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Bringing solar home systems to rural El Salvador: lessons for small NGOs

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Abstract

This paper presents the results of case studies examining two independent projects that worked to bring solar home systems (SHSs) to isolated communities in El Salvador. Both projects were implemented by small nongovernmental organizations (NGOs) that did not have prior experience with SHSs. One project was market-based: families were given the opportunity to purchase the systems at going prices. The other was donor-based: residents were provided the equipment in return for their agreement to cooperate in local environmental protection efforts. Results of a comparative analysis support several conclusions. (1) For small NGOs, the promotion of markets is appealing because of the potential for financial sustainability; yet a reliance on markets may also heighten complexity and increase opportunities for failure. (2) In implementation of market-based projects, all stakeholders, including potential consumers, private-sector service providers, and the staff of NGOs acting as project managers, will face pressures to modify and adapt their attitudes and behaviors. (3) Alternative models for small-scale projects that integrate market-based and donor-based design features deserve consideration.

Keywords: Rural electrification; Solar home systems; El Salvador

1. Introduction

In El Salvador, approximately 2.3 million people, or about 35 percent of the population, lack access to national electricity service. They may be out of reach of conventional grids or may be near power lines but unable to afford connections. For lighting, as is common across rural areas of the developing world, these households typically use some combination of kerosene lanterns, flashlights, and candles. To power appliances—radios or small black-and-white televisions, for example—these families commonly use automobile batteries. In such circumstances, small modular photovoltaic (PV) solar home systems (SHSs) are an attractive alternative source of electricity. SHSs provide energy that is cleaner, safer, more convenient, more reliable, and of better quality. As prices for solar panels have dropped rapidly over the past decade, SHSs have become a cost-effective component of many donor agencies' rural development work, and these systems, in principle at least, have become affordable for individual purchase by many poor families (Martinot et al., 2001).

Yet significant obstacles continue to limit the spread of PV technology into non-electrified areas of El Salvador and other poor and middle-income countries. First, because of limited funds, donors cannot provide SHSs to more than a small percentage of poor families who could benefit from the equipment. Second, markets, which should spread given PV's cost competitiveness, are constrained by several factors, including a lack of access to credit for poor families who cannot afford the initial capital investment or down payment; a lack of confidence and experience among marginalized consumers in the purchase of durable goods; and a lack of service providers willing and able to sell, install, and maintain the systems in communities that are often

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difficult to work in because of isolation and poverty (World Bank, 2000a; Martinot et al., 2001).

Nevertheless, a range of agencies from the Global Environment Facility and the World Bank to small nongovernmental organizations (NGOs) continue to experiment with ways to bring SHSs to poor households in isolated areas, either through donations or markets. A considerable literature now exists documenting and assessing such efforts (e.g., Erickson and Chapman, 1995; Byrne et al., 1998; van Campen et al., 2000; Dauselt, 2001; Martinot et al., 2001; Karekezi and Kithyoma, 2002; Biswas et al., 2004; Gustavsson and Ellegard, 2004). Most country or regional assessments, however, focus on Africa and Asia, and independent scholarly analyses of SHS projects implemented elsewhere, particularly in Central America, the region considered here, are lacking. Documents available on projects in this area generally review relatively large PV efforts funded primarily by the United States government and other international agencies and are prepared by staff affiliated with the projects under discussion (e.g., Richards et al., 1999; Hanley et al., 2000; US Department of Energy et al., 2002; E+Co, 2004).

This paper contributes to the literature by describing two separate, small-scale SHS projects implemented in El Salvador. Each project offered solar home systems to a community isolated from the power grid. One project was market-based, designed to demonstrate that poor households could become consumers of these products at going prices. The second was donor-based, with SHSs provided free of charge, although recipients did incur some non-monetary costs associated with an agreement to support local environmental protection efforts. Both projects were implemented by small NGOs without prior experience in promoting the use of solar home systems. Analyses of these case studies shed light on the strengths and weaknesses of two distinct approaches to promoting the use of SHSs and offer useful lessons for small NGOs interested in developing such projects.

