

# Expanding Electricity Access to Remote Areas: Off-Grid Rural Electrification in Developing Countries

Several World Bank Group projects now underway are exploring improved means to provide modern energy services to the more than two billion people in developing countries who remain without access. In remote areas, new technologies for off-grid rural electrification promise environmentally benign access to electricity at a lower cost than conventional technologies. This paper presents emerging design issues regarding off-grid electricity service, including new business models and, least cost options for village power, as well as initial lessons learned from rural off-grid concessions in Argentina and twelve solar home system projects.

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**T**he Challenge of Rural Energy and Development: The World Bank Group's mission is to work for a world without poverty. An important part of this mission is expanding access to modern energy services for an estimated two billion people who still lack such services (World Bank 1996, ESMAP 2000c). Expanded access to energy services is inexorably linked to today's transforming energy sector. Although ongoing reforms are showing success and being replicated, there is growing concern about their social and environmental sustainability. In developing countries, the concern is twofold: how to derive the most benefit from a liberalised and unbundled energy sector while ensuring environmental sustainability and improving access for the poor.

Lack of access to energy in rural areas is of same order of magnitude as lack of access to other types of infrastructure. In fact, it is often the same rural or urban poor who lack access to modern energy services, electricity, modern telecommunications, clean water and other basic services. This interdependency is obviously part of the problem (high service costs versus low ability to pay due to low income), but may also be part of future solutions: the potential of bundling services on a local demand side basis is just recently being (re)discovered for development.

In this chapter, we look at a special case of access to energy: off-grid rural electrification in developing countries. Some of the rural energy users (households, productive and public uses) will be served by grid connections during the next decade, (see Box 1 for the potential social benefits of rural electrification). But large numbers will remain unconnected because of the high costs of grid extension when serving new loads. Off-grid electrification can provide an alternative solution for many low-demand users - at lower cost than grid extension - and a growing market niche for small types of rural energy-service companies. Costs of off-grid technologies have come down significantly over the last years.

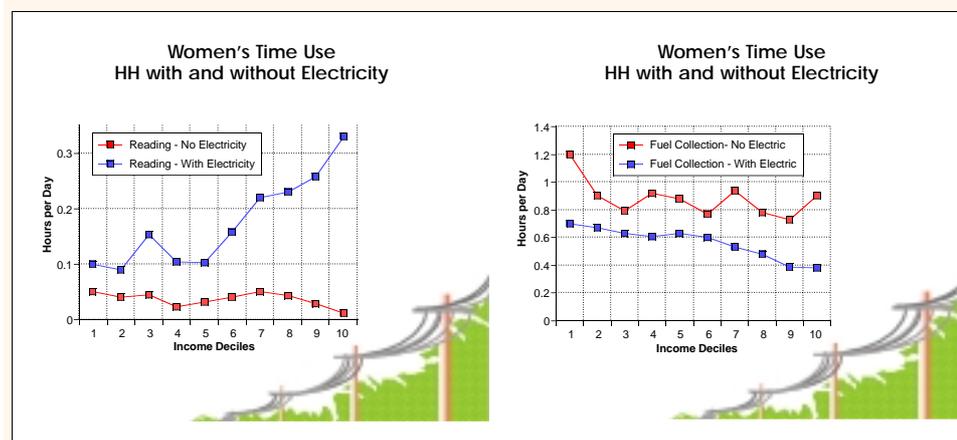
## BOX 1: Impact of Rural Electrification on Poverty

The World Bank has recently started a number of studies on the impact of rural electrification on poverty alleviation (see ESMAP 2000c). While the results of these studies are not known yet, we expect the impact of rural electrification to provide social benefits.

1. improved living standards (amenities and services)
2. reduced negative impact of energy use on health and local environment
3. increased employment (direct & indirect) on supply side (energy service delivery chain) and on demand side (rural industries, productive uses)
4. synergy benefits (synergy due to bundling of services).

In particular, the following social development impacts may be expected: Electric lighting (up to 200 times brighter than kerosene lamps - *van der Plas and de Graff 1988, Nieuwenhout et al 1998*) directly improves the quality of life - it allows children to study in the evening and women to gain some precious time for themselves or to extend income generating work into the evening hours (*Barnes 1988, Bose 1993, Domdom et al 2000*). Residential and public light increases safety - again, children and women profit most (*World Bank 2000*). Money for conventional fuels can partially be saved and then be spent by households on social purposes (*ESMAP 1990, Fitzgerald et al 1990*). Access to means of modern communication and information reduces the marginalization of rural residents (horizontal inequality). Public Centers may profit highly from this access. TV, light or productive uses in community centers enhance social life and may facilitate community based development. Schools may provide better learning conditions - distance learning approaches based on PC or TV can open a wide range of education improvements.

Barnes (ESMAP 2000a, see figures) shows two impacts of rural electrification on women in India: a decrease of time spent on collecting fuel and an increase in time spent reading.



Bundling energy services with other rural services has the potential to boost living standards far in excess of the individual impacts of each service (as well as lower service transaction costs). For example, recent surveys in Peru show that the bundling of services like water, electricity, sanitation and education provides increasing marginal welfare benefits as the number of services increases: addition of a fourth service has about seven times greater marginal benefit than addition of a second service to households (*World Bank 1999b*).

