The GEF Solar PV Portfolio: Emerging Experience and Lessons

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Preface

The GEF Monitoring and Evaluation (M&E) team is tasked with analyzing and documenting GEF results. Until now, conclusions of these efforts have been in the form of evaluation and study reports, annual Project Performance Reports, and GEF Lessons Notes. With the introduction of the M&E series of Working Papers, we are publishing reports that are not full-fledged evaluations, but nevertheless deserve attention.

Many of the issues and early results that these reports identify will be pursued later in broader evaluations to arrive at more definite conclusions. We expect the M&E working papers to be a valuable catalyst for promoting dialogue on issues and results of importance within GEF's operational areas and efforts. We therefore look forward to your feedback and suggestions. Please contact us through the coordinates listed below and visit the GEF Web site to find out more about the Monitoring and Evaluation program.

The GEF Solar PV Portfolio: Emerging Experience and Lessons is the result of a 1999 thematic review. Thematic reviews are not comprehensive evaluations—when many projects in a portfolio are relatively new, such evaluations would be premature. Rather, such reviews are more modest attempts to take stock of progress to date and identify lead indicators of achievements, if any. Additionally, reviewers may identify issues related to project design and implementation, thereby enabling discussion and reexamination of strategic issues within the GEF operational programs.

This review was based on data and information collected from a variety of sources: (a) desk reviews of project documents, including proposals for funding project preparation; (b) Project Implementation Reports and evaluations of completed projects; (c) interviews with project managers in the implementing agencies; and (d) visits to Bangladesh, China, Ghana, India, Sri Lanka, Uganda, and Vietnam.

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GEF Thematic Review of Solar PV Portfolio

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Executive Summary

Since 1991, the GEF has provided grant financing for 23 off-grid solar photovoltaic (PV) projects in 20 countries. In addition, four more projects are under preparation in the pipeline. Though specific objectives vary, the projects, in general, are aimed at stimulating and achieving commercialization of solar PV systems for rural households (called "solar home systems"). In all, these 23 projects together account for about US$210 million of GEF allocation, and about $1.4 billion in total project costs.

The review highlighted a number of important issues associated with solar home systems projects that future projects should explicitly address to varying degrees, depending on the delivery model employed:

- Technological credibility
- The role of solar PV within rural electrification programs
- Government policies vis-á-vis electricity as a basic need
- Household affordability and willingness to pay
- Marketing strategies, costs, and purveyors
- Concession selection and regulation
- Commercial creditworthiness and access to business finance
- Sustainability of development finance.

Projects in the portfolio employ either or both of two primary approaches: with a *sales model* (eight projects), private dealers sell solar home systems to rural households. The system is owned and maintained by the household, which is also responsible for servicing any debt if the system is purchased with credit. With a *service model* (10 projects), an energy-service company provides electricity for a monthly fee to rural households. In this case, the system is owned, financed, and maintained by the energy-service company. Since a large share of the portfolio is still under implementation, it is too early to draw definite conclusions regarding impacts. Nevertheless, the review of the GEF solar PV portfolio suggests ten emerging lessons:

1. Viable business models must be demonstrated to sustain market development for solar PV.

2. Delivery/business model development, evolution, and testing require time and flexibility.

3. Institutional arrangements for project implementation can greatly influence the value of the project in terms of demonstrating viable business models and thus achieving sustainability.

4. Projects must explicitly recognize and account for the high transactions costs associated with marketing, service, and credit collections in rural areas.

5. Consumer credit can be effectively provided by microfinance organizations with close ties to the local communities if such organizations already have a strong history and cultural niche in a specific country.

6. Projects have not produced adequate experience on the viability of dealer-supplied credit under a

sales model, and no project in the portfolio appears set to provide such experience.

7. Rural electrification policies and planning have a major influence on project outcome and sustainability, and must be explicitly addressed in project design and implementation.

8. Establishing reasonable equipment standards and certification procedures for solar home system components that ensure quality service while maintaining affordability is not difficult, and few technical problems have been encountered with systems.

9. Substantial implementation experience is still needed before the success of the service approach can be judged.

10. Post-project sustainability of market gains achieved during projects has not yet been demonstrated in any GEF project; it is too early in the evolution of the portfolio.

The global environmental benefits from rural solar PV projects are primarily indirect, and depend on the degree to which the GEF can help catalyze markets for rural PV applications that serve large shares of the two billion people in developing countries currently without electricity. Development benefits to households and rural communities are clearly connected with these projects, although further surveys of households are desirable to quantify income-generation effects, customer satisfaction, and delivery costs.

We recommend that future projects in the GEF portfolio focus on the following key issues:

- Affordability through fee-for-service or consumer credit approaches
- Use of GEF resources for non-recurring costs related to business and market development
- Access to finance and incremental risk sharing
- Explicit linkages to rural electrification policies and planning
- Commercially feasible business models that are sustainable and can be replicated.

Projects must be careful to avoid an "equipment demonstration" mentality where the main objective is installation and maintenance of a certain number of systems. By project completion, the number of systems installed is much less significant than whether the business, delivery, and credit models are viable, sustainable and being replicated. This emphasis requires implementing agencies to rethink traditional development assistance patterns and evaluation techniques.

We question whether purely private delivery models, by themselves, are able to achieve the widespread market penetration in poorer countries that will satisfy both global environmental and development objectives. We recognize that experience from some countries, such as Kenya, shows that the private-sector can achieve substantial market penetration without much support from subsidies or government or multilateral agencies. Still, we hypothesize that projects that involve government measures will result in greater penetration and larger shares of rural households able to benefit from PV than purely private-sector models. Regardless of government involvement, service models seem more likely to result in larger markets because they provide greater affordability for poorer households. More definitive conclusions must await further experience from the portfolio in the coming years.

Introduction

Role of Solar Photovoltaics

Photovoltaics (PV) already provide electricity to an estimated 500,000 to 1 million rural households in developing countries who lack access to electricity grids. Worldwide, two billion people lack access to electricity, so the potential for continued application of PV is large, with resultant economic, local environmental, and global environmental benefits. Traditionally, bilateral donor assistance has resulted in hardware installations but has placed less emphasis on the key ingredients for sustainability, such as viable service networks and trained personnel. In the past several years, several examples of sustainable commercialization of PV systems have emerged without much direct donor assistance, notably in China, Indonesia, Kenya, and Zimbabwe. But the reality is still much smaller than the potential.[2]

"Solar home systems" (SHS) are one of the most common forms of PV application in rural areas. An SHS usually provides electricity for two or three fluorescent lights, a radio or cassette player, television, and perhaps small fans or other small appliances. Electricity is drawn from rechargeable batteries recharged through an electronic controller by PV modules mounted on a pole beside the house or on the rooftop. The total capacity of the unit is usually in the range of 30 Wp to 100 Wp but can be smaller or larger.[3]

Solar home systems can eliminate or reduce the need for candles, kerosene, liquid propane gas (LPG), and/or battery charging. Direct economics benefits include avoided costs of battery charging and LPG or kerosene purchases; other significant benefits include increased convenience and safety, improved indoor air quality, a higher quality of light than kerosene lamps for reading, and reduced carbon dioxide emissions. Improved lighting quality can assist reading and provide additional educational benefits, especially to children, or allow income-generating activities to occur at night. PV systems can also power lights and vaccine refrigerators in medical clinics, run water pumps, and assist other applications.[4]

1 Gerald Foley, *Photovoltaic Applications in Rural Areas of the Developing World*, World Bank Technical Paper No. 304 (Washington, DC, 1995); GTZ, *Basic Electrification for Rural Households: Experience with the Dissemination of Small-Scale Photovoltaic Systems* (Eschborn, Germany: Deutsche Gesellschaft für Technische Zusammenarbeit, 1995); World Bank, *Rural Energy and Development: Improving Energy Supplies for 2 Billion People* (Washington, DC, 1996); Dan Kammen, "Promoting appropriate energy technologies in the developing world." *Environment* vol. 41, no. 5 (June 1999), pp. 11-15, 34-41; unpublished World Bank Group documents.

2 Other common applications of PV include water pumping in agriculture, commercial applications like telecommunications, and village mini-grids serving small numbers of households (often integrated with diesel and wind systems).