The findings reported in this paper represent partial results of four months of field research conducted at the sites in 1999 and 2000 and supplemented by a follow-up review of outcomes in early 2004. During the initial fieldwork, I applied a combination of techniques drawn from ethnography and program evaluation. Methods included structured, semi-structured, and open-ended interviews; focus groups; household surveys; and participant observation. Summaries presented in the paper regarding general socioeconomic conditions in the communities, energy-related finances for individual families, and quality-of life considerations related to the installation of SHSs are derived from surveys and interviews that I completed during the fieldwork. The organizations involved in the projects are not directly identified in conformity with confidentiality and anonymity agreements reached with individual interviewees.

The paper proceeds as follows. Following this introduction, the second section presents background information on the types of PV systems used in the two projects and considers the effect on household finances for participating families in the case-study sites. The third section includes a detailed description and discussion of the two projects. The fourth section provides comparative analysis. The final section closes with recommendations.

2. SHSs for poor households

2.1. System design and specifications

In the small solar home systems that are the focus of this paper, a PV panel is installed on a roof or pole away from shade and tilted so as to catch the sun's rays as directly as possible. The panel converts solar energy to electricity and charges a storage battery, often an automobile battery. A control device regulates the flow of electricity into and out of the battery to ensure that it is properly charged. The SHSs used in the projects described in this paper were built around a solar panel with a capacity of 80 peak watts (Wp). When installed as part of a system that includes a storage battery, a panel of this capacity can power several 15-W florescent lights and an outlet where families can plug in small appliances such as radios, tape players, or small black-and-white televisions. A basic system of this type does not convert electricity to alternating current. Families can only use appliances that operate on 12-V direct current. Moreover, systems with this level of power generation do not provide sufficient energy for cooking, refrigeration, or home heating. Their primary utility is to provide lighting and to power small appliances.

Despite these limitations, SHSs of this type, with capacities ranging from 20 to 150 Wp have demonstrated considerable appeal in the global marketplace. Approximately 1.5 million small household PV systems have been sold in the developing world, with particularly strong markets over the past ten years found in such countries as Kenya, Morocco, Zimbabwe, China, Indonesia, Sri Lanka, Mexico, and the Dominican Republic (World Bank, 2000b; Martinot et al., 2001; Duke et al., 2002).

2.2. Household finances

In the two study sites discussed in this paper, average incomes for typical households with six to eight members range between $200 and $400 a month—a per capita income at or below $2 per day. (US dollars are used because El Salvador has "dollarized" its economy.) In each community, a third to one half of the residents live on per capita incomes at or below

$1 per day, the United Nations standard for severe income poverty (United Nations Development Programme, 2002). Because these villages fall in El Salvador's lower socioeconomic strata, these poverty statistics are not unexpected. Data from 2002 reveal that approximately 45 percent of the country's population has a per capita income level below $2 per day and that about 21 percent falls below $1 per day (United Nations Development Programme, 2002).

Despite the severe cash flow constraints that families in the two case-study communities face, surveys of their household budgets that I conducted as part of this research indicate that, before implementation of the SHS projects, costs linked to energy for lighting and for powering small appliances typically averaged between 5 and 10 percent of family income, or between $15 and $40 per month per household. Market-based approaches to providing PV electricity in such communities are designed to take advantage of this existing household budget line.

As PV technology has improved and production capacities have increased, prices have dropped until SHSs are now, in principle at least, affordable for a growing percentage of poor households in El Salvador and elsewhere. Over the past 10 years, for example, the cost of solar panels has fallen 50 percent, from approximately $6/W in the early 1990s to about $3/W in 2002. Over the same period, annual production of PV equipment worldwide has risen 10-fold, from 50 MW in 1993 to 500 MW in 2002 (World Bank, 2000c; International Energy Agency, 2003). Consumers can now purchase complete 40-W systems in many areas for $300. Eighty-watt systems, like those installed in the case-study sites discussed in this paper, sell for approximately $600.

For an intermediate system, a family making a down payment of $50–$100 would have monthly payments on the order of $20–$25 for a four-year loan at an interest rate of 18 percent, which is typical in Salvadoran consumer credit markets. The down payment is often a limiting factor—in this region, $50–$100 may equal a month's income for an agricultural or domestic worker. A second constraint is that these families do not routinely have access to consumer loans for such purchases. On the other hand, if credit were available and the problem of a down payment could be overcome, the monthly payments themselves would not represent an additional burden. Money currently spent on batteries, candles, and kerosene could be reallocated to cover installment payments on a loan for an SHS. Moreover, after retiring the loan, after four years in the example given, the family would have the amount of the monthly payment, minus savings set aside to meet maintenance expenses, available for other priorities for the remainder of the estimated 25-year lifespan of the system.