## Options for Off-Grid Rural Electrification & Technology Choice

Off-grid rural electrification can provide power for **domestic uses** (lighting, cooling, TV, radio, communication), **productive uses** (e.g., water pumping, fencing, cooling, mills, sewing machines, etc) and **public uses** (e.g., schools, health stations, police stations). Power may be supplied through two basic distribution options: **village minigrids** (serving tens or hundreds of users) or **isolated systems** (serving just one or two users). And power

may be generated from a variety of resources, using diesel-, biomass-, wind-, PV-, or small hydro-generators, or hybrid combinations of these. Depending on the characteristics of a specific use (i.e. willingness to pay and load profile) and the local supply options, the least cost solution for a rural off-grid system may consist of any combination of the above options (see Box 2). Three typical types of off-grid service provision systems are described below (*Foley 1995; Fraunhofer 1995; World Bank 1996*).

## BOX 2: Technology Assessment for Village Power: Minigrids & Isolated Systems

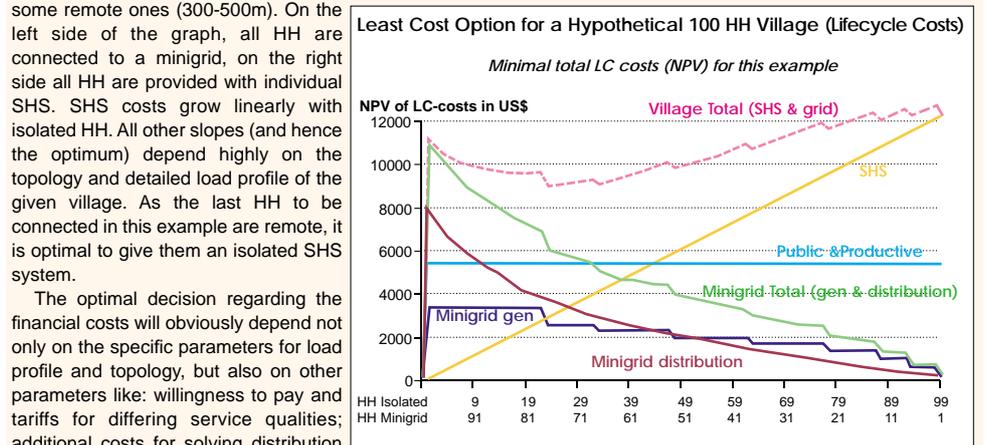
When is it least cost to connect some of the households in a rural village core by means of a minigrid, while providing the more dispersed households with SHS? In typical villages, the marginal generation costs of an additional household (HH) connected to the grid are negligible. Hence, the main trade-off is between the marginal distribution-line costs (e.g., \$5/m for low voltage (LV) line and posts plus \$100/HH for meter & installation) and the SHS costs (e.g., \$1000 net present value (NPV) per 50 Wp system) for a given HH consumption.

As a very rough rule of thumb, separate SHS (50 Wp) will generally be least cost for typical rural HH (e.g., 200 Wh/d consumption) which are more than 300m away from the next LV line. **The Figure below illustrates the dominating cost factors in a village power system.** For this example, a hypothetical 100 HH village with a load of 200 Wh/d/HH has been assumed for demonstration purposes, with mainly agglomerated HH (30 m distance) and some remote ones (300-500m).

**Solar Home System (SHS):** A SHS typically includes a photovoltaic (PV) module, a battery, a charge controller, wiring, fluorescent DC (direct current) lights, and outlets for other DC appliances. A standard small SHS can operate several lights, a black-and-white television, a radio or cassette player, and a small fan. A SHS can eliminate or reduce the need for candles, kerosene, liquid propane gas, and/or battery charging, and provide increased convenience and safety, improved indoor air quality, and a higher quality of light than kerosene lamps for reading. The size of the system (typically 10 to 100 Wp) determines the number of 'light-hours' or 'TV-hours' available. For example, a 35 Wp SHS provides enough power for four hours of lighting from four 7W lamps each evening, as well as several hours of television. There are more than 500,000 SHS now installed in rural areas of developing countries (Foley 1995; Cabraal et al. 1996 and 1998; Kammen 1999; Kapadia 1999; Loois and Hemert 1999).

**Water pumping** is a typical stand-alone rural productive use. Productive uses are of high interest because electricity may directly improve productivity, and thus income and welfare, which guarantees a high ability to pay. The pump is often located far from an existing grid. It is typically driven either directly by a windmill - rural best practice for many centuries - or by a diesel or PV generator. Which of these solutions is least cost depends on the specific type of water use (e.g. whether drip irrigation is possible). Water pumping is a specifically suited application for PV because sunshine in arid areas is often abundant and the storage of pumped water circumvents the high losses of batteries.

**Village minigrid:** Agglomerated consumers far from existing utility grids may be served by isolated minigrids. Because the distribution system is similar whether served by a central grid, a local diesel generator, a local renewable-energy source, or hybrid systems (RE with diesel back-up) these minigrids may be 'upgraded' in the future through grid



The optimal decision regarding the financial costs will obviously depend not only on the specific parameters for load profile and topology, but also on other parameters like: willingness to pay and tariffs for differing service qualities; additional costs for solving distribution and user satisfaction problems; consumption growth in a connected HH; decisions on minigrid generation technology; potential integration of a productive use into the minigrid; value assigned to optional future grid connection of minigrids; standardisation considerations of the service provider etc. A general recommendation for 'the optimal village power system' can hence not be given. Rural energy service providers and provincial tariff decisions will require tools for cost optimisation.

