Rural Energy in Developing Countries: A Challenge for Economic Development1

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RURAL ENERGY IN DEVELOPING COUNTRIES: A Challenge for Economic Development[1]

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ABSTRACT

The energy problems of the developing world are both serious and widespread. Lack of access to sufficient and sustainable supplies of energy affects as much as 90% of the population of many developing countries. Some 2 billion people are without electricity; a similar number remain dependent on fuels such as animal dung, crop residues, wood, and charcoal to cook their daily meals. Without efficient, clean energy, people are undermined in their efforts to engage effectively in productive activities or to improve their quality of life. Developing countries are facing two crucial—and related—problems in the energy sector. The first is the widespread inefficient production and use of traditional energy sources, such as fuelwood and agricultural residues, which pose economic, environmental, and health threats. The second is the highly uneven distribution and use of modern energy sources, such as electricity, petroleum products, and liquefied or compressed natural gas, which pose important issues of economics, equity, and quality of life. To address these problems, this paper evaluates some successful programs and recommends that governments support market-oriented approaches that make the energy market equally accessible and attractive to local investors, communities, and consumers. Such approaches ideally improve access to energy for rural and poor people by revising energy pricing and by making the first costs of the transition to modern and more sustainable uses of energy more affordable.

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INTRODUCTION

Energy and environmental policies are being shaped at the national and international levels in response to a wide range of challenges. These include improving the energy efficiency of transport and power generation; financing the expansion of the electricity, oil, and gas industries in the burgeoning markets of developing countries; addressing global warming; and reducing pollution caused by fossil fuels. An equally important but often neglected aspect of energy production and use is the lack of access for rural populations to affordable "modern" energy sources, such as electricity, liquid fuels, and modern biomass. In developing countries, this situation can have serious social, economic, and environmental consequences.

The prevailing focus on industry, transport, and large-scale energy issues has obscured the fact that most people in developing countries continue to rely on "traditional" biofuels, such as wood, crop residues, and animal dung. In fact, one third of all energy consumed in developing countries derives from biofuels. Two billion people remain dependent on biofuels for cooking and an equal number lack electricity. Annual biofuels consumption in developing countries exceeds 1 billion tons of oil equivalent (btoe), which is more than three times the amount provided by coal in Europe (0.28 btoe) and twice that provided by coal in the United States (0.47 btoe) or China (0.5 btoe).

Developing countries are facing two crucial and related problems in the energy sector. The first is the widespread inefficient production and use of traditional energy sources, such as fuelwood and agricultural residues, which pose economic, environmental, and health threats. The second is the highly uneven distribution and use of modern energy sources, such as electricity, petroleum products, and liquefied or compressed natural gas, which raise important issues of economics, equity, and quality of life. Simply expanding supplies of modern energy will not solve the problems in practice, because even under the most optimistic growth scenarios, many rural and urban poor people in the developing world are likely to depend for the next 20–30 years on traditional fuels produced in rural areas. Hence, an energy strategy for the developing world should be designed to make production and use of traditional energy more sustainable and efficient while expanding and accelerating a broader social transition to clean and efficient use of modern fuels.

The energy problems of the developing world are both serious and widespread. Lack of access to sufficient and sustainable supplies of energy affects as much as 90% of the population of many developing countries. Some 2 billion people are without electricity; a similar number remain dependent on fuels such as animal dung, crop residues, wood, and charcoal to cook their daily meals. Without efficient, clean energy, people are undermined in their efforts to engage effectively in productive activities or to improve their quality of life. People cannot farm efficiently or produce goods if much of their time must be spent searching farther and farther afield to gather diminishing woodfuels or if much of their income is used to pay for inefficient power. Moreover, local environments, and the global environment as well, are threatened by the emissions of air pollutants and greenhouse gases from inefficient energy production and use. In particular, the welfare of women and children is endangered by long-term exposure to high concentrations of smoke produced by traditional biomass stoves. Similarly, the low-quality, expensive kerosene lanterns or paraffin candles used for lighting in many households do not provide sufficient light for evening activities, such as doing homework.

In this paper, the recommendations for mitigating the damaging consequences of current rural energy use in developing countries are designed to achieve two parallel goals. The first goal is to make modern forms of energy more accessible, affordable, and widely used (1). A successful transition to modern fuels will require broad-based income growth in both rural and urban areas. This growth, in turn, requires development policies that support innovative electrification programs, expansion of oil and gas markets, and increased use of renewable energy. The second goal is to make biofuel use more sustainable. Even in the most optimistic transition scenario, biofuels will remain a major energy source for rural households in developing countries for three or more decades (1–4). Rationalizing the continued, sustainable use of biofuels requires policies that encourage afforestation and that help people—through education, extension services, and use of more efficient equipment—to produce, manage, and use biofuels in ways less harmful to human and environmental health. Much research has shown that such strategies are both feasible and economically rewarding.

ENERGY USE, INCOME, AND THE ENERGY LADDER

An overview of the main forms of energy used in rural areas of developing countries indicates that the general pattern is to move from biofuels, and human and animal power, to a mix of traditional and modern fuels (Table 1). The main energy end-uses are cooking, lighting, running appliances, and sometimes space heating. For cooking, wood is the fuel of choice. When wood becomes scarce, people generally turn to agricultural residues or animal dung. In more prosperous regions, people may use kerosene or coal. In regions with significant numbers of livestock, biogas is sometimes used. For lighting, the poor and those lacking access to electricity use candles or kerosene. Wealthier households use electricity if it is available because it is convenient and produces superior lighting. For agriculture and rural industry, the general pattern is to move from human and animal power to mechanical power. For process heat, the trend is to move to more efficient use of biomass, as well as to modern fuels.

Movement up the "rural energy ladder" can be smoothed and sustained by policies and investments that emphasize both affordability and efficiency (5). Gains in efficiency for cooking can be made in small steps. For example, a farmer who uses wood for cooking may be able to afford an improved biomass stove long before being able to switch to liquid petroleum gas (LPG) (6, 7). For lighting, however, the differences in efficiency between biomass or kerosene on the one hand and electricity on the other are so large that the recommended path is to move quickly to some form of electric lighting, such as incandescent or fluorescent lamps (8, 9).

Any review of policies to address the dual objectives of shifting to modern energy and improving the production, management, and use of traditional fuels must recognize the preeminent importance of good enabling conditions for income growth. The fact that projects to extend energy supplies are most successful where development is proceeding and incomes are rising is not a coincidence. Per capita income levels and increasing use of modern fuels are unequivocally correlated (see Figure 1). When a country's per capita income is less than $300 (in US dollars), typically 90% or more of the population uses fuelwood and dung for cooking. Once incomes have exceeded $1000 per capita, most people switch to modern fuels, and substitution is nearly complete. An encouraging finding is that advances in technology and reduced costs of supplying modern fuels have, for many years, been lowering the income level at which a complete shift to modern fuels can be made.