Maintenance costs on SHSs are relatively low. Solar panels of good quality require no maintenance other than occasional cleaning in the dry season when dust may accumulate. The other major system component, the storage battery, generally needs to be replaced every three to five years at a cost each time of about $75. Low-wattage florescent bulbs, which cost about $2 each, also would occasionally need to be replaced. Setting aside $2–$4 a month would cover these contingencies over the lifetime of the system.

Thus with consumer education, with support in gaining access to credit, and with help on down payments or in securing loans that did not require down payments, most households in these communities could purchase SHSs on terms that (1) would not increase current expenses in the short term, (2) would generate long-term financial benefits, and (3) would provide an energy supply of significantly improved quality, reliability, and convenience. These calculations for households in the study sites in El Salvador match those reported for many potential consumers among poor households in other developing countries (Cabraal et al., 1996, Martinot et al., 2001) and suggest that markets for this technology should be able to succeed among the target group.

2.3. Additional benefits

Members of families involved in the projects at the two study sites indicated in interviews with me that PV electricity brings important quality-of-life advantages beyond long-run cost savings over the sources of energy that they had been using previously. First, 15-W fluorescent bulbs provide a light that is superior to that given off by flashlights, kerosene lanterns, or candles. In the evenings, adults can do chores, socialize, or watch television in well-lighted spaces that promote comfort and dignity, and children can do schoolwork with less eye strain. Various studies have noted that families with SHSs particularly value the benefits to school-age children (e.g., Ellegard et al., 2004; Gustavsson and Ellegard, 2004). Second, lights and appliances connected to PV systems do not require constant tending. In contrast, candles burn down, flashlight batteries run low, and kerosene lanterns, depending on their mode of operation, are noisy or smoky. Third, car batteries, which many families currently use to power small radios or televisions, are heavy, awkward, and inconvenient to transport for the frequent, often weekly, recharging that is required. Finally, PV electrical systems are considerably safer than the alternatives mentioned. Children in particular are at risk of injury from the open flames of candles or the heated surfaces of lanterns. Thus, in addition to the potential for long-term cost savings, the added safety, convenience, and quality of service that SHSs provide to poor households significantly improve

wellbeing when compared to other available energy sources.

3. The case studies

This section of the paper discusses each of the two projects individually. The communities directly affected were Casa Blanca, located in the coffee growing highlands just west of the capital San Salvador, and El Naranjito, situated in the rugged, isolated buffer zone of El Imposible National Park near the country's western border with Guatemala. In Casa Blanca, a development NGO based in the United States supported the efforts of a Salvadoran private firm to sell SHSs to residents at market prices. In El Naranjito, the Spanish government's international aid agency worked with a Salvadoran environmental NGO to donate SHSs to community residents in return for changes in their attitudes and behaviors toward the neighboring protected area.

3.1. Casa Blanca

3.1.1. Background and project implementation

Casa Blanca includes 75 households, a total of about 600 people. The homes and small cultivated plots that make up the community lie entirely within the boundaries of a large private coffee plantation. Historically, the village served as a residence area for plantation workers and their families. As the community has grown, however, many household members now work off the plantation.

Houses in Casa Blanca are not connected to the national grid even though the plantation is within sight of lines distributing electricity in the nearby town of Villa Colón. Because the community is located on private property, the power company would not extend service into the village unless residents paid expenses associated with the installation of poles and lines. Before the project described in this paper was initiated, village leaders had contracted an engineering firm to draw up plans, but the estimated cost of bringing in commercial power—about $35,000—was beyond the community's means.

Families in Casa Blanca live in poverty. Many men from the village work on the coffee plantation where they reside or on other plantations nearby. Other family members, particularly women, work as domestic servants in San Salvador or as employees in clothing factories that have recently sprung up in the area around the capital. Surveys and interviews that I conducted during the case study indicate that a typical household in the community includes six to eight people, of whom two or three have full-time jobs and one or two others have part-time work. Family incomes average in the range of $350–$400 per month.

