WORLD BANK SOLAR HOME SYSTEMS PROJECTS: EXPERIENCES AND LESSONS LEARNED 1993-2000

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ABSTRACT

Twelve projects provide energy services to off-grid rural households in developing countries by enhancing markets for solar home systems and by removing barriers to their dissemination. Project approaches are reviewed, along with early implementation experience and lessons suggested by experience. Projects pilot private-sector and NGO delivery models; pilot consumer credit delivery mechanisms; pay first-cost subsidies and offer affordable system sizes; support policy development and capacity; develop codes and standards and establish certification, testing, and enforcement institutions; and conduct consumer awareness and marketing programs. Most projects are just beginning implementation; a few are almost completed. Challenges are to demonstrate sustainable and replicable business models, demonstrate regulatory models for energy-service concessions, and integrate rural electrification policy with solar-home-system delivery.

INTRODUCTION

Twelve World Bank Group projects provide basic "energy services" such as lighting, radio, television, and operation of small appliances to rural households without access to electricity grids through the use of solar home systems (Table 1). A solar home system consists of a photovoltaic (PV) solar panel, a storage battery, a battery charging controller, and various end-use equipment like florescent lamps. Solar home systems can eliminate or reduce the need for candles, kerosene, LPG, and/or battery charging, and provide increased convenience and safety, improved indoor air quality, a higher quality of light than kerosene lamps for reading, and reduced CO2 emissions (Foley 1995; Cabraal et al. 1996 and 1998; Kammen 1999; Kapadia 1999; Loois and Hemert 1999).

Solar home systems are also an alternative to grid-based rural electrification. In the early 1990s, the World Bank recognized that solar-home-system technology was maturing, costs were declining, and commercial markets were developing. At the same time, population growth was outpacing the ability of electric utilities to extend rural electricity grids and developing countries were increasingly recognizing the economic difficulties of achieving full grid-based rural electrification. The World Bank and many governments began to perceive that solar home systems could provide least-cost rural electrification and could supplement grid-based electrification policies (World Bank 1996).

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These twelve projects are designed to develop markets for solar home systems and to overcome the key barriers to their widespread and accelerated dissemination.[2] The elements of a sustainable rural PV market include customer satisfaction, affordability, dealer profitability, and effective supply and service chains. 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 organizations or public firms (i.e., public utilities), ongoing subsidies may be part of the business model based on public objectives (e.g., rural electrification and development).

Projects are being financed either by the World Bank or by the International Finance Corporation (IFC)—the Bank's private-sector affiliate—and all are receiving support from the Global Environment Facility (GEF). This paper reviews key features of these projects, experience from early implementation, and emerging lessons applicable to future project design and evaluation (Martinot 1998; Martinot and McDoom 1999).

Projects incorporate a combination of six basic features that are discussed in the following sections (see Table 2). Each project feature is intended to overcome a specific set of barriers. 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 AND 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, 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 (as in Argentina, Benin, and Togo), or it may operate competitively without any explicit monopoly status (as in the Dominican Republic and India).

With dealer sales, qualified dealers receive project support in the form of business finance, capacity building, and/or marketing assistance. For example, in Sri Lanka, private dealers and non-governmental organizations (NGOs) are borrowing from commercial financiers participating in the project. In China, the project will help dealers to improve system quality (through cost-sharing of design, testing and certification), market their products, and provide after-sales service. The IFC/GEF Small and Medium Scale Enterprise Program is providing business financing for solar home systems businesses in Bangladesh, the Dominican Republic and Vietnam.

With energy-service concessions, projects also develop regulatory frameworks and concession selection/bidding procedures. For example, in Argentina, the government is exploring how best to regulate concessions, and the project is helping to address tariff structures (including tariff levels, government subsidies, negotiation procedures, and how often tariffs are reviewed and renegotiated) and the question of how to regulate the quality of services provided to customers.

[2] Some of these projects target other applications of PV and have other development objectives besides those for solar home systems.

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 many 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 (GEF 1998a, 1998b, 1998c). These surveys have revealed a household willingness to pay for energy to meet the end-uses valued most. 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 organization, and credit through a local development finance institution. The Bangladesh SME subproject demonstrates an initially successful application of the dealer credit model. The (non-profit) dealer, Grameen Shakti, performs marketing, sales, service, credit provision, collections, and guarantees. However, Grameen Shakti's credit terms and customers are different from traditional Grameen Bank microfinance terms and customers. Grameen Bank members can receive small, repeatable microenterprise loans, for income-generation purposes only, for terms up to one year. In contrast, Grameen Shakti provides larger, one-time loans for purchase of a consumer durable (solar home system), for terms up to three years.

