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Energy, Equity and Economic Development

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Task Force on Environmental Economics

I. Introduction

We start this chapter with some observations that may be obvious to energy and development experts but less familiar to others in the development field: Why focus on energy? In our view there are four reasons for doing so.

The first is that increased provision of energy services, especially higher quality modern energy services such as electricity, has a demonstrated high marginal value in the context of broader economic growth and social development. Increased provision of more affordable and higher quality energy services in itself will not drive development, but it is difficult to envisage successful development without this occurring.

Second, energy services – especially higher quality services – remain physically scarce and economically costly in many parts of the developing world. This scarcity is especially evident in more impoverished areas. Whatever might be said about the causal relationships between energy scarcity and poverty, their coincidence indicates an important opportunity for poverty alleviation through reducing barriers to affordable higher quality energy services.

Third, production and provision of energy services – especially grid-supplied electricity – at a larger and more organized scale in the economy give rise to thorny issues of economic sector regulation. These problems arise in rich and poor countries alike, but they are especially acute in developing countries and solutions must be tailored to the circumstances of those countries.

Fourth and finally, there are important and challenging energy-environment links throughout the chain of production and consumption. These include environmental damages of fossil energy extraction and transport, air pollution problems from large-scale fuel burning in power stations and industrial boilers, and highly localized (household level) health problems from indoor combustion of smoky fuels. As we know from the first principles of environmental and welfare economics, the social value of energy in economic development must account for the creation *and* amelioration of these environmental impacts, as well as the effects on household production and market production of other goods ands services.

In this chapter we consider in turn the first three of these four aspects of energy and development; we also briefly consider the value of improved energy service availability on household health through improved indoor air quality in the context of the value of energy for development generally. Other issues related to air pollution are addressed in the chapter by Krupnick in this volume, and the specific issues related to the impacts of fossil fuel extraction are beyond our scope here. After discussing in turn these facets of energy-development linkages, we conclude the chapter with a summary of lessons learned from energy-related development activities and implications for future activities in this area.

II. The Value of Energy in Economic and Social Development

The linkages among energy, other inputs, and economic activity change as an economy moves through different stages of development. Barnes and Floor (1996) refer to the "energy ladder" to describe this phenomenon (see also Smith and coauthors, 1994; Sathaye and Tyler, 1991), though it is recognized by the ladder concept does not imply a monotonic transition from one type of energy to another (see also Barnes, Krutilla, and Hyde, 2004). At the lowest levels of income and social development, energy sources tend predominantly to be harvested or scavenged biological sources (wood, dung, sunshine for drying) and human effort (also biologically powered). More processed biofuels (charcoal), animal power, and some commercial fossil energy become more prominent in the intermediate stages. Commercial fossil fuels and ultimately electricity become predominant in the most advanced stages of industrialization and development. Again, energy resources of different levels of development may be used concurrently at any given stage of economic development: electric lighting may be used concurrently with biomass cooking fires. Changes in relative opportunity costs as well as incomes can move households and other energy users up and down the ladder for different energy-related services.

In poor countries with urban per capita incomes of about $300 per year or less, approximately 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 incomes reach approximately $1,000-1,500. With technological progress and reductions in the costs of modern fuels, the income level at which people make the transition has declined. A transition that took nearly 70 years in the United States (1850-1920) took only 30 years in Korea (1950-80).

In earlier stages of the transition, alternatives to woodfuels do not come into play until woodfuel prices rise to the point that modern fuels like kerosene or coal become competitive alternatives. At later stages in the energy transition, the main issues involve the availability of modern fuels, modern appliances, and electricity, especially for the poor. Most of the rural demand for electricity comes from households that use electricity for lighting and from farms, agro-industries, and small commercial and manufacturing establishments, which use the electricity for productive purposes such as irrigation pumping, water supplies, crop processing, refrigeration, and motive power. In regions where electricity can be used both by households and for productive activities, there is ample economic justification for investment in electrification (Barnes, 1988; World Bank, 1996). Most rural electrification programs have focused on connecting rural areas to national or local grids. However, grid-supplied electricity is not the least-cost alternative under all conditions, and planners should consider other possibilities, as discussed later in the chapter.

Despite the substantial differences in energy forms and in the nature of economic activities across different stages of development, some common elements can be seen. Energy provision or acquisition is a costly activity requiring a variety of different kinds of inputs, whether that cost is denominated in terms of household labor allocated to biomass gathering or expenditures for commercial fuels and the inputs needed to provide them. Energy utilization also does not occur in a vacuum but depends on the opportunity costs of other inputs, notably various types of capital goods (be they cook stoves or electricity grids). Finally, the literature makes clear that observed patterns of energy production and utilization reflect a great deal of subtle optimizing behavior, *given* the constraints faced by the economic actors (Barnes and Floor 1996, OTA 1991, 1992). Those constraints can impede better outcomes, however; and much of the work to date on energy development has been concerned with how lower-cost and more effective energy services can be delivered by alleviating or working around financing and informational barriers as well as regulatory distortions.

The energy sector also can have an impact on many different sectors. The development impact of grid rural electrification, for example, has a strong relationship with education and reading (World Bank, 2002b). Obviously, telecommunications is impossible without electricity. A point that is often made is that electricity is a necessary but not a sufficient condition for development. 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 (Wasserman and Davenport, 1993). Increased earnings from agricultural and local industry and commerce then lead, in turn, to greater household demand for electricity.

The complementary nature of social infrastructure means, for example, that asking the question whether a community should have a road or electricity essentially misses the point. The two together have a much higher value than either one of them separately (World Bank, 1999a). At the same time, one must keep in mind the poor results of many past "integrated rural development projects" in which the inflexibility of the funding plans put a constraint on the ability of rural communities to choose for themselves. If they needed a road or a school, then getting a little bit of everything did not help them to achieve their goals.

Increased energy availability could make a larger contribution to expanded economic activity in the provision of energy services or in their utilization. Before turning to specific possibilities, we illustrate the argument pictorially in Figure 1, which is taken from World Bank (2002b). In the diagram, we show two different schedules for the marginal value product of lighting services – lumens in providing various household benefits (longer reading time, easier reading, more security, and the like). The schedule MVP_0 represents the situation at a lower level of income, which we assume is also associated with use of lower-quality and higher-per-lumen-cost kerosene lighting. Depending on income levels, it is likely that most households already have significant lighting expenses involving kerosene or candles. Because of inefficiencies of kerosene and candles for producing light, the price of light for poor households actually can be higher than the price of light for wealthy households, mainly because of the efficiency gains associated with using electricity. In this regard, the poor light given off by kerosene wick lamps and candles—200 times less light than one simple electric light bulb--often makes it impossible for adults to read during the evening and children to study in the evening. At the lower level of income corresponding to MVP_0, the introduction of lower-per-lumen-cost electric lighting (with unit cost of d in the figure, versus a for oil lamp lighting) will raise total lighting used and generates an economic welfare increase measured by Area abcd (the fall in cost of inframarginal lighting usage) plus Area bce (the consumer surplus from increased lighting utilization).

The schedule MVP_1 represents the marginal value product of lighting services at a higher income level induced by an increase in energy service availability – perhaps as a result of improved education capacity or ability to shift household tasks to evening hours and devote time during the day to paying work. Along this higher schedule, the additional benefits of lighting are reflected in additional benefits from baseline consumption (Area eghi) as well as in benefits from a further induced increase in usage (Area efg).