3 See A. Cabraal, M. Cosgrove Davies, and L. Schaeffer, *Best Practices for Photovoltaic Household Electrification Programs: Lessons from Experiences in Selected Countries*, World Bank Technical Paper No. 324 (Washington, DC, 1996); Foley 1995, op. cit. note 1; Christoper Flavin and Molly O'Meara, "Shining examples," *World Watch*, May/June (1997), pp. 28-36.

The GEF Solar PV Portfolio

Since 1991, the GEF has provided grant financing for 23 off-grid solar photovoltaic (PV) projects in 20 countries (Annex 1). In addition, four more projects are under preparation. Though specific objectives vary, the projects, in general, are aimed at stimulating and achieving commercialization of solar PV systems for rural households. Some of the projects supported by the GEF fully fund solar PVs and/or related components, while others contain significant solar PV components. In all, these 23 projects together account for about US$210 million of GEF allocation, and about $1.4 billion in total project costs. The division of the portfolio among the implementing agencies and the geographical portfolio allocation are shown in Tables 1-2.[5]

The projects in the GEF portfolio target total direct installations of 500,000 or more solar home systems, comparable in magnitude to the current installed base of such systems in developing countries.[6] However, most projects are just starting implementation and only a few are nearing completion (the Zimbabwe project was the first to be completed, in 1998). Direct installations from the projects in the portfolio by the end of 1999 amounted to about 18,000 systems (see Annex 1).[7]

Table 1. Portfolio by Implementing/Executing Agency and Region (number of projects)

Region	UNDP	World Bank	World Bank/IFC	Total
Africa	4	4		8
East Asia & Pacific	1	3		4
Latin America & Caribbean	2	2		4
South Asia	1	2		3
Global			4	4
Total	8	11	4	23

4 Refer to Annexes 1-4 for more details of the projects covered under the review. For further descriptions and evaluations of these projects, see the GEF web site (www.gefweb.org). See also Eric Martinot and Omar McDoom, *Promoting Energy Efficiency and Renewable Energy: GEF Climate Change Projects and Impacts* (Global Environment Facility, Washington, DC, 2000); Eric Martinot, Anil Cabraal, and Subodh Mathur, "World Bank/GEF solar home systems projects: Experiences and lessons learned 1993-2000" (Washington, DC: World Bank, 2000).

5 The total targeted installations does not include 200,000 systems originally expected from the Indonesia project, which was never implemented because of Indonesia's macroeconomic crisis and will now be cancelled.

6 Most of these installations are stand-alone solar home systems, except in India, where installations directly financed by the project have included 1500 solar lanterns, five village power schemes of 25 kWp each supplying electricity to about 500 families, and 200 SHS sold by a private dealer.

Table 2. Portfolio by Implementing/Executing Agency and Region (million US$)

	UNDP		World Bank		World Bank/IFC		Total	
Region	**GEF allocation**	**Total project**	**GEF allocation**	**Total project**	**GEF allocation**	**Total project**	**GEF allocation**	**Total project**
Africa	14.7	17.4	9.1	86.4			23.8	103.8
East Asia & Pacific	8.8	27.7	60.4	528.1			69.2	555.8
Latin America and Caribbean	8.5	17.7	22.2	251.6			30.7	269.3
South Asia	1.5	1.5	31.9	241.3			33.4	242.8
Global					56.5	222.5	56.5	222.5
Total	**33.5**	**64.3**	**123.6**	**1107.4**	**56.5**	**222.5**	**213.6**	**1394.2**

The Thematic Review

During the 1998 GEF Project Implementation Review, several questions were raised regarding the lessons being derived from this portfolio. It was recommended that a thematic review of the portfolio be conducted with the overall objective of documenting the experience with the design, implementation, and impacts (for completed projects). The review is not a comprehensive evaluation of the portfolio—such an exercise would be premature given the current status of most projects in the portfolio. Rather, the review is a more modest attempt to take stock of the current progress, identify lead indicators of achievements, if any, and identify issues arising from project design and implementation to foster a discussion and reexamination of strategic issues within the GEF climate change program. The specific objectives of the review are to:

- Identify elements and characteristics of project design, implementation, policy, and institutional environments that have been responsible for project performance
- Identify whether (and how) projects that have completed implementation have sustained project achievements or promoted replication and/or expansion
- Identify the roles played by different stakeholders in different parts of the project cycle and their impact on project performance
- Estimate the potential impacts of these projects on global efforts to reduce greenhouse gas emissions
- Make specific recommendations for GEF project design, programming, and performance indicators in solar PV projects.

The review was based on data and information collected from a variety of sources: (i) desk reviews of project documents, including proposals for funding project preparation; (ii) Project Implementation Reports and evaluations of completed projects; (iii) interviews with project managers in the implementing agencies; and (iv) visits to Bangladesh, China, Ghana, India, Sri Lanka, Uganda, and Vietnam. The data and views obtained from country visits are described in Annexes 1-4.[9]

7 In addition to the sources of information and country visits documented in Annexes 1-4 for Bangladesh, Ghana, Sri Lanka, Uganda, Vietnam, and Zimbabwe, the team visited China (met with UNDP, World Bank Project Implementation Unit, State Economic and Trade Commission) and India (met with India Renewable Energy Development Agency). Substantial information was already available on the Argentina project from parallel work done by the World Bank (source noted in Annex 5).

Solar Home Systems Delivery Models in the GEF Portfolio

GEF Operational Programs

The solar PV projects in the GEF portfolio have been funded under GEF Climate Change Operational Program 6, *Promoting the Adoption of Renewable Energy By Removing Barriers and Reducing Implementation Costs,* which has two major objectives:[8]

1. Remove the barriers to the use of commercial or near-commercial renewable energy technologies.
2. Reduce any additional implementation costs for renewable energy technologies that result from a lack of practical experience, initial low volume markets, or from the dispersed nature of applications, such that economically profitable "win-win" transactions and activities increase the deployment of renewable energy technologies.

The output of a GEF-supported project in this operational program is expected to be the removal of a barrier to a particular renewable energy application. Some of the key barriers usually addressed through off-grid solar PV projects in the portfolio are:

- Lack of established market
- Lack of proven business models
- Lack of business financing and business skills
- High transaction costs
- Lack of consumer financing
- High first-cost and affordability
- Unwillingness of utilities to provide off-grid electricity services
- Lack of experience regulating rural energy-service concessions.

Models for Delivery of Solar Home Systems

Projects in the portfolio employ either or both of two primary approaches.[9]

Sales models (8 projects). With a sales model, private dealers sell solar home systems to rural households. The system is owned and maintained by the household, which either pays cash in full or obtains consumer credit and is responsible for servicing the debt. The sales model is employed in projects in Bangladesh, China, India, Indonesia, Sri Lanka, Uganda, Vietnam, and Zimbabwe. Under the sales model, consumer credit may be provided by the dealer (Bangladesh, India, Indonesia, Sri Lanka), by a micro-finance organization (Sri Lanka and Uganda), or by a development finance institution (Uganda, Vietnam, Zimbabwe).

Service models (10 projects). With a service model, an energy-service company provides electricity for a

8 See GEF, Operational Programs (Washington, DC, 1996); Martinot and McDoom, op. cit. note. 4.

9 Not all projects explicitly specify in their design the delivery model to be employed. We treat sub-projects of the SME project as separate "projects" in our accounting here. Since there are three SME solar PV subprojects, we account for 25 "projects" rather than 23. Sri Lanka overlaps both sales and service categories, and thus 8 projects are left as unspecified as to delivery model.

