatives, by trimming back regulatory prerogatives, by reforming standards to increase the range of acceptable technologies, and by reforming and simplifying fuel taxes.

To weather the inevitable resistance, governments need a strong commitment to improving outcomes for the poor. In this context, the quality of the reform process is likely to be critical to the dividends of reform. Processes must focus on stakeholder consultation and consensus building—with particular attention to mobilizing stakeholder groups that stand to gain from reform. These groups include, most notably, the poor. But they also include small businesses (which could take a more active role in serving the poor) and nongovernmental organizations (which could take a more active role in facilitating and monitoring service delivery in rural towns and periurban slums).

Beyond politics, the policy directions described above suggest critical changes in the design of energy projects (particularly reform projects) and in the process by which these projects are developed. For example, they suggest more, and early, emphasis on distribution issues—in particular, restructuring and regulatory reform to facilitate entry prior to engaging in large-scale privatization. They imply more attention to gathering data on such matters as the nature of current energy use and demand for energy by low-income communities (see chapters 2 and 6), and more attention to identifying potential players in energy markets (for example, small businesses with the potential to become energy suppliers). And, in the context of designing regulatory regimes, they suggest more attention to identifying nongovernmental and community organizations that could play a role in monitoring service provision.

As in any area of policy innovation, much can be gained from a concerted effort to monitor and draw lessons from reform experiences in other countries. But the success of any policy will ultimately depend on careful adaptation to local conditions and priorities.

The promise

The policy approaches discussed in this chapter focus on access—on improving the service options available to low-income households and communities. As discussed elsewhere in this report, improving access to better, cheaper energy services contributes directly to the welfare of the poor in a variety of ways—by freeing cash and human resources for more productive uses, by improving access to health care and education, by broadening opportunities for the development of household businesses, and by improving local and household environmental quality.

But the ways in which energy policies are set and energy services are delivered can also have important indirect benefits for the poor. A more efficient, financially sustainable energy sector contributes to national economic productivity and employment and earnings prospects. A more competitive and transparent energy sector provides fewer opportunities and incentives for corruption, which tends to affect the poor disproportionately (see chapter 8). A sector that is less reliant on government subsidies can free fiscal resources for beneficial social purposes—and a sector that is a net contributor to the tax base can boost those resources (see chapter 3).

Entry and competition are the key tools in pushing for growth and attacking poverty.

Would a focus on enhancing these less direct benefits fundamentally change the policy prescriptions set out here? Most likely, the emphasis would differ somewhat—for example, with more emphasis placed on market structure and regulatory reforms aimed at increasing the efficiency of gas and electricity services delivered through networks, and perhaps less on facilitating micro-solutions for small rural towns. But in essence the prescriptions are common ones, with entry and competition serving as key tools both in the push for growth and in the battle against poverty.

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Part 2

Trends in private investment in the energy sector, 1990–99

Private participation in energy

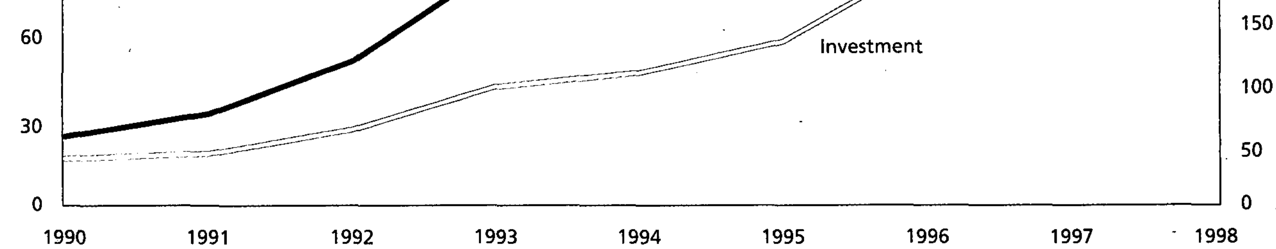
Ada Karina Izaguirre

The past decade has seen a wave of liberalization and privatization of infrastructure activities in developing countries. By the end of the 1990s the private sector had become an important financier and long-term operator of infrastructure activities—in water, transport, energy, and telecommunications—in those economies. In 1990–98 it had undertaken the operating or construction risk (or both) of about 1,700 infrastructure projects in developing countries.[1] Those projects involved investments of almost US$500 billion.[2]

The availability of long-term foreign capital and the opening of infrastructure sectors to private investment allowed the rapid increase in private infrastructure activity in developing countries. Long-term foreign capital flows to developing countries—as foreign direct investment, foreign debt, or equity investment—more than quadrupled between 1990 and 1997 before falling in the late 1990s as a result of the financial crises in developing economies (figure 1). This influx of foreign capital has made foreign investors the main sponsors of private infrastructure in developing countries. In 1990–98 global developers were the top fifteen sponsors, measured by investment, in the infrastructure business in developing countries and were involved in a tenth of the private infrastructure projects in those countries. These projects accounted for almost a third of total investment in such projects.

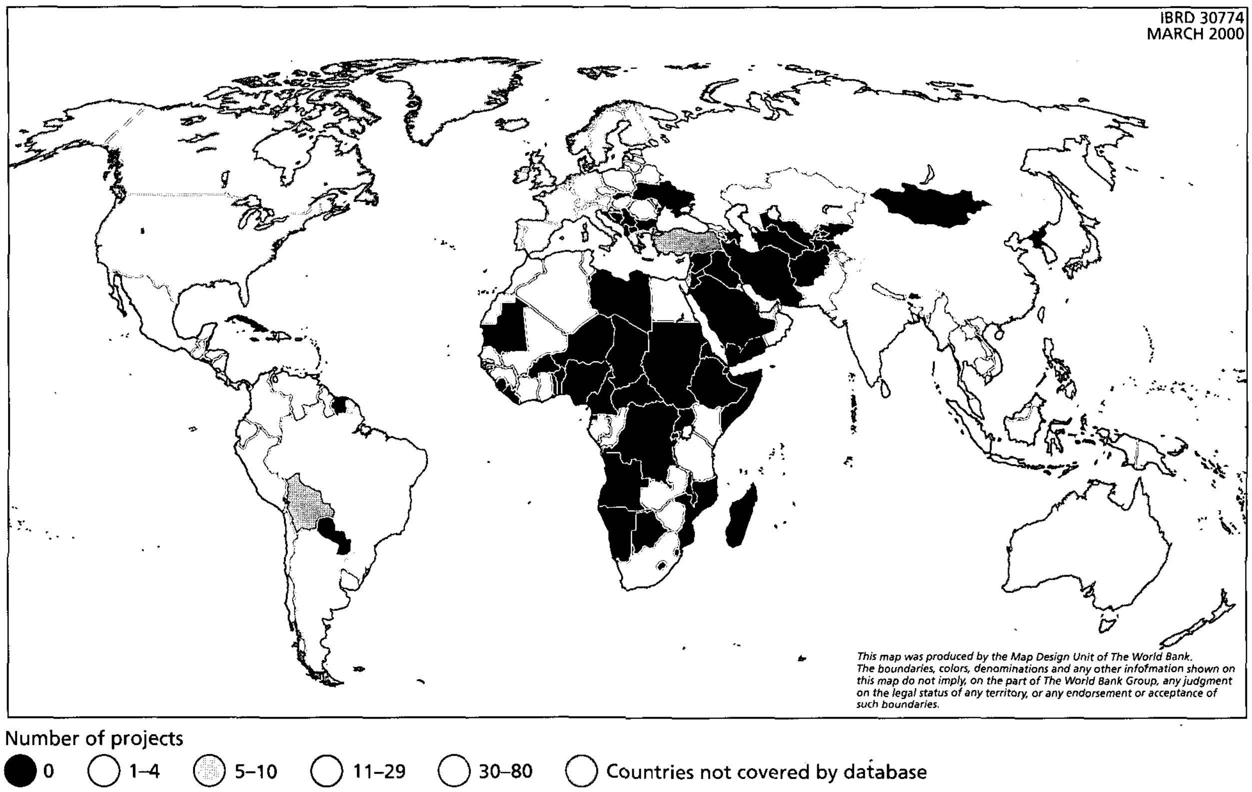
The energy sector, which in this part of the report includes electricity and natural gas transmission and distribution, has been at the center of the liberalization and privatization activity. (Oil and upstream natural gas activities are excluded from this review.) As in other infrastructure businesses, in energy private activity has been driven by the need to expand capacity and increase reliability in an environment of tight public