The NGO that initiated the project believed that successfully demonstrating that households with these socioeconomic characteristics could afford SHSs would support the contention that markets for the technology should be sustainable throughout El Salvador and beyond and would thus promote an effective new rural development strategy. After establishing a partnership with a Salvadoran business experienced in installing PV equipment, but not experienced in rural development, the organization provided 60 80-W solar panels to the firm on consignment. The partners expected that as a market developed, the firm would be able to repay the NGO for the equipment. Casa Blanca was selected as the initial demonstration site because it had the attributes of an isolated rural village but was easily accessible from the capital. The partners hoped that publicity from the Casa Blanca project would stimulate demand and promote the establishment of markets for SHSs in that community and elsewhere in the surrounding area.

The project began with the firm installing SHSs in five houses in Casa Blanca on a trial basis—initially without cost to the families involved—to demonstrate the equipment's functionality and benefits. Before becoming participants, the selected families had to agree that if they wished to keep the systems beyond the initial demonstration period they would begin making installment payments as part of a financing package leading to purchase.

3.1.2. Outcomes and discussion

There were some positive results from the Casa Blanca project but also several significant problems. On the positive side, the five original demonstration households were able to purchase their SHSs. These families indicated to me in interviews that their installment payments were within their previous household energy budgets and that they were very happy with the improved quality of life resulting from access to solar electricity. One head of household, for example, stated firmly that when he made his final payment on the present system, he would immediately buy a second panel and battery to increase his household power supply.

On the negative side, the project failed to demonstrate in this particular case that self-sustaining markets for SHSs could be established in poor communities isolated from the grid. The only target families who acquired PV systems were the original five demonstration families, who made their purchases under conditions that allowed them to avoid costly down payments. As the firm marketed the products elsewhere in the country, it found that its business expenses were consistently higher than its revenues. Ultimately, the firm sold and installed the solar panels at a loss and was unable to cover its debt to the NGO. Moreover, purchasers outside Casa Blanca

were primarily community development organizations or better-off households, rather than the poor families that had been the intended beneficiaries of the project. The relationship between the firm and the NGO cooled, and the partnership ultimately ended with less than half of the debt to the NGO repaid.

However, close observation of project implementation practices and interviews that I conducted with participants from the NGO, the firm, and potential consumers indicate that these failures did not result directly from unfavorable underlying economics, but rather from the inexperience and poor preparation of the NGO and the firm. Both partners underestimated difficulties associated with developing and nurturing a market for SHSs in poor communities.

First, the base of target consumers willing and able to purchase the equipment was more limited than anticipated. Advertising, marketing, and consumer education were required to stimulate the market; yet neither the NGO nor the private firm made the necessary investment in these secondary activities. Also, because the NGO had no in-country representative it was unable to detect and respond to problems as they arose. It also failed to recognize the importance of providing consumer education and ensuring the availability of consumer credit. For its part, the firm was ill prepared to work effectively with poor and marginalized families. In community meetings in Casa Blanca, for example, presentations by the firm's spokesman were not well tailored to the audience. Villagers are semi-literate, with most adults not having completed elementary school. In addition, poor villagers tend to listen to talks by outsiders in a quiet and respectful manner and not ask questions even if points are not clear to them. In interviews I conducted after these meetings, community members who had attended often expressed interest in principle in SHSs, but demonstrated through their comments that they did not clearly grasp how such a system would work, what services it would provide, how their household budgets would be affected, and how they could seek financing support. Not one additional family in Casa Blanca, beyond the five original demonstration households, made a serious attempt to purchase a system as part of this project.

Second, the project suffered from poor communication and deteriorating levels of trust and cooperation between the partners. In interviews, each blamed the other for the failure to make progress in establishing a market for the equipment. Staff at the NGO complained that the firm was unreliable, hard to contact, and unresponsive to complaints. The firm's representatives argued that the terms of the arrangement limited their flexibility and made it impossible to cover expenses. The NGO had provided an inventory of 80-W panels. The firm noted, however, that given this fixed inventory, it was not able to take advantage of continuing price declines in solar panels or offer systems with a range of capacities to potential consumers.

