Solar Photovoltaics in Developing Countries: 
Expanding the Private Market through 
Multi- and Bi-lateral Programs 

by 

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ABSTRACT

International funder organizations are expressing a renewed interest in designing electrification projects for developing countries that utilize renewable energy technologies. These new projects are designed to overcome obstacles that inhibited success of the international sponsored aid programs of the 1980's and 1990's. The most notable alteration is to focus on developing the private sector by providing loans to retailers, credit to consumers, and training to retailers and banks in order to encourage their participation.

This paper assesses the effectiveness of the current generation of renewable energy programs, developed by the World Bank Group, the US Agency for International Development, and the US Department of Energy, in developing a private market for solar photovoltaics in developing countries. It identifies eight barriers to market development that discourage retailers, consumers, and financial institutions from participating in the market. The new programs will collectively contribute hundreds of millions of dollars to the market. This will help to overcome several of the barriers, however there are challenges that will persist into the future. These include the degree to which the national government will influence market development, the extent to which financial institutions can assess the viability of the market and choose to participate by issuing loans, and the ability for retailers to overcome obstacles that inhibit sound business practice.

One way to measure the success of these programs is by how much they impact the size of the market, as well as the extent to which they can lower the cost of solar photovoltaic systems.

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Chapter 1: Introduction

Sustainable energy development has become an increasingly significant issue internationally over the last several years. This is due to several factors, the two most significant being the need to reduce the poverty trap in developing countries and the mounting concerns over global warming. As a result of these and other issues, the use of renewable energy technologies has become more attractive as a means for meeting energy demand in developing countries. These technologies include both on- and off-grid applications such as solar photovoltaics, wind, and mini-hydroelectric.

The first issue is reducing the poverty trap. Over two billion people in the world do not have access to modern forms of energy. Nearly one-third of all energy consumption in the developing world comes from burning wood, crop residues, and animal dung. Collecting these resources takes several hours each day. Water must also be collected daily for agriculture and other activities, which also takes a few hours. These activities alone account for a significant portion of the day and do not leave much time for income generating activities, education, or recreation. Without electricity, households do not have access to reliable sources of lighting and are without refrigeration, television or radio, which if available can enhance one’s standard of living.

Currently, households not connected to the electricity grid use kerosene or batteries for lighting. The use of these energy sources is unreliable and unsatisfactory compared to traditional electricity service. If electricity was available a portion of the workday would be freed and more time could be allocated towards income generating activities or education. These discouraging facts and figures affirm the need for immediate attention.
The second factor influencing the emergence of renewable energy technologies is the growing concerns about global climate change. The intense use of fossil fuels coupled with the increasing global population and growing demand for energy services is raising concern as to the sustainability of current practices. A part of the response to this problem is to increase the utilization of low or non-greenhouse gas emitting technologies such as solar photovoltaics (PV’s).

Solar photovoltaic technology is presently significantly more expensive than other high-density grid-connected sources for electricity but is becoming more attractive as a renewable energy supply option in developing countries for several reasons. Currently, photovoltaics are cost-competitive in certain niche applications. The cost-effectiveness of solar photovoltaics depends directly on three factors - population density, proximity to the grid, and the cost of alternate fuels such as diesel or kerosene. Another important element is that the solar radiation is sufficient for providing basic electrical services in many developing countries, since most of them are located in areas with warm climates and significant sun exposure. This means that households living in these regions find solar energy a more practical solution than households do in colder climates.

Solar photovoltaics can be used as a stand-alone system, which is ideal for remote, rural areas of the developing world that are not yet connected to the power grid. PV’s are also becoming more attractive now due to the increased interest by international and bilateral funder organizations such as the World Bank Group and the U.S. Department of Energy to invest in small energy projects that reap environmental and social benefits.
Although still in its early stages, the market for solar photovoltaics has experienced many successes. One measure of success is the annual increase in photovoltaic sales in developed countries. In 1997, the industry was valued at $1 billion and global production reached 130 megawatts, up 40 percent from 1996.2 The United States is the leader in sales with 44 percent of the market share.3 Other key players include Japan with 24 percent of the global market and Europe with 20 percent.4 Furthermore, the price of photovoltaic modules has fallen to just over $4 per peak watt, down from over $10 per watt in 1980 (1993 dollars).5

Several developing countries have witnessed great progress in the penetration of photovoltaics into rural markets. The market in Kenya is growing so quickly that PV systems have outpaced grid connections.6 In Kenya, over two-thirds of the PV systems have been installed by the private sector despite high import taxes and a heavily subsidized rural electrification program. Indonesia was in the process of implementing a vigorous million solar homes program prior to 1997’s financial crisis.

However great the successes have been, the private market for solar photovoltaics is still immature and faces many obstacles. This paper will set out the barriers that inhibit the design of effective solar photovoltaic projects and private market expansion efforts in developing countries. It will then evaluate how current international aid programs are addressing these barriers. Particular focus is placed on multilateral and bilateral funder agencies that provide funds for solar PV projects: the World Bank Group, US Agency for International Development, and the US Department of Energy. The analysis is based on archival research and interviews.
This paper is organized as follows. The next section discusses solar photovoltaic technology and the existing market. The barriers to developing a market will then be discussed. The three following sections look at the role of the World Bank Group, US Agency for International Development (US AID), and US Department of Energy (US DOE) respectively in renewable energy and rural electrification projects. Each section includes a description of the programs they have designed. The final section will first provide examples of projects that are in operation, then analyze the Programs to determine how well they are addressing the barriers. Lastly, the manufacturing and system cost implications will be laid out.

Chapter 2: PV Technology for Rural Development

Solar photovoltaics have gained enormous attention as a means to meet rural electrification needs in a sustainable fashion due to the recent cost reductions for the technology coupled with the growing demand for energy services in developing countries. Under certain conditions, PV’s are the least cost option for rural electrification. Another attractive feature is that PV’s are a low greenhouse gas emitting technology, which allows for energy growth with little harm to the environment. Additional factors responsible for its appeal are its reliance on the abundant solar resource and its modularity.

Energy demand in developing countries is expected to increase at seven percent per year, and up to 15 percent per year in Southeast Asia and some of the more industrialized of these countries, presuming resolution of the economic crisis and renewed rapid economic growth. In order to meet this demand, substantial investment must be made in new physical infrastructure. It is
estimated that $100 billion per year will be needed if the demand is met in the conventional form with fossil fuels. Currently, only $50-60 billion per year is being invested resulting in a $50 billion deficit.\(^8\) This figure illustrates the significant gap between energy supply and demand. Exacerbating this problem is the fact that revenue collection does not cover the marginal costs of electricity, resulting in an economic loss for utilities and a disincentive for further investment. In addition to electricity rates being below cost, revenue collection systems are also poor and electricity is often pirated from transmission lines. Due to monetary loss and high demand, utilities are reluctant to expand services to all households especially those in remote areas.

The marginal cost of central power generated electricity depends directly on the population density of the area, the load densities, the number of connections in an area, fuel availability, and generation technology. Households in rural areas have low densities and few connections making grid expansion costly. As a result, in rural areas the marginal cost of electricity can reach $0.20 - $0.40 per kWh, whereas urban areas are roughly $0.10 per kWh or lower.\(^9\)

The most suitable household for a solar home system is one that is currently without electricity because it is in a remote or lightly settled region and will not be connected to the electricity grid within the next few years. There are 300-400 million households in the developing world that fall under this category.\(^10\) These rural and off-grid households currently make up over 50 percent of the market for PV and are the fastest growing niche.\(^11\) The target household currently uses kerosene lamps for lighting and disposable automotive batteries for operating small appliances.\(^12\)
For households that have no access to the electricity grid or are presently utilizing kerosene and batteries for energy, solar photovoltaics are often the least cost energy option. Currently, over 500,000 systems have been installed worldwide and roughly 80,000 are installed annually.\textsuperscript{13}

Figure 1 provides the break-even thresholds for PV and grid based electricity supply in rural Indonesia under three different village types. Rural Indonesia is used as an example, however the thresholds are similar for other developing countries as well. These figures illustrate under what parameters solar PV’s are the least-cost option and how dependent the thresholds are on population density. The break-even curve represents the line at which levelized costs are the same for either PV or grid-based power. For instance, in case two where the village is five km from the MV line, when less than 400 households are served and the density is low, PV’s are the least-cost option.
Figure 1: Thresholds for PV and Grid Supplied Electricity, Indonesia

Case 1: Isolated Village

Case 2: Village Located 5 km from MV line

Case 3: Village Located 3 km from LV Line

Source: World Bank Technical Paper Number 324
Table 1 lists the monthly economic costs of kerosene and diesel batteries versus PV systems. The figures are based on the discounted cash flows of the costs of both options for twenty-five years, and include capital costs, operation and maintenance, fuel costs, and equipment refurbishment and replacement. Lighting I and II only utilize a solar lantern or kerosene lamp, whereas Lighting/Electric I is equal to roughly 15 kWh per month and 30 kWh per month for Lighting/Electric II. For providing task or area lighting, the cost of solar and kerosene are similar with solar costing $0.25 less per month for six hours of task lighting. In all cases, including environmental benefits make solar energy even more attractive. Under the other conditions much larger savings are realized if solar photovoltaics are used.