Minigrids may be more cost-effective than either fully decentralised SHS or fully centralised grid extensions (Cabraal et al 1998). However, technology cost comparisons of minigrids are difficult because minigrid lifecycle costs are often unknown to a large extent. This is due to several factors:

- Minigrid costs depend significantly on local conditions, for which information may be lacking (e.g., village topologies, load profiles, site dependent time series data for wind speeds or water flow).
- For many rural poor households, even very low levels service levels may be above their ability to pay, which makes it difficult to determine a willingness to pay at higher service levels where minigrids would have cost advantages.
- It is difficult to compare the cost and quality of energy service between isolated systems and minigrids.
- The management regime of energy demand in a minigrid has significant effects on specific energy costs.

connection (ESMAP 2000d). The capital costs for a low-voltage distribution line are typically around \$5 per meter and the costs of an electricity meter may be around \$100. The resource used for generating electricity will vary according to village load profile, availability of renewable resources, and fuel transportation costs. In most cases, either a diesel generator, a wind-diesel-hybrid, or a small hydropower plant will be least cost, depending on local conditions.

In choosing among these or other options, service providers, regulators, and/or rural households need the knowledge and tools to find the least-cost options (on a lifecycle basis) for a given level of service (see Box 2). The best options may also change over time and will continue to invite comparison with grid extension. For example, a local Energy Service Company (ESCO) may first provide a village with a minigrid solution. Over time, as demand grows, the ESCO may decide a grid extension has become

cost-effective and phase out generation. "Path dependence" can become a serious consideration as well, if "stranded assets" cannot be effectively redeployed elsewhere. The least cost decisions will not be taken on basis of the marginal costs of one isolated village, but have to be seen as part of the company's long term investment plans over its whole service area (Albouy 1983).

Energy demand, costs, and user satisfaction are particularly interwoven in the case of minigrids, making technology assessment difficult. Minigrids have the potential to 'shave peaks and dips' of consumption of individual users by means of the common grid and storage. However, matching demand with supply can be particularly tricky. Minigrids are sized according to estimated consumption. But once installed, no/low-fee users may boost their consumption, resulting in system failure or further expansion costs. Some installations have tried to solve this problem by oversizing

### Box 3: Market Development Fostered by UNDP/World Bank ESMAP

In the Comoros, a small island nation in the Indian Ocean, ESMAP (The UNDP/World Bank Energy Sector Management Assistance Programme) assisted the Government to identify an international consortium through a tender to locally develop the market for solar equipment. The Government granted the firm a three-year grace period for taxes and duties: it could freely import equipment, and it had the right to export earnings free of taxes. The Government also pledged that it would grant the firm contracts for all public projects dealing with solar energy during the period when/if these happened to materialise. Finally, to support the activity the Government launched an awareness campaign to promote, in general, the use of solar energy in areas not served by the national electricity grid. The firm credits ESMAP with its decision to enter the market. Similar projects are underway in Swaziland and Bolivia (ESMAP 2000a).

systems (which brings the costs up) and/or sharply restricting the consumption per user (which brings the user satisfaction down). More modern approaches try to solve the dilemma with intelligent meters (energy dispensers) which limit both kWp and kWh and allow storage to a certain extent as well as tariffs reflecting the marginal costs.

#### Current World Bank Group Off-grid Rural Electrification Programs

The World Bank Group is currently implementing or preparing a number of projects with off-grid rural electrification components. Many of these are testing new project design approaches for the first time. The basic components of this new

projects in the Bank Group's portfolio include amongst others the India and Indonesia Solar Home System projects, the Solar Development Group (SDG, see Box 4), the International Finance Corporation (IFC) -administered PVMTI (Photovoltaic Markets Transformation Initiative), the Argentina PERMER (see Covarrubias and Reiche 2000), the Uganda and Sri Lanka rural electrification projects, a number of small loans to PV companies carried out by the IFC/GEF (Global Environment Facility) SME (Small and Medium Scale Enterprise) Program and a number of innovative ESMAP projects (see Box 3 and ESMAP 1998 for examples).

Markets will only be sustainable if they allow private firms to make profit beyond the short term. As the ability to pay of rural poor is low and long-term off-grid service costs are unknown, market entry in rural off-grid markets is still considered high risk. This requires identifying well balanced public private partnership mechanisms that will allow private-sector service delivery companies to build their business to the specific requirements of each local market. How to balance maximum private sector participation with minimal subsidies is a main challenge for new rural service delivery mechanisms.

These new service delivery mechanisms may involve rural ESCOs (with concessions or licenses), equipment dealers (selling or leasing systems), or cooperatives – a whole variety of new business models are emerging. As a large fraction of the service costs are transaction costs (Maintenance & Operation (M&O), fee collection, marketing), the value added in the target region may be high on the supply side, benefiting local SME. SME may in fact profit from rural renewable electrification projects in two ways: on the supply side (service delivery chain) and on the demand side (rural industries, productive uses). Successful rural electrification projects will have to develop viable business plans for both sides. The main types of emerging service delivery mechanisms are (taken from Jechoutek 2000):

#### “Decentralised virtual utilities”.

Operating on the same principle of “fee for service” as traditional utilities, these enterprises rely on dispersed technology such as SHS, which are placed at consumers' premises and charged for in fixed monthly payments, or through pre-paid cards. South Africa is pioneering this concept, in partnership with international energy players.

**Local electricity retailers.** Small local businesses or cooperatives establish an electricity retail business, either off-grid as an isolated system, or connected to the grid and buying in bulk. Isolated systems have the choice of technology that is best suited to the location – fossil, small hydro, other renewable energy, or a hybrid. Grid-connected retailers either establish a new local distribution system on the basis of a substation delivery point, or lease an existing one. The common denominator is the ability to prepare a sound business plan to obtain credit financing, or the backing of a stronger partner. India is moving ahead with such “independent rural power producers (IRPP)”, a small version of IPPs contracting with local communities.