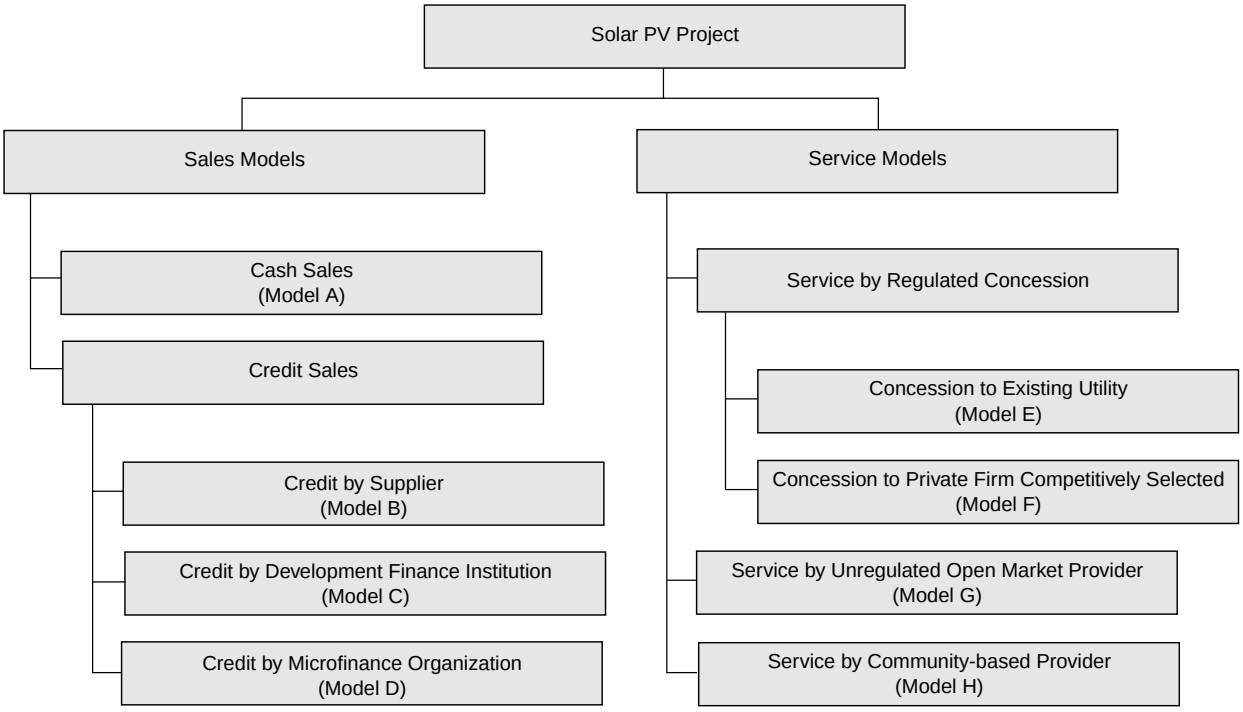
monthly fee to rural households. The system is owned and maintained by the energy-service company. The service model is employed in projects in Argentina, Benin, Cape Verde, Dominican Republic, Guinea, Ghana, Lao PDR, Peru, Sri Lanka, and Togo. In almost all of these projects, the energy-service company is regulated by government and awarded monopoly status for specific geographic regions. The main alternative to regulated energy-service concession is an open-market approach without regulation, which occurs in Dominican Republic and is supposed to occur in Peru after the project is completed. (See also Box 1 for a non-GEF project using a service model.)

Two projects, the Photovoltaic Market Transformation Initiative (in India, Kenya, and Morocco) and the Solar Development Group (a global project), do not explicitly define the delivery models; eligible businesses financed through these projects may employ models of any type.

Of the 12 solar PV projects most recently approved by the GEF (since 1996), nine employ service models and three employ sales models. In addition, at least two of the four existing Project Development Funds (Block B) related to rural energy will lead to projects with service models. Thus the recent trend among implementing agencies is to pursue service models.[10]

Figure 1 and Table 3 depict the different types of sales and service models employed in the solar PV portfolio.

Figure 1. Typology of GEF-supported Solar PV Projects



10 Sales models are employed in China, Malawi, and Sri Lanka. The Sri Lanka project also employed a service model during initial phases. The Malawi project envisions considering service approaches later in the project but excludes them in the beginning. The Bolivia project does not specify in advance the models to be developed.

Table 3: Delivery Models, Relevant Issues, and Country Applications

Delivery Models	Most Relevant Issues as Indicated by Emerging Lessons	Country Applications
SALES MODELS		
A. Cash	• Demographics and household income limit demand. • Sales to niche markets do not render comprehensive rural service. • Marketing can be costly and labor-intensive.	China India Uganda Vietnam Zimbabwe
B. Consumer credit by supplier	• Credit delivery and collection can be costly and risky. • Additional business finance required for extending consumer credit; supplier must be creditworthy. • Marketing can be costly and labor-intensive. • NGO suppliers may lack appropriate business skills for credit delivery.	Bangladesh India Indonesia Malawi Sri Lanka
C. Consumer credit by development finance institution	• Development finance institution must be willing and able to continue lending post-project. • Continued subsidies for concessional finance may be needed. • Development finance institution can assist with marketing.	Malawi Uganda Vietnam Zimbabwe
D. Consumer credit by microfinance organization	• Microfinance organization must be creditworthy. • Credible microfinance organizations must exist. • Existing microfinance organizations may not be commercially oriented for rapid delivery of credit. • Microfinance organization can assist with marketing.	Sri Lanka Uganda
SERVICE MODELS		
E. Regulated concession by existing utility	• Utility must have interest and experience in rural areas. • How should government regulate concession and set tariffs? • How should government specify/ensure quality of service in concession contracts?	Argentina Ghana (as designed) Lao PDR
F. Regulated concession by private firm competitively selected	• Concession must be creditworthy and commercially viable. • How should government regulate concession and set tariffs? • How should government specify/ensure quality of service in concession contracts? • What should be the terms and conditions for renegotiation of concession contracts? • How should government conduct competitive selection and attract qualified bidders?	Argentina Benin Cape Verde Guinea Peru Togo
G. Unregulated, open market	• Marketing can be costly and labor-intensive. • Long-term business finance required for initial capital investments. • Long-term recurring service costs may threaten continued profitability or limit financial ability to expand.	Benin Dominican Rep. India Peru (post-project) Togo
H. Community	• Supplier should have strong ties to the community, which may overcome other barriers. • Supplier may need development of technical skills. • May be community-driven if government lacks ability or interest to develop concessions for community.	India

Box 1: A Fee-for-Service Approach in Kiribati[11]

In the outer islands of Kiribati, 500 solar home systems have been installed by a government-owned energy-service company. The initial capital for the 100 Wp PV solar home systems was donated by the European Union (EU) under its Pacific Regional Energy Programme (PREP). This program also provided training and technical assistance to the company in installation, maintenance, competitive procurement, and other business practices.

The company charges households an equivalent of roughly $6-7 per month, which covers direct maintenance costs and replacement capital costs for the batteries, controllers, and lights over a period of 20 years.[12] The company maintains an interest-bearing account in which part of the fees are kept to provide financing for future equipment replacements. The monthly fees do not yet cover the full central overhead costs of the company, but they do include a component to finance PV panel replacement after 20 years. The company was supplementing its operating costs with income from other PV projects, such as installation of PV pumping systems and sales of controllers it was manufacturing itself. An evaluation by the EU estimated that an installed base of 1,000 systems minimum would allow the company to cover these overhead costs as well.

The program provides a sustainable mechanism for continued maintenance (and perpetual replacement) of donor-supplied systems and provides customers with affordable energy services. However, the scheme is not commercially replicable because it relies on donor-supplied capital equipment to get started. If the company were to finance the initial capital costs on its own, the monthly fees needed to amortize these costs would be higher (perhaps double by one estimate), and some additional financing mechanism would be needed.

The European Union is planning to extend this program and supply additional PV systems to extend the installed base to the 1,000 systems necessary for sustainable operation of the energy-service company.

Issues Associated with the Delivery Models

The review suggested a number of important issues associated with solar home systems in general and with specific delivery models in particular (refer to Table 3). These include:

Technological credibility (all models). It is important to assure the quality both of hardware and service to establish long-term credibility of the technology. The quality of panels and PV-related hardware has been more or less well-established, though the reliability of locally produced hardware, such as charge controllers, may have to be established. Even where reliability has been established, it is strongly influenced by maintenance, hence the need to focus on reliable service as a goal to establish long-term credibility. For sales models (models A-D), customer education on proper maintenance is especially important. See also lesson #8.

The role of solar PV within rural electrification programs (all models). Without the government demarcating an identified niche for solar PVs in its policies, rural consumers are enticed by the promise, often false, of electricity provision through the grid, adversely affecting demand for solar PV through private suppliers. This has been observed in several countries, including Sri Lanka and Vietnam. Grid expansion is often not a cost-effective option for provision of electricity to the most remote of rural areas. See also lesson #7.

Government policies vis-á-vis electricity as a basic need (models E, F, and G). If government policy gives rural electrification priority even in areas where grid extension is impractical, then regulated concessions (models E and F) are more likely to be favored—as has happened in Argentina. Subsidies may be provided to concessions with the clear understand-

11 Box 1 based on Bill Gillet and Gill Wilkins, "Solar so good—An EC funded solar utility succeeds in Kiribati," *The ACP-EC Courier* No. 177 (Oct-Nov, 1999), pp.5-7; personal communication with Suresh Hurry, UNDP (New York), January 2000; personal communication with Gill Wilkins, AEA Technology-ETSU (Oxfordshire, UK), April 2000.

