



meeting the  
challenge



# Rural Energy and Development for Two Billion People





**The World Bank**

# Meeting the Challenge for Rural Energy and Development

Vice Presidency for Finance and Private Sector Development

Industry & Energy Department

It is hard not to be daunted by the scale of the problem of providing modern energy service to the world's rural population. There are nearly two billion people without access to modern forms of energy, such as electricity and oil. This brochure describes the plight of these two billion and summarizes the many ways in which their situation can be improved. For though the problem is daunting, practical and affordable prescriptions are now available.



## FOREWORD

Many people do not think about where their energy comes from. They just flick a switch or start their car. For nearly two billion people in developing countries, however, the search for energy is a daily grind. These people have neither electricity nor gas nor oil to cook their food. Women and children from these families often spend hours each day gathering dung and wood—hours they might otherwise be able to spend on productive work or education. Their health is damaged by the smoke given off by these fuels. Their environment may be damaged as they chop down trees for wood.

The problems of rural energy have long been recognized. What is the World Bank doing about them? In recent years the Bank's work in energy has largely focused on making existing energy supply and consuming industries more efficient, opening them up to competition, and encouraging private sector participation. This is an important job and is far from finished. In many developing countries, for example, electricity prices are heavily subsidized. These subsidies often benefit the wealthiest households the most. They also undermine the financial health of utilities, making it difficult for them to extend services to rural areas.

But the Bank should not concentrate on reforming existing energy markets alone. Any reform will fail in the long run if it does not benefit the whole population. Improving rural energy should therefore be seen as an important goal in itself. The exciting message of this paper is that, through a combination of better technology and decades of experience, we are now able to tackle the problems of rural energy better than ever before. The paper draws on the experience of many experts in government, industry, and nongovernmental organizations (NGOs). We thank them for sharing their knowledge with us.

Tackling the problems of rural energy will force us to challenge some old assumptions. Those kings of the energy world—

coal, oil, and gas, for example—are not the only modern forms of energy suitable for rural areas. This paper describes the growing attractions of renewable technologies, such as solar power. It argues that policymakers, governments, NGOs, and the private sector should concentrate on improving the use of traditional fuels, such as wood, and not just on promoting modern energy, such as electricity. It stresses the importance of designing policies and projects with local people rather than imposing schemes from above. It shows, for example, how the environment can be protected by giving farmers responsibility for managing forests.

Rural energy presents the Bank with an important challenge. It should be a key part of our work, whether we are discussing country assistance strategies, energy sector reform, or new investments. While the Bank can play an important catalytic role, real progress in tackling these issues is critically linked to the adoption of the needed policy and institutional reforms, mobilization of local entrepreneurial and NGO resources, and development of innovative rural energy delivery and financing mechanisms. We therefore also plan to promote regional and country workshops to discuss these issues, encourage investment in rural energy, and foster policy reform. Such an effort has started already; this paper itself reflects the results of widespread consultations between the Bank, donors, NGOs, and recipient governments that took place during its preparation. We intend to regularly report back on our progress on this vital task.

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The World Bank



A third of all energy consumption in developing countries comes from burning wood, crop residues, and animal dung

To understand the possible solutions for providing energy service to the rural population in the developing world, consider first what is known about the problem. Around a third of all energy consumption in developing countries comes from burning wood, crop residues, and animal dung. Such biofuels are mostly used in rural areas, though wood is also used as a fuel by the urban poor. Biofuels produce the equivalent of twice the energy of the coal mined in China or the United States in a single year. They produce energy, however, in a seriously inefficient way.

For a start they help trap the user in poverty. Gathering fuelwood and dung takes time—time that could be devoted to more productive activities such as farming. A recent study in the hill areas of Nepal showed that even in areas with fairly good supplies of wood, women need to spend over an hour a day collecting fuels. In areas where wood was more scarce, the chore lasted about 2.5 hours a day. Moreover, most biofuels need to be collected in large quantities. They are a highly inefficient means of cooking compared with fuels such as liquid petroleum gas (LPG)—used by wealthier households. A kilogram of wood, for example, generates a mere tenth of the useful heat for cooking delivered by a kilogram of LPG.