**Energy equipment dealers.** Renewable energy technologies such as solar and wind, and other small-scale distributed energy sources lend themselves to being sold by local dealer networks that penetrate into remote and low-income areas. A World Bank-supported project in Indonesia used the national banking system as a channel for credit financing of small dealers in household solar systems. A key feature of establishing effective dealer networks is the creation of a financing infrastructure that enables dealers to extend retail credit to their off-grid customers. Unfortunately, the Indonesia project has not been implemented because of that country's macroeconomic crisis.

**Creative concessions.** The example of Argentina (see Box 6) illustrates that the process to invite bidders for concessions to supply electricity in remote provinces

generation of projects are similar: Their goal is to help build sustainable local markets that will persist beyond the development assistance phase, which helped initiate them. The technologies involved are well proven - so the need for studies and one-off demonstration projects has passed. Now projects help to overcome existing market barriers, on both the **demand side** (e.g., awareness, training, local ownership) and the **supply side** (e.g., business development services, market surveys, databases on renewable energy resource availability), with new **financing** schemes (e.g., microfinance, consumer credit, and revolving funds) and **institution** building (e.g., government, regulators, quality assurance and certification institutions).

Examples for recent rural off-grid



Jujuy, Argentina:  
Testing efficient light bulbs in an off-grid rural school

### Box 4: IFC Financing for Private-Sector PV Businesses in Developing Countries

The World Bank Group (World Bank and IFC), with the assistance of the Global Environment Facility (GEF), has sought to finance the accelerated dissemination of PV technology in the developing world through a number of projects that target the private sector. Strategies have continued to evolve, starting with the first project in India in 1992. More recently, the Bank Group has recognised that greater support should go directly to entrepreneurs and other potential private sector developers of the rural PV market (including NGOs and financial intermediaries).

In particular, the IFC has been providing financing and business services to private sector firms to accelerate the commercialisation and financial viability of PV technology. This began with the Small and Medium Scale Enterprise Program (SME), in which financing is preceded by technical assistance. By 2000, the SME program was financing PV businesses in Bangladesh, Dominican Republic, and Vietnam. Also by 2000, the PV Market Transformation Initiative (PVMTI) began to provide concessional loans and business assistance to PV distribution enterprises in India, Kenya and Morocco. Most recently, drawing on the experience of successful SME investing, the World Bank and IFC, along with a number of charitable foundations, have developed the Solar Development Group (SDG). Like PVMTI, SDG finances small PV enterprises in developing countries and provides business advisory services.

can be tailored to include creative elements of rural service expansion, introduction of renewable energy, and minimisation of subsidies. Several ESMAP projects invite private companies to tender for time bound rights to develop the market in a specific area. The winning bidder is then provided incentives for doing so (Box 3).

Historically, rural electrification projects have often been technology driven: they either provided access exclusively through grid-extension, or exclusively with diesel-minigrids, or exclusively with SHS. The World Bank has tried to make its current generation of projects more technology neutral - to answer a specific local demand for energy service, private sector players are free to choose the technology suited best for a given village or productive use on a least cost basis. Such a technology-neutral approach requires a greater emphasis on the tools and planning skills needed to find least-cost solutions to rural needs.

#### Rural Electricity Services from Solar Home Systems

Solar home systems (SHS) are one of the main alternatives to grid-based rural electrification currently being pursued by the World Bank Group. Twelve approved World Bank Group projects provide basic energy services to rural households through the use of SHS and more such projects are in preparation. These projects are designed to develop markets for SHS and to overcome the key barriers to their widespread and accelerated dissemination. In all projects, demonstration of a viable business model, whether public or private, is key to achieving project sustainability and replication. For commercial firms, profit is the measure of viability. For non-profit organisations or public firms (i.e., public utilities), ongoing subsidies may be part of the business model based on public objectives (i.e., rural development). Other challenges are to demonstrate regulatory models for energy-service concessions and to integrate rural electrification policy with solar-home-system delivery (*Martinot and McDoom 1999; Martinot et al. 2000*).

Below are six key features of these projects, along with emerging lessons from early implementation experience. Projects take different approaches to incorporating these features and are essentially experimental because there simply isn't enough accumulated experience yet from any institution, government, or firm to provide definitive answers about the best approaches.

**1. Pilot private-sector & NGO delivery models.** Projects employ two basic models for delivery of solar home systems: "dealer sales" and "energy-service company." A dealer-sales model means that a dealer purchases systems or components from manufacturers and sells them directly to households, usually as an installed system, and sometimes on credit. The household owns and is responsible for servicing the system, although the dealer may provide service contracts or guarantees. The dealer sales model is being employed in Bangladesh, China, Indonesia, India, Kenya, Sri Lanka, and Vietnam. An energy-service-company (ESCO) model means that the ESCO owns the system, charges a monthly fee to the household, and is responsible for service. The ESCO may be a monopoly concession regulated by the government to serve specific geographic regions, or it may operate competitively without any explicit monopoly status.

Lessons from early experience suggest that solar-home-system delivery firms face a myriad of difficulties operating in rural areas. These low-margin firms must develop good business models and need flexibility from projects in doing so. Firms with rural experience and/or distribution infrastructure will do better. Most will benefit from training and support in obtaining business finance and other business skills. And indirectly, projects can attract other potential distribution channels into the solar PV business (e.g., existing retailers of other goods or providers of other rural services).

**2. Pilot consumer credit delivery mechanisms.** For dealer sales, consumer credit makes systems more affordable to rural households. Market studies have

revealed that rural households not connected to rural electricity grids typically pay \$3 to \$15 per month for energy, in the form of candles, kerosene, battery charging and disposable batteries (*van der Plas and Hankins 1998, GEF 1998a, 1998b, 1998c*). In a fee-for-service arrangement, monthly fees can be made competitive with these expenditures. But dealer sales must overcome the "first-cost barrier" (the high initial system cost relative to conventional alternatives) and provide a means whereby households can continue to pay amounts roughly equivalent to their conventional energy purchases. Long-term consumer credit is one way to do this. Consumer credit is provided through three primary mechanisms in World Bank Group/GEF projects: dealer-extended credit, credit through a microfinance organisation, and credit through a local development finance institution (Box 5).

