Tackling the Rural Energy Problem in Developing Countries

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Many people in the developing world lack access to energy sources such as oil, gas, and electricity, and still depend on biomass. The problems of supplying them with modern fuels appear daunting, but practical and financially sustainable solutions exist.

ENERGY MARKETS do not function efficiently in many developing countries, particularly in rural areas, where nearly 2 billion people do not have electricity or access to modern fuels such as oil and gas. The problem is likely to worsen in coming decades. The population of the developing world is expected to increase by 3 billion over the next forty years, and energy demand per capita will grow rapidly. As countries' economic development proceeds, their per capita consumption of commercial energy increases. Per capita consumption of commercial energy in the United States, for example, is 80 times higher than in Africa, 40 times higher than in South Asia, 15 times higher than in East Asia, and 8 times higher than in Latin America.

Inadequate energy markets threaten to dampen economic growth, hobble development, and keep living standards low. Although grid electrification is the traditional means of providing reliable electricity supplies, connection to distant grids will be too expensive to be cost effective for many rural areas. Fortunately, there are a number of promising alternatives for increasing energy supplies even in very remote areas, ranging from more efficient use of traditional fuels to advanced technologies based on renewable energy sources.

The current situation

Efforts since 1970 to increase electricity supplies in developing countries have been remarkably successful (see table). But because of population growth, the number of households without electricity is still large and is even growing in some regions. One-third of all energy consumed in the developing world comes from biomass. In addition to being their primary source of energy, biomass also provides many people in the developing world with a livelihood. In Africa alone, the production and marketing of wood fuels (fuelwood and charcoal) is a $5 billion business that employs more than 400,000 people.

Wood and other traditional fuels such as dung have numerous disadvantages, however. They are far less efficient than other energy sources; a kilogram of wood, for example, generates only one-tenth of the heat yielded by a kilogram of liquid petroleum gas (LPG). Moreover, burning these types of fuels in an enclosed, poorly

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Urban and rural people connected to electricity in developing countries
(percent of population)

	Urban		Rural	
	1970	1990	1970	1990
North Africa and the Middle East	65	81	14	35
Latin America and the Caribbean	67	82	15	40
Sub-Saharan Africa	28	38	4	8
South Asia	39	53	12	25
East Asia and the Pacific	51	82	25	45
All developing countries	52	76	18	33
Total served (in millions)	**320**	**1,100**	**340**	**820**

Source: World Bank project and sector reports, and surveys of electricity statistics by the World Bank's regional staff in Asia and Latin America.
Note: Figures are estimates.

ventilated space presents a major health hazard. According to some estimates, smoke contributes to acute respiratory infections that affect 4 million infants and children a year. Studies have shown that nonsmoking women in India and Nepal who have cooked on biomass stoves for many years have a higher-than-normal incidence of chronic respiratory disease. The use of wood fuels has also taken a serious toll on the environment in many regions, leading to deforestation, soil erosion, and reduced soil fertility. Deforestation, in turn, has forced many poor people to resort to even less efficient sources of energy, such as crop residues and dung—materials that could otherwise have been used for fertilizer. Finally, many children and adults in developing countries must spend up to several hours per day gathering fuel; this leaves them less time for schooling and productive activities and thus perpetuates poverty.

Moving up the energy ladder

In poor countries with annual per capita incomes of $300 or less, at least 90 percent of the population depends on wood and dung for cooking. But people move up the "energy ladder" as their incomes grow, eventually switching to electricity for lighting and fossil fuels for cooking; in agriculture and industry, diesel engines and electricity replace manual and animal power. The transition to modern fuels is usually complete by the time annual per capita incomes reach $1,000–$1,500. With technological progress and reductions in the costs of modern fuels, the income level at which people make the transition can decline significantly. For example, a transition that took nearly 70 years in the United States (1850–1920) took only 30 years in Korea (1950–80). But such transitions will not happen overnight. Even in East Asia and the Pacific, a region that has experienced rapid economic growth and significant increases in the supply of commercial energy, biomass still accounts for 33 percent of energy supplies and its use is expected to decrease by only 50 percent over the next 15–25 years.

What are the options?

Because biomass use will continue throughout the developing world for some time to come, energy policies must support ways to use wood fuels more efficiently and sustainably, while creating the necessary conditions for supplying modern fuels to those who lack them.