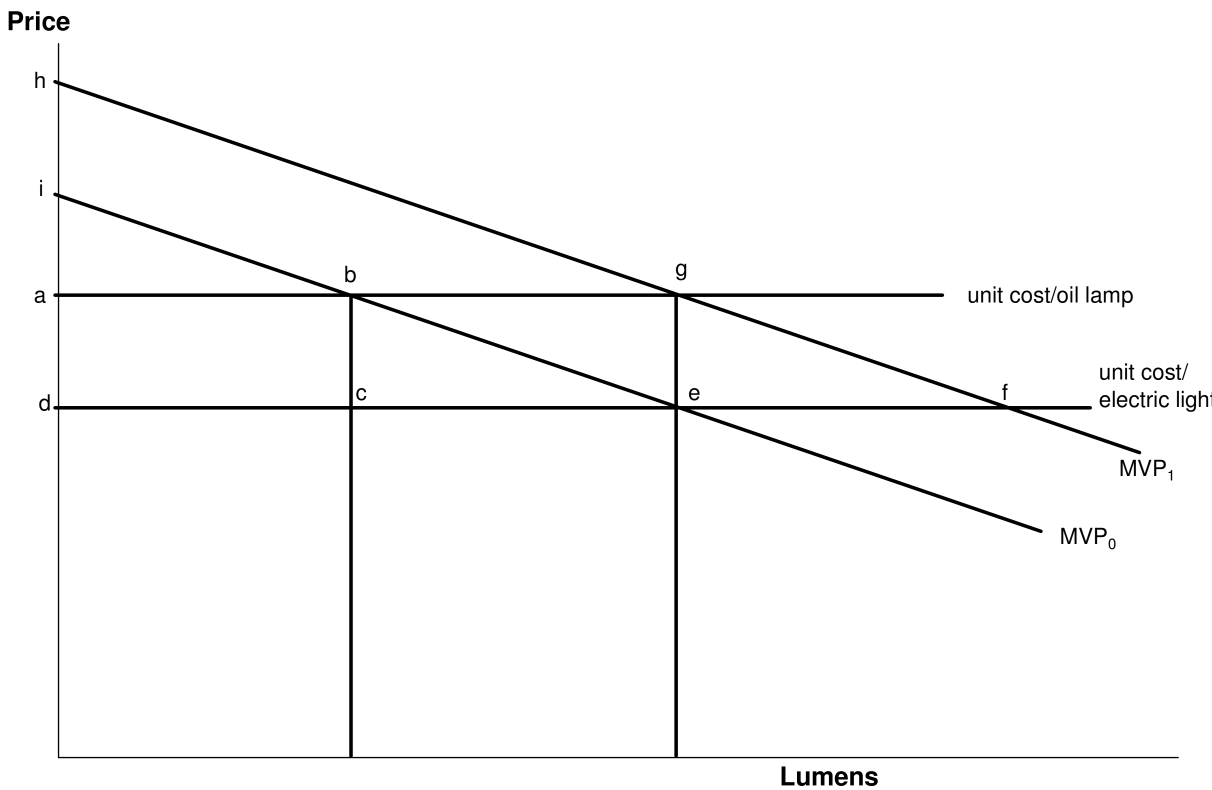


Figure 1. Illustration of economic effects from increased energy services utilization.
Source: Adapted from World Bank (2002b).

As modern energy systems develop they require investments in large infrastructure-like capital like pipelines and transmission systems that show declining unit costs over a wide range of scale and utilization. Moreover, the transformation of primary energy into deliverable energy (electricity generation, petroleum refining) also exhibits increasing returns to scale, though the magnitude of increasing returns at least in electricity generation probably fallen over time with technical advances (Joskow and Schmalensee 1983, Nakicenovic 1996, Brennan et al 1996).

Different kinds of increasing returns in lower-scale energy provision also seem to exist and may be quite important to the earlier stages of development. The energy development literature is replete with discussions of how subsistence energy systems involve large investments of household labor time, notably the time of women and children, in gathering of very low-quality fuels (OTA 1991, 1992). An increase not just in the raw provision of energy *per se*, but an increase in scale that included changes in the types of energy services offered and the organization of markets to allow for greater specialization of effort, seems likely to lower considerably the effective cost of the energy services delivered. There might be a substantial threshold effect in the achievement of these economies. Unless a considerable fraction of households were above some minimum effective income level, it might not be possible to achieve the required specialization of functions at a scale and cost of energy services that could be afforded. On the other hand, raising income across such a threshold might be greatly facilitated by a reduction in the effective cost of energy services.

There are several ways in which increased availability or quality of energy could augment the productivity and thus the effective supply of physical and/or human capital services. The transmission mechanisms are likely to differ across the stages of development. For more advanced level industrialized or industrializing countries, increased energy availability and flexibility can facilitate the use of more modern machinery and techniques that expand the effective capital-labor ratio as well as increasing the productivity of workers (Schurr 1982, Jorgenson 1984). Increased energy service reliability is another key component of quality, again especially for electricity. Estimates for developed countries of the cost of electricity supply interruption per lost MWH are several orders of magnitude larger than the cost of baseload or peak electricity supply costs (OTA 1990). A recent ESMAP report (World Bank 2002a) provides an example from India indicating that many farmers using irrigation pay about twice the subsidized cost of electricity to use diesel for their pump sets; the authors suggest that this reflects the desire to avoid the high costs of unreliable electricity supply (since if irrigation capacity cannot be used at critical times the results for crop yields can be disastrous). A significant amount of capital also can be tied up in providing energy service redundancy (back-up generators) that could be otherwise and more productively deployed if the effective supply of electricity were enhanced through increased reliability.

For less advanced developing countries, factor productivity enhancement effects necessarily operate more through labor inputs. One possibility is through the development and use of human capital. Energy availability for cheaper and better lighting (in concert with the appropriate physical capital) can increase the productivity of education inputs generally and lead to an augmentation effect in human capital provision, as well as extending the length of the workday.

Within the development community recently there has been a greater focus on indoor air pollution as a health problem. Indoor air pollution has been listed as a leading cause of death in developing countries by the World Health Organization. Smoke from cooking fires contain many particulates and carcinogens. When this smoke is contained in an indoor space, the repeated breathing of it has been related to increased incidence of respiratory illness and premature death (Smith, 1993; Smith and coauthors, 1993; Parikh, and Laxmi, 2001; Ezzati and Kammen, 2001, Ezzati, Saleh and Kammen, 2002). In India alone, there have been some recent estimates that indoor air pollution is responsible for about 400 thousand premature deaths per year (Hughes, Lvovsky, and Dunleavy, 2001).

Increased availability of different kinds of energy services also can directly or indirectly improve the health and therefore the productivity of household members and workers. Increased availability of cleaner modern energy forms can improve indoor air quality (see, e.g., World Bank, 2002c, Ezzati and Kammen 2002; Ezzati et al. 2002). It can also help promote access to safer drinking water (e.g., in deeper wells). By facilitating refrigeration, greater energy availability can reduce food-borne illness and the storage of medicines. By lowering costs of food production, it can make it easier for subsistence households to meet and go beyond basic dietary requirements.

Finally, for countries at various stages of development, greater energy availability may interact positively with the availability of other infrastructure services. Investments in a road network that lower transportation costs and thereby increase the geographical size, scale and efficiency of markets are the more valuable if energy is more readily available for fueling transport. The same is true for electricity availability to power more modern telecommunications and information infrastructure.