Figure 1 **Net long-term private capital flows to developing countries, and total investment in infrastructure projects with private participation in developing countries, 1990–98**



Source: World Bank forthcoming; World Bank, PPI Project Database.

Map 1 **Energy projects with private participation in developing countries, 1990–99**



Note: Projects cover electricity and natural gas transmission and distribution. The database includes mass privatization programs such as voucher privatization.
Source: World Bank, PPI Project Database.

budget constraints. Private participation and competition have also been propelled by new technological developments that have reduced the minimum size of competitive power plants, lowered transactions costs, and increased the efficiency of grid utilization.

In 1990–99 seventy-six developing countries introduced private participation in energy (electricity and natural gas transmission and distribution). These countries awarded the private sector more than 700 energy projects, representing investments of almost US$187 billion (map 1; annex table A.1). Foreign capital has been a major source of funds. In 1990–99 global developers were the top ten sponsors of private energy projects, measured by investment, in developing countries and were involved in a fifth of those projects. Their projects accounted for just over a third of total investment (table 1; annex table A.2).

This part of the report draws on the World Bank's Private Participation in Infrastructure (PPI) Project Database to provide an overview of trends in the private energy projects in developing countries. The PPI Project Database tracks infrastructure projects, newly owned or managed by private companies, that reached financial closure in 1990–99 (annex box A.1).

Four main trends have emerged in private energy projects in developing countries during the past decade:

- As in other infrastructure businesses, private participation in energy grew rapidly during the 1990s.
- Investment in energy projects with private participation declined in 1998 and 1999 from a peak in 1997, falling most in East Asia and the Pacific and Latin America and the Caribbean.
- Latin America and East Asia have led in private activity in energy, each following a different approach.
- Private activity in energy—whether measured by countries, projects, or investment—has been concentrated more in electricity than in natural gas.

Table 1 Top ten sponsors of energy projects with private participation in developing countries, 1990–99

Sponsor	Projects	Total investment (billions of 1998 U.S. dollars)
AES Corporation	35	12.7
Enron Corp.	23	12.5
Electricité de France	22	11.5
Endesa (Spain)	11	9.1
Southern Energy Inc.	10	7.6
CMS Energy Corporation	17	6.7
Cia. Naviera Perez Companc	8	6.2
Endesa (Chile)	15	5.7
Tractebel	17	5.6
Enersis	7	5.3
Total	156	68.2

Note: Table includes projects in which the sponsor has at least a 15 percent stake. The data do not sum to totals because in some cases more than one sponsor is involved in a project.
Source: World Bank, PPI Project Database.

Rapid growth in private activity

Private activity in energy, measured by total investment (private and public contributions) in projects with private participation, boomed in 1990–97, rising from less than US$2 billion to US$46 billion (figure 2). It then fell to US$25 billion in 1998 and to US$15 billion in 1999—its 1993 level—as a result of the financial crises in developing countries in 1997–99. The economic downturns dampened the growth in energy demand. Annual growth in electricity demand in developing countries (excluding transition economies) dropped from 6.5 percent in 1990–96 to 4 percent in 1996–2000 (U.S. Department of Energy 2000). The financial crises also made international financial markets reluctant to invest in developing economies. According to preliminary World Bank estimates, net long-term capital flows to developing countries declined by a fifth between 1997 and 1999 (box 1).

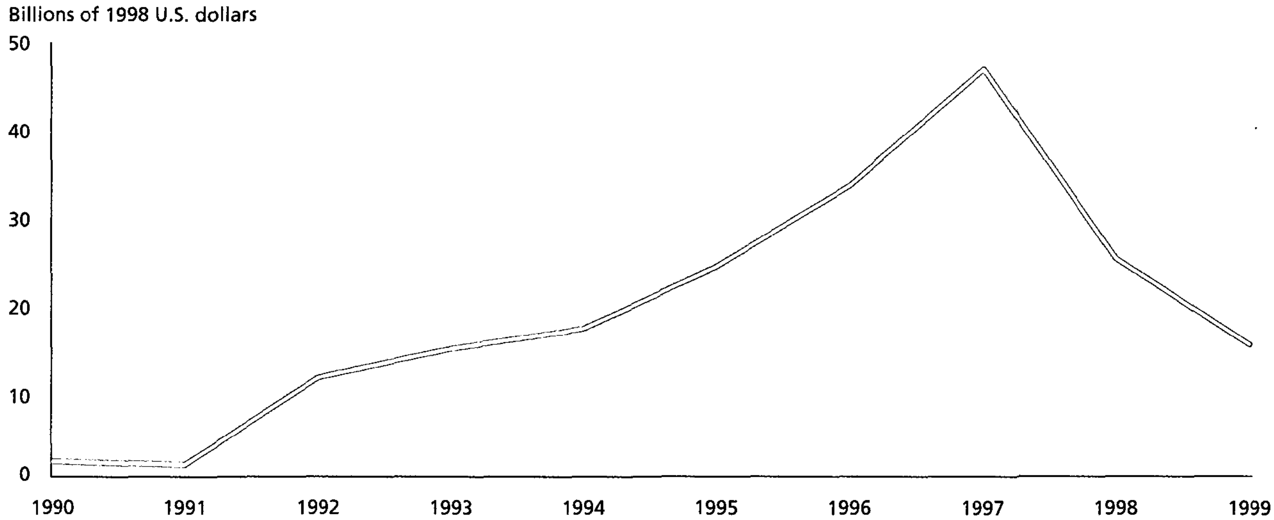
Most affected were Latin America and East Asia. In Latin America investment fell from a high of US$23 billion in 1997 to US$7 billion in 1999, mostly because of the deferral of generating facility sales and new power plants in Brazil (figure 3). In East Asia private activity dropped from US$12 billion to US$3 billion as a result of the cancellation of many high-profile projects in crisis countries and reduced activity in China. In Malaysia, the Philippines, and Thailand annual private activity in energy in 1998–99 was only a fourth that in 1993–97. Indonesia, the country most affected by the crisis, had no new private energy activity in 1998–99.