Table 1: Levelized Monthly Economic Costs of Kerosene and Battery and PV for Rural Households in Indonesia (in 1993 dollars)

<table>
<thead>
<tr>
<th>Service level</th>
<th>Daily Services Provided</th>
<th>Equipment</th>
<th>Monthly Cost</th>
<th>Equipment</th>
<th>Monthly Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting I</td>
<td>8 hrs. area lighting</td>
<td>Solar lantern</td>
<td>2.25</td>
<td>Wick lamp</td>
<td>2.00</td>
</tr>
<tr>
<td>Lighting II</td>
<td>6 hrs. task lighting</td>
<td>Solar lantern</td>
<td>2.25</td>
<td>Mantle lantern</td>
<td>2.50</td>
</tr>
<tr>
<td>Lighting/Electric I</td>
<td>8 hrs. area lighting</td>
<td>50 Wp system</td>
<td>8.25</td>
<td>2 wick lamps</td>
<td>9.25</td>
</tr>
<tr>
<td></td>
<td>6 hrs. task lighting</td>
<td></td>
<td></td>
<td>1 mantle lantern</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 Wh for other loads</td>
<td></td>
<td></td>
<td>1 battery</td>
<td></td>
</tr>
<tr>
<td>Lighting/Electric II</td>
<td>12 hrs. area lighting</td>
<td>100 Wp system</td>
<td>13.75</td>
<td>3 wick lamps</td>
<td>19.25</td>
</tr>
<tr>
<td></td>
<td>14 hrs. task lighting</td>
<td></td>
<td></td>
<td>2 mantle lanterns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>150 Wh for other loads</td>
<td></td>
<td></td>
<td>2 batteries</td>
<td></td>
</tr>
</tbody>
</table>

*Source: World Bank Technical Paper Number 324*

Solar photovoltaic systems can provide a spectrum of useful electrical services to the end-user. Households and businesses use PV's for lighting, refrigeration, and entertainment; to pump water
for agriculture; and for public services like health care facilities, water purification, or street lighting.

A typical solar home system is made up of a 20 Wp to 100 Wp photovoltaic array, a rechargeable battery, a battery charge controller, mounting hardware, and interconnecting wires and switches. For example, a 50Wp system provides enough energy to operate four 6- to 10-W fluorescent lights and a small black and white television for four to five hours per day.

Besides the availability and quantity of solar radiation at the location, the cost of a solar home system varies greatly from one country to another due to several factors. These include the number of systems purchased; duties, taxes, and subsidies in the country; the degree of competition in the market; the number of “reseller” steps in the distribution chain; and the scale of manufacturing and assembly processes. Table 2 lists the cost and size of the system as well as reasons for the variations in cost in selected countries. Kenya’s price stands out because they depend almost solely on a private market. Consumers in Kenya pay $1,378 per system with 33% of the cost covering delivery, installation, and retail margins and 19% for duties and taxes. A more developed private market would bring these costs down in Kenya. Other countries show the effect of subsidized, tied aid, or in the case of Indonesia, a more established private market that reduces the unit price to make it affordable. These factors lower the unit price to the $8-16 range. The United States pays only $10.00 per watt installed if utilizing a 1,000-watt system, but for a 90-watt system similar to those in developing countries the unit price jumps to $16.67 per watt.
### Table 2: Solar Home System Prices and Causes for Variations for Selected Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Size (Wp)</th>
<th>Price ($)</th>
<th>Unit Price (S/Wp)</th>
<th>Variation Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td>1993</td>
<td>53</td>
<td>1,378</td>
<td>26.00</td>
<td>High duties and taxes, high dealer margins</td>
</tr>
<tr>
<td>China</td>
<td>1994</td>
<td>20</td>
<td>160-280</td>
<td>8.00-14.00</td>
<td>Tied aid procurement, low cost producer</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1994</td>
<td>53</td>
<td>425-700</td>
<td>8.02-13.10</td>
<td>Low duties and taxes, competition, high sales volume, higher due to government</td>
</tr>
<tr>
<td>Philippines</td>
<td>1993</td>
<td>53</td>
<td>900</td>
<td>16.98</td>
<td>High duties and taxes, low sales volume</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>1995</td>
<td>50</td>
<td>674</td>
<td>13.48</td>
<td>Tied aid procurement</td>
</tr>
<tr>
<td>Brazil</td>
<td>1994</td>
<td>50</td>
<td>700</td>
<td>14.00</td>
<td>Govt./Donor programs</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>1993</td>
<td>35</td>
<td>575</td>
<td>16.42</td>
<td>Low sales volume</td>
</tr>
<tr>
<td>Mexico</td>
<td>1994</td>
<td>50</td>
<td>700</td>
<td>14.00</td>
<td>Govt./Donor programs</td>
</tr>
<tr>
<td>United States</td>
<td>1994</td>
<td>1,000</td>
<td>10,000</td>
<td>10.00</td>
<td>AC/DC power, high-quality components.</td>
</tr>
<tr>
<td>United States</td>
<td>1994</td>
<td>90</td>
<td>1,500</td>
<td>16.67</td>
<td></td>
</tr>
</tbody>
</table>

*Source: World Bank Technical Paper Number 324*

As shown in table 2, solar home systems are costly for most consumers. Often, the costs can be equal to one year's income for low- to middle-class rural households. This translates to a
electricity cost for the module between $0.25 and $2.50 per kWh (1990 dollars). This is often the least cost option. The initial capital cost for a solar home system is very high. However, PV systems require minimal maintenance and have no fuel costs. Operation and maintenance costs are very low compared to fossil fuel sources. So, although their initial costs are high, their total life-cycle costs are low.

If the market for solar home systems is to be expanded, it is essential that consumers are satisfied with the technology and that it is reliable. Studies from past projects and consumers have indicated that the systems are valued for more reasons than just monetary savings. According to a survey conducted in Kenya, 60 percent of the people interviewed are pleased with their PV system and 94 percent would recommend one to a friend. PV systems are favored over kerosene and diesel generators because they provide higher-quality light, improved safety levels (fewer fires), cleaner indoor air due to reduced fumes and soot, a perceived elevated social status, and a freedom from the need for fuel. The users that benefit the most are women and children. Women save valuable time that would be lost in travelling to get fuel and are able to concentrate on income generating activities. Children are able to study in the evening, watch television, and listen to the radio. However, solar home systems can be considered inferior to grid electricity. PV's only offer limited services and a certain amount of electricity for a certain amount of time. They also require DC appliances or converters, which are not as readily available or as cheap as AC appliances.
Chapter 3: Designing Effective Renewable Energy Projects

Significant lessons have been learned since the first photovoltaic pilot projects were implemented. Many of the bilateral and multilateral demonstration projects over the last 20 years have been deemed unsuccessful and unsustainable. The typical procedure for these early projects was to have a donor agency set up a demonstration project in a developing country and subsidize the use of the technology. The motivation for establishing such a project was the fact that it would allow pre-commercial technologies to be tested and the results recorded. These projects were also part of developed countries' efforts to aid in international social development programs. Host countries rarely were responsible for repaying the donor. In addition, the donor did not make a concerted effort to train local people or to develop a market where repairs could be made or new products sold. Since the technology was subsidized, little attention was placed on how to operate and maintain a PV retail industry. Legal and regulatory issues were also ignored which vary considerably not only from country to country but locally as well. As a result, after the project was complete and the donor agency left the project, the systems would slowly break down or malfunction and there would be no feasible way to have them repaired. Eventually, the homeowners and end-users quit using their systems and the project was considered a failure. This chain of events was displeasing to the host-country leading to disinterest in participating in future demonstration pilot projects.\textsuperscript{19}

Since these first projects, lessons have been learned as to what factors must be considered in order to expand the market for photovoltaics. The key lesson is that donors should not fully subsidize equipment, operation and maintenance, or financing.\textsuperscript{20} Three reasons explain why.
The first is that if dealer costs are greater than revenues then there will be no motivation to participate in the market. The second reason is that if consumers do not pay market price then it will be difficult to ever make another consumer pay market price which in turn will not allow dealers to enter and remain in the market. Last, investors cannot realize potential risks or benefits because they have no idea what consumers are really able to pay or the mechanics of the market. Subsidies used in this fashion are only beneficial if the government is committed to offering them for an extended period of time. For example in Mexico, since 1989, the government has been subsidizing PV equipment to those that qualify as part of its social policies.\textsuperscript{21}

Out of these experiences current practice has evolved. Funders are now focusing on stimulating the development of a private sector market for solar home systems. This includes furnishing some grants issued to the dealer to help them purchase a larger quantity of systems, to cover administrative costs of organizations that are working to develop new projects, or for technical training. Providing loans or equity to be repaid after a dealer is more established is now the most prominent role of funder agencies. Despite this new approach, numerous obstacles to developing a private market for solar photovoltaics persist.