Lessons from early experience suggest that credit risk is a serious concern of both financiers and dealers and makes credit sales particularly challenging. Dealers are reluctant to extend credit to rural customers with little credit history, and credit administration and collections may be costly. Local financiers need to take some commercial risk to increase project sustainability but have the same concerns. Partial credit guarantee schemes, microfinance lending, and partnering promise viable models to reduce risks. Longer credit terms stimulate demand by poorer households but increase risks. In general, projects should allow dealers flexibility to innovate new payment mechanisms to make systems more affordable.

**3. Pay first-cost subsidies and offer affordable system size.** Some projects incorporate per-system subsidies to make systems more affordable and to reduce initial and/or monthly payments by households. Subsidies are used in different ways in different projects; for example, in Sri Lanka, the microfinance organisation providing consumer credit reduces the amount of each monthly credit repayment by a share of the per-system

### Box 5: Consumer Credit Models in World Bank Group/GEF projects

In Bangladesh, a non-profit dealer, Grameen Shakti, demonstrates an initially successful application of dealer-extended credit using a loan from the IFC/GEF SME Program. However, Grameen Shakti's credit terms and customers are different from traditional Grameen Bank microfinance terms and customers. Grameen Bank members can receive small micro-enterprise loans for income-generation purposes repeatable on an annual basis. In contrast, Grameen Shakti provides larger, one-time loans for purchase of a consumer durable for terms up to three years.

Dealer-extended credit was tried early in a Sri Lanka project but soon rejected. Dealers found collections too difficult and time consuming. Building a rural service infrastructure with technicians is a different business from building a rural credit delivery and collection infrastructure, said the dealers. Instead, they turned to microfinance organisations for extending consumer credit. Micro-financing of SHS was accelerating in 1999 and appeared promising. Sri Lanka has a long history of rural microfinance, which has greatly helped the viability of the microfinance model there.

In Vietnam, dealer sales are assisted by a consumer credit scheme involving a private SHS company, SELCO (Solar Electric Light Company), the Vietnam Women's Union (an NGO), and the Vietnam Bank for Agriculture and Rural Development, a development finance institution using a loan from the IFC/GEF SME Program.

Source: Martinot et al. 2000

subsidy (which is \$100). Some projects offer fixed grants while others provide grant amounts that decline for installations made during later years of the project. For example, in Argentina the energy-service concessions are given a variable grant amount (a one-time payment for each system installed) which declines for installations made in later years of the project and also depends upon system size. Some projects also allow system sizes smaller than traditional 50-100 Wp sizes, such as 30 Wp or even 10 Wp systems, or simpler components to improve affordability.

Lessons from early experience suggest that customers desire a range of component options and service levels and can benefit from even small systems. Even with subsidies and smaller systems, customers in early market phases may still be limited to the wealthiest rural households. Delivery models that allow households to purchase small systems initially and "trade up" or expand these systems are another way to increase affordability (this has been happening in Kenya).

**4. Support policy development and capacity.** Projects can support or influence policy in several ways. For projects using the energy-service concession model, technical assistance to national regulatory agencies helps with concession bidding and contracting, training of agency staff, and monitoring and regulation of concessions. Projects may also indirectly or directly influence government planning and policy related to rural electrification. For example, the Sri Lanka project has encouraged the national electric utility and the government to more explicitly recognise and incorporate SHS into rural electrification planning. Also, reduced import duties on PV components can

remove market distortions and make SHS more affordable for rural households.

Lessons from early experience suggest that concession tariff-setting, bidding and regulation present numerous challenges and require substantial time and resources. Projects must recognise the link between rural electric-grid extension and SHS demand; customers' perceptions of future rural electric grid extensions, whether based upon concrete government plans or merely unrealistic political promises, can limit demand for SHS. Thus clear, open and realistic rural electrification policies can help create and/or stabilise market demand. All else being equal, consumers are going to prefer being connected to the grid rather than receiving energy services from a SHS. But there is added value from SHS if customers have to wait some years for the grid to arrive.

**5. Develop codes and standards and establish certification, testing, and enforcement institutions.** Poor-quality equipment and installation and exaggerated performance claims hurt markets. Most projects develop or establish equipment standards and create or strengthen certification and testing institutions to ensure quality, safety and long-term reliability. Enforcement of standards, including associated institutional capacity, and domestic certification and testing agencies are also important. Few technical problems have been encountered with PV systems in World Bank Group projects. Lessons from early experience suggest that establishing reasonable equipment standards and certification procedures for SHS components that ensure quality service while maintaining affordability is not difficult. Projects should allow some flexibility in standards to enable dealers to meet them. Standards should be set to promote consumer satisfaction and thus

a sustainable market but not excessively stifle the market.

**6. Conduct consumer awareness and marketing programs.** Most projects conduct some type of consumer awareness and marketing program and may also conduct detailed market surveys. For example, in Argentina, provincial governments assist concessions by preparing detailed market studies, conducting information dissemination workshops, and preparing studies on how to improve the availability of DC appliances compatible with SHS in dispersed rural areas. Lessons from early experience suggest that marketing campaigns can be extremely costly and time consuming in rural areas, often requiring door-to-door and direct contact. Simple consumer awareness is usually insufficient by itself. Dealers benefit from marketing assistance in early phases of new market development until a "critical mass" of customers develops that makes marketing easier.