Latin America and East Asia lead

Latin America and East Asia have led the growth in private participation in energy. Latin America accounted for 42 percent of the investment in private energy projects during the 1990s. Most of the region's countries promoted private participation in energy as part of broader sectoral reforms aimed at creating efficient, competitive energy markets. This approach has been reflected in an emphasis on privatization. Divestitures accounted for more than three-fourths of the investment in energy projects with private participation in the region (figure 4; annex table A.2). Greenfield projects, which accounted for the other fourth, developed mainly in reformed markets, driven by such market signals as energy prices and demand growth.

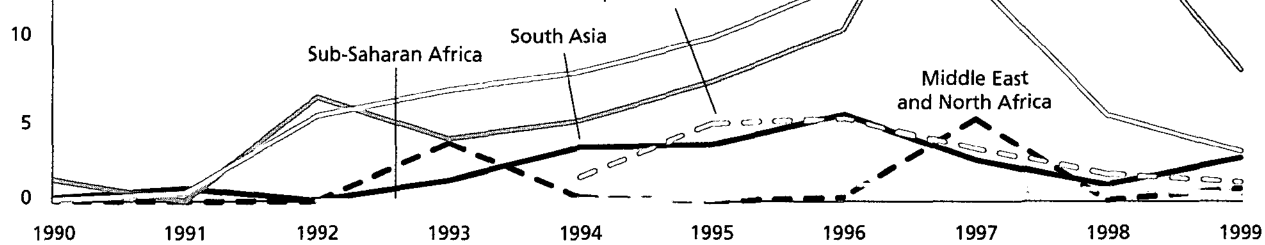
East Asia accounted for a third of the investment in energy projects with private participation in 1990–99. Private activity in this region—as well as in South Asia, the third-ranked region—focused on introducing independent power producers in markets dominated by vertically integrated, state-owned enterprises. This strategy was aimed at

Figure 2 **Total investment in energy projects with private participation in developing countries, 1990–99**



Source: World Bank, PPI Project Database.

Figure 3 **Total investment in energy projects with private participation in developing countries by region, 1990–99**



Source: World Bank, PPI Project Database.

expanding generating capacity to keep pace with expected demand growth. Greenfield power projects accounted for 80 percent of the investment in East Asia and 93 percent in South Asia. Other forms of private participation were also designed to expand generating capacity. Divestitures, involving the sale of minority stakes through public offerings, were aimed at raising funds for state-owned enterprises. And operations and management contracts centered on rehabilitating power plants.

In the other regions private activity in energy was limited. In Europe and Central Asia it was restricted to a few countries that mainly privatized existing facilities through

Box 1 Changes in project finance for energy

The big decline in long-term private capital flows to developing countries since 1997 reflects a sharp change in mood—from the excessive optimism of the precrisis 1990s to the conservatism of the late 1990s. Before the crisis large amounts of financing were chasing marginal projects in the electricity sector. This frenzied approach to lending "resulted in lenders downplaying the role of sponsor equity through overleveraging of projects, the loosening of project structure, and a failure to adequately assess the fundamentals of long-term country risk and to take a sufficiently long-term view of the nature and values of such assets" (Lack 1999, p. 7).

In the short term international financial markets' conservative approach to developing countries has made financing scarce and expensive. According to preliminary World Bank estimates, net long-term funds from international capital markets to developing countries dropped from a peak of US$151 billion in 1996 to around US$40 billion in 1999 (World Bank forthcoming). The biggest drop was in net lending from international banks, which turned negative in 1999. The cost of debt increased sharply. Secondary market spreads on Brady bonds rose from 500 basis points at the end of 1997 to more than 1,100 basis points in late 1998, declining in 1999 only in major East Asian economies and Brazil.

The scarcity and high cost of foreign resources forced some power sponsors to finance acquisitions on their balance sheets. U.S.-based firms such as AES Corporation, Duke Energy Corporation, and CMS Energy Corporation opted to purchase existing assets in Latin America on their own balance sheets in 1999, hoping to refinance them later under more favorable market conditions (Gelinas 1999).

In the long term international capital flows will return to developing countries as major economies recover from the crises. But lenders will become more cautious, focusing more on project quality and taking a more realistic view of long-term project risks, including macroeconomic, political, and regulatory risk. Project financiers will expect local and regional capital to play a greater role in project financing (Lack 1999). Sponsors will be expected to assume a greater share of project risk by accepting lower debt-equity ratios (Gelinas 1999). Ratios of 60:40 and 50:50 will be more likely than the precrisis ratios of 80:20.

mass privatization or sales of controlling stakes to operators. Economic problems, low energy tariffs, and rudimentary legal frameworks limited additional investment in these countries. In Sub-Saharan Africa and the Middle East and North Africa private participation was limited to some greenfield projects for capacity expansion and a few operations and management contracts for integrated utilities.

Investment concentrated in middle-income countries

Investment in energy projects with private participation has been concentrated in a few countries, but it is beginning to spread. The top five countries accounted for 100 percent of investment in 1990, but only 56 percent in 1997–99. Although the top five vary from year to year, they usually include Argentina, Brazil, China, and India, which also account for a major share of developing country income.

By 1999 forty-eight middle-income countries had private energy projects (twenty upper middle income and twenty-eight lower middle income), but twenty-eight low-income countries also had opened their energy sectors to private activity (figure 5). Middle-income countries still attracted most of the private activity in the sector, however (figure 6). Among low-income countries, China and India accounted for most of the investment.

Electricity projects predominate

Electricity has led the growth of private activity in energy. More than 600 private electricity projects, representing investment of US$160 billion, reached financial closure in seventy developing economies in 1990–99. Private electricity projects have been concentrated in generation, with projects involving generation assets capturing four-fifths of the investment.

Natural gas projects—around 100 in thirty countries—accounted for more than US$27 billion in investment in 1990–99. This investment has been concentrated in transmission assets, which accounted for almost three-fourths of total investment in natural gas projects in 1990–99. The natural gas business has attracted so much less investment than electricity mainly because of its early stage of development in most developing countries. Except for countries in Europe and Central Asia and a few in Asia and Latin America, most developing countries have limited transport facilities and natural gas resources or none at all.