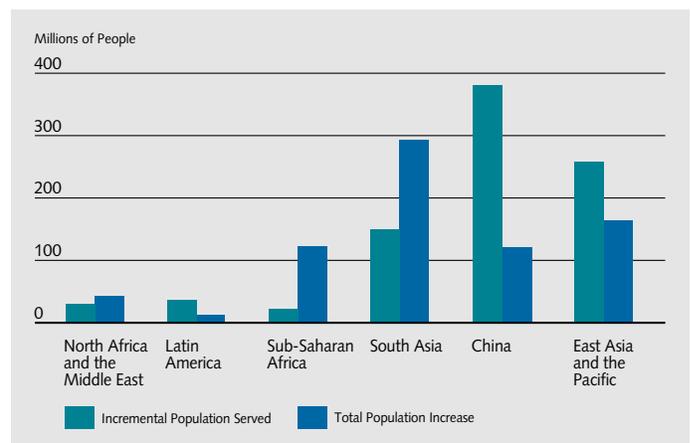
Biofuels can also damage people's health, because they give off smoke that contains many hazardous chemicals. Studies of rural areas show that smoke levels inside dwellings often far exceed safe levels recommended by the World Health Organization. Cooking with biofuels does not cause health problems everywhere, but in houses that have poor ventilation it can be as dangerous as smoking cigarettes. A study in The Gambia, for example, examined the health of 500 children under five years old. It found that children who were carried on their mothers' backs as they cooked in smoky huts were six times more likely to develop acute respiratory illness than other children. Studies of women in Nepal and India exposed to biomass smoke—but who did not smoke themselves—found that their death rate from chronic respiratory disease was similar to that of male heavy smokers.

The use of biofuels can also damage the environment. The search for fuelwood often involves chopping down local trees. As trees disappear, fuelwood has to be sought further and further away. Using dung and crop residues as a fuel reduces the amount available for use as a fertilizer for growing crops. Such problems are avoidable. Farmers in many areas use biofuels in sustainable

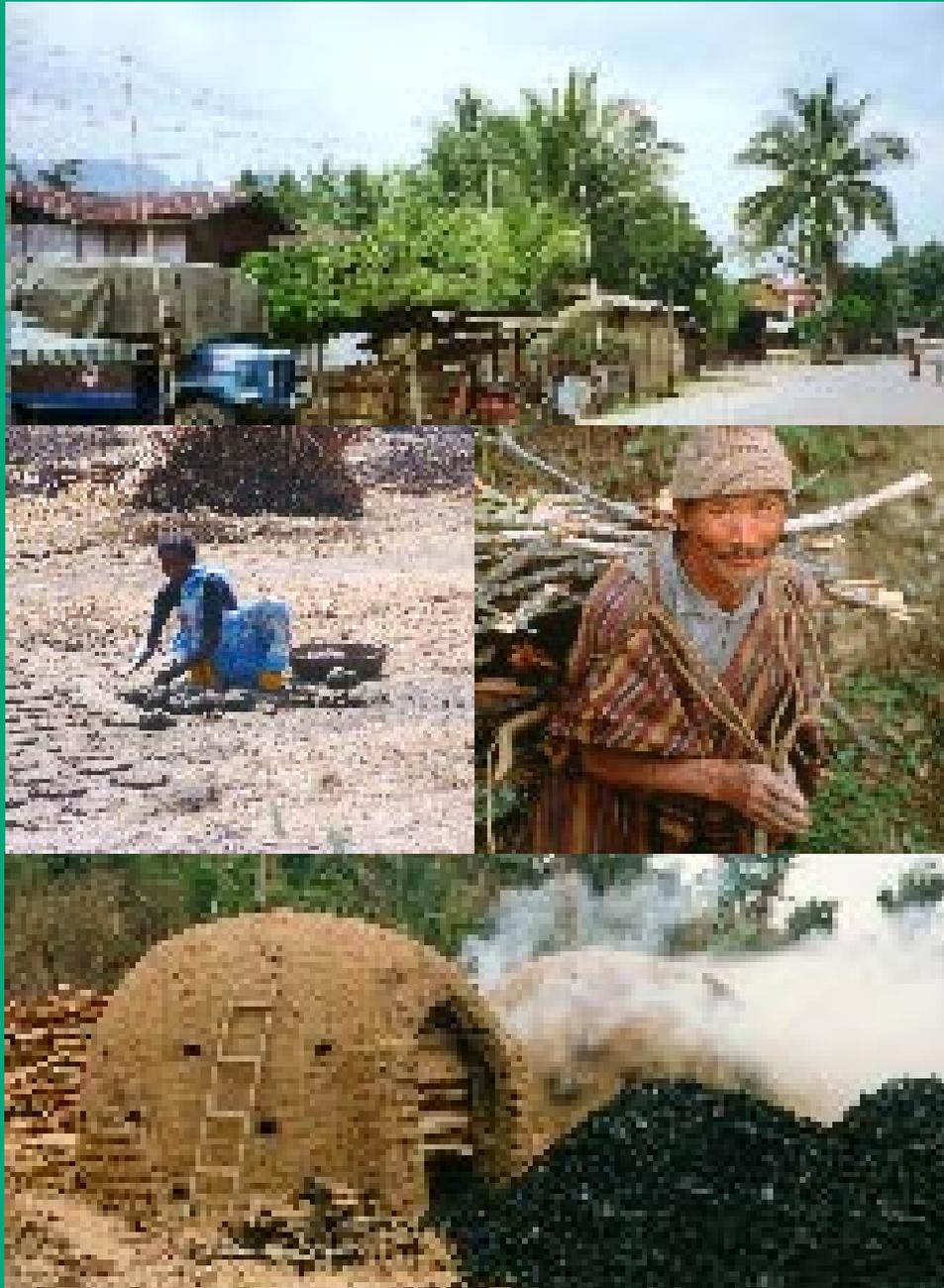
ways. But in many other areas the gathering of biofuels ranks together with logging, and the clearing of land for agriculture, as a cause of deforestation. In the northern Chinese county of Kezuo, for example, people have already cut down most of the trees around the farm lands. Poorer households are now turning to even less efficient fuels such as straw and dung.