To summarize, our discussion so far suggests several possible channels through which increased energy availability (including availability of energy forms previously not available) could disproportionately affect economic development:

- Reallocation of household time (especially that of women) away from energy provision for improved education and income generation and greater specialization of economic functions.
- Economies of scale in more industrial-type energy provision.
- Greater flexibility in time allocation through the day and evening.
- Enhanced productivity of education efforts.
- With more flexible and reliable as well as plentiful energy, greater ability to use a more efficient capital stock and take advantage of new technologies.
- Lower transportation and communication costs – greater market size and access, more access to information (combined result of energy and other infrastructure).
- Health-related benefits: reduced smoke exposure, clean water, refrigeration (direct benefits and higher productivity).

This discussion of how increased energy availability may promote different stages of development also underscores the need to think about more than energy development in isolation. Even if we think about the issue fairly narrowly, capital equipment (more modern stoves, refrigerators, lighting, motors, boilers, as well as marketing and delivery systems for modern fuels like LPG) and increased knowledge are required to expand energy use and increase the productivity of household and industrial labor. Attempts to expand energy availability will accomplish little if bottlenecks to such investments are not overcome.

It is necessary also to consider what happens to the labor services saved through an increase in the scale and technical sophistication of energy service provision. One option could be the expansion of other household production activities, e.g., animal husbandry and micro-enterprise. The size of such benefits depends on, among other things, the status of women in society. A less direct but important potential link is through the lowering of households' opportunity cost of education, especially for children. But this requires in practice the needed investment in the capacity for increased education, not just the freeing up of household labor time from drudge work.

Similar observations can be made about the development of social institutions that permit effective use and enjoyment of the increasing returns. If energy markets are poorly established or organized because of weak property rights, for example, then the potential benefits of economies of scale in service provision may not be realized. This would apply to the creation of both additional biomass plantations and additional electricity supply capacity. Thus, while increasing returns in the provision of energy services may offer the *potential* for a disproportionate effect of energy development on overall development, the fuller realization of this potential requires other economic and social development interventions as well.

Finally, whatever disproportionate effects increased energy availability may have in facilitating development on the supply side of the economy, it is important not to lose track of direct demand-side benefits as well. Quality of life improvements stemming from better health, less drudgery, more leisure, greater communication opportunities and increased social status all have direct positive effects on the well-being of various household members, in addition to whatever effects might enjoyed through increasing the production possibilities of the economy.

In reviewing the evidence on the development impact of energy and poverty, it should be kept in mind that there is a complementarity between energy and poverty reduction programs. In Peru, recent surveys show that the bundling of services like water, electricity, sanitation and education has major welfare benefits for local populations. Adding a fourth service has a development impact that is about seven times greater than a second service for rural households in Peru. Such linkages also have been confirmed in the Philippines, where the combination of electricity and education appear to have an independent impact on a family’s earnings (Box 1), as well as in urban Indonesia (Fitzgerald and coauthors 1990). Second, at least for cooking energy, there is a concept of an energy transition, and different policies are appropriate for different levels of the transition.

Box 1: The Benefits of Rural Electrification for Development: The Case of the Philippines

Sometimes the benefits of certain social investments serve to enhance the benefits of other, seemingly unrelated, social investments. Thus, rural electrification generates not only direct benefits to consumers of electricity (in the form of, say, better lighting or cheaper irrigation) but also indirectly complements governmental efforts to improve education and health. The full benefit of rural electrification consists of both these direct and indirect benefits. Thus, rural electrification may be just as important in complementing other programs as in providing direct benefits to rural households.

In order to better measure the full benefits of rural electrification, the World Bank has initiated a study in the Philippines to quantify all rural electrification benefits in monetary terms. Some of these benefits, such as those resulting from a cheaper source of lighting, are fairly easy to measure with conventional techniques. However, the more indirect benefits in terms of better education, more comfort, increase convenience, and improved health are not as easily measured since price-quantity relationships are more difficult to observe. In these cases, benefits can be measured by determining what individuals would be willing to pay for these benefits. For example, increased educational benefits due to electrification could be measured by the expected increases in income that are likely to result.

Based on a survey of 2000 households in the Philippines, the study finds that one year of education increases, on average, annual income by about 13 thousand pesos. However, this increase is augmented by an additional two thousand pesos if the household has electricity. The gain in income reflects the fact that electrification appears to increase the probability of participating in the labor force. More importantly, the quality of education may improve with electrification. Both the decision to read and the amount of time spent studying and reading are significantly higher in homes with electricity. Children in homes with electricity, for example, study about 30 minutes longer each day than children in households without electricity. Take together, these findings support the notion that electricity is an complement to other rural development programs, and especially education.

Source: World Bank, 2002b.

The impact of electrification also can be understood by examining the use of women's time from a survey of rural areas in India (Table1). The survey involved random samples from selected districts in the states, broken down by whether or not they have electricity. As indicated, the households without electricity have the advantage of reading more in the evening and having greater levels of entertainment in the form of television. Of the 60 percent of households with electricity, 10 percent reported that they typically read in the course of their day. Of the remaining 40 percent of households without electricity, only one percent of the women reports that they read. Although the figures for reading appear to be low, literacy rates are also low for women in India. Some women, especially older women, cannot read because they are not literate. Women who report that they read during a typical day spend about 1 hour and 15 minutes reading. This once again underscores the complementarity of social infrastructure programs.

Table 1. Women's Time Use for Leisure Activities, India 1966
(Household Survey of Hours Spent on Activity in 6 States)

	HH with Electricity	Leisure (Radio & Social Activities)		Read (Studying & Homework)		TV Watching	
Income Decile	Percent	No Electric	With Electric	No Electric	With Electric	No Electric	With Electric
<Rs 600	43	0.69	0.96	0.06	0.10	0.06	0.23
Rs 600-799	39	0.87	1.11	0.03	0.09	0.05	0.44
Rs 800-949	47	0.83	0.82	0.04	0.17	0.05	0.41
Rs 950-1159	47	0.87	0.85	0.01	0.14	0.05	0.45
Rs 1160-1409	52	0.78	1.01	0.03	0.13	0.05	0.47
Rs 1410-1749	61	0.98	0.77	0.04	0.18	0.06	0.64
Rs 1750-2349	70	0.94	0.95	0.05	0.21	0.01	0.79
Rs 2350-3249	79	0.74	0.89	0.04	0.22	0.07	0.96
Rs 3250-4999	82	0.79	0.99	0.02	0.28	0.13	1.18
Rs 5000+	83	0.63	0.87	0.01	0.32	0.14	1.17
Average	61	0.82	0.91	0.03	0.21	0.06	0.76

Source: World Bank, 2002a; World Bank, 2004.