Even for those people who cannot afford to switch to modern fuels, a sound economic environment is needed to promote effective use of biofuels. With secure land tenure and the absence of gross inequities in land holdings, farmers can grow, process, and market biofuels commercially and sustainably (10, 11). Good biofuels policy requires a commitment by farmers to introduce more sustainable land management practices, such as those based on farm forestry. Not surprisingly, farmers are most willing to respond when favorable economic

Table 1 Rural energy use patterns in developing countries by end uses

	Income stage		
End use	Low	Medium	High
Household			
Cooking	Wood, residues, and dung	Wood, residues, dung, kerosene, and biogas	Wood, kerosene, biogas, LPG, and coal
Lighting	Candles and kerosene (sometimes none)	Candles, kerosene, and gasoline	Kerosene, electricity, and gasoline
Space heating	Wood, residues, and dung (often none)	Wood, residues, and dung	Wood, residues, dung, and coal
Other appliances	None	Electricity and storage cells	Electricity and storage cells
Agriculture			
Tilling	Hand	Animal	Animal, gasoline, and diesel (tractors and small power tillers)
Irrigation	Hand	Animal	Diesel and electricity
Postharvest processing	Hand	Animal	Diesel and electricity
Industry			
Milling and mechanical	Hand	Hand and animal	Hand, animal, diesel, and electricity
Process heat	Wood and residues	Coal, charcoal, wood, and residues	Coal, charcoal, kerosene, wood, and residues

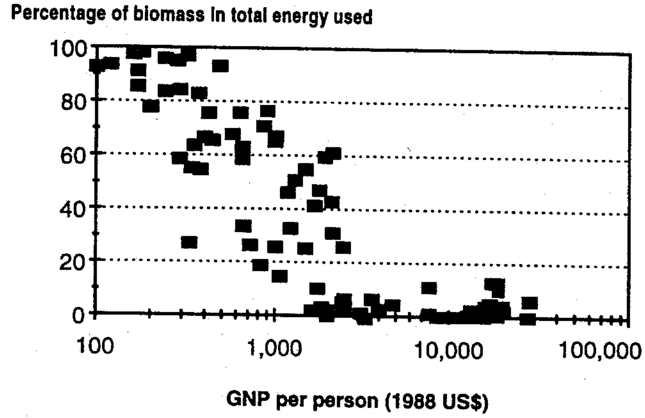

Figure 1 Traditional energy and gross national product (GNP). Percent biomass use and GNP per person (11).

conditions bring good returns on their investments (12). Such a supportive strategy also requires that farmers be given access to adequate credit and to local expertise to help process and distribute biofuels and disseminate improved biomass stoves.

BROADEN THE RANGE OF ENERGY CHOICES

Energy investments are fundamentally justifiable if they reduce the costs and raise the benefits of using energy. A well-articulated rural energy strategy can achieve these goals not only through direct investments in modern energy markets but also through investments in sustainable production and use of biofuels. For example, rural electrification grids have the best returns when they reduce the costs of light, heat, motive power, and refrigeration in rural areas and towns relative to alternative sources of power and energy. Modern grid-supplied electricity often brings affordable motive power and refrigeration to developing-country agriculture and agroindustries for the first time. But the grid is not always the best alternative. Decentralized sources of power and renewable energy, such as small diesel generators, photovoltaics, small hydro systems, biogas plants, or wind generators, are preferable when they are less costly than grid supplies (13, 14).

For cooking, rural energy strategies must incorporate greater use of LPG and kerosene. Not only are these fuels more convenient and less polluting to indoor air, they also reduce the social costs of the time and labor spent gathering fuelwood (15). For millions of people who cannot afford modern fuels but have ready access to low-cost biomass, the modern biomass stove is an important bridge between technologies (6). Woodstove programs can reduce the social costs of fuelwood consumption by improving end-use efficiency and reducing pollution.

The introduction of farm forestry and other management practices, such as the planting of windbreaks in association with agriculture, reduces the costs and increases the supply of biofuels. These changes sometimes occur autonomously when fuelwood prices are rising, farm soils are eroding, or soil fertility is declining. At other times, farm forestry can be encouraged through agricultural extension, education, and creating seedling nurseries. By reducing soil erosion, improving soil moisture retention, and increasing soil nutrients, such effective management practices have also increased crop yields.

Neither the environmental nor the economic problems associated with poor access to commercial energy forms in rural areas are historically unique to developing countries. Between 1930 and 1960, the United States began specially funded programs to electrify its rural areas. European countries relied heavily on their public utilities to provide virtually universal access by the end of the first half of this century. India has had a rural electrification program for more than three decades (although more than 70% of its rural population remains without service). Some developing countries have had rural electrification programs for 20 years or more. India, China, and several African countries have also introduced farm forestry programs, and many countries in Asia and Africa have initiated woodstove programs. Many of these efforts have been supported by the development assistance community. Most notable perhaps are farm forestry and woodstove programs supported by nongovernmental organizations (NGOs). What does this wealth of experience tell us? First, rural energy investments have yielded both accomplishments and disappointments. These are best reviewed in relation to the types of energy in use, which are discussed below.

Rural Electrification

PROGRESS TO DATE Nearly 1.3 billion people in developing countries have been newly supplied with electricity service during the past 20 years. Of these, 700 million were in rural areas and 600 million in urban areas (Table 2). All regions doubled the shares and nearly tripled the numbers of people served over the period. The overall increase in people newly served approached twice the combined populations of the United States, Europe, and Japan, an extraordinary achievement testifying to the efforts developing countries are making in expanding service. Geographically, however, the process has been uneven. China has accounted for nearly half the increases, and service in South Asia and Africa remains disproportionately low. Developing-country populations have grown by 1.5 billion over the period, and in South Asia and Africa, where electrification programs started with a small number of people, population increases have outstripped the increase in numbers served.

Results Evaluations show that some rural electrification programs have been an economic success, as measured by the ex post facto returns on investment, while others have failed (16–19). But the distinguishing features of the successful and unsuccessful cases were predicted and are by now familiar:

1. Cost effectiveness. The goal of universal coverage often took precedence over cost considerations or recognition that alternatives, such as diesel generators for local supplies or diesel engines for pumping, were sometimes less expensive.

2. Presence of enabling conditions and priorities for rural development. Rural electrification is more likely to succeed when the overall conditions favor income growth—that is, when incentives are present for the development of agriculture and agroindustries and when electrification is based on social and economic infrastructures, such as rural water supplies, health programs, primary and secondary education, and regional and feeder roads (20, 21).

Surveys have shown consistently that such complementary programs make rural electrification more meaningful and successful (e.g. by generating markets for electricity and leading to higher rates of return on investment). Rural

Table 2 Percentages of urban and rural people served by electrification in developing countries, by region, 1970 and 1990[a]

	Urban		Rural	
Region	1970	1990	1970	1990
North Africa and Middle East	65	81	14	35
Latin America and Caribbean	67	82	15	40
Sub-Saharan Africa	28	50	4	8
South Asia	39	67	12	25
East Asia and Pacific	51	82	25	45
All developing countries	52	76	18	33
Total served (in millions)	320	1100	340	820

[a]These estimates are approximate and were compiled from a survey of World Bank project and sector reports, as well as published and unpublished materials for several countries. Surveys of electricity statistics by the Bank's regional staff in Asia and Latin America also helped fill in data gaps.

electrification does not substitute for basic rural development programs; rather, it is a contributing factor in regional development. These points, as well as the importance of basing investments on the economic rate of return, have sometimes been overlooked (22–24).

PRICES Subsidies for grid-based rural electrification have often been large and unproductive. For example, by decreasing power-company cash flows, subsidies can undermine both the quality of service (e.g. poor voltages and frequent outages) and the extension of service to new areas. By steering consumers away from increasingly affordable renewable energy alternatives, grid-power subsidies can also lead people away from cost-effective and environmentally sound choices. Contrary to appearances, across-the-board power subsidies generally do not benefit consumers equitably (25–27). Because grid-power subsidies are generally applied to all consumers, regardless of their level of use or their income, such subsidies help only a small proportion of low-income consumers and provide nothing for the poorest energy users, who are often not connected to the grid. Blanket subsidies, at least on a large scale, are therefore difficult to justify on economic and social grounds.