\textit{Section 3.1: Prerequisites for Participation by Key Players}

Several factors must be addressed in order for a private market for solar photovoltaics to be developed in a sustainable and successful manner. Key players in the market, similar to players in virtually any market, must see advantages to participating for the market to develop.
Developing a private market is dependent on successful interaction between the consumer, the PV retailer, the financial or investment banks, and the national or local government and affiliated agencies such as the utility company. In this section, the interests of these four actors are examined in order to provide insights to the barriers to market development. I next present the general criteria needed for the actors to participate in a private market. Then the specific issues that are restraining these actors from successfully becoming active players in a private market for solar photovoltaics is presented.

In order for a consumer to participate in a particular market at least two conditions must be met. The most obvious and crucial element is the belief that the service will meet their needs and is the "best" available option. When assessing the utility of the service parameters such as price, reliability, serviceability, and potential benefits must be calculated. Of course, this requires awareness of the service as the starting point. The ability to pay for the service is the second requirement. In many cases this includes access to financing options because the service is too costly to be purchased in a single cash payment. For example, in the United States, a car cannot typically be purchased with cash alone. Financing options allow the consumer to spread the expense over a suitable period of time with payments plus interest.

The key criterion for a retailer is that the business is profitable. The retailer must be able to market and distribute its service and respond to demand for the service. One essential component is to employ personnel and management that have expertise in the field. Further, the retailer must have an effective operation and maintenance system. Included under this is the ability to collect fees for the service, offer repairs, and provide replacement parts or upgrades if
necessary. Typically, if demand exists for the service and the retailer is able to provide an adequate service then he will profit from the business. This is the retailers last prerequisite for participation. If these conditions are not met the retailer will either lose motivation to participate in the market or will not be able to sustain business activity.

An instrumental component in most private sector markets is the involvement of financial or investment institutions. Whether these institutions participate in the market depends solely on their ability to profit from the activity. Financiers or investors typically incur significant risks since they invest or provide credit to retailers or consumers and depend on repayment plus interest. These institutions must be able to accurately determine what the risks are and how they can insure themselves against the risks. In addition, individuals who have knowledge of the particular market must appraise investments. This often means visiting project sites. Financial institutions in developing countries typically favor investing in urban areas. This is because they have more experience in urban areas, projects are easier to appraise, and borrowers are usually wealthier. These factors reduce the risk incurred by the lender.

The last major player that influences the development of a private market is the national or local government. National policies such as import duties, regulated monopolies, and taxes and subsidies are typical in the energy sector. They effect the price of imported goods, such as PV’s, as well as their competitors, such as kerosene. These policies have considerable impact on profitability to retailers and attractiveness to consumers of goods such as PV’s. Because the policies are often part of social development strategy, they are usually difficult to change.
Section 3.2: Barriers Facing Actors

The conditions for private sector development outlined above apply to the market for solar photovoltaics. Each actor currently faces several barriers that are inhibiting the growth of the market. Table 3 lists the barriers as they apply to PV’s.

Table 3: List of Barriers to PV Market Expansion

<table>
<thead>
<tr>
<th>Actor</th>
<th>Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer:</td>
<td>Awareness of and satisfaction with technology.</td>
</tr>
<tr>
<td></td>
<td>Ability to pay (access to finance).</td>
</tr>
<tr>
<td>PV Retailer:</td>
<td>Lack of access to capital and infrastructure improvements.</td>
</tr>
<tr>
<td></td>
<td>Untrained personnel, technicians, management – poor operation &amp; maintenance.</td>
</tr>
<tr>
<td>Financial Institution:</td>
<td>Immature/undeveloped financial institutions.</td>
</tr>
<tr>
<td></td>
<td>No profits or motivation for financial institutions to enter the private market, risk of PV market.</td>
</tr>
<tr>
<td>Government/Utility:</td>
<td>Subsidies for competing fuels.</td>
</tr>
<tr>
<td></td>
<td>Import duties and high tariffs on PV modules and parts.</td>
</tr>
</tbody>
</table>

Regardless of the fact that nearly two billion people are without electricity and grid connection is not anticipated in the near future, even consumers who can afford the service are often unaware that PV’s are cost effective and available. Furthermore, many of those households that are aware of solar photovoltaics either perceive the technology as risky because of past projects or feel that they are being offered an inadequate service. Perceptions are changing however and awareness is slowly increasing which is leading to a growing demand for solar home systems.
Unfortunately, a consumer’s inability to pay for the service on a cash basis has hindered the number of sales. As previously discussed, a solar home system is nearly one year’s income or the cost equivalent of an automobile in the United States. Without access to a menu of financing options that offer various ways to pay for the service, few consumers are able to become active players in the market. Figure 2 developed by Enersol Associates for the photovoltaic market in the Dominican Republic demonstrates consumer’s ability to pay under five different payment scenarios. The top of the pyramid shows that only five percent of the customers are able to pay on a cash basis, but that 25 percent could finance the system and an additional 25 percent could lease the system if the option was offered.

Figure 2: Rural Market Pyramid Structure, Dominican Republic

- High Cost Commercial Applications
- Cash Customers – 5% or 20,000 customers
- Financed – 25% or 100,000 customers
- Leasing or ESCo – 25% or 100,000 (or more)
- Unaffordable Except Through Grant or Donor

Source: PVMTI Background Paper

The largest hurdle that PV retailers encounter is lack of access to capital. Without a significant amount of capital it is impossible to purchase large amounts of solar home systems and replacement parts. Two issues arise when a retailer does not have enough systems or parts. First, they are not able to provide a reliable service to their customers, which in turn means that they do not retain customers or a favorable public image. Second, without adequate volume of
sales, it is impossible to maintain or make a profit from the business. Concurrent with this issue is the fact that transaction costs and system costs are higher if few systems are purchased from the manufacturer.

The second issue for retailers is the lack of trained personnel or experts in the field. This creates two problems. First, operation and maintenance services are poor. The issue here is both technical (e.g. repairs) and organizational (e.g. fee collection). Second, poor quality technologies are purchased by the retailer and sold to the consumer only to have them break down or malfunction shortly after they are used. International technical standards, although they do not currently exist, would be one way to avoid this problem.

Financial institutions are key players in the expansion of a private market for solar PV’s. As discussed, knowledge of the market and the ability to profit determines whether they become active. There are several reasons that explain why financiers do not provide credit to PV retailers or consumers. First, financial institutions consider the investment to be risky given that most of the target households are not wealthy. A consumer must display to the investor an asset base and cash flow to demonstrate credit worthiness. Many rural households do not qualify because they do not have large expendable incomes or collateral. Second, financial intermediaries often have difficulty mobilizing local financial resources to supply debt or equity to a project. In developing countries the current financing structure supports investments in large multi-million dollar power projects. Selling small solar home systems in dispersed rural areas requires a different investment method, which is still premature and precarious for many
traditional investors. Last, policies in developing countries are biased toward investing in urban infrastructure projects rather than rural ones.

The last dominant player in the development of a sustainable private market for photovoltaics is the national or local government. There are two significant regulatory biases that are hindering expansion of the market. First, import duties and trade tariffs for solar home systems often account for up to 30 percent of the system cost. Table 2, which gave the costs for systems in various countries, illustrated the effect on the consumer price when these additional charges are added. If developing country officials are serious about rural electrification and poverty eradication measures then import duties and trade tariffs must be lowered if not removed. The second notable barrier is subsidies for competing fuels. Typically, subsidies exist for rural grid service or for kerosene fuels. In the early 1990’s typical electricity tariffs were just under $0.04 per kWh while the average cost of supply was $0.10 per kWh. Among the other harmful effects of subsidies, they make solar home systems appear more costly to the end-user. The subsidies for other fuels, coupled with the duties and taxes, indicate that solar home systems are not playing on a level field.