To summarize the project's weaknesses, the NGO relied too heavily on a technological and market-based solution to community development, assumed that it could operate without a permanent in-country representative, and failed to anticipate or respond effectively to problems as they arose. Compounding these limitations, the firm was inexperienced, undercapitalized, and operating in a business environment in which its potential customers were unfamiliar with its product and lacked access to credit and other consumer support services.

3.2. *El Naranjito*

3.2.1. *Background and project implementation*

El Naranjito is an isolated village of 30 households, about 200 people altogether, located in the rugged, mountainous buffer zone of El Imposible National Park. Families in El Naranjito are on average worse off economically than their counterparts in Casa Blanca. Because of the village's isolation, few goods, services, and employment opportunities are available in El Naranjito itself, and, unlike in Casa Blanca, the rugged terrain, poor roads, and lack of public transportation make it impractical to commute daily to an outside job. Adults in the community are primarily agricultural laborers, cultivating their own small plots or working for other property owners. Surveys and interviews that I conducted in the village as part of the case study indicate that total income for the average seven- to nine-person household is approximately $250 a month—about two-thirds of the average family income in Casa Blanca.

Before the PV project, families in El Naranjito, as in Casa Blanca, typically spent 10–15 percent of household income on energy, primarily batteries, candles, and kerosene. For residents of El Naranjito, however, the non-monetary costs associated with acquiring energy-related supplies were significantly greater than in Casa Blanca, where the urban center is only a 10-min walk away. Tacuba, the town nearest to El Naranjito, is a three-hour walk each way on a steep, rough road. Carrying heavy automobile batteries into town for recharging was particularly burdensome.

The proximity of El Imposible National Park played a central role in site selection for this SHS project. The protected area, created in 1980, contains the largest remaining reservoir of biological diversity in a country that has lost over 90 percent of its forests to agriculture and urban development (Foy and Daly, 1993; Serrano et al., 1993; Colorado, 1999). To extend environmental protections, the government in 1986 established a buffer zone around the park that included El Naranjito and other small villages (SalvaNATURA, 1997). In theory, the creation of the park and buffer zone significantly

restricted opportunities that local residents had previously taken for granted. According to the new regulations, villagers could no longer hunt and gather in the park itself, and smallholders with property in the newly created buffer zone, while permitted to continue cultivation of existing plots, were not allowed to clear new land. In practice, however, these rules initially had little impact. The country was embroiled in a long civil war, environmental protection was a low national priority, and regulations were not enforced.

But beginning in 1990, a well-connected Salvadoran environmental NGO based in the capital became active in conservation activities in the area. Since the national government had neither the funds nor the political will to manage El Imposible effectively, the NGO, relying on a private donor base and other funding sources, was able to fill the gap. In 1991, the ministry responsible for national parks gave the NGO quasi-governmental authority for management of El Imposible (SalvaNATURA, 1997). Not surprisingly, as the NGO instituted a more active conservation program and attempted to enforce restrictions on local residents' activities in the park and buffer zone, tensions rose. Some villagers responded to the loss of access to these resources, which in many cases they had depended on for subsistence, by actively sabotaging environmental protection efforts in the area.

By the late 1990s, as relations with local residents reached a low point, the NGO changed tactics and developed programs to reduce the conflict. As part of this new approach, NGO staff conducted community needs assessments that, confirming findings from a previous survey (Guadrón, 1996), identified lack of electricity—along with poor roads and unreliable water supplies—as an issue of particular concern to villagers. In response, the organization solicited a grant from the Spanish government to support a solar home system project in the community. The project included an innovative component: an explicit quid pro quo that offered residents a desired benefit, solar electricity, in return for their agreement to support instead of undermine environmental protection efforts in the park area. With this funding, the NGO was able to install SHSs in all 30 homes in the village. The project was limited to the village and did not include an effort to establish a wider market for SHSs.

3.2.2. Outcomes and discussion

The El Naranjito project began with clear and specific objectives, and in the short term the goals were achieved. In discussions with me, both NGO staff and villagers indicated satisfaction with the results. People in El Naranjito now had working solar home systems, for them an extraordinary and unexpected benefit, and the NGO had succeeded in largely eliminating poaching and illegal woodcutting by villagers and in defusing their general hostility toward park management activities.