The financing problems posed by the high fixed costs of establishing the networks can be addressed by taking a long view on market growth and cost recovery: With market growth and declining costs, marginal cost pricing will generally give good financial returns; meanwhile, "lifeline rates" for small consumers can be maintained without seriously affecting the cash-flow positions of the utilities if they are limited to basic household needs and do not jeopardize the financial viability of the utilities (16). Distributors therefore need to have a mix of regular price and lifeline consumers. [A lifeline rate is a pricing structure that charges poor customers, who usually do not use much electricity (up to 35–50 kWh/month), a lower rate than higher income customers, who typically use greater amounts of electricity.]

Developing countries will continue to pursue rural electrification programs over the next few decades, driven by the realities of 2 billion people unserved and by the prospects of populations growing by nearly 4 billion over the next 40 years. The task will be made easier if rural energy policy is designed to be cost effective, through the implementation of sound pricing policies and the establishment of good enabling conditions (28, 29).

Kerosene and Gas

Kerosene and LPG, commonly used for cooking, are vastly more convenient, more efficient, and cleaner-burning fuels than wood, residues, or dung (15, 30). Kerosene is 3–5 times more efficient than wood, and LPG is 5–10 times more efficient (see Table 3). Cooking with kerosene and LPG is also less damaging

Table 3 Energy efficiency of cooking fuels[a]

Fuel	Delivered energy (MJ/ kg of fuel)[b]
Wood	3
Wood, with stove	5
Charcoal, with stove	10
Kerosene	12
Biogas	15
LPG	25–30

[a]The values in this table are derived from a combination of a fuel's energy content and the efficiency with which the fuels are typically burned for cooking in developing countries.

[b]Energy "delivered" to the cooking pot. Figures are approximate and rounded.

to the user's health and to the natural environment. However, because these fuels are more expensive than wood, they are seldom used by the poorest people. Typically, kerosene and LPG are used by households at the upper end of the low-income ranges and above (30). At the same time, substitution of kerosene and LPG for wood is induced more by income growth than by relative prices in developing countries (31). In Indonesia, Ecuador, and several African countries, governments have tried to encourage substitution through subsidies, but these efforts have not produced the hoped-for results. In the case of LPG, subsidy policies have undermined supplies. Subsidies for kerosene have often led to adulteration and remarketing of smoky vehicle fuels (32). These problems, of course, defeat the purpose of the subsidy and bring no benefit to the poorest people.

Further expansion of the use of these fuels, particularly LPG, will occur with development and should be encouraged for both environmental and economic reasons. In some urban areas of colder climates, the use of natural gas may also increase rapidly, replacing the use of LPG—as well as fuelwood, charcoal, and coal—as infrastructure is developed. In modern times, this replacement took place in industrialized countries, adding to the convenience of urban life and generating good economic returns on investment while greatly reducing pollution.

The main question, then, is how the process of fuel substitution can best be encouraged. A fully satisfactory answer, which is beyond the scope of this paper, would require a thorough analysis of oil and gas policies and of energy taxation (33–40). However, this review does point to two general recommendations beyond the need for enabling conditions for income growth discussed above. The first recommendation is that oil and gas markets be liberalized. In the city of Hyderabad, India, only 10% of urban households used LPG 15 years ago because the government had restricted production and imports. Since then, however, the government has liberalized the trade in LPG. In Hyderabad today, more than 60% of urban households use LPG as a cooking fuel (39).

The second recommendation concerns revision of subsidies and fuel taxes. As suggested above, subsidies often have counterproductive effects. However, lightly taxing LPG and gas can be justified by the environmental benefits that result. A light tax on kerosene might also be considered; the tax would not undermine profits and would create a positive incentive for the use of the fuel, provided the lower tax did not encourage diversion to vehicle fuels.

Even with liberalization of energy markets and revised tax and subsidy treatment, the process of fuel substitution is lengthy. A major barrier to substitution is the cost of modern cooking appliances in relation to per capita income. Little can be done directly about the costs of appliances. Thus, to reiterate, the main policy implication is to encourage good enabling conditions for income growth and the reduction of poverty.

Supplies and Use of Biofuels

Most developing countries have investment programs to improve the supply and use of biofuels, but these programs are exceedingly small compared to the resources allocated to electrification. The programs implemented thus far aim to 1. increase supplies through woodlots and sustainable forest management and farm forestry practices (41) and 2. increase end-use efficiency through improved woodstove programs (42–44).

BIOFUEL SUPPLIES In the late 1970s and early 1980s, biofuels development commonly centered on plantations and community and private woodlots (45). Often expensive and of limited success, such programs have recently given way to a rediscovery of the principles and practices of farm forestry, as well as the introduction of natural forest management. Project experience in China, India, and several African countries shows that farm forestry and natural forest management programs have the following advantages:

1. They provide market and tax incentives for effectively managing existing trees and shrubs and the planting of new ones, thereby helping to accelerate afforestation rates significantly (12).
2. They help address farmers' needs directly, often supplying fodder, building materials, green mulch, fruit, and other valuable wood and nonwood by-products.
3. By helping to address the problems of soil erosion and desiccation and by improving soil fertility, they lead to increased crop yields and farm incomes, making fuelwood a useful by-product.

Some experimentation with the precepts of natural forest management is already being done. In Burkina Faso, Mali, and Niger, for example, participatory programs that draw on natural forest reserves in sustainable ways are being tested (41). Although these new approaches seem attractive for biofuel production and management, success has been mixed for many of the same reasons that rural electrification has not been entirely successful. Involvement of farmers requires favorable enabling conditions for rural development and the support of sound research, extension, education, and land-tenure programs (46–48). Moreover, afforestation programs have too frequently lacked something that rural electrification programs have not—a strong public commitment to their success.

Government policies are not the only crucial factor in determining the success of farm forestry. According to several reports, many farmers have adopted farm forestry practices independently in response to economic incentives and ecological problems. Higher wood prices, although an incentive for logging, also stimulate tree growing and management of local tree stocks, whether on farmlands or in forests (49). The spread of farm forestry in Kenya is an often-cited example of relatively autonomous development of efficient practices, but many others can be found (e.g. in India, Pakistan, and the Philippines). The extraction of wood itself need not lead to significant damage. When wood is a by-product of tree planting and management, biofuel harvesting can be a force, overall, for environmentally beneficial afforestation. In such circumstances, the role of public policies becomes more modest. Government becomes less a manager and more a catalyst and provider of supporting research and educational services.

WOODSTOVE PROGRAMS Simple and inexpensive woodstoves designed for use by low-income households can double the energy efficiency of wood use, reduce indoor air pollution, and reduce the cost of wood and the time spent gathering it. Despite these apparent benefits, many developing-country households have failed to adopt improved stoves. Early programs in the late 1970s and early 1980s, supported by developing-country governments, donors, NGOs, and others, assumed that the benefits were self-evident. They believed people would adopt the improved stoves quickly and that an initial intervention would lead seamlessly to a self-sustaining program. Hence, most early efforts were focused only on dissemination, and such factors as local customs, the economic setting, and the availability and prices of local biofuels were essentially ignored.