Chapter 4: The New Generation of PV

This section will describe programs by the World Bank Group, the United States Agency for International Development, and the United States Department of Energy that are being developed or are already operational to meet electrification needs in developing countries using solar photovoltaics. Table 4 offers a quick reference of the programs and provides the name,
acronym, date at which it became or is slated to become operational, a brief project description, the sponsoring organizations, and the project budget.
<table>
<thead>
<tr>
<th>Program Name</th>
<th>Program Acronym</th>
<th>Operation Date</th>
<th>Program Description</th>
<th>Sponsoring Organization</th>
<th>Budget (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small and Medium Scale Enterprise Program</td>
<td>SME</td>
<td>1995</td>
<td>Financing intermediaries who in turn work with SMEs to expand the private market.</td>
<td>International Finance Corp., Global Environment Facility</td>
<td>$16.5 (includes all renewable tech.'s)</td>
</tr>
<tr>
<td>Solar Development Corporation</td>
<td>SDC</td>
<td>Mid 1999</td>
<td>Stand-alone private company providing business services and access to financing services.</td>
<td>World Bank, International Finance Corp., US private foundations</td>
<td>$50</td>
</tr>
<tr>
<td>GEF country projects</td>
<td>N/A</td>
<td>N/A</td>
<td>Accelerate PV market expansion in a particular country.</td>
<td>World Bank, Global Environment Facility, host-country government</td>
<td>N/A</td>
</tr>
<tr>
<td>Renewables for Sustainable Village Power</td>
<td>RSVP</td>
<td>Early 1990's</td>
<td>Computer model development, system analyses, and technical assistance.</td>
<td>US Department of Energy</td>
<td>?</td>
</tr>
</tbody>
</table>
Section 4.1: The World Bank Group

Within the World Bank Group the International Finance Corporation (IFC), Global Environment Facility (GEF), International Bank for Reconstruction and Development (IBRD), and Asia Alternative Energy Unit (ASTAE) have designed programs that aim to expand the market for solar photovoltaics. The World Bank established ASTAE in January 1992, in order to continue the efforts of Project FINESSE (Financing Energy Services for Small-Scale Energy Users). ASTAE’s mission is to incorporate energy conservation and renewable energy technologies into energy programs and lending operations in the Asian region. ASTAE is comprised of a small group of individuals who are highly trained in the field of renewable energy and believe that there is a role for the World Bank in promoting alternate technologies.

The GEF was initially founded in 1991 as a pilot program with funds to be applied in the form of grants or concessional funds to one of four possible focal areas: climate change; biological diversity; international waters; and stratospheric ozone. In 1994, the Facility was restructured and the fund was replenished with over two billion dollars (US) to be allocated over a three-year period.

It was the development of ASTAE and the GEF that made it possible for the World Bank to begin investing in solar photovoltaics. In 1992, the World Bank had only one alternative energy project in its portfolio for US$2.0 million. Since then the Bank has invested in over 50 renewable energy projects. The current level of funding dedicated to all types of renewable
energy projects is estimated at well over one billion dollars. Following are five programs, which are examples of how the World Bank Group is achieving this goal.

**SME**

As part of the catalytic efforts to expand private sector participation in emerging markets, the IFC and GEF are working together on the Small and Medium scale Enterprise Program (SME). This program was founded in 1995 with a pilot phase budget of $4.3 million. In 1997, the budget was replenished and the program expanded in order to reach a target of 100 projects. IFC is acting as the executing agency and the GEF is supplying $16.5 million in financing. Roughly two to three million of this total will be dedicated to PV projects. The objective of the program is to stimulate more involvement from the private sector in the sustainable use of biodiversity and the reduction of greenhouse gases as outlined in the GEF Operational Programs. The use of solar photovoltaics qualifies as a technology that will reduce greenhouse gas accumulation. The program functions as follows: IFC selects institutions that work with small and medium scale enterprises (SMEs) in GEF eligible countries to act as Intermediaries for the Program. Each intermediary will receive from $500,000 to $1 million as a long term low interest rate loan to be used for financing SME’s or their projects which address one of the two issues. The intermediaries and SME’s will need to secure co-financing for the majority of the costs. The intermediaries face a notable degree of risk since they have to repay the loan to IFC, so as a benefit and security the Intermediaries are allowed to retain up to 50 percent of the funds that are repaid by the SME’s.
At the time of the interim project review in January 1997, five Intermediaries have been selected which in turn have financed 23 SME projects. The program has since expanded and selected additional intermediaries. Three of the intermediaries, the Environmental Enterprises Assistance Fund (EEAF), Solar Electric Light Company (SECO), and Grameen Shakti are implementing solar photovoltaic projects.\(^{29}\)

The EEAF project had funds disbursed from the Program in early 1998. They are using some of the funds to assist Soluz Dominicana in expanding their solar home business in the Dominican Republic. Soluz Dominicana received a $75,000 equity investment in August 1997. Consumers buy solar home systems from Soluz Dominicana with a down payment and then make monthly payments. The funds from the SME Program will be used to purchase more systems since there are currently not enough systems to meet the high demand in the Dominican Republic. This equity line allows Soluz to expand its operations and simultaneously reducing its overhead cost per unit.

SECO, another intermediary chosen through the SME Program, is the for-profit arm of the Solar Electric Light Fund. SECO is broadening access to solar home systems in Vietnam by providing local financing to consumers. They are able to do this primarily using a World Bank line of credit through agricultural banks that have agreed to lend up to seventy percent of the cost of the panel to the consumer. A loan was issued from SME and the Mekong Project Development Facility in October 1998. SECO Vietnam also received training on how to facilitate a rural customer credit scheme. Some of the funds will be used as collateral to the lending institution. On average, consumers in Vietnam are only able to provide up to 20 percent
of the initial cost of the system. The bank is willing to provide the other 70 percent. SELCO will use the SME funds to provide the last 10 percent of the system.

The last intermediary using SME funds for photovoltaic projects is Grameen Shakti, a not-for-profit rural power company established in 1996 by the Grameen Bank of Bangladesh. Grameen Shakti’s intentions are to finance and operate the supply, marketing, sales, testing, and development of solar home systems in Bangladesh. A $750,000 loan was dispersed in the summer of 1998 and will be used to purchase systems and to offer consumer credit. The Grameen Bank has been very successful in issuing microcredit to rural households. They have an outstanding re-payment record and an impressive network of customers across the region. This makes them an outstanding candidate as an intermediary for PV sales. However, they have little experience in this field so under the SME program they are able to receive technical training and support for developing a business plan and strategy. Each of these projects are discussed in greater detail in the analysis section.

REEF

Another partnership between IFC and GEF is the Renewable Energy and Energy Efficiency Fund (REEF) which was launched in 1997 although it has yet to complete raising funds. This program was born out of a study completed by IFC, which determined that there is growing private investment activity in renewable energy in developing countries and that a fund could help accelerate the flow of investments. The fund will target the following activities: grid-connected private power projects using wind, biomass, geothermal, etc; distributed off-grid
applications such as solar home systems; energy service companies and end users themselves; and local manufacturers.

The fund will consist of a $110 million equity fund for capitalization and $100 million to set up a debt facility for loan commitments to finance grid-connected and off-grid energy and energy efficiency projects. The program focuses on projects where IFC can add value through technical expertise and financial structuring to overcome market barriers, reduce high transaction costs, and mitigate risks that otherwise prevent companies from pursuing renewable energy investments. The funds will be dispersed over a 5-year period and it is anticipated that the portfolio will be liquidated within 10 to 13 years. The debt facility will receive funds through IFC and international commercial banks, whereas the equity fund will include the IFC as well as other institutional and strategic investors. The role of the GEF is to provide up to $30 million in grant support to help open up markets that would otherwise be absent due to risks such as rate of return or size of project. The GEF funds will also be used to pay the incremental management costs that the Fund Management Company; a consortium of EnergyHouse Capital Corp., Energy Investors Funds, and EEAF; will incur. It is estimated that the GEF grant will leverage investments of $210 million in the debt facility and the fund, which will in turn support projects with total costs ranging from $300-800 million. This will yield a leverage ratio on GEF funds from 12 to 1 up to 27 to 1.32

REEF’s debt and equity funds will be used to aid part of a project. The funds are intended to complement current efforts and to catalyze future investments rather than finance entire projects. On average, REEF will investment between twenty-five and thirty-three percent of total project
costs, but never more than forty-nine percent. Once funds are issued, loan recipients will have access to a network of organizations that will be able to provide ad hoc advice and information on investment opportunities. This will allow less experienced companies to receive advice and instruction from other companies.

Unfortunately, there have been delays in starting the program due to difficulties reaching an agreement as to who would provide the debt component. It was decided in early 1998 that Dresdner Bank will supply $80 million of the debt and play the lead in attracting other banks and the IFC will supply the remaining $20 million.\textsuperscript{33} Since this agreement has been reached, the IFC has begun inviting interested investors and project sponsors to supply the $100 million for the equity fund. The fund management team, Energy Investors Funds, expects that financial closure will occur in mid 1999.\textsuperscript{34} EnergyHouse Capital Corp. and Environmental Enterprises Assistance Fund will serve as co-managers and will be responsible for the small-grid connected and off-grid projects such as solar home systems.

\textit{PVMTI}

The last joint project between the GEF and IFC is the Photovoltaic Market Transformation Initiative (PVMTI) which focuses solely on accelerating the penetration of PV's as a source of electric power in three developing countries. The project was supposed to take off in the Fall of 1998, but has been stalled in the planning stages for well over a year. The project focuses on three countries – Morocco, Kenya, and India. GEF has agreed to provide $30 million, $25 million for concessional investments and $5 million for implementation costs. India will receive $15 million and $5 million each will be allocated to both Kenya and Morocco.\textsuperscript{35}
The goal of the project is to offer concessional financing to private companies offering PV services that do not have access to financing from the existing market. This method will help expand the private sector market. PVMTI is expected to increase sales by 55% in India, 66% in Kenya, 33% in Morocco, and 5% globally through the lifetime of the project. It is anticipated that four to seven projects will be developed in each country within three years and that funds will be recovered within ten years (the life of the program). Total project investment is estimated at $85-115 million.