III. Energy Scarcity

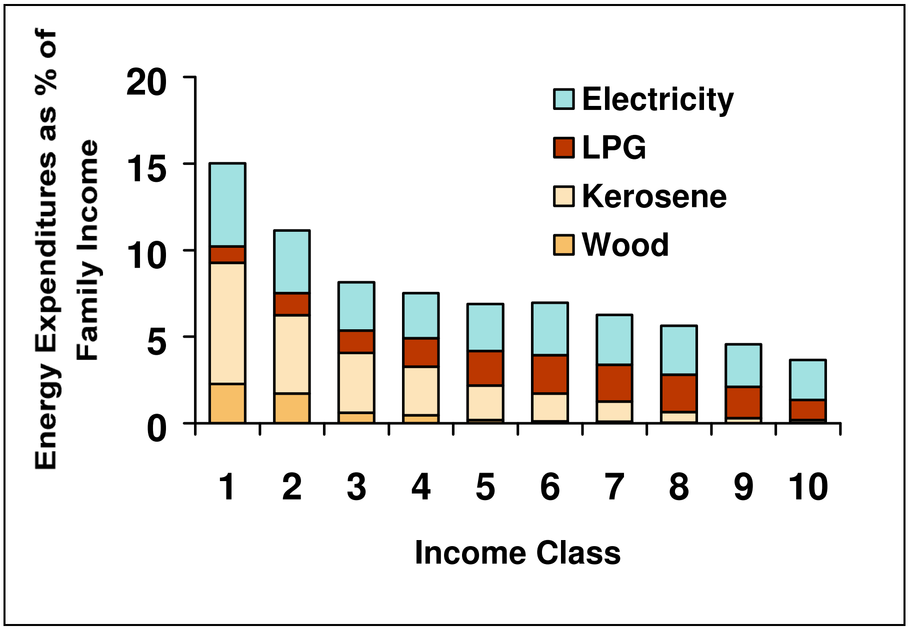
At present about two billion people do not have access to electricity in the world. An equal number rely on biomass energy for cooking (World Bank, 1996). The number of people gaining access to electricity has increased remarkably during the last 25 years, reaching over 1 billion new people. Although this may appear to be an impressive accomplishment, it is still the case that higher income households now have electricity, and the world's poorest and mostly rural households do not. For petroleum and other "modern" fuels, the scenario is similar. The rich have access and the poor do not. The poor also often spend a significant amount of their time collecting energy for their household needs or spend a very large percentage of their income on energy. This is clearly not a problem that can be ignored.

The "modern" fuels being used by households in developing countries include electricity, liquefied petroleum gas (LPG), and kerosene (Sathaye and Meyers, 1985; Reddy and Reddy, 1983; Leach, 1993; Hosier, 1993). The supplies of these fuels is often irregular. Policies on their use also vary, from taxation to subsidies in various countries. In many circumstances, development assistance programs have been directed towards making the supplies of these fuels more regular, reliable, and efficient. Unfortunately, the attempt to improve sector performance often does not take into consideration those who presently do not have access to such services.

In spite of poor access to modern energy services, poor people often spend a significant proportion of their scarce income on energy. In urban areas, especially those experiencing "wood scarcities around their perimeters," the price of fuelwood for cooking often is higher than modern fuels. Although the poor do have fewer energy expenditures than more wealthy households, energy as a percent of total expenditures is often well above 10 percent of their income. In rural areas that are experiencing wood scarcity, rural people either pay for fuelwood or switch down the energy ladder to crop residues or dung. However, it is more typical that they spend a significant number of hours per week collecting fuel, and this is often a tradeoff with other productive activities. Thus, the use of traditional fuels does not mean poor people are using "free" energy, but rather that they are paying through labor or expenditures for traditional fuels. In some circumstances, this collection of fuelwood also can have adverse environmental consequences.

From a poverty standpoint, the expenditures of the poor on the very meager amounts of energy that they use is a very important part of their overall cash expenditures. The cash income of the poor is so low that even modest changes in energy expenditures can be a real hardship for them. The poor spend less cash on energy than the more wealthy households, but the percentage of income the poor spend on energy is typically much greater (for a typical example, see Figure 1). The urban poor spend between 10 and 20 percent of their income on energy, whereas the wealthy spend less than 5 percent. In addition, the cost of energy services for the poor is also higher than for the rich because cooking with fuelwood and lighting with kerosene are inefficient compared with cooking and lighting with modern fuels. Moreover, the poor often buy fuelwood and charcoal in small amounts, and the higher transaction costs of buying in small quantities inflate the price. Once the comparative efficiencies and transaction costs have been taken into consideration, the delivered energy for cooking often is more expensive for poor people compared to better off households.

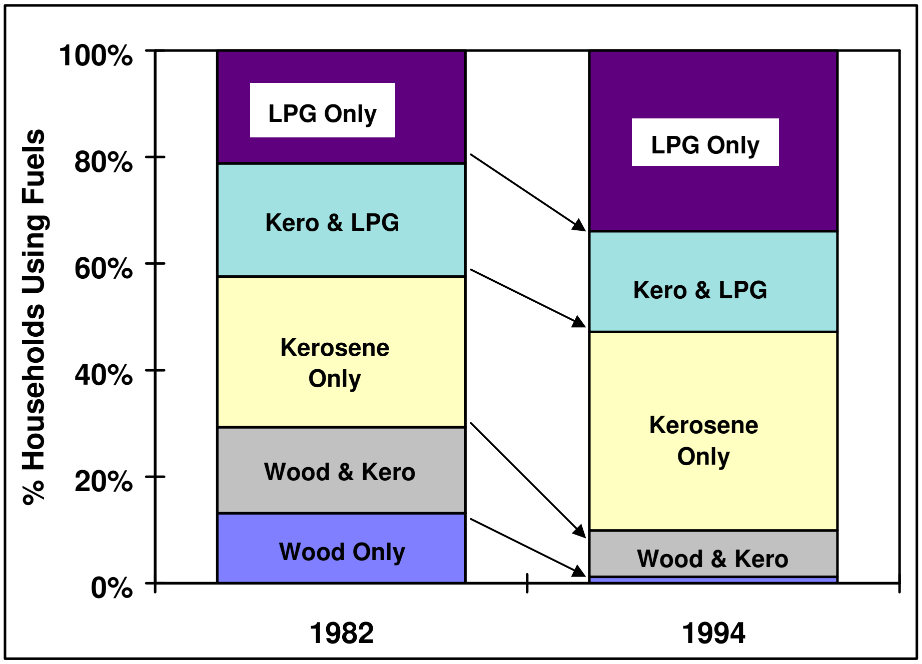
Figure 1. Household Energy Expenditures by Income Class, Hyderabad, 1994



Note: Income classes are in rupees per household per month and are as follows: 1= < 185, 2 = 186-250, 3 = 251-300, 4 = 301-375, 5 = 376-498, 6 = 499-583, 7 = 584-725, 8 =726-990, 9 = 991-1480, 10 = > 1480.
Source: World Bank, 1999b.

Over time, as urban populations and land areas grow, incomes rise, and more traditional energy sources become more scarce and costly in the urban market, changes in the composition of household energy demand can be expected. Figure 2 illustrates one case. These transitions will vary considerably with local and national conditions including policies that affect the prices of competing energy sources.

Figure 2 Changes in Choice of Household Cooking Fuels, Hyderabad, 1982 & 1994



Source: World Bank, 1999b.

How long the transition will take in today's developing countries will vary, depending on a number of factors, including a country's economic performance and development policies, the percentage of people dependent on biomass, and the population growth rate (see Barnes, Krutilla, and Hyde, 2004). But it 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 biomass use is expected to decrease by only 50 percent over the next 15-25 years. Therefore, while energy policies should create the necessary conditions for supplying modern fuels to those who lack them, they must also support ways to use existing biofuel energy resources more efficiently and sustainably.

Although in rural areas people spend less of the income on energy, poor people still pay a significant proportion of their income on energy. Some typical figures for India are presented in Table 2. As indicated, the poor pay as much as 8 percent of their very small incomes on energy, and most of it goes for kerosene for lighting purposes. As indicated, most of the cooking energy, with the exception of some wood, is generally collected from the local environment. The average time spent collecting wood or other fuels is about one hour per day in rural areas. Thus, both energy expenditures and energy collection time are important components of formal and informal expenditures by rural households.