These early efforts were based on an overestimation of the energy efficiency of the improved stoves in regular use and underestimation of the efficiency of traditional stoves. Successful programs were expected to decrease wood consumption by 75% or more. Today, a decrease of 25% is considered realistic. As a consequence of their perhaps naive approach, many early programs failed.

Yet the success of some programs shows that efficiency improvement and reductions in pollution can and have been achieved. The development community has evaluated the programs comprehensively to determine the causes of success and failure (6, 50–52). The evaluations clearly show that the best programs have the following features:

1. They first identify, through local inquiry, the families most likely to adopt and benefit from the improved stoves. These have always been low-income households spending a high proportion of their earnings on food and cooking fuel (7).
2. They involve much interaction among stove designers, producers, and users, including testing by representative households. This process of cooperative design and market testing keeps producers and designers focused on meeting the needs of prospective users, increasing the likelihood that people will purchase the stoves.
3. The stoves are not heavily subsidized, although public funds are used throughout the programs to support marketing, design, and training.
4. Parts and techniques are standardized, which facilitates more widespread manufacture and reduced costs.

Technical improvements in stove efficiency are indeed feasible and worth seeking. The economic returns of successful programs have been good. In urban areas, where most people purchase woodfuels, the money saved on purchased fuels can sometimes pay off the investment in the improved stove in as little as a few months. In rural areas, where fuel for cooking is often collected, the time spent gathering fuelwood is significantly reduced. For programs to take root, however, appropriate design and institutional support must complement technical improvements.

Renewable Energy

Developments in renewable energy technologies have expanded the range of options available for improving rural energy supplies (53). Until recently, the main technologies in favorable locations were micro-hydro, biogas, wind generators, wind pumps, and the sustainable ways of providing wood supplies discussed above. All these technologies remain relevant. A more recent development has been the use of photovoltaic (PV) systems to provide electricity supplies for small-scale applications. Familiar examples include electric lights and domestic appliances, refrigeration for clinics, village water pumps, street lighting, and supplies for health clinics and schools. In many areas of developing countries, PVs are now less expensive on a life-cycle cost basis and more reliable and accessible than are grid supplies or diesel motors for small-scale applications (13, 14, 54). In Kenya, for example, 20,000 rural households were newly supplied with electricity using PVs between 1987 and 1992, more than were newly connected to the grid (55, 57).

The encouraging feature of this development is that it was financed solely by private funds. Currently, however, the high initial cost of the hardware puts PV systems beyond the reach of most low-income rural households in developing countries, including Kenya. Despite the encouraging start of Kenya's PV program, electrification is still minimal in rural areas. Hence, creative financing schemes that consider consumer willingness and ability to pay will be required if PV systems are to penetrate rural markets significantly (58, 59). Although important and encouraging lessons can be drawn from the Kenya case, experience with PV projects strongly indicates that such programs must be closely tailored to national and local conditions if commercialization is to succeed. Where productive use of energy is high and significant load growth is imminent, PV systems may not be an appropriate choice.

Further development and cost-efficient use of renewable energy technologies in rural areas can be encouraged in three ways. First, large subsidies for a particular way of supplying energy, such as grid-supplied rural electrification, should be discouraged (60, 54). In the past, subsidies for grid-supplied electricity often undermined consumers' choice of less costly alternatives, such as diesel generators and motors. Such policies now endanger consumers' choice of renewable energy technologies. Second, extension and educational services can be used to promote renewables (61). Careful system design and proper installation are essential, as are after-sales service, adequate local management skills, and dissemination of truthful and adequate information to consumers (13, 14). Third, electricity distribution companies (both public and private) should be encouraged to consider the costs and merits of the solar alternative to grid supplies for meeting small loads and for providing supplementary power on the longer distribution networks. Provided solar alternatives and supplementary power programs are implemented without extensive subsidies, they would not undermine the development of private markets in solar energy.

STRATEGIES FOR EXPANDING RURAL ENERGY CHOICES IN DEVELOPING COUNTRIES

Governments and multilateral institutions have begun to play a more systematic and catalytic role in improving access to energy services for rural and poor people. Sustained success in these efforts, however, requires a reorientation of rural energy strategies. A demand-driven, diversified approach is called for, characterized by multiple fuels, multiple borrowers, inclusion of smaller projects, and greater local participation and investment.

This chapter discusses some of the policies and strategies in the energy sector that can promote more equitable access to a greater variety of improved energy services for substantial numbers of the world's rural and poor people. These strategies focus on pricing, easing the first costs of services [these include costs such as service initiation fees as well as the cost of appliances and other things necessary to utilize service (stoves, LPG bottles, house wiring, etc)], diversifying and encouraging investors, and new roles for governments.

Pricing Energy to Broaden Access

Poor urban households in developing countries may spend as much as 15–20% of their incomes on energy purchases. This percentage is perhaps surprising, given their generally low energy demands. In remote rural areas, people are frequently without efficient energy services because it is too expensive for retailers to service these low-density markets. Governments have sought to remedy some of these equity problems through various price subsidies and taxation programs. Although they are well-intentioned, most of these programs have proven ineffective and costly or inadequate in reaching substantial numbers of rural and poor urban households. Table 4 illustrates the effects of pricing and supply policy interactions on rural people and the urban poor.

Problems of Present Pricing Approaches

Some governments have tried to make energy services more accessible and affordable to rural consumers by heavily subsidizing some types of energy. Such an approach may lower the unit cost of energy for the poor, but it is not well directed, is often unsustainable, and may end up helping others more. For example, in Indonesia, subsidized kerosene for cooking and lighting is available to anyone who wants to buy it. In China, government subsidies have kept the prices of household coal extremely low; consequently, urban Chinese households spend a comparatively lower percentage of their incomes on energy than do households in other countries. Such general fuel subsidies have proven inadequate in benefiting the poor. Without restricting who may purchase energy products, benefits accrue throughout the society, not just to the resource poor. Thus, the more numerous middle-class and comparatively wealthy households, which can afford to buy more energy than the poor, reap a disproportionate share of the benefits. In addition to the economic inefficiency introduced by the subsidy, equity is not served.

For rural electrification programs, large subsidies also have been ineffective in reaching the poor. In many programs, the poor face barriers of high connection costs or cumbersome application procedures. In addition, government policies often are directed to covering villages, with little concern for cost. The consequence is that poor people remain unserved. Also, by decreasing the cash flows of power companies, such subsidies undermine both the quality of service and the ability to extend service to remote areas. Finally, general electricity subsidies can work against providing more cost-effective and environmentally sound alternatives by steering consumers away from affordable renewable-energy services. Blanket subsidies, at least on a large scale, are thus difficult to justify economically, socially, and environmentally.

For fuels that can be diverted and resold, subsidies may have only a fraction of their intended effect, even when they are earmarked for the poor, and they can cause a host of problems. For example, until several years ago, the Government of Ecuador subsidized kerosene, a fuel used predominantly by the poor. However, poor households ended up receiving only limited amounts because retailers diverted the bulk of supply to the more profitable transport sector (56).