Looking ahead

Private energy activity should revive in developing countries as they recover from the economic crises of the late 1990s and as the fundamental reasons for long-term private activity—increasing demand for energy, sector inefficiencies, Box 2

Plans for reform in East Asian electricity markets

The 1997 financial crisis made East Asian governments recognize the potential problems of introducing private independent power producers—to sell power to state-owned enterprises—without reforming the sector. That strategy ignored the main problems in the sector, such as subsidized tariffs, sector inefficiencies, and monopolistic market structures. And it forced governments to assume contingent liabilities, through take-or-pay power purchase agreements, that they have had to cover when least able to, as in the case of Indonesia.

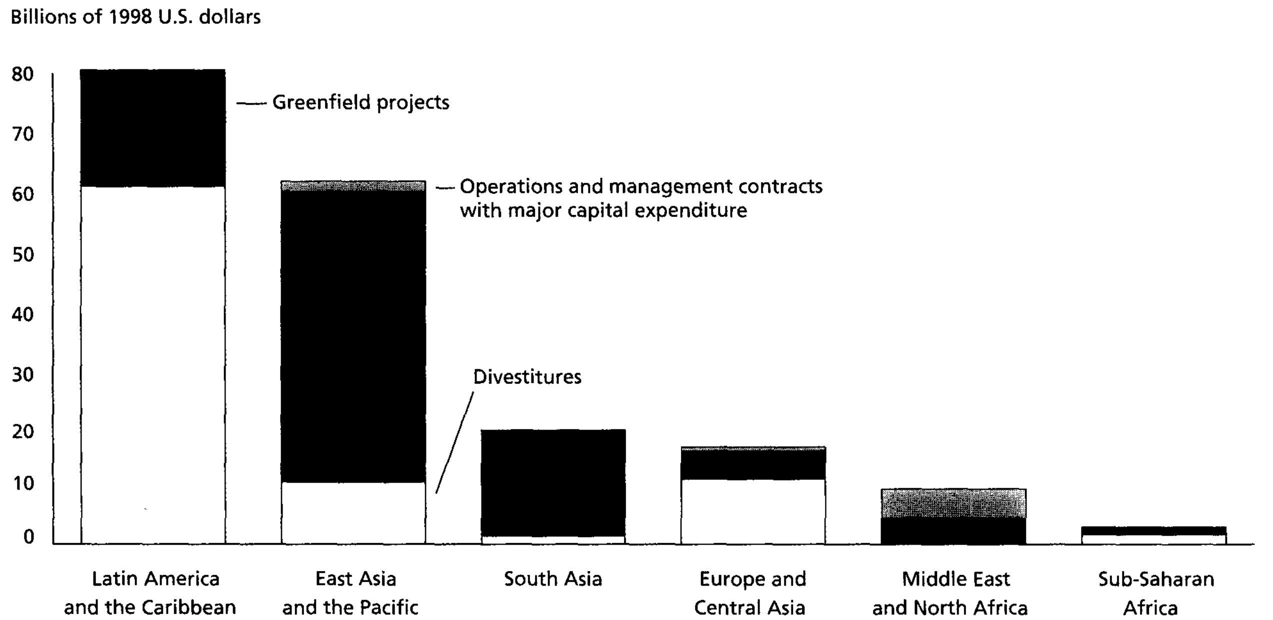
The limitations of the strategy coupled with growing budget constraints made East Asian governments realize the need to reform their electricity sectors. China, Indonesia, the Republic of Korea, the Philippines, and Thailand have announced plans to introduce competition in their electricity markets by establishing power pool markets. Power pools, open-bid processes in which the cheapest power is purchased first, have been introduced all over the world—in Argentina, Australia, Canada, Chile, South Africa, the United Kingdom, and the United States—to improve the management of system capacity and reduce electricity prices.

- Korea plans to liberalize its electricity market and create a competitive power pool by 2003. As part of the plan, the government has allowed private power generators to sell electricity directly to industrial consumers since August 1999. It plans to divide the generating assets of state-owned Korea Electric Power (Kepco) into six independent companies, to be privatized by 2005. Korea is also revising the 50 percent equity cap on foreign investment in power to encourage greater private participation and competition.
- Thailand plans to establish a wholesale electricity market by 2005. The National Energy Policy Office plans to vertically separate the electricity business into basic units (generation, transmission, and distribution) and privatize them. Retail competition will be introduced initially for large customers, gradually expanding to a wider market. Regulated distribution companies will serve the remaining consumers. The government may include a "competition transition charge" in tariffs to cover transitional costs of the reform, such as liabilities under power purchase agreements.
- The Philippines has plans for privatizing Napocor, the state-owned generation and transmission utility, and opening the electricity market to competition. But reforms have been put on hold until Congress approves the omnibus Electric Power Industry Code under discussion. The bill would establish the legal framework for privatizing Napocor, creating a competitive electricity market, and dealing with liabilities under Napocor's power purchase agreements.
- Indonesia plans to establish a fully competitive power market in phases. As a first step the state-owned utility PT Perusahaan Listrik Negara (PLN) will separate electricity assets into two regions, Java and outside Java. In Java, which has a well-developed electricity system, PLN will divide its assets into several companies for generation, transmission, and distribution to create a fully competitive power pool market by 2003. During the transition the transmission company will purchase electricity from all generators connected to the grid on behalf of distribution companies and major consumers. This transitional single-buyer model is designed to deal with short-term constraints such as take-or-pay power purchase agreements, fuel contracts, underdeveloped transmission systems in some areas, and lack of regulatory capacity.

Outside Java, where the electricity system is much less developed, PLN will transfer its assets to a new state-owned company. This company will manage the system while contracting out new opportunities for generation, transmission, and distribution through competitive and transparent bidding. The Indonesian government also plans to privatize state-owned assets, taking a phased approach until international market conditions become more favorable.