Farm forestry and local forest management. Farm forestry—planting trees, shrubs, and grasses on farmlands and between crops—and forest management have long played an important role in alleviating wood shortages in China, India, and many other countries. Because farmers outnumber foresters in most countries by several thousand to one, involving them in planting trees and shrubs can dramatically accelerate afforestation. And the incentive to participate in farm forestry programs is strong: wood fetches a high price in some urban markets, and trees and shrubs can supply farmers with fodder, building materials, green mulch, fruit, and other byproducts that may be as valuable as the firewood itself.

Experience suggests that effective management of existing forest resources depends on letting local people take responsibility for forests or woodlands. Some successful participatory effects have now been pioneered in several countries. In these programs, farmers get to sell all the wood extracted from local woodlands; however, they must participate in a resource-management program developed in collaboration with the national forestry department.

Improved charcoal efficiency. Charcoal represents an intermediate rung on the energy ladder, between wood and kerosene or LPG. It burns without smoke or dangerous flames and requires only a simple stove whose heat output is relatively easy to control. However, local charcoal producers often use inefficient charcoaling kilns that consume more wood than necessary. Kilns based on traditional designs but that are more energy efficient have been developed in collaboration with end users in Madagascar, Rwanda, and Thailand and successfully disseminated through extension programs and training. Programs promoting technical innovation have been most successful when accompanied by the forest-management programs described above, which give villagers custody of local forest resources.

Efficient use of biomass. One way to improve wood fuel use is for governments to encourage the private sector to develop and market improved stoves in rural areas by supporting stove design and testing, and conducting publicity campaigns and training programs. Relatively simple and inexpensive stoves—for example, with improved chimneys—can reduce the amount of fuel needed for cooking by as much as 30 percent, yield substantial health benefits, and free women and children from hours of gathering firewood. Experience has shown, however, that such programs need to be targeted. For example, the successful Chinese National Improved Stove Program, the largest ever undertaken (120 million stoves have been installed in rural households), was concentrated on areas with the greatest shortages of wood for fuel.

Although fuels from biomass are generally much less efficient for cooking than modern fuels, biogas derived from digesters of dung and farm residues is an exception. Both China and India have done much to develop biogas and encourage its use. However, only farmers who raise livestock can easily acquire biogas; it is thus a cost-effective option for less than 10 percent of most rural populations.

Rural electrification. Rural demand for electricity comes mainly from households that use electricity for lighting and from farms, agro-industries, and small commercial and manufacturing establishments, which use electricity for productive purposes such as irrigation pumping, water supplies, crop processing, refrigeration, and motive power. Most rural electrification programs have focused on connecting rural areas to national or local grids (see box). However, grid-supplied electricity is not the lowest cost alternative under all conditions.

For example, technologies involving wind power, solar thermal power (sunlight used to heat air or water), photovoltaic (PV) cells (which produce electricity directly from sunlight), and small-scale hydropower merit more attention from policymakers. They are often an ideal way to get energy to rural areas and have significant environmental advantages relative to fossil fuels. Solar power is a particularly attractive option for countries with abundant sunlight and a poorly developed rural grid electrification system.

The costs associated with these technologies, once prohibitive, have decreased significantly over the past decade. Today, PV systems supply electricity economically to rural areas throughout the developing world for lighting in homes and schools, domestic appliances, refrigeration in health clinics, village water pumps, telephones, and street lighting.

Rural energy policies

Evidence suggests that people are willing to spend a significant portion of their incomes on higher quality energy that improves their quality of life and enables them to be more productive. Governments have an important role to play in creating conditions that provide consumers with more energy choices and encourage innovation and investment in new technologies. Prices should be liberalized to reflect costs, and regulatory policies need to encourage competition and level the playing field for all types of energy markets, whether they are served by public utilities, private firms, or community enterprises. For example "off-grid" power companies and cooperatives are often totally excluded by electricity regulations from serving people, and policies that artificially hold down prices sometimes provide little incentive for such local initiatives to get started.

Pricing and market reforms. In general, energy subsidies (prevalent in developing countries) should be avoided. Subsidies undermine incentives both for consumers to make least-cost choices and for investors to develop alternative energy forms, and more often disproportionately benefit higher-income households, which use more energy than poor households. In some cases, subsidized fuels never even reach the poor. In Ecuador, for example, kerosene for cooking and lighting was subsidized until recently, but retailers preferred to sell the kerosene for use in vehicles, which was more lucrative than selling it to the poor. Electricity subsidies are a particular problem. They have left many utilities economically crippled, unable to finance the extension of services to rural areas. Moreover, they distort the market, encourage consumers to buy grid-supplied electricity, and discourage the development of decentralized, off-grid companies. Universal pricing (charging the same prices countrywide), a common practice, also creates disincentives for electric utilities to serve rural markets, where costs tend to be higher.