Moreover, interviews that I conducted with NGO personnel and community residents suggest that significant shifts in attitude had taken place on both sides and that observed behavioral changes had a good chance of being sustained. NGO staff had come to see local residents as potential allies rather than as adversaries, and villagers showed signs of beginning to internalize a conservation ethic. Residents reported pride in the natural beauty of their area and expressed hopes that they would realize economic gains as the park began to draw tourists.

In the short term, only minor problems developed. For example, park rangers discovered instances of boys continuing to harvest crabs from streams in the protected area, and some families fell behind in the small monthly contributions they were expected to make to a maintenance fund established primarily to cover costs of battery replacement. While these concerns were manageable, it is easy to envision more serious issues developing in the future. The area's intransigent economic and social problems, particularly poverty and population growth, present the most daunting challenges.

Poverty may threaten long-term benefits because, although household solar energy is undoubtedly a desirable quality-of-life improvement, it does not provide a direct substitute for park resources foregone. Most families will see compensating gains in their financial situation as they spend less on candles, flashlight batteries, and kerosene, but for many families in this very poor village, the temptation to violate the ban on unauthorized use of park resources will certainly recur.

Local population growth is also likely to put the project's long-term success at risk. As adult children of beneficiary families build their own homes, these new residences will not have SHSs unless families are able to purchase them independently. If recent trends continue, the community will double in size in 20–25 years, and even if growth slows as a result of more rapid emigration from rural areas to the urban centers, significant community expansion is inevitable. Consequently, the pressure on park resources that the current project has temporarily alleviated will reappear.

4. Comparative analysis

In this section, I compare and contrast findings from the Casa Blanca and El Naranjito case studies, focusing particularly on the relative strengths and weaknesses in small-scale projects of market-based and donor-based approaches for bringing PV electricity to the rural poor.

While both projects worked to bring SHSs to rural communities isolated from the national electricity grid, the approaches were quite different. In El Naranjito, an outside agency donated the equipment. Beneficiaries

received the systems without charge and saw direct savings in energy costs as they reduced their consumption of batteries, candles, and kerosene. In return, they were required to forego exploitation of natural resources in the protected area. In contrast, families in Casa Blanca that acquired SHSs purchased them at market prices. They also realized savings in expenses related to batteries and other traditional energy sources, but in return they had to make monthly installment payments to service the loans that financed their purchase of the solar home systems.

Although the project in Casa Blanca struggled while the project in El Naranjito, at least in the short term, was successful, the market-based SHS project in Casa Blanca may be a more instructive example with wider implications for small NGOs than the donor-based effort in El Naranjito. Donor-based programs cannot be applied broadly enough to solve rural electrification problems in the developing world. In El Salvador, approximately 2 million poor people in rural areas lack electricity service, and globally the number is approximately 2 billion (World Bank, 2000d; Duke et al., 2002). Assuming an average household size of six persons, and an average cost of $500 per SHS, the total initial cost for providing PV systems to all affected families would be on the order of $150 million for El Salvador and $150 billion worldwide. For comparison, total annual government spending on foreign aid is less than half this amount (Cooper, 2002), and there are many other development priorities beyond rural electrification.

On the other hand, financially self-sustaining market-based projects have the potential to bring SHSs within the reach of many poor families. While other studies have reported that in sub-Saharan Africa costs related to the purchase of SHSs may be higher than baseline energy budgets for many families (Ellegard et al., 2004; Gustavsson and Ellegard, 2004), households in rural El Salvador and other areas with similar socioeconomic characteristics should be able to purchase systems by reallocating outlays for batteries, candles, and kerosene without incurring additional short-term expenses, and with the prospect of long-term financial gains.

Results of the Casa Blanca case study also suggest that market approaches may provide additional, non-material benefits relating to independence and self-reliance. In interviews that I conducted during the case studies, heads of families in the community who purchased systems clearly demonstrated pride of ownership. Responses indicated enhanced self-esteem and a heightened sense of dignity. Families in El Naranjito were equally satisfied with benefits provided by their PV systems, but sentiments they expressed in interviews tended more towards gratitude and humility rather than pride and self-respect.