#### Rural Energy Service Concessions: A Promising Service Delivery Mechanism

One new model for rural off-grid electrification that has received growing international attention during the last two years is the off-grid concession model. Concession/regulation type approaches to rural electrification are currently being tested in South Africa, and by the World Bank in Argentina, Benin, Bolivia, Cape Verde, and Togo (Martinot et al 2000; Martinot and Reiche 1999). While other service delivery models allow for competition in the market (licenses, dealership), concession models only allow a limited number of bidders to compete for an exclusive right to serve the market. There are several rationales for taking such a step away from the optimal efficiency in a free market, an important one being the

high risk involved with the new business situation of off-grid rural electrification with markets and costs not known yet, long pay back times against investment requirements and returns that may be relatively low. Compared to a competitive market with private dealers, the basic potential advantages of the concession approach in the Argentine rural electrification project PERMER were seen to be (*World Bank 1999a*):

- creates a market of sufficient “critical mass” for commercially sustainable business by granting exclusive rights over a large geographic area;
- attracts larger, better organised private companies with their own sources of financing;
- permits easier administration and regulation;
- brings better chances of covering a large number of customers in a few years;
- involves good potential for reducing unit costs of equipment (through volume discounts), transactions, operation and maintenance (through economies of scale) and reduced per-unit overhead costs; and
- ensures service to the consumer over a long period (i.e., 15-year contract life of the concession).

As experience with rural energy service concessions is so far limited, there still is a long way to go in the evolution of best practices and understanding of which local conditions favour a concession approach. In some circumstances concessions may be problematic, especially since the regulatory, institutional, and financing challenges of concessions are usually formidable. Some of the key regulatory and contracting issues involved in creating concessions are described below. Many of these issues are being understood and confronted in the World Bank/GEF PERMER project in Argentina (see Box 6).

- **Terms of concessions and mechanisms for terminating concessions.** The design of incentives and risk allocation in a concession contract will affect first the

### Box 6: Off-Grid Electricity Concessions: The World Bank/GEF PERMER Project in Argentina

Argentina has made great progress thus far in its efforts to reform and privatise the power sector. While it has a relatively high overall rate of electrification (95%), substantial numbers of the rural population still remain without either electricity services (30%) or other basic infrastructure. In 1995 the Argentine Secretaría de Energía (SE) created the *Programa de Abastecimiento Eléctrico a la Población Rural de Argentina* (PAEPRA) for the provision of off-grid electricity to the dispersed rural population and to provincial public services such as schools, police stations and health centers. This program aims at ensuring electricity supply to a rural population of about 1.4 people million living in 314,000 households and 6,000 public services distributed in 16 provinces, which are distant from the power distribution grids.

The Argentine government and the World Bank are implementing the PERMER project (*Proyecto de Energía Renovable en el Mercado Eléctrico Rural*) as a component of PAEPRA in eight participant provinces (*World Bank 1999a*). PERMER aims at providing electricity for lighting and social communication (radio and TV) to about 70,000 rural households and 1,100 provincial public service institutions through eight private concessionaires using mainly renewable energy systems. The estimated total costs of PERMER are US\$120.5 million which will be financed by the Bank (US\$30 million loan), the GEF (US\$10 million grant), the Electricity Investment Development Fund FEDEI (US\$26.5 million subsidy to customers), the concessionaires (US\$44 million) and the customers (US\$10 million), over an implementation period of six years (GEF, 1998a).

In PAEPRA and PERMER, a concession approach has been chosen for rural electrification, mainly because of the country's ample experience with concessions for the provision of infrastructure services (e.g., telecommunications, water). The concessionaire obtains the monopoly of a given province in turn for the obligation to connect the service when requested by the customers, and to maintain its continuity over the duration of the concession. The concession contracts are tailored to the condition prevailing in each particular province and awarded through a competitive bidding process that minimises subsidies. Concessions are eligible to re-bid for their business every 15 years up to a total of 45 years, competitively against other eligible firms. Tariffs are renegotiated every 2 years. The financial rate of return to be obtained by the concessionaires has been estimated to be close to 14%.

Average willingness to pay in the PERMER target provinces for basic lighting and communication varies between \$10 and \$20 per month. A household with a typical 50 Wp SHS might expect to pay \$8-10 per month and receive perhaps 3 kWh monthly, enough for lighting and television for a few hours each day (see Table 1). The household might pay 10% of the initial installation cost of \$800, and be expected to pay 40% of the system lifecycle cost (\$1,400 including maintenance and battery costs - see Table 2) over the 15-year life of the system - with the remaining 50% of the lifecycle cost covered by government subsidies.

The province of Jujuy is one of the first in which PERMER began implementation. Here, the world's first and most advanced rural off-grid concessionaire began providing rural-off-grid electricity services in 1995. By 1999 this concessionaire had furnished 556 additional rural households and 43 additional schools with individual SHS of different sizes, now serving a total of 3,050 rural customers, 1,333 of these with individual or collective PV systems.



The wind generator of a hybrid-minigrid in rural Chubut, Argentina

intensity of competition and then the sustainability of the original contract (*Klein 1998a*). Regulatory frameworks need to assure that the phasing out of the concession will not be hindered by the responsible local regulatory or other interested parties whose function or business would be eliminated or curtailed with the end of the concession. Could

licenses instead of monopolies make sense in some cases?