12 The program expects PV panels to last 20 years. Lifetimes are estimated at 5 years for batteries and lighting ballasts and 8 years for controllers and DC/DC converters.

ing that electricity is part of rural development policy. If national policy is lacking, local communities may decide to promote community-based energy service delivery as a way of obtaining service for an entire community (model G). See also lesson #7.

Household affordability and willingness to pay (all models). The choice of delivery model is influenced by the affordability and willingness of households to pay. Affordability is most at issue with cash sales (model A), as only a small fraction of the rural population may be able to afford to purchase a system outright (depending on rural demographics). Other sales models with credit (models B, C, and D) may improve but still limit affordability, depending on the term of credit available. In absence of government interest in and/or regulation of concessions, an "open-market" energy-service company (model G) may be an attractive alternative. Under this model, a firm provides fee-for-service to specific territories but without monopoly status granted by a regulator (as has been seen in the Dominican Republic). Refer to Box 2 for typical cost comparisions facing a consumer between the sales and service models.

Marketing strategies, costs, and purveyors (models A, B, C, D, and G). Private firms may need to expend substantial resources on marketing their products, especially if rural households are highly dispersed or difficult to reach (Bangladesh is one such case). Mass media methods may be ineffective; door-to-door campaigns may prove most effective. For sales models with credit, the purveyor of credit may provide marketing services in addition to or instead of the dealer (this has happened in Sri Lanka and Vietnam). Under regulated concession models, marketing may still be important but not as essential to the survival of the business. See also lesson #4.

Concession selection and regulation (models E and F). For concession models, numerous issues must be resolved: setting tariffs, finding and attracting capable bidders, and conducting competitive bidding procedures, plus ensuring service quality and regulating concessions on an ongoing basis. If an existing utility is being considered for rural energy service delivery, then the interest and experience of that utility in operating in rural areas becomes a factor. These issues are clearly visible in Argentina.

Commercial creditworthiness and access to business finance (all models). Business finance is an important issue for all delivery models except perhaps model E, where an existing utility would be presumed to have access to credit. Supplier-provided credit (model B), as well as private concessions (model F) and open-market energy service companies (model G) in particular require large amounts of business finance because they must finance installed systems over extended periods. Creditworthiness also affects the terms of consumer credit that can be provided, and thus the market demand (this is clearly seen in Bangladesh; see also lesson #6). If a microfinance organization is providing consumer credit (model D), then it must itself be creditworthy enough to obtain credit from the banking or financial system, a major issue in Sri Lanka.

Sustainability of development finance (model C). If development finance organizations provide consumer credit, then their willingness or ability to continue after the project completes (including the need for any ongoing subsidies) is an important issue—as seen in Zimbabwe and potentially in Vietnam. See also lesson #5.

The next section amplifies these issues in the context of emerging lessons from the thematic review.

Box 2: Consumer Costs of Solar Home Systems: Credit Sales versus Fee-for-Service

How much will a consumer pay for a solar home system over its lifetime if purchased on credit compared to the same system provided with a fee-for-service arrangement? There is little available cost data with which to make such an analysis, but the following numbers are illustrative. Based upon data collected during this review and published sources, a typical 50 Wp solar home system can be expected to cost between $450 to $800 fully installed, depending upon several factors:

- level of import duties on imported components like PV panels
- level of profit margins incorporated by system integrator and/or system installer firms
- degree to which components are produced locally and are cheaper than imported components
- quality standards applied to components and installation
- complexity/features of battery controller.

Assuming an installed cost of $600, a lifetime of 10 years, a 3-year loan at 20 percent real interest with 25 percent down-payment, an average annual cost of battery replacement of $20 ($50 battery with 2.5 year life), and estimated O&M costs of $20/year, the lifecycle costs of a purchased system are about $1200. With fee-for-service, a $17/month charge for the system over a 10-year period totals $2040, or almost double the lifecycle costs of a purchased system.[13] But fee-for-service has several advantages:

- the energy-service company assumes the performance risk
- an initial down payment may not be required (or is smaller than for a credit sale)
- service is guaranteed as long as the firm is providing fee-for-service
- consumers can return the system at any time, minimizing the risk of electric-grid extensions.

Given a choice, some consumers may prefer these benefits even though total lifecycle costs may be higher.

13 Monthly charges vary in the projects examined. In the Argentina Renewable Energy in Rural Markets Project, an estimated monthly recovery cost to the concession is given as $17 for a 50-Wp system (15-year SHS life, 14% return on investment, various other assumptions); this figure is only calculated ("Argentina Renewable Energy in the Rural Market: Project Appraisal Document," World Bank, 1999). In the Dominican Republic, Soluz Dominicana has been charging customers $20/month for a 50-Wp system (see Annex 4).

Ten Emerging Lessons from the Review of Solar PV Projects

The review of the GEF solar PV portfolio suggests ten emerging lessons. Since a large share of the portfolio is still under implementation, it is too early to draw definite conclusions regarding impacts. However, from trends identified during project implementation, and early indication of some impacts on the ground, some initial lessons can be drawn.

Lesson 1. Viable business models must be demonstrated to sustain market development for solar PV.

Demonstration of a viable business model, whether that business is public, private, utility, or even permanently subsidized, is key to achieving project sustainability and achieving GEF's programmatic objective of transforming (or developing) markets for solar PV. Viability means that expenses and receipts, cash flow, profits (or subsidies), management and service arrangements demonstrate an entity can continue to exist and function on commercial terms. "There is a high value-added [by the GEF] in terms of developing and improving business models...you want to stimulate markets based on these business models" said one dealer being supported by the GEF.

For profit-oriented commercial businesses, profit is the ultimate measure of whether a business model is viable, which in turn depends on maximizing income (which depends on demand, pricing, and competition) and minimizing expenses (for marketing, service, training, procurement, and operations). If a business receives public support because of economic development or other public objectives associated with solar home systems, such that continuing subsidies are required to sustain it, then the extent of these subsidies must be clearly documented within an income-expense framework, and arrangements for their continuation must be secured.

Virtually all GEF projects have explicit or implicit goals directed towards developing viable business models (see Annexes 1-4). But these pilot models have yet to be tested. Delivery is clearly linked with profitability and business model development in projects in Bangladesh, China, Dominican Republic, Sri Lanka, and Zimbabwe. For example, the firm Soluz Dominicana in the Dominican Republic is demonstrating a "proof of concept" for its fee-for-service business model for up to 5,000 systems and is seeking to adapt the model to a larger scale—perhaps 25,000 systems (see Annex 4).

Lesson 2. Delivery/business model development, evolution, and testing require time and flexibility.

Building markets and identifying viable sustainable delivery models in specific contexts are slow and time-consuming processes requiring a much greater degree of flexibility and adaptation than currently allowed by most GEF project designs. GEF projects do not allow sufficient time or resources to first identify the most promising approaches and, then, develop those approaches to a point where their viability and sustainability are clear and tested. Projects should explicitly allow for testing multiple models and for adapting and modifying models over time until viable approaches become clear and are tested sufficiently. Insufficient project durations, de-

lays in project start-up due to unanticipated circumstances, and fixed project completion dates can hinder this process.

This lesson is clearly illustrated in Sri Lanka, where dealer credit and fee-for-service approaches were tried early in the project without much success and the project began to emphasize consumer credit through microfinance organizations (see Annex 3). This later approach appeared to the dealers and the project to show the most promise, and the rate of system installations under this approach was accelerating through one main microfinance organization. But more time would be needed to replicate and amplify the microfinance model to provide greater volumes of installations and include greater numbers of microfinance organizations. Unfortunately, the project is scheduled to close before the microfinance model can be adequately tested. In particular, there is a question as to whether commercial financiers will consider microfinance organizations beyond the main one participating in the project good enough credit risks to extend commercial credit to them.

Lesson 3. Institutional arrangements for project implementation can greatly influence the value of the project in terms of demonstrating viable business models and thus achieving sustainability.