Like subsidies, uniform pricing policies for an entire country have proven ineffective in helping rural and poor people. Although intended to market energy fairly and avoid excessive profits by energy companies, such policies inadvertently discourage these companies from investing in rural areas. Be-

Table 4 Impact of energy pricing and supply policies on rural people and urban poor

	Energy pricing policy		
Supply policy	Subsidized prices	Market prices	Fuel taxation
Limited or targeted supply	Subsidy is redirected away from poor to other groups	Higher-income groups are served first	Traditional fuel prices are unaffected by those of alternatives
	Rural and poor people lack access to fuel	Rural and poor people lack access to fuel	Rural and poor people lack access to fuel
Unlimited or untargeted supply	Modern fuel subsidies mean lower prices for traditional fuel	Traditional fuel prices are capped at price of alternatives	First costs of service, along with fuel costs, constrain poor from purchasing fuel
	Rural and poor people can access service, but it is fiscally unsustainable	Rural and poor people can access service, and it is fiscally sustainable	Rural and poor people can access service, but it is expensive
	Poor benefit from lower fuel prices, but other income groups benefit more	First costs of service constrain poor from purchasing modern fuels	Traditional fuel prices are often high because of higher-priced alternative fuels

cause such policies are often combined with limiting fuel imports, suppliers naturally gravitate toward the more profitable markets located in wealthy urban areas. Consequently, the urban poor remain underserved and rural people may end up without any service.

Import tariffs and taxes that countries impose on such modern fuels as kerosene and LPG can also hurt the poor, particularly in urban areas where all fuels are sold commercially and modern fuel prices act as a cap on traditional fuel prices. In Haiti, for example, the government reasoned that taxing LPG and kerosene, which are purchased primarily by wealthy consumers, would not negatively affect the poor. These policymakers failed to recognize that, in wood-scarce urban areas, kerosene and LPG provide a price ceiling for wood and charcoal. Taxing kerosene and LPG thus resulted in higher prices for fuelwood and charcoal, and poor people now spend a significant amount of income on energy for cooking.

Haiti's LPG prices are among the highest in the Caribbean, if not the world (62). These prices make fuels like LPG and kerosene available to only a small fraction of the population. Massive deforestation over the past 25 years has depleted the country's wood supplies, so the urban poor, most of whom depend on charcoal for cooking, now pay higher prices.

As Figure 2 illustrates, kerosene and LPG prices have historically been related to the price of charcoal. As wood resources have disappeared from rural markets, the price of charcoal for cooking has approached that of alternative commercial fuels. Today there is hardly any price difference, and taxes on kerosene and LPG mean higher prices for charcoal.

Analysis shows that under normal supply conditions, gas would become the best financial option for the Haitian consumer and the best economic option for the country. Thus, if liquid fuels were taxed lightly instead of heavily and priced to reflect their economic cost, consumers would also pay less for wood and charcoal, making it easier for the entire country to move toward greater energy efficiency.

Successful Pricing Policies

PRICING ENERGY AT ECONOMIC COST Paradoxically perhaps, energy that is not heavily subsidized or taxed and that is free of import restrictions may have the best chance of reaching rural and poor people. The direct advantages of taxing modern fuels in order to conserve energy, raise government revenues, and lower foreign exchange can be offset by the indirect harm they cause the poor. This possibility is particularly likely for such household fuels as LPG and kerosene. If energy prices are allowed to achieve levels that give distributors a rural market incentive, reliable service is more likely to reach rural and poor people. Economic efficiency is not a major problem as long as the approach to

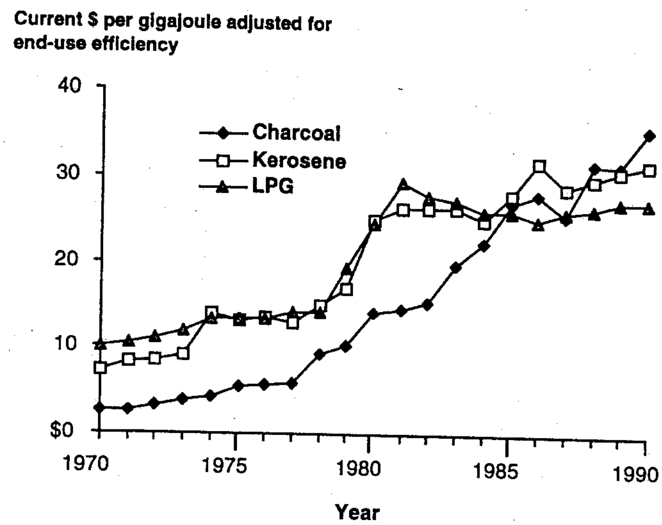

Figure 2 Energy prices in Haiti, 1970–1990. Current cost per GJ adjusted for end-use efficiency.

it is to remove taxes rather than to give subsidies. Policymakers concerned with the equity implications of energy policy should thus encourage cost-covering energy prices and modest, nondistorting taxes, which have real benefits for the poor. Moreover, such a policy is easy to administer.

Allowing rural retailers to increase the price of kerosene or electricity to levels that cover costs and provide reasonable profit margins will increase availability in rural areas. Once the rural market develops, economies of scale in distribution may lower prices to more uniform levels, which are based on market conditions rather than government policies.

MODEST CROSS-SUBSIDIES For high-quality fuels that are supplied by large companies, such as electricity and LPG, modest cross-subsidies between higher-income, heavy consumers and lower-income, low-volume consumers can be justified as good practice for market development and easily administered by suppliers.

In the electricity sector, the poor can be well targeted by using modest cross-subsidies to support lifeline rates for low blocks of electricity consumption. This exception to the principle of pricing energy at its economic cost can be effective in facilitating access by rural and poor people without creating significant efficiency losses. In urban areas, the basic monthly consumption level per low-income household is typically only about 35–40 kWh and 25 kWh or less in rural areas. Because the poor consume so little electricity, the subsidy is well targeted, and cumbersome methods to test whether incomes are low enough to qualify for a subsidy program are not needed.

Thailand's rural electrification program is an example of the effective use of cross-subsidies to promote rural electrification (28). This program began during the early 1970s. At that time, the country was considered a middle-income developing nation, and its political climate dictated that rural electrification be a priority. Between 1975 and 1994, the number of electrified villages increased from 20% to 98%. Over the same period, the population covered outside the Bangkok metropolitan area increased from 18% to more than 80%. In Thailand, a major contributing factor to the country's successful rural electrification program was a system of cross-subsidies from large to small consumers, including lifeline rates for the first 35 kWh of service. Lifeline rates for the first 35 kWh were designed to make service affordable for poor people who used small amounts of electricity, primarily for lighting. Because of such limited use by the poor, lifeline rates did not adversely affect the company's financial performance. Under this program of increasing block rates, the urban poor actually pay less than wealthier households for electric lighting. Other reasons for the success of the program include thorough planning for careful system expansion; keeping costs low; an effective billing program to ensure revenue collection; careful attention to customer service, marketing, and community involvement; and a system of cross-subsidies from large to small customers.

Lifeline rates for small consumers can only be maintained if they are limited to the basic needs of poor households and do not jeopardize the financial viability of the utilities (1). Distributors need to have a mix of regular price and lifeline consumers. In the case of small, local distribution companies, such as rural cooperatives, bulk suppliers might be able to charge retailers that serve only low-volume consumers lower bulk-supply rates, effectively providing a cross-subsidy. If it does not negatively affect the supplier's financial performance, this incentive can also be a business development tool.

A similar policy is appropriate for LPG. High-volume consumers can cross-subsidize the small LPG bottles and initial service costs required for low-volume users. LPG is typically sold in bottles containing 12–15 kg. If the fuel were also available in smaller-quantity bottles, such as 2.5, 5, or 8 kg, poor people could more easily afford LPG. Increasing the options on the size of purchase, combined with reducing taxes on LPG, may make the fuel cheaper for rich and poor alike. Although not all poor people will use LPG, they will at least be better able to afford the smaller cash outlays it requires. Further, because woodfuel prices are related to those of petroleum products in many countries, a policy that reduces taxes on such liquid fuels may indirectly lower the price of woodfuels, which are used mainly by the poor.