- **Bidding process design, competition, negotiation, and re-bidding.** Formal competitive bidding takes time, is costly, and may discourage innovation. Negotiated contracts may be much quicker but more costly and be less politically acceptable (*Klein 1998b*). Many

**Table 1: Rural Households' Income Distribution & Expenditure in Energy**

Rural households expend a significant part of income in energy for lighting and communications – values for the PERMER province Jujuy

INCOME DISTRIBUTION & EXPENDITURE IN ENERGY	Population Segment	Monthly expenditure in energy	
	Percentage	Amount	Percentage
Monthly income category			
Low income: less than \$150	42%	\$9/month	> 6%
Low to medium income: between \$150-250	31%	\$15/month	6% - 10%
Medium to high income: between \$250-400	17%	\$18/month	5% - 7%
High income: more than \$400	10%	\$21/month	< 5%

Source: World Bank 1999a

**Table 2: Initial Installation Costs of Solar Home Systems**

The initial installation costs of Solar Home Systems (SHS) in PERMER 1999.

SHS size	Initial installation cost	Lifetime O&M cost	Lifetime battery cost	Lifetime total cost	Monthly recovery cost
50 Wp	764	390	216	1370	16.8
70 Wp	1074	390	299	1763	23.1
100 Wp	1347	390	418	2155	26.7

Source: World Bank 1999a

Note: assumed are: 14% concessionaire's return on investment, 15 year SHS life, battery replacement every 3 years, O&M, controller replacement every 7 years.

other decisions about how to structure a competitive bidding process can greatly affect the outcome (Klein 1998c). For long-term concession contracts, re-negotiation can diminish the importance of initial competitive bidding and affect costs. If concession contracts are subject to periodic re-bidding, then service adjustments (costs, prices, etc.) can be made competitively and continued competition may decrease the need for price regulation. (Klein 1998d). Should existing rural service experience be a precondition for bidding? How to select between bidders offering different quality of energy service? How to ensure that enough capable bidders will bid for a concession contract? Would a standard bidding document help attract investors to rural electrification, as seen in the case of IPP solicitations?

- **Regulatory agency performance.** Regulation of concessions is quite different from traditional regulatory practices for state-owned electric utilities. Where utilities have been privatised and new regulatory mechanisms established, new regulatory skills will be needed for rural energy concessions. Among the biggest challenges in regulatory design are achieving political independence and introducing rules to ensure accountability (Estache 1997).

- **Bundling of rural services.** Delivery of services to rural populations is expensive

mainly due to the costly customer contacts. One way to reduce the high transaction costs may be to bundle energy services with other services in demand to profit from economies of scope (e.g. water, communications, financial services, or consumer electronics sales and service). In addition, bundling of services may increase the development impacts in a more than linear relationship (see Box 1). When does unbundling of the vertical service delivery chain make sense?

- **Capacity building.** What specific types of capacity building do concessionaires, regulators, government and end-users need? Concessionaires and regulatory agencies will need the knowledge and appropriate tools to find the least cost solution for each individual village. They will have to address questions like: Should the choice of service levels and technologies be regulated at all? Which energy service levels should be offered? How can energy service quality be assured, verified and be guaranteed in contracts? How to get system users to feel ownership?

### Subsidies for Rural Electrification

How to maximize private sector investment and minimize subsidies for rural electrification is a key issue in developing a sustainable rural electrification market. Very often, subsidies are applied if a

government decides to reach the poorest segments of rural population (see income pyramid in Figure 1). In these cases, it is crucial to design subsidies with careful attention to the danger of market distortion (see Table 3).

One of the reasons for energy sector reform is to increase sector efficiency. Existing subsidies may already distort markets away from an optimal allocation of resources. Additional subsidies for rural electrification would seem to further such distortion. Yet a purely private-sector driven energy sector may not provide improved access for the rural poor due to market imperfections. The incentives for private sector to enter this high-risk, low-return, long-term return market seem to be insufficient. If service provision for the rural poor is high on a country's development agenda, additional incentives are necessary to overcome these market imperfections and achieve greater equity. How should such subsidies be structured to minimize further distortion? There is no easy recipe, but some important factors are known:

- **A "level playing field":** Existing energy subsidies often distort markets because they are poorly designed, poorly administered or simply outdated. Examples abound (Barnes and Halpern 2000). These subsidies frequently hamper rural electrification. Outdated import duties may have the same effect. A first step to facilitate expansion of rural access as part of an energy sector reform should always be to revise the existing energy policy framework and minimize existing subsidies (compare Figure 2 from Barnes and Halpern 2000).

- **Targeting:** Subsidies targeted at the rural poor often do not reach them at all. Direct fuel subsidies for example, often only reach better-off consumers instead of rural poor because companies will prefer to sell limited fuel resources in urban areas with low transaction costs and in higher quantities. Lifeline rates for service expansion seem to offer a better way to reach rural poor (Barnes and Halpern 2000). In the Argentine PERMER

Figure 1 & 2:

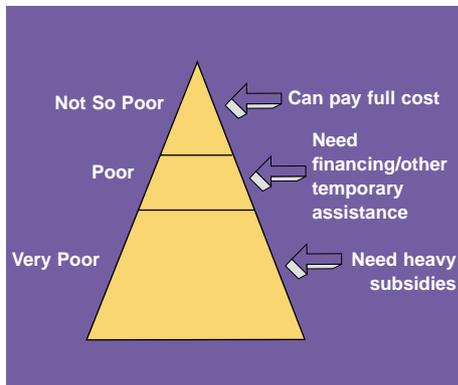


Figure 1. If Governments decide to serve the poorer segments of rural population, there may be the need for subsidies.