Rural and poor people also often have difficulties affording the first costs of modern energy. For instance, the connection fees for gaining access to grid electricity in developing countries range anywhere between 20 and 1000 dollars. A solar home system for lighting and television sets costs in the neighborhood of 500 to 1000 dollars depending on the system. Installing a community microgrid can cost a community tens of thousands of dollars. Such costs are prohibitive for rural consumers with relatively low incomes and little access to long or even short term credit.

Table 2. Percent of Income Spent on Energy in Rural India, 1996

	Wood	Charcoal	Straw	Dung	Coal	Kerosene-Ration	Kerosene Market	LPG	Electri-city	Total
Income Decile Rs per Family per year										
<Rs575	0.9	0.1	0.2	0.5	0.0	3.0	1.0	0.1	2.1	8.1
Rs575-791	1.0	0.1	0.4	0.9	0.0	2.2	0.5	0.2	1.4	6.5
Rs792-957	1.6	0.3	0.3	0.5	0.0	2.0	0.5	0.2	1.5	7.0
Rs958-1165	1.2	0.3	0.4	0.5	0.0	1.5	0.3	0.3	1.4	6.0
Rs1166-1415	1.8	0.2	0.3	0.5	0.0	1.4	0.3	0.3	1.3	6.2
Rs1416-1740	1.3	0.1	0.4	0.5	0.0	1.1	0.3	0.3	1.7	5.8
Rs1741-2349	1.6	0.2	0.3	0.3	0.0	0.7	0.2	0.4	1.6	5.4
Rs2350-3249	1.3	0.1	0.2	0.1	0.0	0.5	0.2	0.4	1.4	4.3
Rs3250-4999	0.9	0.1	0.2	0.0	0.0	0.3	0.1	0.5	1.1	3.3
Rs5000+	0.5	0.1	0.0	0.0	0.0	0.2	0.0	0.4	0.8	2.0

Source: World Bank, 2002a.

As noted above, recent work on household fuel use and indoor air pollution underscores the importance for poor urban and rural people of having access to cleaner fuls such as kerosene and LPG for cooking. There are many circumstances in which cooking with LPG or kerosene is actually cheaper than cooking with wood in urban areas. Under these conditions, poor people in some countries are paying more for their cooking energy than do the wealthy.

The use of fuels in inefficient stoves appears to be at the root of this problem (Smith and coauthors, 1993). Although the nominal price of the fuels poor people use may be less than that of modern fuels, the *useful energy* derived from these fuels is much, much less because of the low energy efficiency of wood stoves. The typical efficiencies of woodstoves or open fires range from 10 to 15 percent, and charcoal stoves reach up to about 25 percent. In contrast, LPG and electric stoves have efficiencies of between 55 and 75 percent. Realistic assessments of the price of energy thus must take account of energy *actually delivered* to cooking utensils such as pots and pans rather than the value per unit of energy.

Table 3 illustrates the wide variation among fuels as well as across countries in energy costs per useful energy unit for cooking. Even in the absence of subsidies, modern fuels often are less expensive than traditional fuels. Continued use of traditional fuels by the poor reflects the fact that often they do not possess the income or influence to get a service connection for LPG. The poor also buy fuels in very small quantities, which costs more than purchasing in bulk. The initial costs of cooking equipment also discourage the poor from adopting modern fuels for cooking. Finally, in some countries the there are import restrictions on modern fuels, and after servicing the higher income groups there is nothing left for the poor.

Table 3 The Price of Cooking Energy in Urban Areas of 12 Countries, 1990
(Price in US Dollars Per KgOE of Useful Cooking Energy)

Country	*Income $/HH/M*	*Policy for Kerosene or LPG*	*Wood*	*Charcoal*	*Kerosene*	*LPG*	*Electricity*	*Coal*
Thailand	99	Market	1.48	1.42	0.81	0.54	0.97	NA
Yemen	70	Market	4.35	4.92	1.55	0.61	2.41	NA
Bolivia	64	Market	1.64	1.28	0.98	0.44	0.86	NA
Haiti	59	Tax	0.87	1.12	1.41	1.19	2.16	NA
Cape Verde	54	Market	1.72	2.69	1.63	1.28	3.22	NA
Zimbabwe	51	Subsidy	1.58	2.58	1.10	0.98	1.07	NA
Philippines	32	Market	1.86	1.16	0,80	0.46	0.85	NA
Burkina Faso	29	Tax	1.63	1.99	2.10	1.90	2.18	NA
Mauritania	27	Tax	3.46	1.71	1.23	1.17	4.12	NA
Indonesia	20	Subsidy	1.18	1.11	0.41	0.54	0.94	NA
Zambia	20	Subsidy	1.14	0.55	0.66	0.50	0.28	NA
China	18	Subsidy	0.51	0.60	1.00	0.34	0.69	0.09

Source: Barnes, Krutilla, and Hyder, 2004.
Note: The between country differences can be affected by exchange rate differences, but this would not affect within country differences. The information is based on what people actually have paid according to household surveys. The surveys were conducted in the late 1980a and early 1990s.

IV. Electricity Sector Structure, Regulation, and Economic Efficiency

At the earlier stages of the energy transition, much of the energy production and consumption occurs in a very decentralized fashion through household provision or localized fuel markets. As the energy transition proceeds, however, and especially as the electricity sector grows, additional problems arise in the governance of large and more centralized energy suppliers. In this section we focus especially on electricity given its importance in the energy transition, though the general points we make could apply as well to natural gas, the other important network-based energy resource.

All countries, developed and developing, face challenges in the governance of the electricity sector. This reflects at least partly the inherent nature of the sector. The sector is technologically complex. While individual power generating units can vary in their complexity, these units are linked together in a grid of transmission and distribution lines that must be continuously balanced to avoid outages. There are enormous economies of scale in transmission and significant economies of scale in local distribution, so competition in these stages is limited or impossible. These services must be provided either by publicly owned and managed enterprises or through some sort of privately regulated enterprises to ensure both that service is provided and that users are not subjected to the adverse effects of monopoly power.

Traditionally, power production also has been provided publicly or by regulated private enterprises. In principle, and increasingly in practice in developed countries, power generation and marketing services can be provided under more competitive market conditions. But success in engendering competitive *and* efficient generation markets requires in turn a different set of regulations to ensure appropriate conditions of market access and transmission pricing, as well as structures to maintain competitive conditions in power production and purchase transactions. Moreover, while the minimum technically efficient scale of power generation facilities has fallen in the past two decades, it may still be large relative to total electricity demand in small markets, calling into question the ability to engender competition.

The abovementioned problems are relatively generic, affecting in various ways developed and developing countries alike (Joskow 1998, 2003). The particular circumstances of developing countries, however, can give rise to additional or more serious problems (Bacon and Besant-Jones 2001, Wolak 2003, Millan and von der Fehr 2004). Weaker governance institutions and limited financial resources lead to poor economic performance of state owned enterprises and low quality of service, even while the costs of maintaining capacity become unbearable. Indeed, it is often less a desire to improve the efficiency of resource allocation per se than the desire to lighten the financial burden on public coffers while improving service that lead to interest in privatization and sector restructuring. However, the same governance problems also can engender lack of independence and other weaknesses of sector regulators when privatization and sector restructuring are attempted. Efforts to improve financial sustainability and improve quality and efficiency of service also become entangled in debates over reforms of tariffs to reflect the real opportunity costs of services.