Dealer credit was tried early in the 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 organizations for extending consumer credit, with one national microfinance organization participating so far in the project. Customers purchase solar home systems from the dealers, who are responsible for marketing, sales, and after-sales service, while the microfinance organization is responsible for credit and collections. Microfinancing of solar home systems 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 India, consumer credit through commercial firms has been problematic because of credit risk concerns. In Vietnam, however, dealer sales are successfully being assisted by a consumer credit scheme involving the Vietnam Women's Union, an NGO, and the Vietnam Bank for Agriculture and Rural Development, a development finance institution.

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 SIZES

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 organization providing consumer credit reduces the amount of each monthly credit repayment by a share of the per-system 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 China, a fixed cash grant equal to $1.50/Wp of installed capacity is paid directly to the dealer. In Argentina, the ESCO 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. The grants decline gradually to zero by the end of the five-year project.

Some projects also allow smaller system sizes or simpler components to improve affordability. Early projects specified a minimum system size of 50 Wp but more recent ones, for example in Sri Lanka and China, allow smaller system sizes. Most sales in Sri Lanka have been of 32 Wp systems (selling for about $450). In China, systems as small as 10 Wp are allowed as long as components meet the relevant standards. Sales of 50 Wp systems predominate in Bangladesh, where the dealer has been able to achieve very low system costs of roughly $500 for a 50 Wp system because of cheaper domestically produced components and favorably-priced PV module purchases.

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.

4. SUPPORT POLICY DEVELOPMENT AND CAPACITY

Projects can support or influence policy in several ways:

Regulatory assistance for concessions. For projects using the ESCO concession model, technical assistance to national regulatory agencies is also included for concession bidding and contracting, training of agency staff, and monitoring and regulation of concessions. In Argentina, sustainability is enhanced by strengthening provincial regulatory functions and institutions and appropriate incentives and returns for the concessions.

Rural grid extension planning and policy. Projects indirectly or directly influence government planning and policy related to rural electrification. For example, in Sri Lanka, the project has encouraged the national electric utility and the government to more explicitly recognize and incorporate solar home systems into rural electrification planning, and to recognize that unrealistic political promises and uncoordinated grid extension harm the market for solar home systems.

Industry participation in policy and planning. In Sri Lanka**,** a project workshop led to the creation of a solar energy industries association. In part this association formed to act as a unified voice for companies to interact with the World Bank, the government, and the national electric utility on project matters and rural electrification policy and planning.

Import duties. Reduced import duties on PV components can remove market distortions and make solar home systems more affordable for rural households. In China**,** import duties were eliminated for PV components in conjunction with China's policy that all government-approved renewable energy projects can import materials duty free (although most components are expected to be produced domestically because China has a large PV industry). Duties were also reduced from 30% to 10% in Sri Lanka.

Lessons from early experience suggest that concession tariff-setting, bidding and regulation present numerous challenges and require substantial time and resources. Projects must recognize the link between rural electric-grid extension and solar home system demand; customers' perceptions of future rural electric grid extensions, whether based upon concrete government plans or merely unrealistic political promises, can limit demand for solar home systems. Thus clear, open and realistic rural electrification policies can help create and/or stabilize market demand. All else being equal, consumers are going to prefer being connected to the grid rather than receiving energy services from a solar home system. But there is added value from solar home systems 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, is equally important. Projects also provide capacity building for dealers to meet standards—in most projects dealers who wish to participate must get their equipment certified at an approved testing laboratory. For example, in the Benin and Togo projects, the rural electrification agencies will issue and enforce a "PV code of practice" and technical standards. The China project has resulted in the adoption of equipment standards and certification procedures appropriate for China's market and hopes these are adopted outside the project as a proposal for national standards.

Domestic certification and testing agencies are also important and many projects provide capacity building for them. For example, in China, grants provide equipment and training to create a national PV testing and certification center. Assistance is also provided to strengthen PV module and balance-of-system testing and certification agencies, as well as strengthening the capabilities of a design-assistance center.

Few technical problems have been encountered with systems. Lessons from early experience suggest that establishing reasonable equipment standards and certification procedures for solar home system 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 used only to the degree to which they contribute to adequate consumer satisfaction and thus a sustainable market, but not so as to 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, the India project has been conducting promotional campaigns for photovoltaic technologies in the media. The Sri Lanka project has conducted village-level workshops throughout the country to promote solar home systems. 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 solar home systems 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.

CONCLUSION

Most projects are just beginning implementation; none are yet completed. Five leading projects in Bangladesh, the Dominican Republic, India, Sri Lanka and Vietnam have installed approximately 8,000 systems. Installation targets from all projects could total more than 500,000. But commercial sustainability and replication of viable models has not yet been achieved or conclusively demonstrated in any project. A key challenge is to demonstrate business models in which all firms in the supply and service chain make profit. Other challenges are to demonstrate regulatory models for energy-service concessions and to integrate rural electrification policy with solar-home-system delivery. Project designs continue to evolve with increased understanding of best practices. Future projects need to draw from these lessons, incorporate flexibility and adaptation, and allow sufficient time and resources to develop and test viable models.