This lesson can be illustrated by the Ghana project, which was originally designed to demonstrate a business model in which the national utility would provide fee-for-service to rural households using solar home systems (see Annex 2). At the conclusion of the project, the costs, service, cash flow, and management of these installations could be assessed in terms of the viability of this model from the utility's perspective. The demonstration of this business model could also be used to convince other private companies to enter the market, which is an explicit project objective. But project implementation responsibility was transferred to a "project" established under the Ministry of Mines and Energy early in the project implementation. Although this office may succeed in installing and servicing a given number of systems, given that it is subject to the rules and regulations of a government ministry, demonstrating and judging business viability in a transparent commercial manner is bound to be difficult, meaning that sustainability is seriously called into question. Changes in institutional arrangements can go unnoticed by GEF or implementing agency staff; but the overriding importance of sustainability and replication in a GEF project demand a much greater awareness of how implementation arrangements affect the demonstration value of a project.

Lesson 4. Projects must explicitly recognize and account for the high transactions costs associated with marketing, service, and credit collections in rural areas.

Long distances, poor transport infrastructure, impassable roads during monsoons, low literacy rates, cash-and-barter based transactions, and lack of technical skills all mean that transaction costs of operating a rural PV business, whether sales or service-for-fee, can be quite high. The costs and staff time needed for marketing, credit or fee collections, service, establishing business infrastructure, and training staff can easily eat away already-slim profit margins. This lesson is illustrated in Sri Lanka, where dealers decided not to offer consumer credit, citing the high costs of credit collections in remote rural areas (see Annex 3), and in Bangladesh, where a dealer was investing heavily in marketing out of its own operating budget (without government or grant assistance), delaying its ability to begin to make a profit (see Annex 4).

No one has figured out how to conduct a standardized-product/high-volume approach to low transaction costs. Some form of subsidies (e.g., multilateral or host-country government) may be a permanent and essential feature of SHS delivery for this reason alone. Dealers and energy-service companies need experience, training, and developed business infrastructure in rural areas to be able to operate effectively with low transaction costs.

Lesson 5. Consumer credit can be effectively provided by microfinance organizations with close ties to the local communities if such organizations already have a strong history and cultural niche in a specific country.

Under the sales model, a few projects are successfully providing consumer credit through microfinance organizations (Sri Lanka) and development-finance organizations (Zimbabwe and Vietnam). However, the sustainability of these consumer credit mechanisms is questionable in two of the three. The Agricultural Finance Corporation in Zimbabwe has not been able

to replenish their credit revolving fund, which will wind down otherwise (see Annex 2). In Vietnam, consumer credit by the Vietnam Bank for Agriculture and Rural Development is partly dependent on dealer-provided credit guarantees (see Annex 4). In Sri Lanka, consumer credit by microfinance organizations appears sustainable, but perhaps because Sri Lanka has a strong and long-standing microfinance industry (see Annex 3).

Lesson 6. Projects have not produced adequate experience on the viability of dealer-supplied credit under a sales model, and no project in the portfolio appears set to provide such experience.

The Indonesia Solar Home Systems project was one of the first projects to utilize dealer-supplied credit as a delivery mode. The experience from this project would have been extremely valuable. Unfortunately, this project never really got started because of the macroeconomic difficulties in Indonesia in the late 1990s, and now will be cancelled.[14] The Solar PV project in Bangladesh is the only one that shows dealer-supplied credit to be working (see Annex 4). The dealer receives three-year credit from the IFC. Once this credit is completed, the dealer may depend on continued development institution assistance unless commercial business financing for the dealer becomes available for longer terms thus increasing profitablilty. Longer term commercial financing depends on the dealer's ability to overcome high overhead and marketing costs.

Lesson 7. Rural electrification policies and planning have a major influence on project outcome and sustainability, and must be explicitly addressed in project design and implementation.

Participants in some projects cited unrealistic political promises or planning about rural grid extension as a serious barrier to solar-home-system market expansion, one that was not anticipated adequately in project design. "Our main competition is the false promise of the grid and kerosene and battery charging, not other companies" said one supplier in Sri Lanka when asked about competition (see Annex 3). A private dealer in Vietnam was also encountering problems as rural electrification encroached upon potential customers and interfered with marketing (see Annex 4). Of course, all else being equal, households would prefer to be connected to a grid than obtain energy services from a solar PV system. Still, in most countries, 100 percent grid extension is too costly and unrealistic. Policy development, in conjunction with solar home system delivery models, is thus crucial so that areas of planned rural electrification are clear and realistic, and rural electrification planning explicitly accounts for the potential of solar home systems in providing a least-cost path to rural electrification in some areas (and ultimately, the utility itself may explicitly plan to install solar home systems in certain areas as an alternative to grid extension).

Lesson 8. Establishing reasonable equipment standards and certification procedures for solar home system components that ensure quality service while maintaining affordability is not difficult, and few technical problems have been encountered with systems.

Suppliers in all projects have generally been able to comply with standards and certification procedures established under projects. The technologies have worked with few problems. Where difficulties with standards compliance have occurred in projects, projects were able to slightly relax standards without sacrificing quality of installations or performance of systems. Few customer complaints or technical problems have been encountered in those projects where substantial systems have been installed (Zimbabwe, Sri Lanka, Dominican Republic, and Bangladesh). Certification has been often slower than anticipated; for example, in Sri Lanka it took almost the whole first year of the project before suppliers had certified products on hand to deliver to customers.

Lesson 9. Substantial implementation experience is still needed before the success of the service approach can be judged.

The best experience with the service model has taken place in the Dominican Republic, where 3,500 systems were installed from 1996–2000, about 1,700 of these on a fee-for-service basis (see Annex 4). In 2000, the great majority of new installations were being installed on a fee-for-service basis and the firm, Soluz Dominicana, had passed the break-even point

14 A project completion report for the Indonesia project is expected in 2000.

of profitability.[15] In Sri Lanka, one dealer attempted a service approach in 1998–99 but quickly (perhaps prematurely) gave up on this approach and switched to a sales approach, citing the high administration and transaction costs and other difficulties of monthly fee collections in rural areas (see Annex 3). Early experience in Argentina also suggests that selecting and effectively regulating energy-service concessions in rural areas can be a formidable regulatory challenge that requires significant assistance and capacity building for regulatory and institutional development (see Annex 5). The Argentina project should provide a wealth of new experience with the service approach, but was just getting under way in 2000.

Lesson 10. Post-project sustainability of market gains achieved during projects has not yet been demonstrated in any GEF project; it is too early in the evolution of the portfolio.

Most projects are in early implementation and those few completed or nearly completed are not yet demonstrating market sustainability. Even in Zimbabwe, where the private dealer market was greatly expanded and 10,000 systems were sold under the project, the question of continued consumer credit mentioned above—and the sustainability of many of the businesses created during the project—is still in question (see Annex 2). Sri Lanka appears to be closest to demonstrating sustainability, based upon consumer credit through microfinance organizations and the entry of Shell International Renewables into the Sri Lanka market (see Annex 3). Shell attributed their entry to the World Bank/GEF project there, and other dealers see Shell's entry as helpful to market maturity and sustainability after the project.[16]

15 IFC/GEF assistance to Soluz has taken the form of a $75,000 convertible loan with a 12% interest rate and a six-year term, through the IFC Small and Medium Scale Enterprise program. Counting all sources, Soluz has raised over $1.5 million to invest in Soluz Dominicana's operations.

16 For a fuller treatment of methodologies for monitoring and evaluating post-project market gains, see Eric Martinot, *Monitoring and Evaluation of Market Development in World Bank-GEF Climate Change Projects: Framework and Guidelines,* World Bank Environment Department Paper No. 66 (Washington, DC, 1998).

Conclusions and Recommendations

The global environmental benefits from rural solar PV projects are primarily indirect. That is, the direct global environmental benefits from solar home systems projects, in terms of avoided carbon dioxide from displaced kerosene, candles and batteries, are small relative to other sources of carbon dioxide emissions in these countries.[17] The emergence of significant global environmental benefits is primarily dependent on the degree to which a market for PV emerges, serving large shares of the two billion rural population currently without electricity. This is expected to have two results: (i) avoidance of fossil-fuel use for providing electricity in rural services; and (ii) lowering of global PV cost and spurring of applications in both developed and developing countries that would otherwise be delayed.