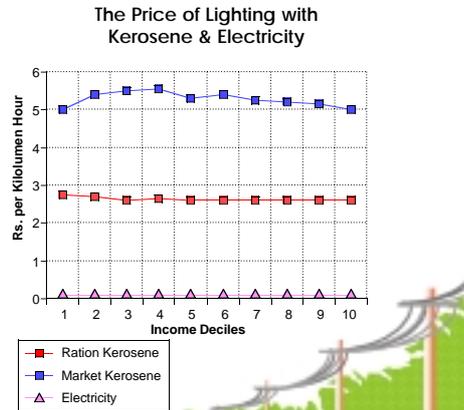


Figure 2. Due to the higher efficiency of electric light bulbs as compared to the kerosene lamps used in India, the real cost of energy service in \$ per kilolumen is much lower for electricity than for subsidised kerosene.

systems have taken hold of a market, it may be difficult or impossible for ordinary businesses to operate profitably. Rather, business development costs (like marketing, distribution infrastructure and training) should be subsidised instead of hardware because these long-term costs are the crucial barrier in rural areas. Examples for characteristics of development assistance aimed at long term market development are given in the above section on SHS.

**Exit Strategy:** A crucial feature of any subsidy design is a viable exit strategy over time (see Barnes and Halpern 2000 for an example of a rural electrification subsidy in India that outlived its usefulness). The Global Environment Facility (GEF) justifies subsidies for SHS projects on the basis that cost reductions are expected over the life of the project due to several factors, so that markets become commercially viable and subsidies are no longer needed (Martinot et al 2000). Examples of these factors include larger market volume and increased competition, refinement of procurement methods and bulk purchasing; economies of scale in sales and service networks and assembly of balance-of-system, and improved quality and acceptance of the new technology.

Nevertheless, the experience in Kenya, where an estimated 80,000 households had solar PV systems in 1999 and growth has been 10-18% annually, shows that in specific "pockets of opportunity" the private-sector can achieve substantial market penetration without much support from subsidies (although training and performance standards are still important components of market facilitation there). In Kenya, most households have purchased systems for cash, and a thriving market has emerged, including smaller systems of 12Wp. A "modular system of buying" has emerged where households can invest small sums in modest systems and upgrade as income allows. After ten years, the commercial market had reached about one percent of rural households (van der Plas and Hankins 1998, Kammen 1999).

Table 3: Hierarchy of Market Interventions

Priority Level	Type of Project	Type of Intervention
Highest priority (closest to commercial viability)	Projects expected to have commercially viable returns and risks once they are funded but which have higher-than-usual development costs.	Concessional funding is provided for project development only, not for financing.
Medium priority	Projects expected to have commercially viable returns but above-market risks (and possibly higher-than-usual project development costs).	Concessional financing is provided on a contingent basis only to address risks (and possibly for project development).
Lowest priority (farthest from commercial viability)	Projects expected to have below-market returns (risks can be at or above market levels).	Concessional financing is used only if future generations of technology and/or operating practices are expected to become commercially viable and then only on a limited and targeted basis.

Increasing Caution

Source: Boorstin 2000

project for example, a minimum rural household electricity consumption of about 10 kWh per month is subsidised, while higher service levels don't receive subsidies. Similar subsidies for rural low consumption households are given in Chile (Jadresic 2000) and Thailand (Tuntivate and Barnes 1997).

**Participation of beneficiaries:** To allocate tight development resources efficiently, the optimal combination of services has to be identified on a local basis. Some projects let each rural community decide on which type of infrastructure to spend their part of a

development budget. Taking part in the decision process creates ownership.

**Market development instead of hardware subsidies:** Subsidies should have the long-term target to build a market for private sector players. Simple hardware subsidy or give-away programs, all too common in many historical bilateral assistance programs, may harm the market in many ways. Once announced, the market becomes depressed because user will delay purchases until subsidies begin. During program implementation, free riders may profit while others won't get a system at all. Once cheap or free

## Conclusions

Reforming power sectors in developing countries requires finding solutions for extending service gradually to the estimated 2 billion people currently without access to electricity. For those remote rural low consumption energy uses (households, productive and public uses) which will not be served by the grid in the next decade, off-grid technologies may provide a solution. This chapter has presented design issues from current Bank Group (World Bank and IFC) projects which aim at exploring this potential. The common target of all these projects is to develop sustainable local markets for off-grid service provision, which will outlast the funding. This requires innovative solutions for **demand side, supply side,**

## financing and institutional strengthening.

On the **demand side**, off-grid rural electrification programs will only work if they maximize the local content. The more that local communities are integrated into the decision making process and the more ownership they develop, the more sustainable the project will be. Awareness and training for local retailers, operators and fee collectors are needed to keep rural lights shining for twenty years.

The main emerging business models on the **supply side** are: Equipment dealers (leasing or cash sales) wherever the market is ready for this on demand and supply side - and rural energy service companies (ESCOS) either working with licenses or concessions. The Argentine

rural concessionaire EJSDSA is pioneering this type of service provision. Their most pressing question today is how to assure and verify energy service quality in remote off-grid uses.

Because of the high up-front costs of most rural electrification options and the low cash capacity of rural households, innovative small scale **financing** must be provided. Micro credit, leasing and pre-paid meters for fee-for-service provision seem to be the most promising options. Projects may have to include the use of subsidies if governments decide they want to reach the poorest segments of population. If so, these have to be well targeted and designed with "eyes wide open" to the inherent danger of market distortion. How to design well balanced public private partnerships with maximum private sector participation and minimum subsidies is a crucial question for rural electrification.

On the **institutional level** it is important to first "level the playing field" by reducing distorting subsidies and improving the dialogue between the stakeholders. Local regulation and certification capacity is crucial, as is awareness of policy makers of energy service demand and technology options.

While the issues at hand are known today, not many rural off-grid programs have actually been implemented, so that success stories and lessons learned are still scarce. For rural off-grid markets to take off, more examples of viable business models would be the best fuel ■

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