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Table 1. World Bank Group Projects with Solar Home System (SHS) Components

Project name (Bank approval date)	Finance* GEF	Bank	SHS component description
India Renewable Resources Development Project (1992)	26	190	2.5 MWp of PV in various applications, (commercial, water pumping and SHS)
Small and Medium Scale Enterprise Program in Vietnam, Bangladesh and Dominican Rep. (1995 by IFC)	1.6	---	Finance commercial SHS business ventures
Indonesia Solar Home Systems Project (1997)	24	20	200,000 SHS sold and installed by private dealers/ entrepreneurs
Sri Lanka Energy Services Delivery Project (1997)	5.9	24	30,000 SHS sold and installed through dealers and microfinance organizations
PV Market Transformation Initiative in India, Kenya and Morocco (1998 by IFC)	30	---	Finance commercial SHS business ventures
Lao PDR Southern Provinces Rural Electrification Project (1998)	0.7	1.5	20 solar battery charging stations by national utility and village electricity associations
Argentina Renewable Energy in Rural Markets Project (1999)	10	30	66,000 SHS in households through regulated energy-service concessions
Cape Verde Energy & Water Sector Reform and Development (1999)	4.9	18	4,000 SHS in households through regulated energy-service concessions
China Renewable Energy Development (1999)	35	100	10 MWp of SHS and PV-wind hybrid systems installed through private dealers
Solar Development Group (1999 by IFC)	10	6	Finance PV-related businesses and provide technical assistance and business services
Benin Off-Grid Electrification/Traditional (under preparation; GEF grant approved in 1998)	1.1	2.2	5,000 SHS through regulated energy-service concessions
Togo Off-Grid Electrification/Traditional (under preparation; GEF grant approved in 1998)	1.1	2.2	5,000 SHS through regulated energy-service concessions

(*) Note: amounts (in million USD) are for entire project; most projects contain other components besides SHS. Total project costs are often much greater than amounts shown, as recipient governments and other donors provide funding.

Table 2. Project Features and Approaches

Project feature	Summary of project approaches	Barriers addressed
1. Pilot private-sector and NGO delivery models	Private dealers or NGOs sell systems (Indonesia, India, Sri Lanka, Vietnam, Bangladesh, China). Energy-service companies (i.e., monthly fee-for-service) operate as regulated concessions (Argentina, Cape Verde, Benin, Togo). Energy-service companies (i.e., monthly fee-for-service) operate in an open market (Dominican Republic, India). Provide business information, training, and consulting services to private dealers, ESCOs and NGOs (Indonesia, Sri Lanka, China, Cape Verde, Argentina, Benin, Togo).	• Lack of established market • Lack of successful business models • Lack of business financing • Lack of business skills • Unwillingness of utilities to provide off-grid electricity services • High transactions costs
2. Pilot consumer credit delivery mechanisms	Offer consumer credit through dealers (India, Indonesia, Sri Lanka, Bangladesh, Vietnam). Offer consumer credit through established microfinance (microenterprise) organizations (Sri Lanka). Offer consumer credit through local development finance organizations (Vietnam).	• High first-cost and affordability • Lack of consumer financing • High transactions costs
3. Pay first-cost-subsidies and offer affordable system sizes	Pay one-time-per-system subsidies (Argentina, Benin, China, Indonesia, Sri Lanka, Togo, Cape Verde). Specify and sell smaller, more affordable systems, (Indonesia, Sri Lanka, China, Cape Verde, Benin, Togo).	• High first-cost and affordability • Lack of an installed base enabling profitable after-sales service and lower marketing costs
4. Support policy development and capacity	Provide technical assistance to national regulatory agencies for concession bidding and contracting and regulation of concessions (Argentina, Benin, Cape Verde, Togo). Build capacity of public renewable energy agencies (India). Incorporate solar PV into rural electrification policy and planning (Sri Lanka). Lower import duties (Sri Lanka, China).	• Lack of experience regulating rural energy-service concessions • High import duties • Unrealistic political promises of grid extension • Uncertain rural electrification policies
5. Develop codes and standards and establish certification, testing, and enforcement institutions	Develop equipment standards for use in project-financed installations (Indonesia, Sri Lanka, China, Benin, Togo). Provide support for certification and testing agencies and laboratories (Indonesia, China). Provide capacity building for dealers to meet standards and for regulatory agencies or financiers to verify compliance with standards (Indonesia, Sri Lanka, China, Benin, Togo).	• Poor system quality • Uncertain technological track record • Lack of information about product quality and performance
6. Conduct consumer awareness and marketing programs	Conduct promotional ads on TV and radio. Distribute information at local fairs and community events. Conduct door-to-door marketing.	• Uncertain technological track record • Lack of information about products, costs, and benefits