Loan recipients will include companies that lease, distribute, install, and/or service PV equipment for both on and off-grid applications. Projects that seek to develop local PV markets in innovative ways will be given priority. Examples of innovative projects include building distribution networks, expanding finance schemes or utilizing clever marketing techniques. IFC will not directly provide financing, but may invest in projects as they meet their commercially viable requirements. Investee companies will be required to provide a portion of the co-financing as well, either in the form of owner equity, commercial debt, other investors, or in-kind contributions.

It is estimated that sixty to seventy percent of the funds will be distributed in the form of debt. Companies will be able to use these funds to overcome cash flow constraints, as credit mechanisms to offer customers, or to purchase working capital. Another 10-20 percent of the funds will be made up of partial guarantees and/or equity in order to hedge the degree of risk associated with these types of projects. The guarantees may be necessary to secure end-user credit or as a means of mobilizing commercial capital. In addition to providing concessional
financing, PVMTI is also planning on supplying a limited number of grants, up to 10 percent of total funds. Grants will be used for technical training, development of technology standards, as well as other possible applications as they arise.\textsuperscript{38}

PVMTI's scope of operations have changed as appraisal missions have been completed in each country. Originally, PVMTI was largely concerned with expanding manufacturing investment and lowering the cost of the technology. The primary method for accomplishing this was to encourage joint ventures and partnering of manufacturing companies and in-country organizations that were aware of demand, financial mechanisms, and had experience with distribution and sales. These partnerships would increase in-country manufacturing investments, which in turn lower the costs of solar home systems. The Background Paper estimated that if bulk purchases were made and manufacturing capacity expanded, module costs would halve; or drop by 50\% the current amount per peak watt.\textsuperscript{39} This would allow for notable expansion of the existing market. However, the manufacturing goals have been abandoned and in the new Project Document there is no mention of expected cost reductions as a result of this Program and it is noted that it is difficult to make cost projections over a ten year period.\textsuperscript{40}

Moreover, PVMTI initially intended on using the "award" approach, meaning that funds would be awarded to companies with little engagement by IFC. During the appraisal missions it was determined that the market was too immature for this type of approach and that it is necessary that IFC play a more active role in project execution if any of the aforementioned barriers were to be addressed.\textsuperscript{41}
The first round of Solicitation for Project Proposals closed December 21, 1998. According to the revised Project Document there are several projects that were outlined during the appraisal missions and it is likely that most of them receive PVMTI funds. In India anticipated projects include three solar home system retailers, two balance of system companies dedicated to establishing retail networks for PV applications, two companies focusing on developing pumping systems, and a PV manufacturer that will build a network of off-grid dealerships. The potential projects in Kenya are very different from that of India. This is because Kenya already has a strong private market for PV, but lacks involvement from local banks. Therefore, four out of the eight projected fund recipients are banks that will lend to distributors. The remaining four sponsors include two battery manufacturers and two PV distributors. Private market development in Morocco is also unique from Kenya’s. The Moroccan Government has a strong national commitment to rural electrification so it is imperative that the PVMTI efforts are compatible. Three of the seven potential projects will concentrate on expanding retail networks. The others will provide village lighting and/or water supply.

**SDC**

In December 1997, an agreement was reached between the World Bank, IFC, and a number of US private foundations, with E&Co. as their representative, to develop the Solar Development Corporation (SDC). The goal of the US foundations is to increase by an order of magnitude the availability of PV power systems. These foundations believe that the primary obstacles to market expansion are the lack of channels of product distribution and the absence of ready financing. The SDC is also in a favorable position because it will be the last program to become operational. It can draw on the lessons learned from the other programs. It is imperative that
they do so because this program will be implemented worldwide and avoiding past problems can save a great deal of time and ensure that funds are used more efficiently.

SDC will be a stand-alone company, which will provide two services. The first is to facilitate access to pre-commercial and parallel financing to expand channels of distribution and end-user credit. Instead of providing direct financing to consumers, SDC will supply PV businesses and financial intermediaries with equity investments, working capital, and funds for end-user credit. Financing will be between US$25,000 and US$5 million per project, which will allow for expansion of services or establishing new ventures. The second is to deliver market and business development services for a nominal fee to accelerate the growth of private firms and broaden the reach of solar home systems (SHS) and other PV applications. The services will include identifying and aiding entrepreneurs and businesses in preparing plans and financing proposals; educating financial intermediaries about solar home systems; PV marketing and promotion in target countries; advocacy measures in countries with policies that deter the creation of private PV markets; and training and support services for PV firms. The first service, the finance window, will be allocated $32 million to be used for investments and $18 million will be used for market and business development activities.

SDC has identified target countries on their potential for market expansion. Countries that fit the criterion include China, India, Indonesia, Vietnam, Kenya, Morocco, South Africa, Brazil, Argentina, Bolivia, Mexico, Dominican Republic, and Honduras.
Start-up capitalization for the SDC is pegged at US$50 million. The IFC, World Bank, and US foundations have offered $15 million for the market and business development activities. A detailed business plan/investment document was prepared in February 1998. A management team is currently being sought.44

**GEF Financed Projects**

Through coordination between the internal divisions of the World Bank and the Asia Alternative Energy Unit, the Global Environment Facility has begun to finance several country-specific solar home systems projects. This increased interest by the GEF is partially a result of the Facility’s budget replenishment in 1994 and the recent attention given to global warming. The projects implemented through the GEF and the ASTAE team are unique from the joint IFC/GEF projects because they concentrate on implementing sustainable projects in a single country. With this approach the Bank is able to work with the host country to ensure that they have established an environment that will support the market. This includes influencing government policy, local bank policy, certifying technology in-country, and focusing on extensive technical training. Using this approach is very time intensive however, and requires dedicated commitment to the project from both the World Bank and the host country.

Last year, two projects were approved and set to commence the first stage of operation – the Sri Lanka Energy Services Delivery Project and the Indonesia Solar Home Systems Project. According to representatives at the World Bank, these two projects are the first that consider the results of past renewable energy projects and incorporate new financing methods. In the past, the Bank would only invest in large million dollar “bankable” projects.45 This criterion did not
apply to renewable energy projects, which is verified by the fact that until 1992 the Bank was supporting only one alternative energy project.

The Sri Lanka Energy Services Project is a $55.3 million project that provides medium and long-term financing to private sector firms, NGO’s, and cooperatives for solar home systems and other renewable energy schemes through private credit institutions. The GEF provides grant co-financing to credit institutions to cover the administrative costs of feasibility studies, business plans, and loan documentation necessary for solar home system project development. Goals of the program include installation of at least 26 MW of grid and off-grid renewable energy capacity serving up to 32,000 consumers. Recent reports indicate that the project is succeeding, but that the solar home component has been slow to take off.

There are several components of the project that will directly address the barriers previously discussed. For instance, the Bank requires that projects are designed in a manner that insures they operate on a full-cost recovery basis, provide adequate consumer information, and train local implementing organizations in order to achieve effective management skills. The Ceylon Electricity Board (CEB) will have at least fifteen CEB staff, private sector developers, and NGO staff on hand to provide technical assistance and ensure that the above objectives are met. Coordination with Bank staff is designed to assure that the hired staff members are performing their duties effectively. Moreover, the World Bank is coordinating with the Government of Sri Lanka to rationalize import duties on photovoltaic modules thus lowering the end-user system cost. Once these issues are addressed, then it will be possible for projects in the future to operate
without aid from funder organizations. This is true because the private market will have some experience and the major barriers to expansion will have been addressed.

The Asia Alternative Energy Unit designed the second project, the Indonesia Solar Home Systems Project, in a similar manner as the Sri Lanka project. This $118.1 million project includes a credit component as well as technical assistance support. The goal of the project is to install 200,000 solar home systems in three provinces – West Java, Lampung, and South Sulawesi. Private enterprises will sell systems to consumers and will be responsible for procurement of capital, installation, and maintenance of systems. The SHS dealers will sell systems to consumers in the following manner. First, the customer will supply a down payment of about US$75-100 equivalent. Next, the GEF grant will “buy down” the cost of the system by supplying roughly $100 per system. Then, the dealer will allow the customer to make monthly installments on the system over an approximate four-year period. Credit will be offered to the dealers through participating banks for up to five years. The IBRD department in the World Bank will supply credit at market rates to the banks, allowing them to refinance eighty percent of the credit they extend to the dealers. During project development, thirteen potential SHS dealers were identified and four participating banks, thus illustrating the interest in the project, which in turn helps insure its sustainability.49

Unfortunately, given the current financial crisis facing Indonesia the project has been postponed. Officials at the World Bank are confident that the project will be implemented in the future once conditions improve. In response to the decrease in individual household income, it is anticipated that the project will now also offer 30 Wp systems, instead of only 50 Wp, at a lowered cost.50 It
is also questionable whether or not the participating banks will continue to be able to participate in the project since the majority of the local banks are closed. Finally, many of the dealers have shut down their businesses and lost interest in the project.