Against this backdrop, efforts have been undertaken by a number of developing countries to reform their power sectors for greater economic efficiency, including activities to promote privatization, entry of independent power producers, greater competition in generation, more efficient tariffs, and improved transmission efficiency (Bacon and Besant-Jones 2001). However, these efforts have had decidedly mixed results. To some extent, the limited success may reflect efforts to implement the same kinds of reforms that have been used with success in developed countries while failing to adequately allow for the specific conditions in developing countries. To some extent, it may reflect only partial implementation of reforms in the face of political constraints. In any event, the disappointments that have been experienced seem to have weakened at least somewhat the enthusiasm for reform that was in evidence a few years ago, while leaving many developing countries still facing the dilemma of how to promote a well functioning electricity system.

Aside from these challenges, developing countries also face the additional hurdle of how best to extend modern grid-based electricity services to currently under-served populations, especially in poorer and more rural areas. The marginal cost of grid extension typically is high, and while the relative willingness to pay of underserved populations also is significant there is often a gap between the cost of extending service and what can be recovered efficiently even with the best designed tariffs. This is precisely the reason why alternatives to grid based energy services are so important to consider in a broader energy and development strategy. But access to modern electricity services also provides broader development benefits, as already noted, giving it some attributes of a public good. Where the balance between the marginal *social* value of extending grid electricity service and its marginal cost is seen as favorable, developing countries face the practical challenge of how to most efficiently channel any public subsidies provided for such extension, given limited financial resources, in lieu of less focused consumption subsidies based on non-remunerative tariffs that actually benefit the higher-consuming wealthy.

V. Improving the Energy Transition in Urban and Rural Areas

We have argued that the energy transition is an ongoing process that involves movement from the inefficient use of traditional energy to the efficient use of modern fuels for cooking, heating, lighting, and other uses. The two groups that have the greatest difficulty gaining access to energy services in developing countries are people living in rural areas, and poor people residing in urban areas. The problems of these two groups of people are somewhat similar, although the solutions to their problems can be somewhat different. Poor people in urban areas at least live near companies that provide energy services. In rural areas the infrastructure is often totally absent.

The evidence suggests that people are willing to spend a significant portion of their incomes on higher quality energy that improves their quality of life or enables them to be more productive. It can be said with some confidence that in the long term people will switch away from the inefficient ways of using biomass fuels and will use energy for a much wider range of services than they do now. For example, people in urban areas in Africa will eventually replace their kerosene lamps with electric lights. In Asia, the inefficient refrigerators will be replaced with more efficient models. In Latin America, cooking with electricity and LPG will become more common.

However, the long-term solution to these problems cannot be forced indiscriminately onto countries or cities regardless of their stage in the energy transition. Although there are exceptions, most people in cities will move through the energy transition slowly and in due course. Thus, it is important to address their present energy problems as well as their upcoming problems. Current problems may include stress on wood resources around some urban areas (Ravindranath and Hall, 1995), low standards of energy service, high prices for wood, and poorly functioning markets for modern fuels. Enabling consumers to choose among alternative forms of energy requires, among other things, liberalizing prices to reflect costs and adopting regulatory policies that 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. Regardless of the types of assistance, the ideal should be to also expand the menu of choices available to people in rural areas.

We divide our discussion of lessons learned and recommendations for action into three broad categories: promoting efficiency in primary fuel supplies and energy efficiency; improving access to electricity for poor and rural populations; and improving the efficiency and sustainability of the modern electricity sector.

Improving Efficiency of Primary Energy Supplies and Energy Efficiency

Many cities where fuelwood is used extensively have good access to wood resources. The problem in many cases, however, is that wood is harvested faster than it is regrown, and such harvesting cannot be kept up for long. When wood is mined from existing woodlands, the result is both fuel shortages and extensive ecological damage from deforestation.

Farm forestry and forest management have long played an important role in alleviating wood shortages and providing sustainable fuelwood supplies. Farm forestry entails planting trees, shrubs, and sometimes grasses on farmlands and crop boundaries. 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 in regions serving urban markets with high wood prices. In addition, trees and shrubs can supply farmers with fodder, building materials, green mulch, fruit, and other by-products that may be as valuable as the firewood itself.

While fuelwood markets themselves will provide economic signals of the benefit of increased farm forestry, experience suggests that effective management of existing forest resources also depends on letting local people take responsibility for forests or woodlands that might otherwise be open access resources with no effective management. In participatory programs in several countries, farmers get to sell all the wood extracted from local woodlands; to do so, however, they must also participate in a resource-management program developed in collaboration with the national forestry department. In Niger, for example, communities were given control over natural woodlands and their products if they participated in a program to manage the land (Foley and coauthors, 1997).

Identification of the appropriate social unit with which to work is 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 actuality, the interests of subgroups 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. Afforestation projects in which farmers themselves plant trees on farmlands have been far more successful.

For cities with extensive wood and charcoal use and relatively high energy prices, the promotion of improved stoves as well as improved fuelwood management often involves a situation in which there are no losers (World Bank, 2002c). Women spend fewer hours gathering fuelwood, so that time is released for both productive and domestic activities. Scarce cash income is saved and income generation may be promoted. The stoves give off less smoke, and thus also have health benefits since they reduce the level of indoor air pollution in homes. In areas where resources are scarce, greater efficiency also reduces aggregate wood demand diminishes pressure on the land surrounding urban areas.

Experience suggests that while fuelwood costs are one powerful influence on incentives to upgrade stoves, other measures typically are needed (Barnes, Openshaw, Smith, and van der Plas, 1994). In some cases with very poor populations, even the modest first costs of a new stove are a barrier that can only be overcome with improved access to micro-credit or outright subsidization of the purchase. Information must also be provided about options to encourage consideration on non-traditional designs. For such programs to work well, however, it is necessary to target carefully to those who would derive the most benefit from them, as demonstrated by the failure of several programs in the 1970s and early 1980s. Among other reasons, the Chinese National Improved Stove Program, the largest ever undertaken (120 million stoves have been used rural households) was a success because it concentrated on areas with the greatest shortages of fuelwood (Smith and coauthors, 1993).

There are also numerous opportunities for improvement by reducing distortions in the pricing and allocation of modern energy resources. Taxes on modern fuels are a convenient revenue source, but such taxes also drive many middle-class people into continuing their reliance on wood beyond the point at which they would have normally changed fuels. The tax raises the cap on fuelwood prices, thereby hurting the poor (Box 2), while also putting additional pressure on forest areas around cities.

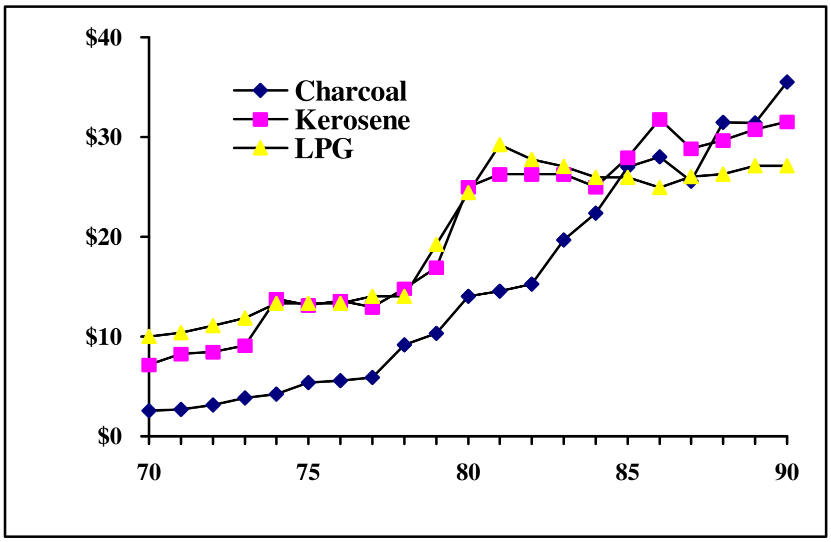
Box 2. Taxing the Rich Inadvertently Hurts the Poor

Haiti is characterized by LPG prices among the highest in the Caribbean, if not the world. This means that fuels like LPG and kerosene are limited to only a small fraction of the population. Massive deforestation over the past 25 years has depleted the country's wood supplies, meaning that the urban poor, most of whom depend on charcoal for cooking, now pay higher prices.