Clearly there are immediate welfare-enhancing benefits from rural solar PV systems or services. In addition to the direct benefits to households discussed in the introduction, local economic benefits from employment by PV dealers and service firms are significant. The extent of income-generation benefits for rural households is more uncertain.[18] Field visits in Ghana, Sri Lanka, Uganda, and Vietnam showed early purchasers of systems to be among the wealthiest households in rural areas. Some historical surveys have shown substantial income-generation benefits are possible, but further survey work will be required to assess the economic benefits achieved in GEF projects.[19] Such surveys should also include other unknowns that influence market sustainability, such as customer satisfaction, system performance, dealer marketing costs, and system prices. Surveys conducted in Kenya, for example, by the UNDP/World Bank Energy Sector Management Assistance Program, have shown high levels of customer satisfaction and technical performance.[20]

How well suited are GEF-supported projects for achieving both global environment and development goals? The evidence from emerging project experience suggests that some GEF projects will demonstrate delivery models with significant replication potential, but it is too early to be more definitive. Based upon this review, we recommend that future projects in the GEF portfolio focus on five key issues:

17 Steven Kaufman, "Rural electrification with solar energy as a climate protection strategy." Renewable Energy Policy Project Research Report No. 9 (Washington, DC, 2000). Due to the inefficiency of kerosene lighting, avoided CO_2 emissions per installed Wp of PV in rural households are greater than for grid-connected applications, in some cases by a factor of ten, says Kaufman. This presumes that PV is used to displace kerosene rather than provide additional energy services; the issue of fuel displacement vs. added services has been inadequately studied.

18 We have not looked at rural development literature to examine income-generation and income-distribution effects.

19 Kaufman, op. cit. note 17.

20 Robert J. van der Plas and Mark Hankins, "Solar electricity in Africa: A reality." *Energy Policy* vol. 26, no. 4 (1998), pp. 295-300.

1. *Affordability.* Affordability through fee-for-service or consumer credit approaches will continue to be a central issue. Projects should experiment with different approaches to affordability and show a reasonable chance of making solar PV available to more than just the wealthiest households. The potential for widespread affordability exists; some private sector studies claim 25-50 percent of rural households currently without electricity would be able to afford systems under fee-for-service or consumer credit arrangements.[21]

2. *Use of GEF resources for non-recurring costs.* GEF resources should pay for incremental, non-recurring business and market development costs, rather than partial equipment subsidies. Such non-recurring costs include, for example, business planning, feasibility studies, consumer awareness, credit delivery pilot schemes, and initial marketing and market development efforts.

3. *Access to credit and incremental risk sharing.* Initial market development efforts can be assisted by providing financial services such as partial risk guarantees, performance incentives, and other forms of contingent finance to local PV businesses.

4. *Explicit linkages to rural electrification policies and planning.* Policy development and rural utility planning should be explicitly linked to solar PV delivery models, so that areas of planned rural electrification are clear and realistic and provide greater certainty for off-grid markets. Rural electrification planning should account for the potential of solar home systems and other rural energy options, and consider incentive mechanisms, like energy-service concessions, to provide a least-cost path to rural electrification.

5. *Commercially feasible business models.* Projects must be careful to avoid an "equipment demonstration" mentality where the main objective is installation and maintenance of a certain number of systems. By project completion, the number of systems installed is less significant than whether the business, delivery, and credit models are sustainable and whether replication mechanisms are effective. This emphasis requires implementing agencies to rethink traditional development assistance patterns and evaluation techniques.

We conclude the review by questioning whether purely private delivery models, by themselves, are able to achieve the widespread market penetration in poorer countries that will satisfy both global environmental and development objectives. In many countries, rural populations are simply too poor to afford solar home systems on their own. This can be seen in particular in the African GEF projects. Short-term profits may exist for a few dealers serving the wealthiest households, but market penetration may be limited. However, if sales to the wealthiest households provides a future "pathway" to more widespread sales because of significant cost reductions (there are analogies in diffusion of technologies like mobile phones), then private delivery models may lead to further market gains.

One cannot dispute the private-sector-led experience in Kenya, where an estimated 80,000 households had solar PV systems in 1999. This experience shows that the private sector can achieve substantial market penetration without much support from subsidies, governments, or multilateral agencies (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, now growing at 10-18 percent annually. A modular system of buying has emerged where households can invest small sums in modest systems and upgrade as income allows. After 10 years, the commercial market has reached about one percent of rural households.[22]

Still, we hypothesize that projects involving government measures will result in greater penetration and larger shares of rural households able to benefit from PV than purely private sector models. Such measures may include government support for local industry, policy approaches like regulated concessions, favorable rural development or power sector reform policies, and even continuing government subsidies for

21 Kaufman, op. cit. note 17.

22 Van der Plas and Hankins 1998, op. cit. note 20; Dan Kammen, op. cit. note 1. For other experiences with solar PV in rural areas, also see GTZ, op. cit. note 1; Geerling Loois and Bernard van Hemert, eds., *Stand-Alone Photovoltaic Applications: Lessons Learned* (London: James and James, 1999).

the rural poor as part of poverty reduction objectives (perhaps equivalent to those for grid-connected customers). Regardless of government involvement, service models seem more likely to result in larger markets because they provide greater affordability for poorer households, particularly if available credit terms under sales models are short. Evidence for these conclusions from GEF experience is still lacking and may not exist for several more years as service models in the portfolio are tested.

Annex 1: List of Projects and Status (as of 12/99)

Project (year approved by GEF)	Responsible agency	GEF contribution ($mn)	Total project cost ($mn)	Status	Approximate number of installations by end of 1999
India: Alternate energy/renewable resources development (1991)	WB	26	186	under implementation	2,200
Zimbabwe: PV for household and community use (1991)	UNDP	7	7	completed	10,000
Small and Medium Scale Enterprise Program (1994)	IFC	1.6	4.8	under implementation	5,100
Indonesia: Solar home systems (1995)	WB	24	118	to be cancelled	—
Uganda: PV pilot project for rural electrification (1995)	UNDP	1.8	3.6	under implementation	—
Ghana: Renewable energy-based electricity for rural, social and economic development (1996)	UNDP	2.5	3.1	under implementation	—
PV Market Transformation Initiative (1996)	IFC	30	120	under implementation	—
Renewable Energy and Energy Efficiency Fund (1996)	IFC	30	130	soon operational	—
Sri Lanka: Renewable energy capacity building (1996)	UNDP	1.5	1.5	under implementation	—
Sri Lanka: Energy services delivery (1996)	WB	5.9	55	under implementation	1,000
Argentina: Renewable energy in rural markets (1997)	WB	10	120	under implementation	—-
Bolivia: Rural electrification with renewable energy (1997)	UNDP	4.5	8.5	under \implementation	—
China: Capacity building for renewable energy commercialization (1997)	UNDP	8.8	28	under implementation	—-
Lao PDR: S. provinces renewable energy pilot (1997)	WB	0.7	2.1	under implementation	—
Benin: Decentralized rural energy (1998)	WB	1.1	5.7	pending approval by WB	—
Cape Verde: Energy & water sector reform and development (1998)	WB	4.9	65	under implementation	—
China: Renewable energy development (1998)	WB	35	445	under implementation	—
Peru: PV-based rural electrification (1998)	UNDP	4	9.2	under implementation	—
Solar Development Group (1998)	IFC	10	50	under implementation	—
Togo: Decentralized rural energy (1998)	WB	1.1	5.7	pending approval by WB	—
Guinea: Rural energy (1999)	WB	2	10	pending approval by WB	—
Malawi: Barrier removal to Malawi renewable energy program (1999)	UNDP	3.4	10.7	pending approval by UNDP	—
Mexico: Renewable energy for agriculture (1999)	WB	8.7	26	pending approval by WB	—

Annex 2: Approaches to Solar Home Systems in Africa[23]

Three UNDP/GEF African projects illustrate the two primary approaches to solar home systems. The Ghana project employs the fee-for-service model, while the Uganda and Zimbabwe projects employ a dealer-sales model. While Ghana and Uganda have been under implementation for less than a year, the Zimbabwe project was the first solar home system project in the GEF portfolio to be completed (in 1998).

The goal of the Ghana project is to establish a sustainable capacity in Ghana to provide decentralized renewable energy-based electricity services to rural communities through the fee-for-service model. The project is under implementation through a special office—the Renewable Energy Services Project (RESPRO)—established in the Ministry of Mines and Energy (MOME). RESPRO is intended to act as a for-profit enterprise to be "spun-off" as a private sector company towards the end of GEF project design. This is a departure from the original project design, where the project was to have been implemented by the Volta River Authority/Northern Electric Department (VRA/NED), the electricity utility in Ghana, which is expected to be privatized in the future. The current implementation structure does raise questions about the potential for privatization of RESPRO, as it is currently housed within a ministry.