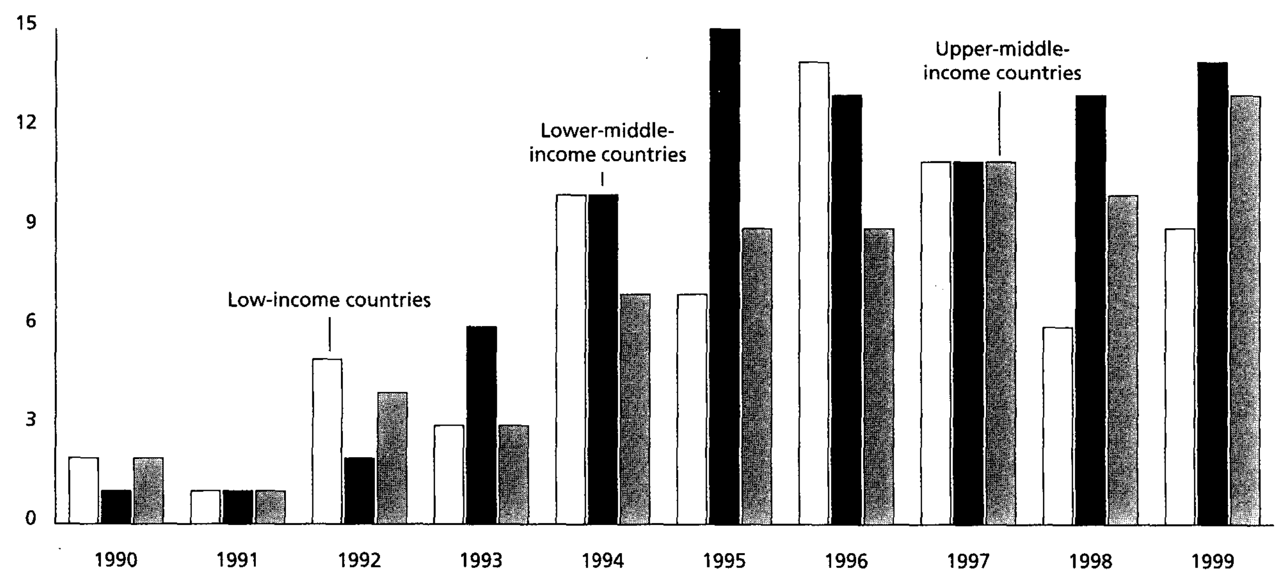
- China has launched a reform aimed at introducing competition in generation. Over the next decade State Power Corporation (SPC), the monopoly power grid company, will move electricity purchases from a contract system to a pooling program. Initially, SPC operating units will buy 15 percent of their annual electricity needs from a pooling program and the other 85 percent under existing contracts. Purchases through open bidding will rise 3–4 percent annually until all electricity is bought and sold through power pooling. Zhejiang and Shanghai Provinces and Shanghai City will be the first to launch power pool reform. Three other provinces will introduce it by the end of 2000, and the rest will follow.

Figure 4 Total investment in energy projects with private participation by region and type, 1990–99



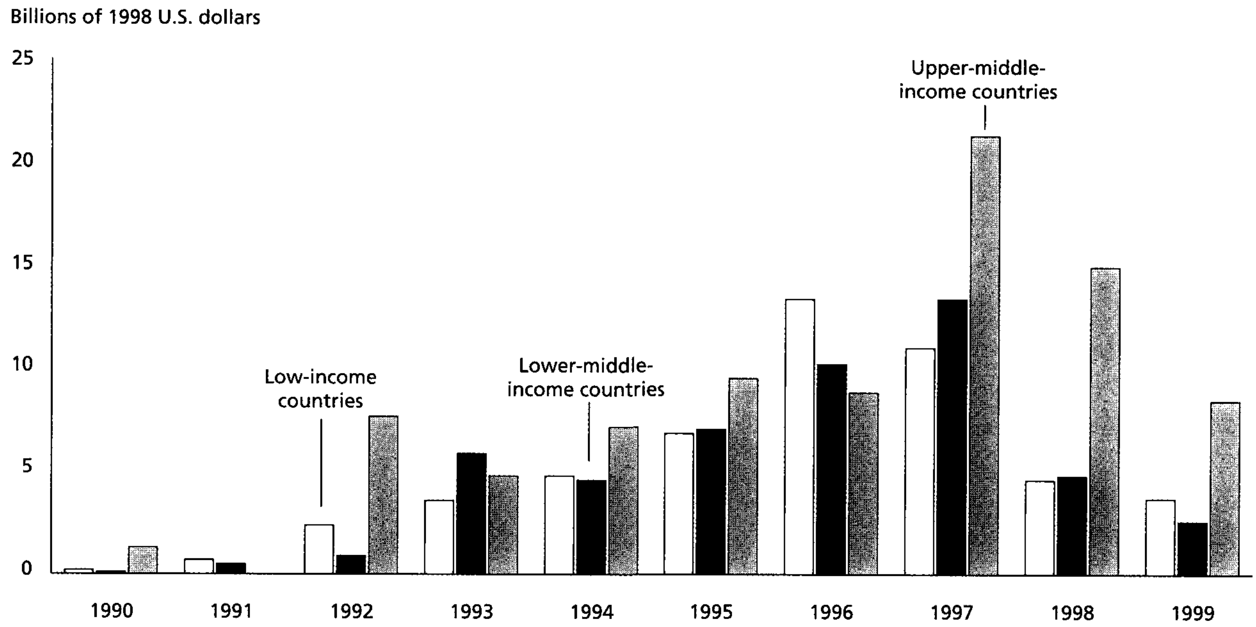
Source: World Bank, PPI Project Database.

Figure 5 New energy projects with private participation in developing countries by income level, 1990–99



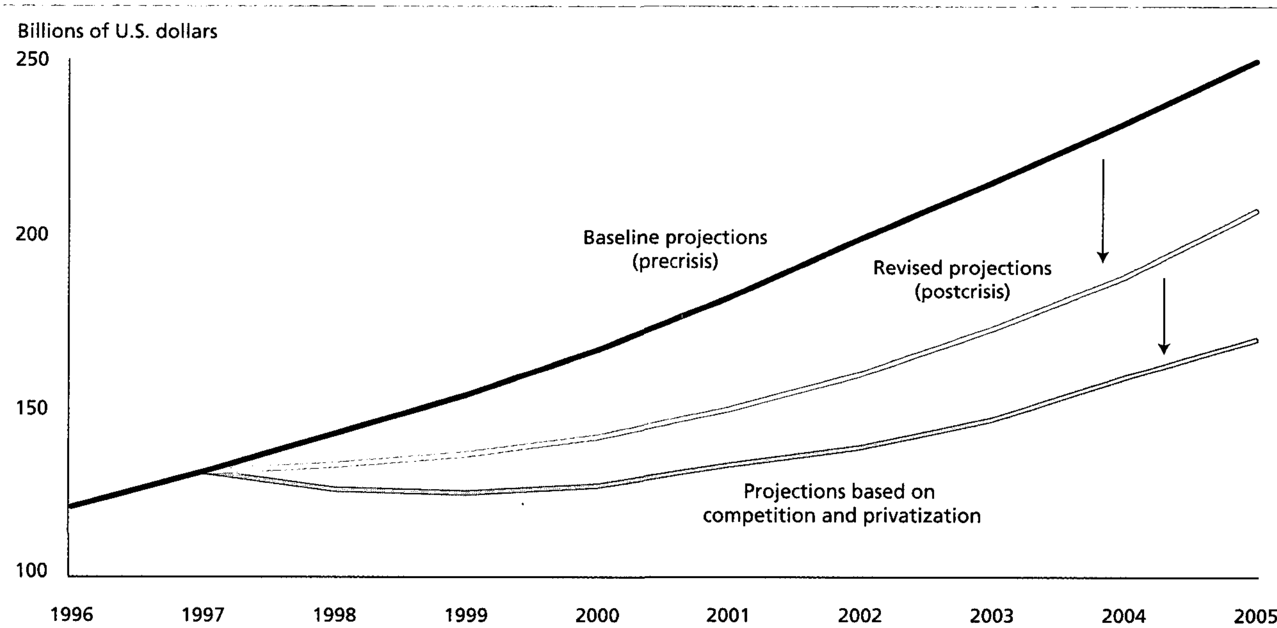
Source: World Bank, PPI Project Database.