There are several more projects that are in the pipeline and in the midst of the design and approval stage. One project is the China Renewable Energy Development Project, which is also an ASTAE project. This project will utilize both solar PV and wind technologies. It is anticipated that 200,000 PV systems will be installed in four Northwestern provinces. The total cost of the project is $408 million including $100 million from the IBRD, $35 million from the GEF, $15 million from the government, and the remainder in the form of debt and equity. Appraisal missions were scheduled to occur in December of 1998 with Board approval slated for March 1999.

Another GEF project in the planning stage that is not located in Asia is the Argentina Renewable Energy in Rural Markets project. This project will issue concessional contracts to existing concessionaires and new contractors will participate by responding to international competitive bids. Provincial Regulatory Agencies will be responsible for supervising concession contract compliance. Two pilot concessionaires, Jujuy and Salta, that have been operating since November 1996, have already been chosen. The technologies included in this project are solar PV; small decentralized power supply units using renewable energy and diesel units; and wind and small-hydro systems. The unconfirmed project cost is $187 million, funded in a similar fashion as the other projects with $46 million from the IBRD, $14 million from the GEF, and the balance from customers, concessionaires, and the government. The last GEF project in the
pipeline is in Brazil, which is slated to receive $67 million in Bank funding. Details regarding the project are not yet available to the public.

\textit{Section 4.2: US Agency for International Development}

The United States Agency for International Development (US AID) is a bilateral funder agency that has been and continues to play an active role in developing renewable energy projects. US AID has been active in the growth of the solar photovoltaic market primarily through its Renewable Energy Applications Training Program (REAT). Bilateral funder agencies play a fundamentally different role than the World Bank Programs. The central difference is that bilaterals primarily offer grants and donations rather than loans. Also, the level of funding is often smaller meaning that they often provide technical assistance, project development services, and small pilot projects rather than capital improvements. It is bilaterals that are infamous for having set up demonstration projects in developing countries that failed due to poor design. However, even in the private market approach there is a role for these organizations.

\textit{REAT}

The Renewable Energy Applications and Training program (REAT) was initiated in 1985. This year the remainder of the funds were disbursed and the project was terminated. Project implementers included the former US Export Council for Renewable Energy (US/ECRE) and the Environmental Enterprises Assistance Fund (EEAF). The life of project funding was US$52 million.
The largest portion of funding went to US/ECRE who was responsible for technical assistance through subcontracts with the International Fund for Renewable Energy, Winrock International, Volunteers in Technical Assistance, and US/ECRE’s Renewable Energy Efficiency Training Institute. Once projects had been identified it was EEAF’s responsibility to mobilize grant funding and capital from other funders such as the Rockefeller Foundation, The MacArthur Foundation, or US AID bureaus. US AID and Winrock International created EEAF. Their primary activity is to provide loans to businesses. US AID funded EEAF’s staff time and travel expenses incurred for “due diligence” and capital research. Partial funding for EEAF now comes from the InterAmerican Development Bank (IDB) since funding from the REAT Program is exhausted.

Components of the REAT Program included strategic assessments and planning and design assistance, information dissemination, market development, and project development. In 1994, the REAT Program had implemented design, pre-investment studies, and/or financing for more than 20 renewable energy projects, and as a result of its efforts, projects were completed in eleven countries in Asia, Latin America, and the Caribbean.

This program focused its assistance and finance efforts differently from World Bank programs. For instance, US AID often financed small projects that would demonstrate success in order to be able to attract greater amounts of funding from larger donor agencies. One of their more innovative efforts was establishing, with coordination from Winrock International, Renewable Energy Project Support Offices (REPSO). There are currently five support offices located in the Philippines, Guatemala, Costa Rica, Indonesia, and India. The project is a partnership of non-
governmental organizations that aim to help accelerate the use of renewable energy technologies in rural areas of the developing world. Unique from other efforts, this initiative has built in-country facilities that are managed by local institutions in coordination with Winrock International. The primary objective of these offices is to provide financial and technical assistance services to help developers identify and evaluate opportunities for renewable energy projects.53

The first step in developing a REPSO is to establish a partnership with a local institution that is well positioned in the energy community. Projects are then collaboratively identified. A key component of the REPSO’s is matching global interests with those of rural people in the developing world that are currently without access to electricity. Essentially, the REPSO serves as a link between US industries and local developers. Another function is to circulate vital information between each REPSO to ensure that lessons learned are shared.

There are three specific functions of the REPSO: project identification, evaluation, and implementation; trade and technology transfer; and utility collaboration. Under the first function, these offices prepare market and resource assessments and help to discover sources of project financing. As well as offering pre-feasibility studies and assessments, REPSO’s also offer some reimbursable grants to share pre-investment costs with developers.54 The second function is to organize trade missions, conferences, and workshops, and identify joint ventures. Last, they collaborate with utilities to increase their awareness of renewable energy options as a means to meet power needs in rural and remote areas.
US AID’s REAT Program was involved in several efforts to support renewable energy entrepreneurs and advocates. The organization was one of the firsts to provide financial support to Enersol Associates in the Dominican Republic, the parent company to Soluz Dominicana. The REAT Program also paid partial salaries of three World Bank employees in order for them to complete pre-investment studies for PV projects in South East Asia. They often pay for the training of entrepreneurs once World Bank projects have been developed. Another organization that has received funding from REAT is the Fundacion Solar, a Guatemalan non-profit that uses renewable energy technologies to meet communities’ energy needs. This organization focuses its labor on addressing institutional and regulatory barriers such as trade tariffs and privatization efforts.

The last major activity of the program was information dissemination. This included several conferences and public brochures and videos. Through CREST, the Center for Renewable Energy and Sustainable Technology, and US AID a CD-ROM was developed illustrating different types of renewable energy. CREST also worked with the REPSO in Guatemala to teach them how the Internet can be used to meet some of their needs. Fundacion Solar published a trade guide for renewable energy projects in Guatemala using loans from US AID. Lastly, REAT has sponsored conferences in Peru, Puerto Rico, and Washington, DC.

Determining the success of the REAT program has been a challenge. This is because within AID it appears that reports were never completed offering lessons learned or project results. Furthermore, there is no document that explains how the $52 million was distributed. There is no way to measure success by tabulating the number of systems installed or the number of
households electrified. Nevertheless, there are some conclusions that can be drawn about the efficacy of the Program. First, the Program influenced the creation of PV enterprises and non-profit organizations such as Winrock International and the REPSO’s that fill important niches in the market. Second, they have had some success in effectively targeting the placement of grants. Examples include acting as an information clearinghouse and covering administrative costs incurred by the ASTAE team. In conclusion, it is unlikely that AID will play an integral role in the new approach to renewable energy expansion. Nonetheless, it is important that they play a complementary role in the international schematic by providing information, training, and capacity building.

Section 4.3: US Department of Energy

The US Department of Energy (US DOE) has been investing in solar energy technology for the last forty years. Originally researching the role of solar photovoltaic technology in space, the US DOE’s National Photovoltaics Program now focuses on three areas. These include research and development, technology development, and systems engineering and applications. The systems engineering and applications area includes international projects. These efforts are primarily realized through the National Renewable Energy Laboratory (NREL) and Sandia National Laboratory.

RSVP

The National Renewable Energy Laboratory (NREL), through the United States Department of Energy, has initiated a program to expand the supply of electricity and services to villages in
developing countries. The program is titled RSVP or Renewables for Sustainable Village Power, emphasizing its goal of identifying sustainable projects. RSVP develops and implements applications that satisfy four objectives: technical performance, economic competitiveness, operational viability, and environmental benefits of renewable rural electric solutions. The RSVP program is a multi-disciplinary, multi-technology, multi-application program that relies on six functions: resource assessment, comparative analysis and modeling, performance monitoring and analysis, pilot project development, training, and Internet-based project data communications. The primary technologies are photovoltaics, wind, and hybrids of the two with diesel gen-sets. RSVP is currently working in twenty developing countries and has pilot projects in twelve - Argentina, Brazil, Chile, China, Dominican Republic, Ghana, Guatemala, India, Indonesia, Mexico, Russia, and South Africa.