The project, which has just started implementation, targets some of the poorest households in northern Ghana, and expects to sell electricity through installation of 50 Wp (for the equivalent of US$7 per month) or 100 Wp (US$12 per month) in households. Willingness-to-pay surveys and demand from households show that these rates are affordable. However, it is unclear whether these rates can generate enough revenue to offset expenses, including capital, operation, and maintenance costs.

In contrast, the Uganda project is based on the sales model. Consumer credit is provided through two local credit institutions: a private rural development bank and a credit-union type of women's trust. In addition to the GEF grant, UNDP has provided cofinancing to guarantee credit lines of these institutions. The project is at very early stages of implementation, and hence it is not possible to assess the likelihood of overall project success. But there is a clear contrast in this approach to the Ghana project; in Uganda, the project is clearly targeted towards those who are credit worthy and can afford the cost of credit (perhaps only the top 10% wealthiest households). Households that cannot afford commercial credit still constitute the vast majority of the rural population.

The Zimbabwe project was also based on the sales model. From 1995 to 1998, over 10,000 solar home systems were sold, primarily through private dealers. A utility-sales model was also piloted, through the national electric utility, which sold about 200 systems under the project but appeared to lack sufficient interest to continue after the project completed. Expected experience with sales by NGOs was limited. Consumer credit was provided by the Agricultural Finance Corporation (AFC), a development institution, through a revolving fund mechanism. The AFC provided credit to 4,200 households but has been unable to replenish the fund, which will be depleted without replenishment.

The Zimbabwe project was designed to enhance and upgrade indigenous solar manufacturing and delivery infrastructure, to develop an expanded commercial market in rural areas for affordable domestic solar electric lighting by providing low-interest financing through existing institutions, and to establish new credit mechanisms at the grassroots level to benefit lower income groups in rural areas (both households

23 Annex 2 is based on: field visit to Ghana, October, 1999 (met with UNDP; World Bank; Ministry of Finance and Economic Planning; Ministry of Environment, Science and Technology; Ministry of Mines and Energy; a member of parliament; University of Science and Technology; MICAP Coral Technology; Solarvent; Solarco; Wilkins Engineering, Gold River Solar Electric, Deng Limited, and Solar Light Co.); field visit to Uganda, October, 1999 (met with UNDP; World Bank; African Development Bank; Ministry of Finance, Planning and Economic Development; Ministry of Energy and Mineral Development; Uganda Renewable Energy Association; Uganda Women's Finance and Credit Trust Ltd.; Solar Energy Uganda Ltd; Solar Energy for Africa; Impact Solar Systems; Shell Uganda Ltd.); Martinot and McDoom, op. cit. note 4; Resource Futures International, "Lessons learned during the GEF pilot phase" (Ottawa, Ontario, 1998).

and community-based institutions). The project has had a number of impacts on the market for PV systems in Zimbabwe, including a greatly expanded network of dealers, reduced market prices (partly through elimination of import duties on imported components), improved technical knowledge among firms, establishment of PV module standards for certifying and guaranteeing installed systems, development of equipment certification institutions and procedures, and much greater awareness of PV by consumers, NGOs and government.

In comparing these projects, the fee-for-service delivery model seems to be oriented more towards the poorer of the rural population than the sales model. Also, the fee-for-service model looks affordable to larger sections of the rural population, and hence might have better potential for developing large markets for rural solar PV applications. Regardless of the model used, continued finance after the project, either from private or public sources, will be essential for the sustainability of the energy-service businesses or the delivery of consumer credit through development-finance or credit-union institutions.

Annex 3: Consumer Credit Through Microfinance Organizations in Sri Lanka[24]

The Sri Lanka project demonstrates the initial viability of a "microfinance model" in which solar home system (SHS) dealers market, sell, service, and guarantee their products to rural consumers through their own local sales/service offices. Consumers obtain loans from Sarvodaya, a national microfinance institution (MFI) with many local branches and strong ties to the communities in which it operates. A customer signs a credit agreement with Sarvodaya, Sarvodaya pays the supplier, and Sarvodaya is responsible for repayment and collections. The supplier provides maintenance service for the first three years, a one-year warranty for the system and a 10-year warranty for the PV module. The credit provided by the microfinance organization for purchase of solar home systems is similar in kind to that provided for enterprise development: $500 with 20 percent down payment, terms of up to five years, and 24 percent interest rate. "This is the only way to go," said the two major SHS suppliers in the market, who today sell more than 90 percent of their systems this way (now 50-100 systems per month). For 2000, Sarvodaya has signed agreements with the two major SHS suppliers to provide credit for an additional 5,000 systems and is looking at extending credit for 10,000 systems in 2001.

However, Sarvodaya is currently "the only game in town" in terms of consumer credit, and there is a need for other MFIs to participate in the SHS market. It appears that the market is being constrained by the lack of other MFIs with whom suppliers can sell systems on credit. "Help us to strengthen the rural credit structure," advised the two suppliers. "Sarvodaya is a social mobilization organization, not really a business," said one SHS industry observer. Sarvodaya sees these projects as primarily social projects and thus does not approach the market with the aggressiveness of a private company. Without other MFIs in the market, credit delivery through Sarvodaya may simply be too slow for the market expansion desired by suppliers.

The project also demonstrates the initial failure of a fee-for-service model in that country. Initially, one dealer provided 140 systems on a fee-for-service basis and thought this approach held promise. But it soon stopped offering systems this way because it did not want the expense of monthly collections in a fee-for-service scheme. "Collection costs were eating up our entire profit margin," the dealer said. "You need a strong fee collection system with good timing, otherwise customers will spend the money on something else (if your timing is off) and default. Or they say they will pay next month and ask us to wait, or cite poor performance. It's a continuing problem. Also, we found that if customers don't own the system, they won't take proper care of it and this increases our costs."

Dealer credit through the project suffered the same fate. In the early stages of the project, suppliers found collections too difficult and time-consuming. "Building a rural service infrastructure with technicians is a very different business from building a rural credit delivery and collection infrastructure," said the suppliers. "Credit is not [the suppliers] business," echoed one industry observer, "it is the business of microfinance institutions, and the success of credit depends on local connections, knowledge, and institutions already in place." One factor affecting the viability of dealer credit is a very low rural population density in Sri Lanka. Transport and labor costs involved in collections are substantial because of the long distances and time required to travel those distances by supplier personnel. Population density and transport costs also greatly influence supplier costs for marketing and service.

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24 Annex 3 is based on: field visit to Sri Lanka, November 14-19, 1999 (met with World Bank Project Management Unit, Shell Renewables Lanka Ltd., Resco Asia Ltd., Alpha Thermal Systems Ltd., Sarvodaya Economic Enterprises Development Services (central office and Mayangaya district office), UNDP, World Bank, Lalith Gunaratne & Associates, DFCC Bank, Sanasa Development Bank Ltd., Hatton National Bank, Browns Ltd., and three households that purchased solar PV systems); World Bank project supervision reports; Lalith Gunaratne, "Funding and repayment management of PV system dissemination in Sri Lanka," paper presented at Financial Services for Decentralized Solar Energy Applications II, 20-23 October 1998, Harare, Zimbabawe; Jayantha Nagendran, "Building local capacity in rural and renewable energy: Emerging lessons from Sri Lanka," paper presented at World Bank Energy Week, 6-9 April 1999, Washington, DC.

Both SHS suppliers and Sarvodaya have had no problem obtaining business financing from commercial banks and do not anticipate having problems in the future. But other MFIs besides Sarvodaya may face more difficulty, as commercial financiers see lending to MFIs as too risky and a marginal business. Because MFIs do not have assets, some observers felt that commercial banks would not lend to them, but this has not been tested yet in the project.

In 1999, Shell International Renewables purchased one of the existing SHS dealers and observers saw Shell's entry into the market as a very promising sign, one directly attributable to the World Bank/GEF project.[25] "Anybody who is really going to advance the market here has to have deep pockets," said one long-time participant and observer of Sri Lanka's SHS market. Shell also signed a memorandum of understanding with the national electric utility that included a statement by the prime minister that the government would promote the private SHS industry. "The credibility of SHS has increased several notches" within the government due to the World Bank/GEF project and Shell's entry into the market, said an industry observer.