Without electricity, moreover, poor households are denied a host of modern services such as electric lighting and refrigeration. To an extent, some of these problems are being alleviated. Electricity supplies have been extended to over 1.3 billion people in developing countries over the last twenty-five years. Yet most of these connections have been in urban areas. In many regions of the world, including Sub-Saharan Africa and South Asia, populations have grown even faster (figure 1). With the total population of developing countries expected to grow by more than 3 billion in less than four decades, the problems of rural energy are likely to become more pressing than ever. So what can be done to solve them?

**Figure 1**  
Rural Electrification, Increases in the Number of People with and without Service, Selected Countries and Regions, 1970-90



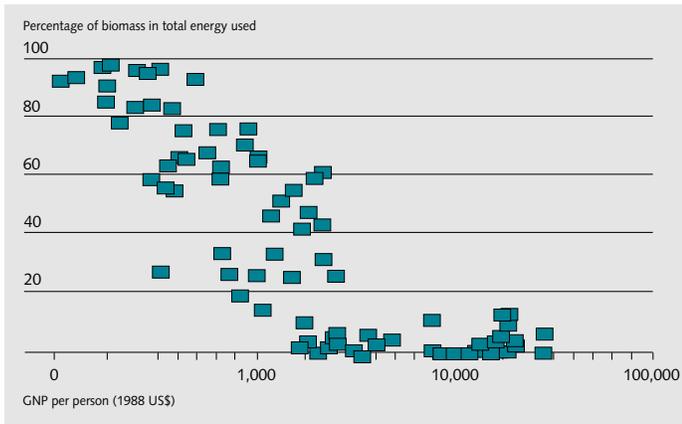
The problems of rural energy should certainly not be dealt with in isolation. Poverty and dependence on biofuels go hand-in-hand. As household incomes rise, people normally switch to modern fuels, if these are available (figure 2). Higher-income countries also depend much less on biofuels than do poor countries. The best schemes for improving rural energy may therefore fail if other policies prevent economic growth.



People are willing to spend a significant proportion of their income on better energy, which improves their way of life

**Figure 2**

**Use of Biomass in Relation to GNP per Person in Eighty Countries**



Provided the background conditions are right, one of the most powerful ways to improve energy supplies is to ensure that the energy market is determined by consumers' choices. In particular that means both that the price of energy should reflect its cost and that regulation of energy industries should encourage competition and choice. Governments should concentrate on ensuring that there is a level playing field for different investors in energy, whether they are public utilities, private firms, or enterprises set up by the local community.

The opposite has been true in most developing countries. Rules and regulations have strangled the emergence of firms other than the state-run utility. For example, it is illegal in many countries for local private or cooperative non-grid-connected generation and distribution enterprises to enter the market. Many government programs have attempted to extend energy supplies to rural areas. But too often the result has been unsustainable public institutions promoting technologies that are unsuitable for rural consumers.