Figure 6 Total investment in energy projects with private participation in developing countries by income level, 1990–99



Source: World Bank, PPI Project Database.

Figure 7 Estimated infrastructure investment requirements in East Asia under different scenarios, 1996–2005



Source: Asian Development Bank 1999.

2 TRENDS IN PRIVATE INVESTMENT IN THE ENERGY SECTOR, 1990–99

and public budget constraints—continue. But private activity in the next decade will differ from the precrisis activity in two ways. First, new capacity requirements will be smaller, reflecting the slower projected growth in developing countries (excluding transition economies) in 2002–08 compared with the precrisis 1990s (World Bank 1999). Second, most private activity will take place in competitive environments as more governments recognize that competitive electricity markets can provide cheaper and more reliable electricity service than monopolies.

In East Asia private activity will focus on existing assets rather than capacity expansion if major economies implement proposed sector reforms (box 2). The 1997–98 financial crisis significantly reduced new investment requirements in the region for 2000–05 (figure 7). Those requirements may be further reduced if competition and private sector discipline are introduced in the sector (Asian Development Bank 1999).

In Latin America private activity will revive as major economies recover, Brazil relaunches its electricity privatization program, and Mexico accelerates its independent power producer program.

In South Asia private energy activity will remain limited as countries continue to postpone sector reforms and rely on the private sector only for new generating capacity.

In Europe and Central Asia private activity in energy will remain limited by slow economic recovery and delays in sector reforms. But it may accelerate in countries applying for membership to the European Union, which face deadlines for energy sector reform.

In Sub-Saharan Africa and the Middle East and North Africa private activity should increase as recent proposals for new generating facilities are implemented in the coming years.

Ada Karina Izaguirre (aizaguirre@worldbank.org), World Bank, Private Participation in Infrastructure Group

Notes

1. For an overview of private participation in infrastructure see Roger 1999. For earlier reviews of private participation in electricity and in natural gas transmission and distribution see Izaguirre 1998 and 1999.

2. All dollar amounts are in 1998 U.S. dollars. Figures for project investments refer to total investment, not private investment alone.

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Annex
Data sets and database information

Table A.1 Energy projects with private participation in developing countries, 1990–99

Country	Number of projects
East Asia and the Pacific	
Cambodia	3
China	71
Indonesia	14
Korea, Rep. of	3
Lao PDR	2
Malaysia	12
Myanmar	1
Papua New Guinea	1
Philippines	40
Thailand	43
Vietnam	2
Europe and Central Asia	
Armenia	1
Belarus	1
Croatia	2
Czech Republic	23
Estonia	4
Georgia	1
Hungary	22
Kazakhstan	25
Latvia	1
Lithuania	2
Moldova	1
Poland	4
Romania	1
Russian Federation	66
Turkey	6
Latin America and the Caribbean	
Argentina	80
Belize	2
Bolivia	9
Brazil	40
Chile	23
Colombia	24
Costa Rica	10
Dominican Republic	8
Ecuador	1
El Salvador	8
Grenada	1
Guatemala	13
Guyana	1
Haiti	1
Honduras	3

Table A.1 Energy projects with private participation in developing countries, 1990–99 (continued)

Country	Number of projects
Jamaica	3
Mexico	19
Nicaragua	3
Panama	6
Peru	18
Trinidad and Tobago	2
Uruguay	1
Venezuela, R. B. de	1
Middle East and North Africa	
Algeria	1
Bahrain	1
Egypt, Arab Rep. of	2
Morocco	4
Oman	1
Tunisia	3
South Asia	
Bangladesh	3
India	37
Nepal	2
Pakistan	20
Sri Lanka	4
Sub-Saharan Africa	
Comoros	1
Congo, Rep. of	1
Côte d'Ivoire	4
Gabon	1
Ghana	3
Guinea	1
Guinea-Bissau	1
Kenya	3
Mali	1
Mauritius	1
São Tomé and Principe	1
Senegal	2
South Africa	1
Tanzania	2
Zambia	1
Zimbabwe	2
Total	**733**

Note: The PPI Project Database covers only low- and middle-income developing countries, as classified by the World Bank. Low- and middle-income countries not listed in this table have no projects. The data cover electricity and natural gas transmission and distribution businesses. Mass privatization programs such as voucher privatization are considered projects with private participation.
Source: World Bank, PPI Project Database.

Table A.2 **Total investment in energy projects with private participation in developing countries by region and type of project, 1990–99** (billions of 1998 U.S. dollars)

Region and activity	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
East Asia and the Pacific											
Divestitures	0.1	0.2	1.5	0.1	1.5	2.4	1.0	1.2	0.1	2.3	10.3
Greenfield projects	0.0	0.3	2.6	5.9	5.8	6.5	11.1	11.3	4.6	0.5	48.5
Operations and management contracts with major capital expenditure	0.0	0.0	0.7	0.3	0.1	0.3	0.2	0.0	0.1	0.0	1.6
Operations and management contracts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.1	0.5	4.8	6.3	7.3	9.2	12.3	12.4	4.8	2.8	60.4
Europe and Central Asia											
Divestitures	0.0	0.0	0.3	0.0	1.3	2.3	2.7	2.1	1.3	0.8	10.8
Greenfield projects	0.1	0.0	0.0	0.0	0.0	2.0	2.0	0.2	0.2	0.2	4.7
Operations and management contracts with major capital expenditure	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.6
Operations and management contracts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.1	0.0	0.3	0.0	1.3	4.3	4.7	2.9	1.5	1.0	16.2
Latin America and the Caribbean											
Divestitures	0.9	0.0*	5.6	3.2	3.0	3.4	7.3	20.4	11.7	3.9	59.6
Greenfield projects	0.3	0.0	0.3	0.3	1.6	3.3	2.4	2.8	4.8	3.6	19.4
Operations and management contracts with major capital expenditure	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operations and management contracts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.2	0.0*	5.9	3.6	4.6	6.8	9.7	23.2	16.5	7.5	79.0
Middle East and North Africa											
Divestitures	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Greenfield projects	0.0	0.0	0.0	3.3	0.2	0.0	0.0	0.1	0.1	0.7	4.4
Operations and management contracts with major capital expenditure	0.0	0.0	0.0	0.0	0.0	0.0	0.2	4.6	0.0	0.0	4.8
Operations and management contracts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	3.3	0.2	0.0	0.2	4.7	0.1	0.7	9.2