As the graph below illustrates, kerosene and LPG prices have historically been related to that 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.

Energy Prices in Haiti, 1970-90

(Current $ per gigajoule adjusted for end-use efficiency)



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.

Source: World Bank 1991.

Similarly, policies to limit petroleum imports in many countries imply that people in rural areas may have no chance at gaining access to modern and cleaner fuels for cooking. In an Indian study involving 6 states, for example, only two of them had significant use of LPG in rural areas. For one of these states—Himachal Pradesh--the policy to target LPG to urban areas had been relaxed to protect the existing remaining forests in the state. Most of the other states had and insignificant percentage of households using LPG for cooking (World Bank, 2002a).

While subsidies can assist the poor, these subsidies also can cause other problems in the energy sector (see Table 4). Often, not only the poor but also the middle class and the rich get the subsidy. Thus, in Indonesia, for example, the subsidization of kerosene does help the poor, but it is an unnecessary boon to higher-income consumers and keeps the middle class from switching to superior fuels such as LPG. Subsidies to household fuels such as kerosene often wind up being diverted to other markets, including transportation. In Pakistan the government had subsidized kerosene to assist the poor, but much of the kerosene was diverted away from households to the transportation sector. In Ecuador subsidized kerosene wound up on the black market and was exported to a neighboring country.

Even when subsidies do benefit the poor, they may represent an unsustainable financial burden on the state while creating other burdens. For example, imports of petroleum products in limited quantities with subsidies and rationing, as in India, is problematic because the poor have problems obtaining ration cards, and the limited supply means that the fuel has cap effect in capping the price of fuelwood. 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 (World Bank 1999b). When the Indian government liberalized energy markets and relaxed restrictions on the production and import of LPG, more middle-class households could buy LPG, a more efficient fuel than kerosene. The poor could then afford kerosene. Now more than 60 percent of households use LPG. High taxes on cooking fuels are also usually counterproductive. When LPG and kerosene are heavily taxed, demand for other fuels increases, driving up the prices of all fuels and penalizing the poor. Abandonment of targeted subsidies and loosening of restrictions on imports may be needed to clear the bottlenecks to adoption of transition fuels. Since the fuels are comparatively attractive and efficient, it may be more productive to provide credit to low-income consumers for the purchase of appliances such as stoves.

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 fuels.	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.

Improving Access to Electricity for Poor and Rural Populations

In some cases the high initial costs of rural energy services can be addressed by lowering system costs through technology choice and design innovations. Typical power demand in rural areas of developing countries ranges from .2 to .5 kW of power service. Many distribution companies design systems that are capable of delivering between 3 and 7 kW hours of service, which means heavier wires, larger transformers, and generally more expensive distribution systems components. The entire system design can be lightened to provide service at less cost.

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 also merit attention in some circumstances. They are in many cases an ideal way to get energy to rural areas and have significant environmental advantages relative to fossil fuels. Costs, once prohibitive, have decreased significantly over the past decade to the point where it is practical to consider these options where grid-based energy options are not an economical option. These technologies may be used at the level of the individual household or in village-scale micro-grid applications. For example, in remote areas that might otherwise be served by using kerosene, LPG, dry-cell and car batteries, and, occasionally, small diesel or gasoline generators, photovoltaic systems are increasingly demonstrating that they can be competitive on cost and service grounds.

Design innovations also are important to the deployment of these small-scale technologies. For example, the standard household photovoltaic system promoted by many development agencies is a 50 watt household system. There is some recent evidence from Kenya (van der Plas and de Graaff, 1988; Nieuwenhout, van de Rijt, Wiggelinkhuizen, 1998) and China (Tuntivate, Barnes, and Bogach, 2000) that people are starting off by purchasing photovoltaic systems of about 12 watts that are more affordable. Just as important, however, is support for development of effective capacities to provide service for decentralized systems (Box 3).

Box 3: Financing and Supporting Photovoltaic Systems in Rural Dominican Republic

Since 1984, Enersol Associates Inc., a U.S.-based nongovernmental organization (NGO), has supported the development of indigenous Dominican supply, service, and financing mechanisms and a market-driven demand for household photovoltaic (PV) systems. Enersol's immediate objective is to develop an "open-ended self-sustainable program for solar-based rural electrification and, eventually, to integrate solar technologies with rural societies in Latin America". The approach involves using donor grants to train a network of local entrepreneurs to sell and service PV systems; and to develop a community-based solar NGO to manage revolving loan funds that can be used by local people to purchase systems.

Because a standard home PV system costs more than half the average annual per capita income in the Dominican Republic, credit is essential if PV is to penetrate the rural energy market. Accordingly, a key component of the Enersol model is a network of locally managed NGO credit programs to finance systems using revolving loan funds capitalized by external donors. Recipients must repay full capital, installation, and market interest costs with monthly payments over two to five years. The default rate for these credit programs is less than 1 percent, though late payments are not uncommon. Other rural Dominicans have purchased systems with cash or informal three-to six-month loans provided by system suppliers. In addition to building capacity for household systems, Enersol created a program to help communities finance and implement PV water-pumping and community-lighting projects.

Enersol founder Richard Hansen attributes the program's success to several factors: simple, economical, stand-alone systems; emphasis on training and development of local human resources; village-level focus and control; local capital generation to ensure community responsibility and support for the projects; and parallel development of credit programs, service enterprises, and technical and organizational human resources.

Source: K. Kozloff, O. Shobowale, 1994.

Financial innovation also can lower service costs for rural electricity. In particular, costs can be spread over time through enhancing credit availability for both consumers and suppliers of energy services. In particular, credit may be augmented for assisting the poor to pay for the up-front costs that are involved in initiating electricity service. Because the poor gain great benefits from switching from kerosene to electricity for lighting, improved electricity access can yield real improvements in their quality of life, thereby justifying some targeted and judicious subsidization of access. In many developing countries, however, money lenders charge consumers rates of more than 100 percent, which would make purchasing any energy systems unaffordable for rural people. Electricity companies can provide credit for access charges, by spreading payments out over a period of several years and including the charge on regular electricity bills. Some non-governmental organizations are making credit available for the installation of microgrid systems based on renewable energy technologies.

While subsidization of electricity consumption in general is problematic, one subsidy that can be justified in some cases is a lifeline rate for grid electricity (Barnes, Krutilla and Hyde, 2004). Most poor people use very little electricity (one or two light bulbs and a radio), and their demand for electricity is for basic service only. Thus the establishment of a low price for the lowest electricity consumers (generally poor people) is a direct benefit for poor people. Lifeline rates for blocks of approximately 40 to 50 kWh, or even less for rural areas, will cover basic lighting for the poor, especially for cities in the later stages of the energy transition. It also does not cause a significant financial drain on the distribution company because the revenue lost is very minor when compared to the total revenue from the higher income consumers. The financial losses can even be recovered through slightly higher prices paid by the larger volume, generally higher income customers. However, lifeline rates at the 200 to 300 kWh level should be avoided, since this helps the middle class and rich more than the poor who use electricity.