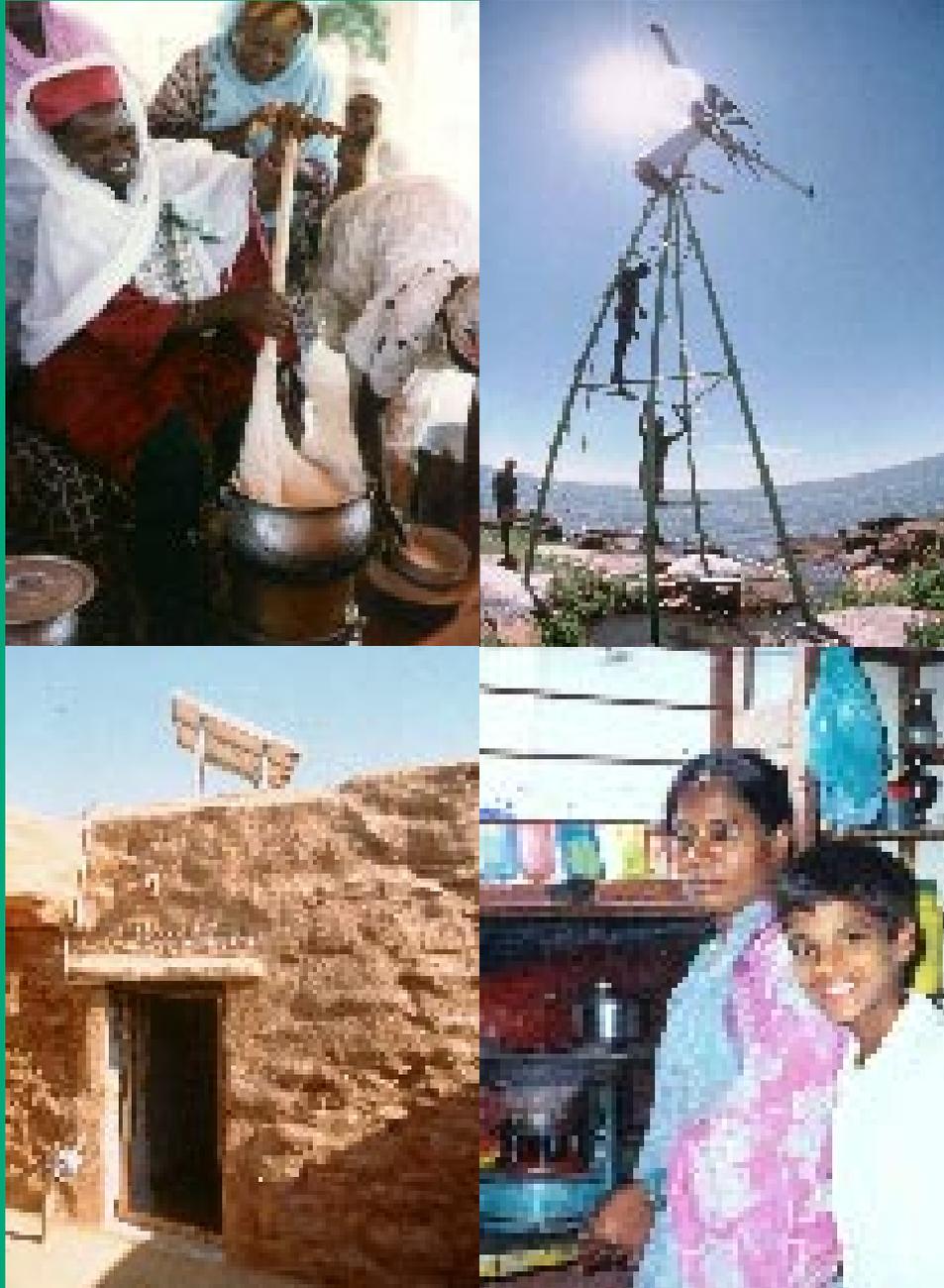
Subsidies for electricity consumption are a particular problem. In the early 1990s average electricity tariffs in developing countries were less than US¢4 per kilowatt hour (kWh), even though the average cost of supply was around US¢10 per kWh. Such subsidies are harmful in a host of ways. They constitute a huge financial drain (revenues from electricity supply in developing countries fall short of costs by some US\$100 billion every year). As a result utilities are often economically crippled, unable to finance the extension of services to rural areas. Where supplies have been extended to rural areas, subsidies often undermine the efforts of businesses to provide cheaper ways of generating electricity. In

remote rural areas, for example, diesel engines or solar photovoltaic (PV) systems may provide electricity at a lower cost than grid supplies. But consumers will not opt for them if grid supplies are subsidized, nor will investors come forward to develop least-cost options to serve rural consumers.