Table A.2 **Total investment in energy projects with private participation in developing countries by region and type of project, 1990–99 (continued)** (billions of 1998 U.S. dollars)

Region and activity	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
South Asia											
Divestitures	0.0	0.0	0.0	0.0*	0.0	0.0*	1.1	0.0	0.0	0.3	1.4
Greenfield projects	0.2	0.7	0.0*	1.2	3.1	3.2	3.8	2.3	0.9	2.2	17.7
Operations and management contracts with major capital expenditure	0.0	0.0	0.0	0.0	0.0	0.0	0.0*	0.0	0.0	0.0	0.0*
Operations and management contracts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.2	0.7	0.0*	1.2	3.1	3.2	4.9	2.3	0.9	2.4	19.0
Sub-Saharan Africa											
Divestitures	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.6	0.1	1.6
Greenfield projects	0.0	0.0	0.0	0.0	0.1	0.0*	0.4	0.2	0.1	0.3	1.2
Operations and management contracts with major capital expenditure	0.0*	0.0	0.0*	0.0	0.0	0.0*	0.0	0.0*	0.0	0.0	0.1
Operations and management contracts	0.0	0.0	0.0	0.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0*
Total	0.0*	0.0	0.0*	0.0*	0.1	0.1	1.0	0.5	0.7	0.4	2.9
Total for developing countries											
Divestitures	1.0	0.2	7.4	3.4	5.8	8.2	12.7	24.0	13.7	7.3	83.7
Greenfield projects	0.5	1.0	2.9	10.7	10.8	15.1	19.7	16.9	10.7	7.5	95.8
Operations and management contracts with major capital expenditure	0.0*	0.0	0.7	0.3	0.1	0.3	0.4	5.2	0.1	0.0	7.2
Operations and management contracts	0.0	0.0	0.0	0.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0*
Total	1.6	1.2	11.0	14.3	16.6	23.6	32.8	46.1	24.6	14.8	186.7

* A negligible amount.
Note: Data may not sum to totals because of rounding.
Source: World Bank, PPI Project Database.

Box A.1 PPI Project Database: project criteria and database terminology

Database coverage

- Projects that have reached financial closure and directly or indirectly serve the public.
- Projects in energy, transport, water, and telecommunications. The energy sector includes electricity generation, transmission, and distribution and natural gas transmission and distribution.
- The database excludes captive facilities, such as natural gas pipelines owned by private upstream gas producers, natural gas condensate operations, incinerators, stand-alone solid waste projects, and small projects such as windmills.
- Low- and middle-income developing countries, as defined and classified by the World Bank.

Definition of private participation. The private company must assume operating risk during the operating period or assume development and operating risk during the contract period. A foreign state-owned company is considered a private entity.

Definition of a project unit. A corporate entity created to operate infrastructure facilities is considered a project. When two or more physical facilities are operated by the corporate entity, all are considered as one project.

Definition of project types

- *Operations and management contract.* A private entity takes over the management of a state-owned enterprise for a given period. This category includes management contracts and leases.
- *Operations and management contract with major capital expenditure.* A private entity takes over the management of a state-owned enterprise for a given period during which it also assumes significant investment risk. This category includes concession-type contracts such as build-transfer-operate, build-lease-operate, and build-rehabilitate-operate-transfer contracts as applied to existing facilities.
- *Greenfield project.* A private entity or a public-private joint venture builds and operates a new facility. This category includes build-own-transfer and build-own-operate contracts as well as merchant power plants.
- *Divestiture.* A private consortium buys an equity stake in a state-owned enterprise. The private stake may or may not imply private management of the company.

Definition of financial closure. For greenfield projects, and for operations and management contracts with major capital expenditure, financial closure is defined as the existence of a legally binding commitment of equity holders or debt financiers to provide or mobilize funding for the project. The funding must account for a significant part of the project cost, securing the construction of the facility. For operations and management contracts, a lease agreement or a contract authorizing the commencement of management or lease service must exist. For divestitures, the equity holders must have a legally binding commitment to acquire the assets of the facility.

Recording of investments. Investments and privatization revenues generally have been recorded on a commitment basis in the year of financial closure (for which data typically are readily available). Actual disbursement has not been tracked. Where privatizations and new investments are phased and data are available at financial closure, they are recorded in phases.

Sources. World Wide Web, commercial databases, specialized publications, developers, sponsors, and regulatory agencies.

Contact. The database is maintained by the Private Participation in Infrastructure Group of the World Bank. For more information contact Shokraneh Minovi at 202-473-0012 or sminovi@worldbank.org.

Part 3

Selected readings and key contacts at the World Bank Group

Energy access, energy reform, and poverty alleviation: selected readings

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Key contacts at the World Bank Group

The World Bank Group consists of five closely associated institutions. References in this report to the World Bank refer to two of these institutions: the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA). The World Bank's purpose is to reduce poverty and improve the living standards for people in the developing world. The Bank provides loans ("credits" in the case of IDA), policy advice based on economic and sector analytical work, technical assistance, and, increasingly, knowledge-sharing activities to its client countries. Closely associated with the World Bank are three other institutions: IFC, MIGA, and ICSID. The International Finance Corporation (IFC) works closely with private investors and provides capital to commercial enterprises in developing countries. The Multilateral Investment Guarantee Agency (MIGA) encourages direct foreign investment in developing countries by offering insurance against noncommercial risk. The International Centre for Settlement of Investment Disputes (ICSID) provides facilities for settling disputes between foreign investors and their host countries.

The energy sector

Through a matrix organizational structure, the Energy and Mining Sector Board provides a regional and sectoral focus for the World Bank Group's energy activities. These are key contacts and sources of information:

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Global Environment Facility (GEF)
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Public-Private Infrastructure Advisory Facility (PPIAF)
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Scorecard for oil and gas sector reform in developing countries, 1998

The World Bank surveyed energy reform in 115 countries to see which of the following reform steps had been taken:

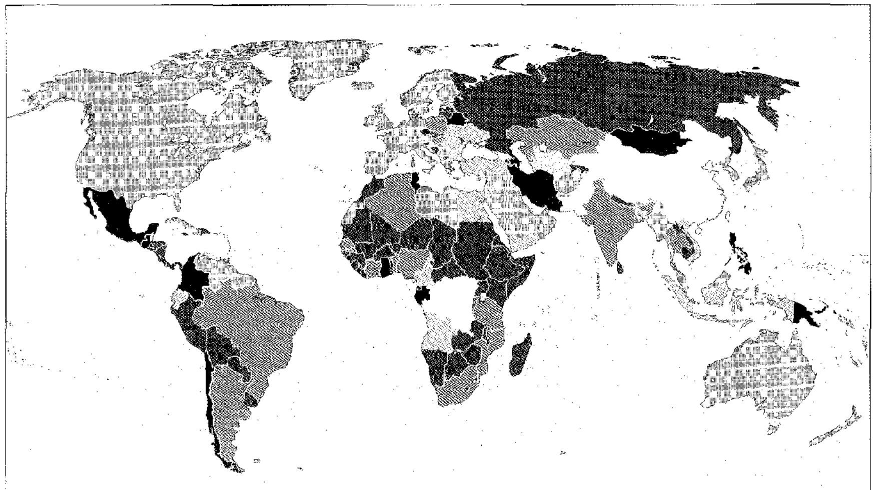
Upstream oil and gas, downstream gas
- Corporatization.
- Laws permitting divestiture and unbundling.
- Regulations.
- Vertical and horizontal unbundling.
- Laws permitting concessions or greenfield investment.
- Privatization of existing assets.