Last but certainly not least, effectively and efficiently expanding electricity service to poor and rural populations requires careful attention to institutional and political considerations, including local participation in decision making and attention to incentives for serving higher-cost rural markets in the wake of privatization and restructuring initiatives. Successful experiences in Senegal, Costa Rica and India illustrate the kinds of endeavors that are required (Box 5). Another example of a rural electrification fund that was set up after privatization that is working is the case of Chile (Jadrasec, 2000). There, a tax on existing electricity users is placed in a fund for the development of new electricity distribution. Access to the fund has been used mainly to the distribution companies throughout the country, but it is also open for the development of decentralized electricity distribution as well. This fund can only be utilized for extending access to new electricity consumers. The funds are available to communities. But the distribution companies or contractors can assist the communities to apply for the funds. Although the funds are not loans, but are straight subsidies, to qualify for the funds both communities and service providers must demonstrate that they are investing much of their own money in the project. Thus, the companies have to match these funds with their own investments based on a set of considerations, including cost of construction and service.

Box 5: Rural Electrification Lessons from a Successful Programs

Cooperative Rural Electrification in Costa Rica. Rural electrification is one of Costa Rica's success stories. In the 1960s as little as 20 percent of people in rural areas had access to electricity. At that time despite growing demands from rural areas, rural electrification remained a low priority for the public electricity company. By the early 1970s, with assistance from USAID, four rural electrification cooperatives were set up in Costa Rica. All four of these cooperatives have prospered and now provide electricity supplies to about 20 percent of the country's rural population. In the meantime, most of the remaining rural areas have been provided with electricity by the national utility. By the end of 1995 over 90 percent of the rural population has been connected into the national electricity supply system.

Village Provision of Electricity Near Bangalore, India, South India, the village of Pura supplies household electricity and water through large community biogas digesters. 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, 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."

Public Company Rural Electrification in Thailand. In Thailand the rural electrification was implemented through a public distribution company. In the early 1970s, the task of rural electrification was given to the Provincial Electricity Authority, which was responsible for serving customers in both urban and rural areas outside of Bangkok. The company established an office of rural electrification to carry out the task. The company was required to be financially viable throughout the rural electrification expansion, and this was accomplished by relying on international donors for investment capital, a bulk supply tariff reduction sanctioned by the government of Thailand, and an internal cross-subsidy from urban consumers. Thus, for the most part existing customers with electricity provided much of the financing for new rural consumers.

Source: World Bank, 1996 ; Foley, 2004; Tuntivate and Barnes, 2004.

Rural electrification on a large scale, whether through grid extension or through off-grid technologies, generally is not a profitable business based on short-term commercial profit motives or financing arrangements. Historically in almost all parts of the world, private sector businesses have tended not to enter the business of providing electricity service to rural areas. The initial capital costs can be recovered over the long term, but this requires long term financing or other forms of financial intermediation. On the other hand, the welfare benefits for rural and poor people of having access to electricity are quite high, as already noted. The challenge is to develop privatization frameworks that do not significantly distort efficiency in the energy sector, but does take into consideration societal goals of expanding access to energy services by poor and rural populations.

Improving the Efficiency and Sustainability of the Modern Electricity Sector

As the modern electricity sector grows in importance within a developing country, so does the importance of a variety of policy reforms to promote its efficiency. The converse is also true – reform to promote efficiency and financial sustainability is a necessary condition in many cases for effective expansion of the sector.

Electricity subsidies are a particular problem. In the early 1990s, the average electricity tariff in developing countries was about 4 cents per kWh, while the average cost was about 10 cents per kWh. Such subsidies have left many utilities economically crippled, unable to finance the extension of services to rural areas. Moreover, they distort the market, encouraging consumers to buy grid-supplied electricity and discouraging the development of cheaper ways of generating electricity. Inefficient pricing also distorts plant dispatch and investment decisions by masking the true opportunity cost of different sources of supply (see Wolak 2003 for illustrations of this).

There is a widespread belief that electricity tariffs need to be extremely low, often well below their true supply costs, if rural electrification is to benefit rural people. The facts do not support this. Rural electrification only makes sense in areas where there is already a demand for electricity-using services such as lighting, television, refrigeration and motive power. In the absence of a grid supply, these services are obtained by spending money on kerosene, LPG, dry-cell batteries, car battery recharging and small power units, all of which are highly expensive per unit of electricity supplied. Recent surveys in regions without electricity in Uganda and Laos indicate that people spend approximately 5 dollars per month on these energy sources. Private suppliers often find a ready market for electricity at more than one US dollar per kilowatt hour. It follows that rural electrification tariffs set at realistic levels do not prevent people making significant savings in their energy costs, as well as obtaining a vastly improved service. Charging the right price allows the electricity company to provide an electricity supply in an effective, reliable, and sustainable manner to an increasing number of satisfied consumers.

Improved sector governance more generally is another key step toward improved efficiency of service provision. This contains a number of components. The economic performance of publicly managed enterprises (generation or transmission and distribution) needs to be improved. Often, however, this is difficult. Privatization can be an alternative, but it will succeed in improving efficiency and acceptability of service only if accompanied by effective regulation and strengthened, independent regulators. This institutional reform also is difficult to achieve. As noted above, moreover, if access to the services by poor households is not improved in the course of privatization, the benefits of such sector reform will materialize mainly to more wealthy households that already have service.

Programs of regulatory reform and promotion of competition are of undoubted importance to the long-term evolution of modern and efficient electricity systems in the developing world. Yet, when these reforms are undertaken they must take account of the particular circumstances of the country or countries undertaking the reform, avoiding a "one size fits all" approach. This is illustrated by the experience with reform in Central America (Millan and von der Fehr 2004). Each of these countries has had experience with reform, with varying results. One concern with attempts to institute competitive generation markets, for example, has been the small size of individual country demands relative to minimum efficient plant scale, raising questions of whether enough competitors could effectively enter national markets. Under these conditions, more traditional cost-based plant dispatch may be more efficient. Even more efficient in the longer term may be the promotion of regional market integration, in particular through transmission system upgrading and extension, to enlarge market size and allow for both greater competition and more efficient investment scales. This observation does not obviate the need for attending as well to the need for smaller-scale investment in more isolated markets.

An interesting question in the context of modern electricity sector development is the need for what has been referred to in developed countries as demand side management. At later stages in the energy transition, people in urban areas increase the number of appliances that they own, and consequently the demand for electricity rises dramatically. This makes the conservation of electricity more salient. While efficient energy pricing and the development of energy service companies are an important part of the development of effective energy conservation, some information and standards programs (such as publishing energy efficiency ratings on appliances) may also be useful in practice.

VI. Concluding Remarks

The energy sector makes an important contribution to both people's quality of life and level of economic well being for people in developing countries. There is a misconception that the percent of energy used by households declines with development. However, the reverse is true. The use of modern energy by households increases both absolutely and as a percentage of energy use with development.

As we move beyond the start of the 21st Century, urban populations will continue to grow at a high rate and rural populations will become more stable. This means that the rural populations by necessity will have to become more productive to meet ever increasing demands for food, fiber and other farm products. They will need energy as an input in this process. Urban populations will switch from the use of traditional fuels to modern fuels as a consequence of changing lifestyles, economic development, and reduced availability of inexpensive biomass around their urban perimeters. However, this transition needs to take place in a environmental sound and equitable manner. Interfuel substitution, energy conservation, efficient small-scale and large-scale investments in electricity supply, and enlightened policies governing energy pricing and access all will influence how this transition takes place.

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