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Even when subsidies do benefit the poor, they may represent an unsustainable financial burden on the state. Market liberalization is usually a far more effective strategy. In Hyderabad, India, for example, only the richest 10 percent of households used LPG in 1980. Middle-class households used kerosene because they could not obtain LPG, a more efficient fuel. There was no kerosene for the poor because the limited amounts available for public distribution were bought by middle-class households. As a result, the poor had to use wood, which was even more expensive than kerosene. When the Indian government liberalized energy markets and relaxed restrictions on the production and import of LPG, more middle-class households switched to LPG. Supplies of kerosene were then more plentiful and more available to the poor. Now more than 60 percent of households in the city use LPG.

One subsidy that can be justified is a lifeline rate for grid electricity. Most poor people use very little electricity and need only the most basic service. Thus, the application of lower tariffs for consumption of small amounts of electricity provides a direct benefit for the poor and usually does not represent a significant financial drain on the distribution company. Any financial losses can be recovered by charging slightly higher prices to large-volume customers, who usually have higher incomes.

Alleviating problems with first costs. In developing countries, the first costs associated with getting access to modern sources of energy are often prohibitively high for the rural poor, who are also usually unable to obtain credit. The fees for being connected to an electricity grid can range between \$20 and \$1,000; a solar home system costs between \$500 and \$1,000. Installing a microgrid can cost a community tens of thousands of dollars.

There are two ways of dealing with the high initial costs of rural energy services—lowering system costs through design innovations and giving rural consumers access to credit.

Many distribution companies design systems with the capacity to deliver between 3 and 7 kilowatts of service and that require heavier wires, larger transformers, and generally more expensive distribution systems components. The entire system design can be lightened to provide service at less cost. Similarly, the standard household PV system promoted by many development agencies provides about 50 watts of power, but recent evidence from Kenya shows that people there are purchasing more affordable PV systems that provide only about 12 watts.

Many practical options exist for providing affordable credit for rural energy. For example, electricity companies could allow customers to pay access charges over several years. In a recent project in Indonesia, banks are advancing credit to consumers for the purchase of household PV systems. Some nongovernmental organizations (NGOs) in Nepal and Peru are making credit available for the installation of microgrid systems based on microhydroelectric systems.

Emphasizing participation and institutional development. Local participation is crucial for the success of rural energy policies. Cooperatives, NGOs, and community organizations can be highly effective vehicles for supporting the delivery of energy services and managing resources.

Participatory efforts must be properly designed, however. The first attempts to promote community biogas systems in the Indian village of Pura failed because they were aimed at getting villagers to use

Options for rural electrification

Between 1970 and 1990, nearly 1.3 billion people, 500 million of them in rural areas, were newly supplied with electricity from national grids. But the population in some developing regions grew faster than electricity supplies. The number of people in sub-Saharan Africa with electricity increased by only 18 million between 1970 and 1990, while the total population grew by 118 million. Similarly, in South Asia, 140 million people gained access to electricity during the same period, but, because of population growth, the number of people without service grew by more than 100 million.

Surveys of rural energy use show that many people spend significant sums on candles, kerosene, and batteries for lighting their homes. Many rural people in Bolivia, for example, spend $4–$5 per month on candles. Switching to electricity and using just one 40-watt bulb or a 20-watt incandescent lamp would cost a few dollars more per month but would provide 25 to 75 times more light than a candle.

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The choices

Many people without electricity in rural areas are therefore willing to pay to get it. Grid supplies are usually the cheapest option in areas with high load densities, as well as in areas near the grid. But connecting small, isolated villages to a grid can be expensive because of the necessary investment in transmission lines, poles, transformers, and other infrastructure. In some instances, other options—including diesel generators, renewable energy (solar energy, micro-hydropower, wind, and small biomass-fired generators), and "hybrids" combining several of these—are more cost-effective.

Grid electrification. The high initial costs of grid electrification can be reduced considerably if design standards suitable for areas with less demand are used. Most rural consumers need from 0.2 kilowatts to 0.5 kilowatts, much less than the typical minimum service connection ratings in developing countries' utilities. The costs of installation and wiring provided by utilities are also high, but these can be lowered by simplifying wiring codes and using load limiters (circuit breakers) to encourage lower levels of consumption. Other cost-cutting strategies include using cheaper utility poles and involving local people in construction and maintenance.