RESOURCE TAXATION OR PAYMENT A resource tax on the urban fuelwood trade collected by local rural communities can benefit rural people. The tax can be justified as payment for the sustainable management of the local forest resources, part of which must be retained by and reinvested in the local community and part of which can be used by the forestry departments in return for their technical support. Although this recommendation may appear to put an upward pressure on the price of wood and charcoal used mainly by the poor, it does not. The tax is low compared to the final price of woodfuels in urban markets. Because of this difference, combined with the fact that fuelwood prices for "useful" energy are similar to those of kerosene and LPG, such a tax would not adversely affect the urban price of woodfuels.

Easing First-Cost Problems

Frequently, poor people pay more for useful units of energy used because they cannot afford the cash outlay needed to initiate service of a more efficient fuel. The costs of connection to a grid, for example, can be as high as $1000. A solar home system costs between $500 and $1000 or more, depending on the system's configuration, import tariffs, and margins (54, 60). Setting up a community grid can cost tens of thousands of dollars. Stoves and cylinders necessary to burn LPG also represent a significant investment for many poor people.

Low-Cost Options

One reason that rural people and the urban poor cannot afford the first costs of energy services is that products and service levels have been developed mainly for use in developed countries and for higher-income groups. Sometimes high levels of service are justified, but in many cases programs suffer from trying to offer urban levels of service to populations that do not require such high standards. The consequence is that their services become extremely costly.

High first costs are clearly a major reason for low-connection rates in rural and poor urban areas. The design standards used in many developing countries do not cater to low-demand consumers. For example, most rural and poor urban consumers use only a few lighting fittings and possibly a radio or small television, resulting in a power demand as low as .2 to about .5 kW. However, the minimum-service connection ratings of many utilities are on the order of 3.5 or 7.0 kW, resulting in unwarranted connection costs. Utilities sometimes attempt to justify the higher gauges on the basis of minimum mechanical strength required for stringing (but this problem can be resolved by using suitable messenger wires, when necessary). Service connection costs can also be reduced with the use of low-cost support poles (63). Many such low-cost options are resisted on the basis that the utility will bear the responsibility for maintenance and replacement. However, this responsibility can easily be transferred to consumers through community participation, such as that achieved in Bangladesh.

Several well-targeted interventions in India and other parts of Asia have developed minimal-cost service connections for rural and poor households. These connections consist of a board with an inexpensive meter, an outlet, and sometimes a light-bulb socket. In some countries, a wide variety of LPG cylinders are available in the marketplace, allowing consumers to select the most appropriate equipment. Also, locally produced adaptations of kerosene stoves that allow the use of traditional pots are sometimes available, such as the "Chip" in Niger and the "Fayida" in Mali. The development of lower service levels for renewable energy, through inexpensive solar lanterns and other systems, is being explored. In Nepal, the distribution costs of a minihydro-based grid system have been reduced by using less expensive poles, a power-based tariff that lowers the costs associated with meter-reading and billing, and other factors. Finally, for similar levels of quality, the costs of custom installation of improved stoves have been reduced through the use of less expensive, mass-produced parts.

Improving Consumer and Supplier Credit

For most people in developing countries, formal credit is unavailable, except at very high rates. In some parts of Africa, for example, moneylenders charge interest rates of 100% or more. Access to credit is further limited by legal, regulatory, and institutional barriers. However, emerging innovations in credit-delivery systems, such as the Grameen Bank in Bangladesh and similar programs, offer some promising approaches to short-term credit in rural markets. Although these programs have been directed mainly at nonenergy uses, similar approaches could be used to finance energy investments such as appliances and products (64).

Electricity companies can provide credit by including connection and service fees on consumers' bills and allowing them to spread costs over several years. A public electricity company in Bolivia, for example, doubled its customers in several villages after offering to finance connection charges over a five-year period.

Similarly, wholesalers or retailers of household PV systems can arrange for or provide credit to potential customers. NGOs and cooperatives can help finance the infrastructure to develop energy services, thus reducing the costs of administering such programs. In addition, wholesalers and retailers should be able to obtain credit for stocking energy appliances. A more sophisticated and efficient banking system in rural areas will go beyond traditional uses of credit in the agricultural sector to accommodate retail finance for energy.

Buying Down Initial Costs: Externalities and Market Scale

Support for capital cost can be justified to buy down some of the initial capital costs of such technologies as grid rural electrification or renewable energy devices if environmental externalities require alleviation. An example of the use of credit to promote growth of commercial energy use comes from studies done in several villages in Bolivia. When people in the villages of Mizque and Aiquile in rural Bolivia were given the opportunity to purchase electricity service, the high connection costs prevented about 75% of households from accepting the offer (65). The electricity companies then decided to finance the connection charges, allowing customers to pay back the costs in small monthly installments over a five-year period. In return, they received electricity service during evening hours. As a result of this financing scheme, the number of households able to purchase electricity service more than doubled.

In the village of Vacas, where 24-hour, grid electricity service was extended without any credit scheme, the connection rate was about the same as in Aiquile and Mizque (see Table 5). Despite having to pay about five times more for service limited to only evening hours, over 50% of households in Aiquile and Mizque valued the benefits of electricity enough to pay for it when an affordable financing scheme became available.

Such capital-cost support should be used mainly for capital equipment or transaction costs. Such support should not threaten the financial viability of energy distribution companies; rather, it should be structured to create incentives for these companies to serve rural consumers. Generally, incentives that lead to market development and sustainable consumer service can be justified, whereas those that restrict the market to government programs should be avoided.

Table 5 Credit access and electricity adoption[a]

Village	System type	Credit available	Percent household taking credit	Percent household with electricity	Price of electricity ($/kWh)
Aiquile	Diesel	Yes	51	55	.25
Mizque	Diesel	Yes	56	59	.30
Vacas	Grid	No	0	54	.06

[a]Source: 66

Diversifying Investments and Investors for Energy Supply

Many private enterprises have given up on low-profit rural markets because of publicly funded competition. Moreover, distribution systems, retailing networks, and local electricity systems are expensive to set up, especially during the initial stages of program implementation. If funding for rural markets is left to the public sector, which has scarce resources, little investment occurs. A policy environment that encourages greater diversity in private, public, and community investments in rural energy supplies can broaden the options available to rural people.

At issue is not whether the service provider is public, private, or community based, but whether it adheres to the principles recommended in this paper. These principles include pricing energy so as not to undermine the financial viability of the distribution company, ensuring a competitive regulatory framework, encouraging greater local participation, and promoting a consumer orientation.

Public Investment: A Continuing Role

Experience teaches that no country—certainly no industrialized country—has ever completed rural electrification without the financial support of its public companies and government. The public utility model for providing electricity supply was firmly established between 1930 and 1960—more than 30 years before the resurgence of interest in private power. In applying the model, such countries as the United States complemented utility programs with rural electrification cooperatives supported by public finances; others relied on direct investments by the utilities. Thailand's rural electrification program, which began in the early 1970s, is an example of a successful rural electrification program that involved a public distribution company. However, the program stressed the principles of pricing, affordability, marketing, and local participation that are set out in this paper.