The first three of the six functions outlined respond to the need in developing countries for accurate resource data and analytic tools. Technically, it is difficult to ensure that a certain technology is the “best” fit if assessment tools do not exist. NREL is able to offer these tools as well as technical expertise. Examples of such tools are computer models they have developed. Through RSVP, the NREL team has developed models that focus on the optimization of hybrid systems (HOMER), the detailed technical and economic performance of hybrids (Hybrid2), and the economics of alternative village electricity options. The Hybrid2 model, which was designed by NREL and the University of Massachusetts, is a versatile, user-friendly and publicly available program used to compare the economics of hybrid systems and conventional diesel systems. Key inputs include village load profile, system architecture and control strategy, unit costs, and
financial parameters. This information reveals component and system performance, diesel-fuel use, and economic parameters.

Using these computer models, the RSVP team is collaborating with NGO’s, government agencies, industry, and international organizations to perform system analyses. These analyses include pre-feasibility, design, and post-installation system performance. Several studies have been conducted and results are available through NREL and conference proceedings.

An example of such collaboration is the Indonesian Solar Home Systems Project. NREL and ASTAE developed a model that compares PV Solar Home Systems to conventional electricity options for rural Indonesia. The results were used to help design the GEF project. This effort will be expanded to other countries as well. These computer models have also been used in the development or evaluation of projects in Argentina, Brazil, the Murmansk region of Russia, and Inner Mongolia in China.

For the Inner Mongolia project, NREL was asked in 1995 to perform a case study of rural electrification options in the region. This entailed conducting a levelized cost analyses for existing systems in four counties in Inner Mongolia. Solar and wind resource data were collected and performance/load data were collected from 10 PV systems, 22 wind systems, and 6 PV/wind hybrid systems, which ranged from 22 watts to 600 watts. For comparison, data were also collected from two 450-500 watt gasoline gen-sets that are commonly used in the area. The results, given in table 5, conclude that wind and PV/wind hybrid systems are the least-cost option for the area.
Table 5: Levelized Cost of Energy Values for Rural Electrification Options in Inner Mongolia for Remote Households

<table>
<thead>
<tr>
<th>System</th>
<th>Output Range (kWh/year)</th>
<th>Levelized Cost of Energy ($/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>200-640</td>
<td>0.24-0.36</td>
</tr>
<tr>
<td>PV/Wind</td>
<td>400-900</td>
<td>0.30-0.45</td>
</tr>
<tr>
<td>PV</td>
<td>45-230</td>
<td>0.70-0.85</td>
</tr>
<tr>
<td>Gas Gen-set</td>
<td>480-730</td>
<td>1.10-1.20</td>
</tr>
</tbody>
</table>

Source: Photovoltaics for Rural Electrification in the People’s Republic of China

The results also illustrate the extreme difference between the renewable energy options and the traditional gasoline gen-sets. NREL recommended to the government and other organizations involved that the PV/wind hybrid system be employed due to its seasonal complementarity. This would allow for a more reliable annual electric power supply and would meet load requirements more easily. NREL is now providing technical assistance to the government and the Planning Commission in developing a project to supply electricity to 300 households. This pilot project will then be expanded to offer services to 25,000 to 80,000 households in Inner Mongolia.

Another critical component of RSVP is the design of pilot projects. The Department of Energy has learned from past projects and understands that many of these developing countries and their citizens are very apprehensive to invest in renewable energy technologies. As a result, the RSVP team makes a great effort to ensure that the technologies, sites, loads, etc., are all accurately determined. Another goal of the program is to try and set up some in-country manufacturing and assembly, in order to both lower the cost of the pilot project and to develop a market for future investments. NREL believes that the most valuable aspect of these projects is the institutional viability of the retailer. They believe that the main reason why their projects and others failed in the past was because there was no emphasis in project design on building administration, operational, and maintenance capacity.
Related to the development of pilot projects, the RSVP program invests in technical assistance in order to expand the in-country knowledge and experience with renewable energy technologies. The team offers assistance to government agencies, private companies, and international institutions in the form of resource assessment, pre-feasibility system analysis, specification development, pilot project design and development, training, and performance monitoring and evaluation. Another way in which they disseminate information is through an Internet database. The team has developed an Internet database that includes project descriptions with information such as location, application, system description, economics, financing, participants, and lessons-learned. There are currently 155 projects in the database with 250 expected by the end of 1998. The site can be found at the NREL web site (http://www.nrel.gov). Benefits of the site include information about the computer models, educational materials, project examples, and contact information.

An example of a project in which NREL offered technical assistance and other services is in Xcalak, a coastal fishing village on the Yucatan Peninsula in Mexico. The Xcalak Project utilizes a hybrid power system. It was installed in 1992 and consists of six wind turbines and a photovoltaic array that together generate 120-250 kWh of AC power per day. A well-established PV supplier in Mexico, Condumex S.A., installed the system and the State of Quintana Roo and PRONOSAL, a Mexican rural development program, offered funding. NREL became involved in the project in 1994 by providing technical assistance and analyzing system performance data. The system performance was initially better than predicted due to a higher wind resource than originally predicted. However, the system was designed to meet the entire load and has not because the load has increased since initially installed. In addition, various technical problems
have occurred including issues with the inverter, the wind turbine alternator, and the PV array. In a project brief, Program officers stated that most of the technical problems could have been fixed in a timely manner if an efficient system maintenance structure was established.

There are several other institutional problems associated with this project that have served as invaluable lessons for future projects. First, there was not a local electrification committee formed before the project was initiated so there was a lack of ownership and responsibility for the system. Also, the local utility and households were not involved in the project, exacerbating the problems. Last, when the project was first started the users were not charged for services so once a fee collection system was established it was difficult to force users to pay. NREL’s services have not had a significant impact on the institutional barriers. Therefore, they fear that the project is in danger of complete failure. At present, NREL is still trying to intervene and address the barriers, but efforts thus far have been fruitless.

The US DOE’s international renewable energy efforts are fundamentally different from those of the World Bank and even US AID. The DOE projects in the past received perhaps the most criticism of any and were even accused of destroying the early development of private markets. Key players at the DOE and NREL realize that there is a great deal of lessons to be learned from the past projects. NREL can play a valuable role in the new market development scheme by being the international technical expert. This role must be complementary to the funders’ efforts to establish a sustainable market. NREL cannot deploy a new technology for testing free of charge to the consumer. This will merely undermine the efforts of the other programs.
Chapter 5: Analysis: How Well Do the New Generation of Programs Address the Barriers to PV Market Development.

The international and bilateral funder organizations discussed in this paper are responding to the role of renewable energy in electrification projects with strong, well-structured programs. The primary goal of these programs is to stimulate private market expansion in order to develop a market that is self-sustaining. This approach is an effort to move beyond the failures of the 1980s, which subsidized technology and were not able to sustain themselves after the projects ended.

Each of the programs discussed and the projects they are funding have proposed methods of addressing the barriers that face the four key actors: the consumer, PV retailer, financial institution, and regulatory bodies. The principal strategy employed is to encourage financial institutions and PV retailers to participate in the market by offering loans and credit at rates that are more favorable than traditional commercial terms. This in turn will allow retailers access to the capital needed to make improvements and the ability to offer consumers financing options. Consumers will then have financing alternatives, which will allow them to purchase systems. This chain of events is intended to lead to a prosperous private market. A prosperous market is expected to provide incentives for improving manufacturing techniques and thus lowering the cost of photovoltaic systems.

If the World Bank Group programs are able to raise private funds and liquidate their portfolios and perform according to their design, collectively they will introduce roughly $200 million to
the international solar photovoltaic market and will attract over $600 million in private sector investment and end-user sales. These figures are examined in Appendix B. Disbursing this amount of money over a ten-year period will be a measure of not only how successful these programs are, but also an indicator of how quickly and easily the market is able to absorb the investment and abolish the barriers. The next four paragraphs review the programs strengths and weaknesses in overcoming the barriers to market development. Each paragraph will be discussed in greater detail in Section 5.2.

These programs will encourage financial institutions and investors to become active players in the SHS market in several ways. The first is by acting as an investor itself. Other methods include offering mechanisms to banks that will help to guarantee success and mitigate risk, and by providing training on how to lend to rural customers for energy services. Potential problems will persist for financiers including foreign exchange risk, high-cost of appraising projects in rural areas, and difficulties in aligning the interests of different parties such as dealers, banks, and NGO’s.

Retailers and dealers will be able to provide a superior service to their customers and improve their business activities due to the variety of loans that these Programs are offering. These loans will allow retailers to purchase systems and components in bulk and to offer financing schemes to their customers. In addition, many of the Programs are providing training to improve technical and organizational aspects of running a PV business. The extent to which the two barriers facing retailers are removed depends on which companies actually receive loans from these Programs.
By promoting a variety of different financing options, these programs will remedy consumer's lack of access to financing. Households can receive credit and long-term financing through retailers and/or local banks. As previously mentioned, these programs intend on educating both parties about rural lending and demonstrating how lending practices should be structured. In the future, it may still be difficult for lenders to appraise the credit worthiness of applicants and many customers may continue to be rejected. If this barrier is to be fully resolved, it may be necessary to develop new methods for determining a customer’s ability to pay.