Overall subsidies on energy consumption tend to benefit rich people more than the poor. A recent World Bank study of seven countries showed that high-income households benefit disproportionately, largely because they use more electricity. In Malawi, for example, a poor consumer on average receives a mere US¢4 a year in electricity subsidies, while a rich one gets US\$6.60. Some subsidies may be justified—but only if they are limited to specific and affordable goals, such as providing cheaper rates for very poor households for a fixed maximum consumption per month (which can be achieved by charging wealthier households a little more than the cost of supply).

Hefty subsidies for modern cooking fuels, such as kerosene and LPG, are also common in a number of developing countries. As with electricity, the results are often counterproductive. In Indonesia, for example, kerosene used for cooking and lighting is subsidized. But richer households reap a disproportionate share of the benefits because they can afford to buy more energy than the poor. The government of Ecuador also subsidized kerosene until recently. But the poor received little of the fuel because retailers could make more money selling it for use in vehicles. Even if subsidies reach the poor they often become unsustainable financial burdens on the state budget. Senegal's annual subsidies for LPG, for example, rose from US\$2 million to US\$10 million between 1990 and 1994—an increase that could have paid for thousands of desperately needed teachers.

Market-opening reforms can be dramatically effective, as shown by the experience of Hyderabad in India. In 1980 only the richest 10 percent of households in Hyderabad used LPG. The proportion has since risen to over 60 percent. Meanwhile fewer households are using fuelwood even though the city's population has doubled since 1980. The main cause of the change was the liberalization of energy markets. In particular the Indian government relaxed restrictions on the production and import of LPG. As a result more middle-class households could buy LPG, a more efficient fuel than kerosene. That in turn allowed the poor to graduate up the fuel ladder from wood to kerosene.



The effective exploitation of renewable technologies requires eliminating tax, subsidy, and import distortion that discriminate against renewables

## THE NEW AGENDA

Liberalizing energy markets, however important, may not be the complete answer. Despite the progress made in encouraging private investment in the electricity industry since the beginning of the 1990s, for example, private companies have shown little interest in extending electricity supplies to rural areas. They have instead preferred to concentrate on more lucrative contracts to generate electricity and to supply industrial and urban customers. There is evidence, in other words, that creating urban-based energy markets by itself will fail to provide rural electricity.

There is one obstacle in particular that discourages companies from providing supplies to rural areas: high start-up costs. Extending an electricity grid to a remote village can be very expensive, especially if only a few households are to be connected. Until more households join the network, the cost of electricity can reach US¢70 per kWh, seven times the typical cost in an urban area. Even setting up a solar electricity system for a single home can cost between US\$500 and US\$1,000, a large sum to spend in one lump.

The problem here is not necessarily that people are unwilling to pay. Evidence suggests that people will spend a significant proportion of their incomes on better energy, which improves their quality of life or enables them to become more productive. In Bangladesh even the poorest people are connecting to the grid when the service is available. In rural China, many people without easy access to cooking fuels are investing in efficient stoves and tree planting.

The problem is that rural customers often cannot get affordable credit. That makes it difficult for them to pay the high start-up costs of improving their energy supplies. One solution may be to establish a local member-supported bank to make small loans (such as the Grameen Bank in Bangladesh, which lends mainly to women and poor people). Another is to promote companies that lease basic equipment to consumers, communities, and local energy suppliers (e.g., LPG distributors and small power companies).

The importance of credit is illustrated by the experience of Mizque and Aiquile, two rural villages in Bolivia that are supplied by local diesel micro-grids. When the villagers were first given the opportunity to buy electricity from their local micro-grids, barely a quarter of them could afford the service. The electricity company that runs the micro-grids then decided to provide credit for the

US\$100 to US\$125 connection charges, allowing customers to pay back the costs in small monthly installments over five years. As a result more than half of the villages' households were able to purchase electricity, even though the prices of local micro-grid power were fairly steep, at US¢25 to US¢30 per kWh.