Micro-grids supplied by diesel generators. Decentralized, isolated distribution systems have been common in remote population centers for many decades—in most developing countries, they predate the establishment of grids. The costs of such systems typically range between 20 and 60 cents per kilowatt hour (kWh). However, diesel generators can be hard to maintain and expensive to operate because of their remote locations and the costs of spare parts and fuel.

Renewable energy sources. Energy from solar, wind, and micro-hydropower schemes is an attractive option in regions with the necessary resources. The costs per kWh of electricity generated by micro-hydropower can be as low as 20–30 cents, depending on the site; 90 cents for PV panels; and 40–90 cents for small wind sets. Electricity for local distribution can also be generated from such fuels as biogas or biomass.

Micro-hydropower can be one of the cheapest options for providing electricity to rural areas too remote to be connected to a grid. Much care needs to be given to selecting the site for a micro-hydro project, however, given possible variations in stream flows during the year and from river to river, and their costs can vary significantly, depending on the terrain. In mountainous countries like Nepal, for example, transportation of equipment and materials can account for as much as 25 percent of total project costs.

Successful approaches

Countries that have succeeded in making grid electricity service available to rural people have done so through strong public leadership and highly strengthened financial support. There are many ways to pay for rural expansion without destroying the financial viability of the electricity industry.

In Thailand, the public distribution system serving areas outside of Bangkok—the Provincial Electricity Authority—was successful in expanding grid electrification. It dealt with the problems of lower loads in rural areas by extending service first to the highest-load villages, developing low-cost connection techniques, and promoting load development. Costs were reduced through standardization of systems design and provision of a financially sustainable lifeline tariff for meeting the minimal requirements of the poorest consumers.

In Costa Rica, rural cooperatives were able to establish a rural grid in the early 1960s with long-term capital from the US Agency for International Development and the Inter-American Development Bank.

A regulatory regime requiring distribution companies to expand service to a blend of high- and low-income households within an assigned territory while requiring full-cost recovery for the system as a whole, is a possibility. There are also examples of communities, innovative private companies, cooperatives, and individuals that are successfully distributing electricity through minigrids without subsidies. However, other potential innovations have often been thwarted by regulations and policies that prohibit private enterprises other than the national utility from selling electricity and by the absence of training and technical support. Another policy that discourages private sector participation in rural electrification is uniform countrywide pricing, which effectively makes small local grids financially unsustainable.

biogas for cooking instead of wood. But since wood is abundant and easy to collect in Pura, people had no incentive to switch. When the villagers revealed their desire for clean and reliable water supplies, the community established a system that produced biogas for fueling a five-horsepower diesel generator. Electricity from the generator was supplied to households through a micro-grid and used to power a deep tube-well pump. Each household participating in the program received a tap providing clean water in front of its house.

Identification of the appropriate social unit to work with is also crucial. Several World Bank-financed community woodlot and forestry projects in the late 1970s and the 1980s had disappointing results because communities had been mistakenly viewed as units of social organization when, in reality, the interests of subgroups within those communities frequently clashed. And insufficient attention was given to other complicating factors: community land was limited and the tenure of common lands uncertain; the influence of local authorities was uneven; and distributional arrangements for the products were contested.

Creating enabling conditions. Investments in rural energy may falter because of economic conditions. For example, in rapidly developing agricultural regions, electricity helps to raise the productivity of local agro-industrial and commercial activities by supplying motive power, refrigeration, lighting, and process heating. Increased earnings from agriculture and local industry and commerce then lead, in turn, to greater household demand for electricity. However, when development efforts fail because of, say, poor crop pricing, flawed marketing policies, and inadequate roads, programs to improve electricity supplies are also likely to languish.

Conclusion

Helping people in rural areas gain access to energy is a great challenge, but the means available for realizing this goal have expanded considerably in recent years. As renewable energy systems come down in cost, they are becoming an increasingly attractive way to provide electricity to rural areas. The costs of grid electrification schemes can also be reduced to make electricity more affordable to a broader spectrum of rural people, and new, off-grid rural companies and cooperatives can emerge if competition is promoted, barriers to entry are reduced, and the pricing playing field is leveled. Moreover, continued use of biomass need not deplete the environment, thanks to farm-forestry and forest-management programs that involve farmers. Concerted efforts by governments, policymakers, the private sector, and NGOs, coupled with significant local participation, can lead to impressive results. F&D

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