The increasing worldwide trend toward privatization of the electricity industry raises concerns about whether the private sector in developing countries will respond adequately to the task of electrification. A similar trend is evident in the industries that supply LPG to households as a cooking fuel. Although a market solution is possible and desirable, few precedents help to alleviate worries about how well or quickly it will proceed. Thus far, private-investor interests in developing countries have centered mainly on power generation, not transmission and distribution. Even in cases in which the rationale for privatization of the electricity industry is fully accepted, complete transition to a privately owned industry cannot be achieved quickly.

Workable solutions involve continuing some public involvement in rural distribution, combined with support for stand-alone, small systems based on diesel or renewables; joint public-private investments with the high fixed costs of distribution supported through public equity and long-term loans at cost; and temporary tax incentives and rebates for private investors, cooperatives, or communities. Such incentives could be directed toward the initial capital costs of the systems but should never include the fuel or operating costs.

Whatever the level of public involvement, the conditions for successful development of energy supply efforts and other energy investments remain: making cost-effective choices, ensuring that enabling conditions and complementary infrastructure are in place, and using more appropriate pricing policies. These goals are fully compatible with policies intended to attract private investment in extension, reinforcement, and management of the downstream components of electricity networks.

Private Investment: An Increasing Role

In addition to the continued and creative involvement of the public sector, growth in the energy sector requires that rural areas become attractive investments for private companies. In the past, private companies have been steered away from rural energy markets because of financing constraints, regulations that prohibited or encumbered development of local grids, poor pricing policies, and government taxation of energy products. Many urban households in Africa, for example, have been prevented from switching from wood or charcoal to kerosene or renewable energy systems because of the high taxes levied on imported liquid fuels and renewable components.

Although donor organizations have been involved in much of the PV growth, the private sector has accounted for about two thirds of the total installed capacity. The cost of PV-supplied electricity for low levels of lighting in rural areas is now competitive with grid electricity. Rural-based electricians are linking up with urban business people and solar electric suppliers, based primarily in Nairobi. Currently, eight or so companies supply the PV market and compete through agents in rural areas to market, install, and maintain PV systems. By 1993, grid electrification in rural Kenya had reached only 17,000 households, although it was significantly subsidized and also included a tax waiver on imported products used in electricity distribution. By contrast, PV systems had reached about 20,000 households, even though their imported components were subject to a 30% duty, which significantly raised the cost of these household systems. Such substantial growth in PV use illustrates the high value people in remote locations place on electric lighting. They view PVs as an attractive alternative to waiting indefinitely for the grid system, which may never reach them.

In the past, private investments in rural areas have centered mainly on retailing energy and energy products. However, private funding of such energy-related products as generation and microgrids should be increased, under favorable conditions. Greater diversity of producers, marketers, and retailers investing in rural areas can and should be encouraged through appropriate deregulation and pricing policies. Such encouragement must occur in response to the demand for energy services in rural areas rather than in response to artificial targets. Special incentives should be used sparingly.

Community-Based Investments: An Overlooked Asset

Community or locally based systems are often ignored, even by publicly supported projects, in favor of the two extremes of small systems for individual consumers or large central schemes that cover wide areas. However, cooperatives, NGOs, and communities should not be overlooked as vehicles for supporting the delivery of energy services. The members of such grassroots organizations have knowledge and understanding of local needs.

For example, in Karnataka State, India, local people in the village of Pura, supported by the Karnataka State Council for Science and Technology and the Centre for the Application of Science and Technology to Rural Areas, now administer household electricity and water generated by large community biogas digesters. Near Bangalore, South India, the village of Pura supplies household electricity and water through large community biogas digesters. Initial attempts to promote community biogas systems in Pura failed because they were directed at substituting biogas for wood as a cooking fuel. Abundant wood resources in Pura make fuelwood collection relatively easy, and villagers therefore had no incentive to maintain the system. Subsequent discussions with villagers revealed that they were more interested in obtaining clean and reliable water supplies located near their houses. Because grid electricity supply was unreliable, the community decided to establish a system of biogas production for fueling a five-horsepower diesel generator. Electricity from the generator was supplied through a microgrid to households and also powered a deep tubewell pump that supplied water to a local system. Each household participating in the program received a tap with clean water at the front of their house, thereby eliminating long walks to the local tank and significantly improving their health. Each household is charged a fixed rate for the water tap and each electricity connection. Some households now have both a grid and a village connection that some in the village have called "people's power" (66).

Another example is Bangladesh's rural electrification program, which is based on a cooperative organizational structure and has achieved considerable success in levels of connections and operational performance. Billing recoveries are close to 100%, and operational and consumer/employee ratios are far superior to those of the two parastatal power companies, evidence of the efficiency gains that can be achieved through community involvement.

Diversity of Future Providers

No single company, public or private, can deliver the entire range of energy services needed to meet the varied needs of rural and poor people. Hence, a diversity of service providers is both necessary and beneficial. Public, private, and community-based investments are all much needed in rural areas. Their services may be complementary or may foster healthy competition. For example, NGOs can support the creation of infrastructure for commercial dissemination of technology, such as improved stoves, charcoal kilns, and micro-hydro plants; public or private companies may sell electricity; and local companies may lease or sell a rural farmer a household PV system.

Ensuring that the regulatory environment for energy is equally accessible and attractive for public, private, and local investments in energy supply is important. Methods to accomplish this goal include eliminating rules and regulations that effectively keep other service providers out and discouraging monopolistic practices, whether public or private. For rural grid electrification, both public and private investments should be encouraged, as well as joint ventures. Provided that public utility services are not heavily subsidized, private investments in electricity and renewable energy distribution will not be undermined, and privatization will not be precluded if it proves a more workable model for extending service efficiently.

Changing from Central Planning to Market/Consumer Approach

In the past, many well-intentioned government programs that promoted energy for disenfranchised groups developed into central planning agencies, and targets and subsidies provided the rationale for their existence. The development of such central planning agencies was, in part, encouraged by international donors determined to support only single technologies or energy devices. Governments became, in effect, the consumers to whom energy suppliers, retailers, and wholesalers geared their sales. Evidence from experience in developing countries has shown that the approach to delivering energy services to rural and poor people needs to shift from selling to governments to servicing local markets and consumers (67). This change in thinking calls for a demand-driven strategy that emphasizes multiple fuels, multiple borrowers, sometimes smaller projects, greater local participation, and higher local investment (see Table 6).

The approach recommended here, based on observation of successful practices, is not meant as a criticism of large, well-managed projects or as an endorsement of poorly managed, small projects, such as the parachuting of small-scale technologies into rural areas. (Parachuting is the practice of bringing technologies into rural areas to be given away or sold at highly subsidized prices). Rather, the approach stresses that both large and small projects can be successful and are most likely to succeed when accompanied by a greater choice of service, greater local participation and investment, and adherence to the principle of serving markets.

Successful Approaches for Governments

Governments should avoid the problems caused by promoting particular technologies that require extensive subsidies. Following this recommendation does not preclude governments from being involved in rural energy projects. On the contrary, they have an important role to play in promoting more equitable access to energy. They should shift to providing technical assistance; establishing regulations and ensuring policies that encourage competition, development, and safety; and providing loans for energy products that are in significant demand in rural areas. These and other successful approaches for governments are described below.