Suppliers can also expand their markets in rural areas simply by reducing start-up costs for rural consumers. A key aspect of the electrification scheme in Mizque and Aiquile, for example, was that supplies were limited to evening hours. Uniform standards and codes that prevail in many developing countries and that have been designed for industrial and higher-income customers often prohibit such service adjustments.

Technologies such as solar, wind, and small-scale hydro-power are often ideal in rural areas and require far more systematic attention by policymakers than they have hitherto received. Renewable technologies have significant environmental advantages relative to fossil fuels. Sunlight is also in ample supply in many developing countries. Most important of all, the costs of many renewable technologies have come down significantly over the last decade. A combination of improved technology and economies of scale has pushed down the costs of wind power, solar thermal power (sunlight is used to heat air or water), and photovoltaic power (electricity is generated directly from sunlight).

In the 1950s and 1960s, for example, PV cells were only used in the space industry. Their costs have fallen so dramatically since then (figure 3) that they are now used to power tens of thousands of homes in developing countries. Though electricity generated from PVs is still more expensive than electricity generated from fossil fuels, PV modules can be easily installed in remote locations, circumventing the need for large investments in extending the electricity grid. For this reason, PVs often make economic sense for rural households or for water pumping. In recent years in Kenya, for example, 25,000 rural households have bought (unsubsidized) PV modules—more than have been connected to the electricity grid under the highly subsidized government rural electrification program. Still, both electrification strategies have so far reached only a tiny fraction of Kenya's rural population of 19 million.

The effective exploitation of the new renewable technologies requires a "leveling of the playing field"—that is, eliminating tax, subsidy, and import distortions that now discriminate against renewables in favor of fossil fuels; initiating national surveys of

## Broadening the Scope of the World Bank Energy Operations

What the Bank's Board of Executive Directors approved in 1992

### World Bank

- Commitment lending
- Promotion of clean technologies

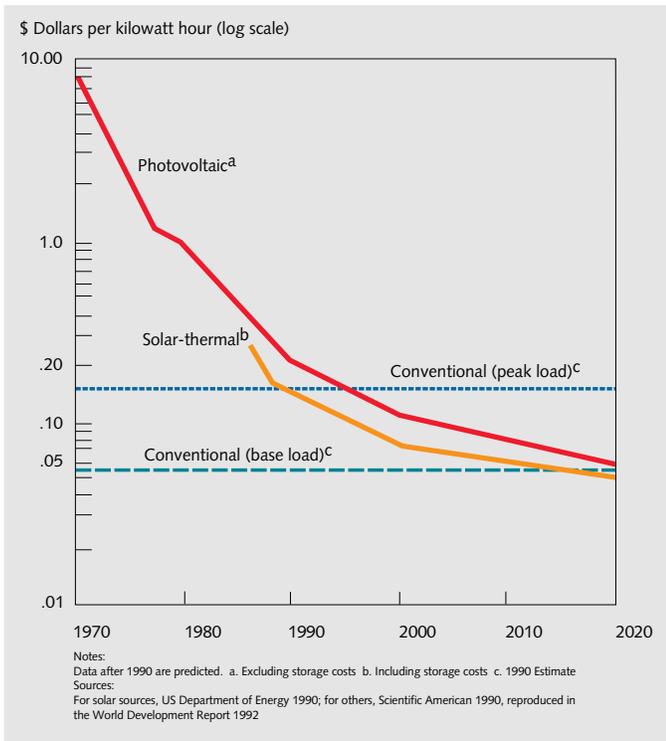
### Countries

- Sector reform
- Transparent regulation
- Commercialization/corporatization
- Private involvement
- Importation of services
- Market pricing
- Demand management

Added dimensions – a renewed commitment to:

- Extend modern energy supplies to unserved populations
- Promote sustainable supply and use of biofuels
- Introduce new renewable energy technologies by
- Promoting commercial pricing and private involvement in distribution
- Supporting agroforestry and biofuel programs
- Encouraging local initiative and open markets

**Figure 3**  
**Cost of alternative means of generating electric power in high-insolation areas, 1970-2020**



wind and solar resources; promoting credit schemes to help consumers meet the high first costs of such systems; developing private supply and service infrastructures and associated training; and supporting selected demonstration projects.

However quickly modern energy spreads in developing countries, dung, crop wastes, and wood will be used by tens of millions for decades to come. Encouraging the use of improved biomass stoves is one step in improving the efficiency and sustainability of the use of biofuels. Relatively simple and inexpensive improved stoves can reduce by as much as 30 percent the amount of fuel needed for cooking, thus cutting the time needed to gather wood. Moreover, because the improved stoves give off less smoke, they make the domestic environment less damaging to householders' health.