Downstream oil refining
- Corporatization.
- Privatization.
- Free prices.

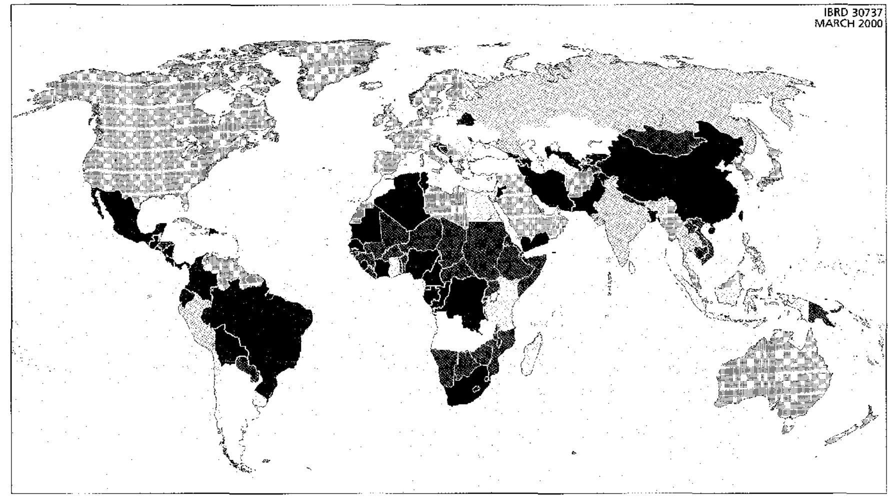
Downstream wholesale and retail oil
- Corporatization.
- Private investment.
- Privatization.

Note that:
- The score does not indicate the quality of reform or the sequence of steps taken.
- For simplicity, success in one region of a country counts as success for the country. In reality some regions may be far from reform.
- Sectors under private ownership for 10 years are not considered part of the current reform movement and are labeled *private*.
- Only countries with oil and gas sectors are included. Those without these sectors are labeled *no capacity*.

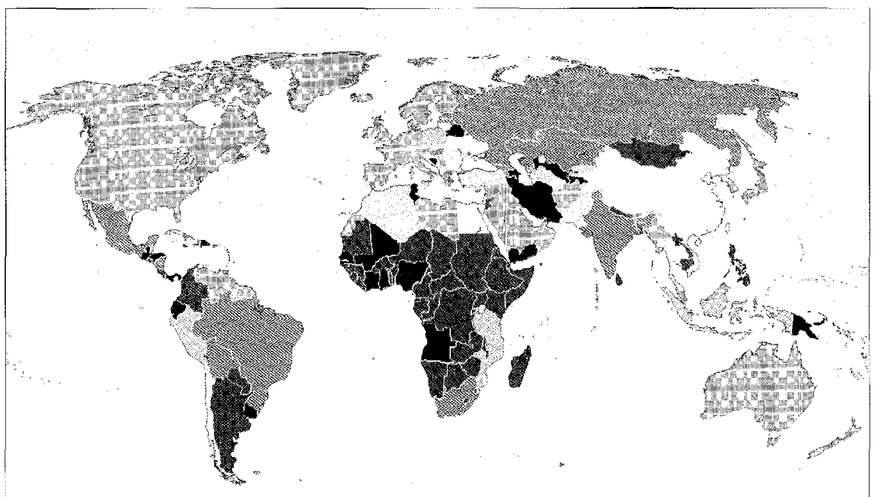
Upstream oil and gas—49 countries with capacity



Downstream oil refining—57 countries with capacity



Downstream gas—55 countries with capacity

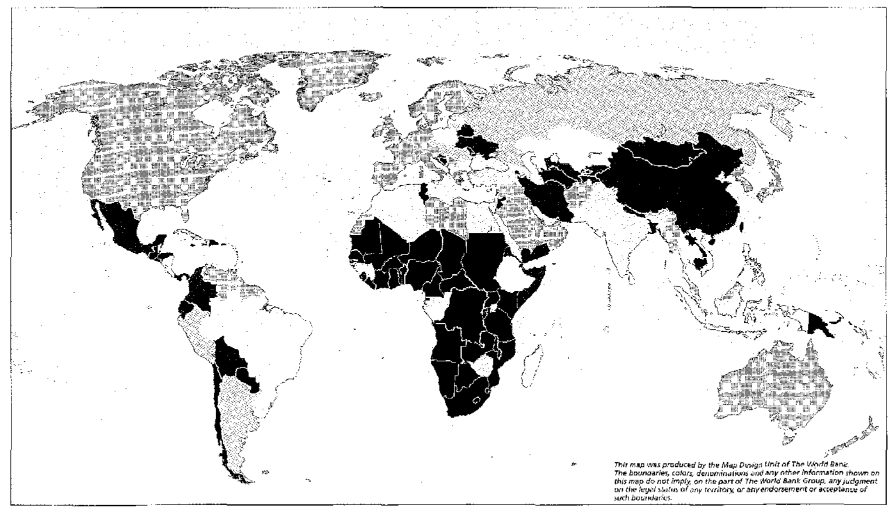


Number of reform steps taken

0 · 1 · 2 · 3 · 4 · 5 · 6 · No capacity · Sector private before wave of reform in 1990s · Countries not in survey

Source: Robert Bacon, "Global Energy Sector Reform in Developing Countries: A Scorecard" (ESMAP, Washington, D.C., 1999).

Downstream wholesale and retail oil—72 countries with capacity



Number of reform steps taken

0 · 1 · 2 · 3 · No capacity · Sector private before wave of reform in 1990s · Countries not in survey

Maps

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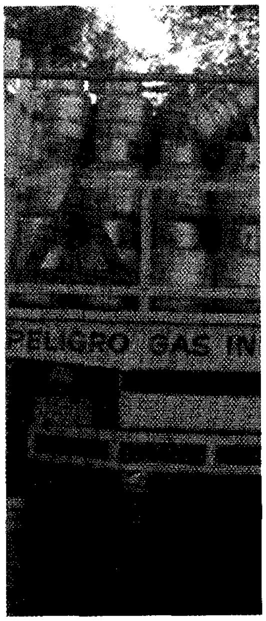

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