TECHNICAL ASSISTANCE Governments can promote and provide technical assistance for new product development and innovation aimed at reaching rural and poor people, including low-cost connections, improved biomass stoves, and other energy products. They can provide appropriate wood management policies, along with training in efficient charcoal kiln construction and techniques to enable local artisans to produce more charcoal from the same amount of biofuel. Governments can also finance the "software" costs of natural forest

Table 6 "Old" vs "new" thinking on energy for rural and poor people

Old	New
Single fuels	Multiple fuels
Central planning	Market approach supported by technical assistance, training, and extension services
Single borrower	Multiple borrowers
Predominant focus on large projects	Large projects plus small, high-return projects
Project development focus primarily between bank and governments	Greater involvement with other donors, stakeholders, and investors
Little local participation	Extensive local participation
Broad subsidies, subsidized fuels, and subsidized capital equipment	Market pricing with limited, temporary incentives
Overemphasis on energy production	Oriented toward consumer demands
Universal access, regardless of level of development	Greater coordination with broader, rural development efforts
Low local investment	High local investment

management and farm forestry programs, such as surveys, as well as the costs of technical training, extension, and demonstration projects. Their support of new technologies, such as renewable energy, should not involve large subsidies that inevitably discourage private initiatives.

RESOURCE MANAGEMENT Transferring responsibility for managing and exploiting wood resources from governments to local communities requires that governments have in place—or establish and enforce—a policy and regulatory framework that penalizes the transport and purchase of opportunistically mined wood and promotes the marketing of wood originating from managed forest areas.

EFFECTIVE AND TRANSPARENT REGULATIONS The goal of market development requires a fair system of regulations that encourages competition and incentives for providing services to rural areas, including the discouraging of monopolistic policies for electricity, liquid fuels, and renewables. Governments should require that some equipment and technologies meet minimum quality or system standards; others should be required to meet safety codes. The goal is to provide a regulatory environment that ensures equal opportunity for different types of energy services.

LIBERALIZATION OF TRADE AND COMMERCIAL MARKETS Policies that restrict access to energy in rural areas usually limit fuel imports, target subsidies to the poor, and levy high import tariffs on imported renewable energy equipment. Such well-intentioned policies make energy companies prefer to serve wealthier consumers located mainly in urban areas, divert subsidies away from rural areas, and increase costs for technologies of potential use in rural areas. All groups will experience restricted access to some degree, but the poor will be the most seriously affected. The quantities of fuels consumed through liberalizing markets are unlikely to be large enough to impact foreign exchange. A recent study conducted in Ecuador concluded that bringing energy prices to levels that are on a par with international ones can contribute to a more rational and equitable pattern of energy use.

Such policies for the energy sector should be directed toward household fuels, and they may not be applicable to transport fuels, such as gasoline. However, because diesel and kerosene are close substitutes, high taxes on diesel are bound to result in diversion of lower-priced kerosene to the transport sector. The spread between diesel and kerosene prices should not be large. Notwithstanding these problems, governments should ensure a liberal trade policy for imported fuels and equipment to be used by rural and poor people, including liquid fuels and renewable energy products and components.

INVESTMENTS AND LOANS For energy products in significant demand in rural areas, governments can provide equity financing and long-term loans through financial intermediaries. For rural electrification, attractive conditions for such financing would include marginal costs that are much higher than average costs until networks are well established and utilization rates are high. Many emerging technologies can be financed through transparent screening, which avoids the discriminatory effects of rural electricity supply because uniform national tariffs are imposed.

CROSS-SECTOR COORDINATION Rural energy planning and development efforts need to involve extensive cross-sectoral support in energy, agriculture, rural development, and forestry. Exchange of knowledge and information across these sectors can help broaden the views of energy specialists, who might otherwise have a more limited picture of the context in which they work. Improving coordination between these sectors is essential for effective rural energy development.

MARKET/CONSUMER ORIENTATION WITH GOVERNMENT SUPPORT Promoting markets for energy in rural areas substitutes for planning, and rural people basically set the priority through their decisions to purchase energy services. This approach is obviously the most efficient; however, markets are not always well developed in rural areas of developing countries, and policies have to address this shortfall.

For example, the 100 Counties Program, an outgrowth of China's integrated rural energy planning program, combines local planning and technical assistance (68). Communities are given grants to assess their own energy needs and to write proposals for technical assistance and loans to meet them. In Brazil, an energy component of a multisectoral rural development project allows the community to choose grid or renewables from a menu of possible projects for using social development funds. Such market/consumer orientation is essential for creating local interest and equitable access to rural energy.

China's 100 Counties Program blends integrated rural energy and market-oriented approaches to ensure local efforts are successfully implemented, while maintaining coherent national planning, information exchange, and oversight (68, 69; see Table 7). Much of the program's success can be attributed to empowering local communities to make decisions about technology use and responsibility for investment, operation, and maintenance. The program's central administration involves broad cooperation across eight ministries, making a wide array of technologies eligible for support. As a result, the program has a rich base from which to address local conditions and needs.

Table 7 Empowering local communities in China: decentralized decision-making in China's 100 Counties Program

Decentralized functions	Centralized functions
System ownership and responsibility	Selection of counties based on principle of choosing most capable first
Investment by local government and/or farmers	Selection of advanced and practical technologies
Decision-making about technologies	Providing guidance to local governments on comprehensive planning
Management of individual projects	Supporting research training, working expenses, and loan subsidies
Operation and maintenance	Monitoring and evaluation

CONCLUSIONS

Developing and extending modern energy supplies, including renewable energy, to 6 billion people in the coming decades, while simultaneously introducing ways to produce and use biofuels more sustainably during the transition, is a daunting task. Within the area of development and the environment, this task is perhaps the main challenge facing the energy industry. All the types of investment discussed above are capable of generating satisfactory rates of return and, with satisfactory pricing policies for "commercial" energy, can be designed to be financially viable. However, no single investment program can be pushed to excess without greatly raising its costs and reducing its benefits. In the high-growth East Asian economies and in parts of Latin America, the programs may be substantially completed within two decades; in Africa and South Asia, the task will take much longer, even given a favorable enabling environment. The main questions facing most countries, therefore, will not be whether to invest but how much to invest, and at what rate of expansion; what the relative roles of public and private investment should be; and what form public policies should take.

Appropriate energy policies combined with enlightened enabling conditions can result in good returns on investment and labor. Enabling conditions include satisfactory fiscal and monetary policies and economic efficiency in the management of exchange rates, agricultural prices, trade, and industrial policy. Along with human resource policies, the enabling conditions provide the foundation for broad-based income growth in rural as well as urban areas. Secure land tenure, absence of gross inequities in land holdings, and agricultural research and extension to encourage broad-based income growth are also needed for rural development (70). Removing the bias against agriculture and small-scale industries, an explicit aim of the above policies, is a stimulus toward a more decentralized and labor-demanding pattern of the growth of commerce in agricultural provinces and towns. This stimulus will help income growth (and the energy transition) by drawing labor into more productive pursuits, and it is also a source of market growth for commercial fuels.

To improve rural quality of life and alleviate local environmental problems in rural areas, bilateral and multilateral donors should continue to finance rural electrification and sustainable ways of producing and using biofuels (mainly through agricultural development and natural resource management projects), and they should strengthen markets for liquid fuels and renewable energy technologies. Donors should also be willing to finance technical assistance and institution building for policy development. Technical assistance and program lending for rural energy have languished in large measure because the enabling environment and energy policies have not been favorable to otherwise well-intentioned and well-conceived projects. The economic and institutional reforms now being implemented in many countries are opening up substantive opportunities for both public and private initiatives to improve the energy supply situation for literally billions of people who cannot yet afford or gain access to modern energy forms. Both the successes and the disappointments of the past two decades provide the insights upon which sound policies and investments can be based.

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