Encouraging the use of improved stoves is easier said than done. A number of programs run by governments and donor agencies in the late 1970s and early 1980s failed, partly because they were oblivious to local customs and the local economic climate. But lessons have been learned—in particular that schemes should target those who would benefit most. For ex-

ample, the Chinese National Improved Stove Program (the world's largest stove scheme, which has installed 120 million stoves in rural households) wisely concentrated on areas with the greatest fuelwood shortages. In Tanzania a project funded by the International Development Association started up a self-sustaining market that by 1992 had sold more than 60,000 improved stoves. It no doubt helped that production and sales of these stoves were put in the hands of local artisans and shopkeepers.

Farm forestry and natural forest management have long played an important role in alleviating wood problems in China, India, and many other countries. By providing market incentives for effective management of existing trees and shrubs and limited planting of new ones, these practices significantly increase afforestation rates. Programs that support such market-driven approaches directly address farmers' needs for fuel, fodder, mulch, medicine, and wood. They also reduce pressure on agricultural residues and can improve soil fertility. Other benefits include curbing soil erosion, improving soil moisture retention, and supplying soil nutrients.

Effective management of existing forest resources requires that local people take active responsibility and that forestry departments must change their role. Success depends on voluntary participation and decisionmaking as well as on formal transfer of responsibility for forest management to the rural communities.

Perhaps the most important lesson learned by the World Bank and other organizations in recent years is that local input is vital to success. Local people understand their situation and their problems better than outsiders. The village of Pura in south India is a prime example of this. Community biogas digesters, which produce gas from dung and farm residues, have a history of problems in India. Initial attempts to promote this technology failed in Pura too. The aim of the initial schemes was to encourage villages to use biogas as a cooking fuel, even though fuelwood is abundant in Pura. When finally asked, villagers explained they were more interested in getting clean water. So the biogas was instead used as a fuel to generate electricity, some of which was used in turn to power a deep tubewell pump. The result was a double gain for the villagers: clean water and electricity supplies.

## THE ROLE OF THE WORLD BANK

In the 1980s the finances of electricity utilities in a number of countries were deteriorating sharply. As a result the Bank turned toward encouraging countries to liberalize their energy markets, introduce transparent forms of regulations, and attract private investment. Two Bank policy papers published in 1993 set out this policy reform agenda. Since then, the Bank has been learning a great deal about how to improve rural energy development. At the same time the economics of renewable energy have also been changing rapidly. As a result the Bank is now pursuing a new set of solutions to supplement the established ones of liberalizing energy markets (see page 10).

Some of the Bank's operations in recent years have borne the stamp of this new knowledge. The sustainable management of forest resources has been improved by empowering local populations to gain revenue from supplying wood to nearby fuel markets. Forestry assistance has led the way, followed by natural resource management and energy operations.

Innovative delivery of renewable energy to consumers has been spearheaded by lending operations in India and Indonesia that focus on developing the ability of retailers and other intermediaries to reach rural markets. Technical assistance co-funded by bilateral donors is identifying policies and projects in many countries of Sub-Saharan Africa, Asia, and Latin America that pave the way for using new decentralized technologies to provide affordable energy.

However, this is just a beginning. The emerging strategies that promise to make a real difference for rural populations require a new and powerful commitment by the Bank and its partners. The Bank is committed to devoting significantly more attention and resources to the alleviation of the "energy poverty" of large portions of the developing world's rural populations. An Action Plan to achieve this is in place.

The Bank's Action Plan calls for a strong effort to accelerate the opening of rural energy markets, help consumers to have a choice, and put in place better systems to deliver and finance rural energy. The Bank intends to base its efforts to provide better access to energy for rural people on five main principles:

- **Provide for consumer choice.** A better choice of affordable energy sources should be provided to rural consumers. Informed consumers will choose the most cost-effective solution, according to their preferences.