25 Shell International Renewables has stated that they would not have entered the Sri Lanka market if the World Bank/GEF project had not taken place, according to the World Bank task manager for the project.

Annex 4: Solar PV Businesses and the IFC/GEF Small and Medium Scale Enterprise Program[26]

Business financing is being provided under the IFC/GEF Small and Medium-Scale Enterprise Program to three solar home systems businesses in Bangladesh, Vietnam, and the Dominican Republic.

The Bangladesh project demonstrates a dealer-credit model in which one organization (Grameen Shakti, legally a non-profit), performs all functions: marketing, sales, service, credit provision, collections, and guarantees. From 1997 to 1999, Grameen Shakti installed 1,500 systems using this model (about 1,100 systems since IFC financing began in July 1998), and plans to install 2,000-2,500 systems in 2000 (consistent with their original business plan). Grameen Shakti is so far the only player in the Bangladesh SHS market. Before the IFC loan, Grameen Shakti was installing about 20 systems per month using Grameen Bank financing exclusively, which was for one-year terms only. Therefore, Grameen Shakti could only extend credit for one-year terms, limiting demand greatly. The IFC SME loan enables Grameen Shakti to extend three-year credit to customers, which has made a large difference in its business. Grameen Shakti believes they will ultimately be able to receive loans from commercial banks in perhaps another 3-4 years, after they demonstrate profitability.

In Bangladesh, Grameen Shakti is selling to households that have incomes two or three times higher than Grameen Bank "members" (those eligible to borrow from the Grameen Bank). Grameen Shakti's customers represent the top 10 percent to top 15 percent of income status among rural households. Grameen Shakti's biggest problem is the cost of marketing and consumer education. They are spending all their own money (financed through business loans) on this. They don't receive any grants from the government or Grameen Bank. Grameen Shakti finds the process of building customer demand and confidence to be enormously draining on their time, resources, and profitability. Grameen Shakti is finding that after a "critical mass" is reached in a particular community (perhaps 100 systems), word spreads among friends and relatives, people see systems in operation, and marketing is easier.

In Vietnam, sales by a private dealer (SELCO) are assisted by a complex credit delivery scheme involving the Vietnam Women's Union (VWU), an NGO, and the Vietnam Bank for Agriculture and Rural Development (VBARD), a development finance institution. VWU markets SELCO's systems and administers consumer loans provided by VBARD (VWU collects fees for these services). SELCO provides systems (receiving full cash payments) and is responsible for service. VBARD provides consumer loans, assuming risk for 75 percent of the purchase price. Of the remaining 25 percent of the purchase price, SELCO provides a collateralized guarantee to VBARD for 5-10 percent and the customer pays 15-20 percent as a down-payment. SELCO covers its collaterized guarantee to VBARD with IFC/GEF financing. If a purchaser defaults on the VBARD loan, SELCO repossesses and refurbishes the system, and VWU finds a new buyer for it. If there is any loss in this repossession/refurbishing/resale process, VBARD has access to the SELCO guarantee. Despite instructions from the head office, some conservative branch managers of VBARD have been reluctant to participate in the SELCO business. Where this has happened, SELCO has extended consumer credit itself. So far SELCO has sold 500 systems in Vietnam.

In the Dominican Republic, the U.S. firm Soluz has been developing a subsidiary, Soluz Dominicana, into a successful fee-for-service business that targets up to 50 percent of the population in the rural communities it serves and charges $10 to $20 per month for

26 Annex 4 is based on: field visit to Bangladesh November 20-22, 1999 (met with Grameen Shakti, Bangladesh Center for Advanced Studies, and World Bank); field visit to Vietnam October, 1999 (met with IFC; World Bank; UNDP; Japan Bank for International Cooperation; Electricity of Vietnam; Ministry of Science, Technology and Environment; Vietnam Women's Union; Vietnam Bank for Agriculture and Rural Development; BP Solar Vietnam; Selco Vietnam; Shell Vietnam; Trans Energ); Richard Hansen, "Solar Electric Energy Delivery—A Business Model," paper presented at Village Power '98, 6-8 October 1998, Washington, DC (Golden, CO: National Renewable Energy Laboratory); personal communications with Richard Hansen of Soluz in October 1998, February 2000 and April 2000.

electricity service from SHS.[27] The Soluz business model revolves around a "service center" for up to 2,000 customers and "zones" of about 500 customers served by technicians collecting payments at "collection points" covering 20 to 100 customers. Collection rates have been typically over 95 percent, although to maintain high rates Soluz Dominicana has needed to make household visits to a portion of customers. Through continuous improvement to the business model, including business and technical systems optimization, Soluz expects to complete a robust "proof of concept" with Soluz Dominicana at a scale of 5,000 fee-for-service customers. As of April 2000, Soluz Dominicana had installed over 3,500 systems and had passed the break-even point where revenues cover the direct costs of operations. About 1,700 of these systems have been installed on a fee-for-service basis. Soluz also established Soluz Honduras to enter the Central American market and diversify.

Soluz is now working on developing its business model to the point where eventually it will be able to support 25,000 customers. Soluz finds such "business model R&D" very difficult to fund from operating revenue alone at the proof-of-concept scale. Thus Soluz sees the need for concessional funding to help it cover first-time commercialization costs, including financial transaction engineering and optimization of its business and technical systems. Said Soluz of its commercialization efforts, "We are doing the work to prepare for a $5-10 million company (25,000-50,000 customers), but we are concerned about burdening a $1 million company (5,000 customers) with the overhead and first-time costs of building an energy-service company on a larger scale. The business is risky, and the GEF still has a legitimate role. This is a lean margin business, so a small difference can affect profitability greatly. Over the next three years we need to create a strong franchise. There are necessary overheads as well as first-time innovation and transaction costs to keep the thing going on a solid path—the question is how to cover these costs. To rely only on equity would place high pressure for rapid and more difficult-to-achieve growth to meet return requirements, which adds risk."

27 Monthly fees are $10 for a 20 Wp system, $15 for 40 Wp, and $20 for 50Wp. Customers own and are responsible for the battery, although Soluz Dominicana can include financing for batteries in the monthly fees.

Annex 5: Rural Energy Service Concessions in Argentina[28]

The World Bank/GEF Renewable Energy in the Rural Market project aims to supply electricity to 66,000 households with individual solar home systems (of 50Wp to 400Wp), 1,100 public facilities with solar photovoltaic systems, and 3,500 households with village power systems (using mini-hydro or hybrids such as solar/wind, wind/diesel, or solar/diesel) through province-level energy service concessions. Concessions are free to select which technology to apply in any given situation, including diesel-only village power systems. Concessions will be obligated to:

- provide electricity services to rural off-grid customers anywhere in the province for a period of at least 15 years, upon request;
- carry out all necessary maintenance, repairs, or replacement of components as needed to ensure the continuity of the electricity service to each and every customer;
- provide "state-of-the-art commercial service standards" for connection requests, billing, collection, and claims handling; and
- provide the provincial utility regulatory agency (ENRESP) with periodic reports on the status of the concession including but not limited to performance indicators such as number of connections by type of consumer and method and technology supply, outages statistics, and financial results.

Concessions are eligible to re-bid for their business every 15 years (for up to a total of 45 years) competitively against other eligible firms. The 15-year period was seen as a compromise between the need for a short period for the quasi-monopoly and a long period for the annuity calculations of the concession. After 15 years, the government may modify the concession rules to account for new technological developments, or may even decide to abandon the concession system and open the market to competition. During the 15 year period, the concession, provincial government, and provincial utility regulatory agency renegotiate the tariffs every 2 years.

Eight provincial governments (out of 22 total) are eligible to participate in the project. Each of these provinces has privatized or is in the process of privatizing its power sector, or at least has made a legal commitment to privatize.Four of these provinces have existing private concessions serving the concentrated (urban) market that are regulated by the provincial governments. Under the project, these governments will first try to negotiate a rural concession contract with their existing concessions (as an amendment to the existing contract). If such negotiation fails, or if there is no existing concession for that province, then a new concession contract will be awarded according to international competitive bidding procedures.

28 Annex 5 is based on Eric Martinot and Kilian Reiche, "Regulatory Approaches to Off-Grid Electrification and Renewable Energy: Case Studies from Six Developing Countries," (Washington, DC: World Bank, 2000).