Yet findings from this research also reinforce the argument that markets and appropriate technology alone are not sufficient to ensure success in efforts to bring SHSs to the rural poor in developing countries (Martinot et al., 2001). The target consumers—typically marginalized and potentially vulnerable families with limited experience in the purchase of expensive durable goods—need consumer education, consumer protection, and help with credit and down payments. Perhaps equally important, private sector suppliers and service providers, who form an essential component of any market approach, also need education and support if they are to work successfully with this atypical consumer base. The Casa Blanca project did not realize its anticipated benefits, not because the underlying economics were inherently unfavorable, but because social and cultural obstacles were overlooked and other barriers to the establishment of markets were underestimated.

5. Recommendations

This section provides recommendations that follow from the case-study findings. The recommendations fall into two categories: NGO activities and SHS project design characteristics.

First, I consider NGO activities. In principle, the application of market forces and appropriate technology should ease the administrative and financial burdens on small environment and development NGOs working to promote solar electrification in rural areas of poor countries. Since PV systems are in many circumstances now cost competitive with other available energy sources, efforts to promote markets should generate broader benefits for lower levels of investment than would be the case with exclusively donor-based projects. Yet the research reported in this paper suggests—reinforcing results from earlier studies (e.g., Cabraal et al., 1996, 1998; World Bank, 2000a; Martinot et al., 2001)—that market-based approaches do not necessarily reduce the complexity of projects or minimize the commitments of time and money required of NGOs.

Moreover, project managers may underestimate the negative impact of stresses likely to emerge as NGOs and private firms attempt to collaborate in promoting markets for SHSs in rural areas of poor countries. The goals, incentives, and cultures of these two types of organizations are inherently different, and conflicts over priorities, areas of responsibility, and performance standards, as occurred in the Casa Blanca project, are likely to surface.

Thus the case-study findings lead to several recommendations for small NGOs involved in market-based SHS projects.

(1) Assume complexity, and expect obstacles to arise.
(2) Do not expect markets to reduce the commitment of time and money required.

(3) Be prepared to take on new responsibilities that require new skills and expertise; for example it may be necessary to:
   (a) assist in the development of business plans,
   (b) provide financial planning for both firms and consumers, and
   (c) mediate between firms and consumers.
(4) Recognize that both firms and consumers are likely to need support:
   (a) purchasers will need (on a continuing basis):
      (i) consumer education and protection, and
      (ii) help with down payments, access to credit, and credit management.
   (b) suppliers will need (on a continuing basis):
      (i) incentives to enter and remain in a market with atypical consumers,
      (ii) training in communicating effectively with poorly educated consumers,
      (iii) training in the ethics of doing business with vulnerable consumers, and
      (iv) oversight to ensure that these firms provide appropriate service and observe ethical standards.

Next, I consider SHS project design characteristics. This paper compares small-scale market-based and donor-based projects and argues that in principle market-based approaches are more likely to be financially self-sustaining and are therefore more generalizable. Nevertheless, the donor-based project in El Naranjito incorporated an innovative design component—a quid pro quo for cooperation in environmental protection—that suggests the possibility of various hybrid models that may be appropriate for similar small-scale projects. Among the wide range of designs that can be imagined, the following alternatives among others could be explored.

(1) Project managers could provide options for combining monetary and non-monetary payments. Non-monetary "payments" could be in the form of participation in various beneficial community development or conservation activities, and households could choose from a menu of alternatives depending on their ability to pay and their willingness to become involved in project activities.
(2) Project beneficiaries could cancel part of the SHS purchase price through project-related training or work. For example, participants could learn the skills necessary to be installers, salespersons, counselors, mechanics, technicians, and so on. With support, participants over time may be able to develop their own independent businesses related to project activities.

Neither of these project designs, or related alternatives, would be entirely financially self-sustaining, but in principle all hybrid models should require less external financial investment than equivalent projects that did not include some contributions from beneficiaries.

To conclude, although market-based projects are likely to have wider applicability than donor-based projects, small NGOs cannot assume that market forces and appropriate technology will reduce the complexity of their development and conservation projects and ensure positive outcomes. For NGOs implementing small-scale SHS projects, hybrid models incorporating market-based and donor-based components deserve consideration.

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