- **Ensure cost-reflective pricing.** Distortions in prices that are created by subsidies and taxes should be eliminated. They create a disincentive for entrepreneurial solutions to rural energy supply, and give consumers the wrong signals.
- **Overcome the high-first-cost barrier.** The obstacle of the high initial cost of obtaining energy needs to be removed. Credit mechanisms, lower-cost equipment, and lower service standards can all contribute to achieve this.
- **Encourage local participation.** Participation of local communities, investors, and consumers in the design and delivery of energy services is essential. Decentralized approaches need to be part of the solution, including systematic local capacity building.
- **Implement good sector policies.** These are the basis for bringing better energy access to rural populations. Energy sector reform should include the opening up of the rural energy market. Macroeconomic policies should not discriminate against rural energy. The role of the government should change from central planning to supporting markets.

The task of improving energy supplies for two billion people remains daunting. What has changed is that we now have solutions more firmly in our grasp.

## **BROADENING ENERGY ACCESS: AN ACTION PLAN FOR THE WORLD BANK**

### **Develop Regional, Country, and Local Ownership and Commitment to Efforts to Broaden Energy Access**

- Conduct regional workshops and training seminars to initiate and reinforce planning for effective and affordable rural energy supply.
- Finance technical assistance and training projects to help countries in developing policies, institutions, and programs designed to promote rural energy.

### **"Operationalize" Rural Energy in Bank Assistance Programs**

- Make a more consistent and systematic effort to address the problems of people's access to energy services.
- Include a description of a country's and the Bank's strategy for rural energy development in appraisal reports for all energy projects.
- Policies to address the problems of large energy industries will indirectly benefit rural and poor people.
- Help develop strategies based on cross sectional approaches for energy projects in coordination with efforts to promote rural development through agriculture, health, and education projects.
- Pay more systematic attention to the energy access problems of people in rural areas.

### **Promote Best Practices and Innovations in Project Design and Implementation**

- Help develop innovative projects and project components for rural energy.
- Promote finance for rural energy as part of a strategy to ease access. This involves working with local financial institutions and NGOs.
- Devise means to ease or defer the first costs of energy access (e.g., connections, appliances, and equipment). Innovative experiments in financing, leasing, and delivering systems could be designed and piloted.
- Develop standard analytical tools for project appraisals of innovative rural energy projects as well as for traditional rural electrification projects.

### **Disseminate Innovations and Best Practice**

- Make available information on good practice in delivering and financing rural energy—including leasing and credit schemes, grid rural electrification, micro-grid systems, renewable energy systems, and natural forest management for fuelwood production. Conduct research on impact of rural energy and energy policies on rural development.
- Promote joint implementation of projects in collaboration with groups outside the Bank, including bilateral donors, NGOs, and foundations.
- Provide technical assistance to make funds available for onlending to NGOs and voluntary and grassroots organizations that can catalyze investments in communities to carry out energy-related programs.

### **Special Initiative on Africa**

- Help address the issues of serving dispersed rural energy demand.
- Help reform the power sectors, find solutions for improving energy access for the unserved population, and facilitate development of local delivery and financing mechanisms.
- Facilitate access to cooking fuels through programs emphasizing fuelwood management, stove efficiency, charcoal efficiency, and transition to modern fuels.
- Assist in policy reform including opening of markets, elimination of price/tax/tariff distortions, and facilitating entry of competitors.

### **Improving the Bank's Capacity to Deal with Rural Energy Issues**

- Training and retraining of Bank staff to deal with rural energy issues is essential. This can be accomplished through courses, internal workshops on best practices, and opportunities to work in agencies dealing with rural energy issues. An internal course should be developed for staff training.
- The Bank also needs to build capacity to deal with rural energy issues by hiring new staff qualified in developing rural energy projects as opportunities occur.

## ABBREVIATIONS AND ACRONYMS

ESMAP	Energy Assessment and Energy Sector Management Assistance Program
kWh	kilowatt hour
LPG	liquid petroleum gas
NGO	nongovernmental organization
PV	photovoltaic

## INFORMATION

More information about the World Bank's work and policies concerning the energy sector are available on the World Wide Web at: <http://www.worldbank.org/html/fpd/IEN/IEN.html>

The present paper is based on the findings of the study "*Rural Energy and Development: Improving Energy Supplies for 2 Billion People*" published by the World Bank in the "Development in Practice" Series.

This study is available from World Bank Publications in Washington, DC, USA and World Bank Publications distributors around the world. Instructions to order this study and the list of World Bank publications distributors are available on the World Wide Web at: <http://www.worldbank.org>

Design: Mitchell & Company Graphic Design

Photography: Douglas Barnes, Curt Camemark, Kay Chernush, William Floor, Richard Spencer, Anke Meyer

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