The last group that these programs will try to affect is the national government or relevant institutions. It is necessary that subsidies for competing fuels and duties and taxes are lowered or removed or SHS’s will never be competing on a level playing field. Programs are using different methods to address these barriers ranging from lobbying techniques to active engagement with the government to reform policies. The barriers imposed by the government may prove to be the most stubborn and difficult to alter. Unfortunately, it may also prove to be the most important since government policies can greatly decrease the attractiveness of an SHS.

In practice, implementing these programs will be arduous and their success depends directly on coordinating the efforts of several different parties. This analysis will first examine these programs by looking at examples of projects that have already received or are about to receive funding from one of the programs. Second, the summary provided above will be discussed in greater detail to determine the degree to which the barriers are addressed by these programs. Appendix A presents this analysis in an abbreviated, matrix form. Last, manufacturing and
system costs will be analyzed to determine whether or not these programs will cause significant cost reductions.

**Section 5.1: Project Examples**

Of the five World Bank Group programs discussed, only one - SME - is currently in operation. PVMTI will be soliciting proposals until the end of December 1998 and REEF is in the process of raising funds for the equity portion of the portfolio. The SME program, one of the IFC/GEF’s renewable energy programs, has invested in three photovoltaic projects to date and there are additional projects in the planning stage as well. This portion of the analysis will look at four projects that have arisen as a result of international funding from one of the programs under operation. Future projects should certainly emulate these successes and retain the lessons learned from these examples.

Soluz, Inc. has been operating for well over a decade and has managed successful financing efforts. It is one of the projects that has received funds from the SME program. Their experience in the field and attention to sound business strategies has affirmed their status as a model for future PV businesses.

In December 1997, Soluz Dominicana, S.A., a subsidiary of Soluz, Inc., successfully completed its prototype 1,000-customer photovoltaic rental operation. This operation, the Solar Electric Energy Delivery (SEED) program, relies on the fee-for-service model that allows consumers to purchase a system with a down payment and then make monthly payments. SEED was initiated
in 1994 in the Dominican Republic after 10 years of selling systems on a cash or credit basis. Consumers now pay up to $20 per month to rent the PV module, wiring, and florescent lamps.

Soluz Dominicana boasts nearly a one hundred percent on-time payment collection and serves as a superior example to other PV distribution companies. This achievement is a result of their commitment to full cost recovery and belief that it is the only way in which the market will expand. According to a paper published by Enersol Associates, a non-profit NGO that founded Soluz, Inc., in order to recover full costs it is essential that the role of subsidies be understood. There is certainly a time and a place for subsidies and it can be defined as “its (subsidies) effectiveness in creating conditions conducive to private investments in photovoltaic projects.”

Using Soluz, Inc. as an example, an interesting question to consider is why a company that is so successful and has been in the business for so many years still must rely on concessionary loans from international funders. The purpose of these programs is to issue loans to companies in order to expand capital or to improve business functions. Down the road it is anticipated that the companies will be self-sustaining and able to make a profit. If this is the case, then why does a company that is so well-established and respected need below commercial term loans? Soluz is successful in that they have expanded operations and maintained sound business activities, but at the same time it appears that the high technology cost and transaction costs are still deterring the company from being self-sufficient.

SME selected intermediary EEAF will disperse funds to ENSO, a PV distributor in Chihuahua, Mexico sometime in the near future (mid 1999). For the past eight years, ENSO has been
selling PV’s for commercial and agricultural services. The company is now about to launch a residential PV program. They will be selling 50 Watt systems to residents that are currently using dry cell batteries. The systems cost ENSO $560 dollars. ENSO will sell and install the systems for $1,000 each. This covers the cost of the system, installation, and profit. EEAF will request funds from the SME program to help ENSO set up a retail financing program to allow end-users to finance the system. EEAF will request $50-60,000 from SME and then provide a loan of roughly $120,000 to ENSO. ENSO will repay the loan over a two year period while EEAF will repay the SME loan over three years. ENSO will first target customers that can pay cash in one lump sum. Then they will allow customers to pay a down payment and finance the remainder over twenty-four months. It is anticipated that the retailer will extend the term to forty-eight months. EEAF projects that during the first year ENSO will sell 100 systems and then 125 and 150 in each of the following two years. EEAF does not expect to see the price fall from $1000 during the three-year period. The feasibility study to determine the demand for the service was conducted by New Mexico State University and Sunwize, the PV manufacturer that will sell ENSO the systems. Households were asked what their current source of power was, how much they paid, whether they would be interested in a more reliable source, and how much they would be willing to pay. The responses were positive. This project appears to be a favorable example of expanding the private market. It is the venture occurring between manufacturers (Sunwize), distributors (ENSO), and financial institutions (EEAF), which is building the environment for successful interaction with end-users.

Another enterprise that has received SME funds is SELCO Vietnam. In September 1998, SELCO closed the loan for $750,000. The Solar Electric Light Company (SELCO) is a solar
energy service and distribution company that grew out of the Solar Electric Light Fund (SELF), a non-profit development organization that set up pilot projects in developing countries. SELCO has operations in Vietnam as well as China, India, Sri Lanka, and South Africa. SELCO Vietnam was established in 1997 and is one hundred percent foreign-owned. SELCO and SELF have been working in Vietnam since 1995. Teaming together with the Vietnam Bank for Agriculture, SELCO plans to use the SME funds to partially collateralize credit extended by the Agriculture Bank to consumers who will purchase systems and pay over a three to four year term. Consumers will pay a twenty percent down payment. The bank agreed to lend up to seventy percent of the remainder. The SME loan will be used as collateral to the bank to cover the remaining ten percent. The loan will provide up to $5 million worth of consumer loans in local currency. It is projected that 12,000 households will be electrified.

An interesting component of SELCO’s operations is that they manufacture all of the balance of system parts in the host country. They purchase the PV module from an international company. By reducing the number of distributors in the chain they have been able to lower the cost to the consumer. SELCO has also been fortunate in that they have established joint ventures with large, credible organizations within the country. This includes not only the Vietnam Bank for Agriculture, but also the Women’s Union and the Local People’s Committee. In the future, SELCO plans on pursuing projects in India with PVMTI funds.

Grameen Shakti is the fourth enterprise that has received funds. Grameen Shakti is one of the new enterprises born out of the Grameen Bank in Bangladesh. SME funds will be used in a similar manner as the previous projects – to offer consumer credit. At the end of 1998, 412
systems have been installed and there are 20 branch offices.\textsuperscript{69} Within three years, the company plans on installing 6,000 systems with 28 branch offices. Grameen Bank has been very successful in issuing small loans, mainly to women, for business activities. Like most developing countries, people living in rural areas have no collateral or means of displaying credit-worthiness. To overcome this problem the bank decided that in order to get a loan there must be a group of 5 people that will be responsible for it. If one person defaulted on their loan there would be four other individuals still responsible for it. The approach has worked unbelievably well – they boast a ninety-eight percent repayment average. This method has been extended to purchase solar home systems as well. In addition, a discount is offered if you are a bank customer. Several innovative examples have come from this approach.\textsuperscript{70} First, a man in Bangladesh bought six solar lamps. He uses one in his office and rents out the other five. He makes $2.5 per month per lamp. A second example is a person who charges cellular phone batteries for 8 hours per day using solar power. He charges 30 cellular phones per day at $1 per cellular. These examples reflect the notion that electrification should also be used to increase income. Obviously, entrepreneurs will respond given the opportunity.

\textit{Section 5.2: How Programs Address Barriers}

The primary role of the World Bank Group’s new PV programs is to fund financial institutions, retailers, and distributors as well as to provide limited grants through the GEF to cover the incremental costs associated with current PV investments. Table 6A and 6B list the possible financing mechanisms that are being currently utilized by one or more of these projects. The table includes two sections. Section A lists the financing options that are being offered to
developing country investors by the World Bank Group or to PV retailers by developing country financial institutions. Listed in section B are the financing options that are being offered to the consumer.

Table 6: List of Possible Financing Mechanisms Offered to Investors and Retailers

<table>
<thead>
<tr>
<th>Financing Mechanism</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial institution or dealer financing options:</td>
<td></td>
</tr>
<tr>
<td>Grants</td>
<td>Funds that do not have to be repaid. Usually used to bring down technology or transaction costs and for training.</td>
</tr>
<tr>
<td>Equity or quasi-equity</td>
<td>Financial institution or funder organization provides to retailer for working capital.</td>
</tr>
<tr>
<td>Concessional loans</td>
<td>Medium- or long-term loan issued to dealers for working capital, end-user credit, or expansions. Below commercial rates.</td>
</tr>
<tr>
<td>Guarantees</td>
<td>Credit enhancement mechanisms, prepaid SHS meters, or cross-collateralization of loans to reduce credit risks for lenders.</td>
</tr>
<tr>
<td>Contingent finance</td>
<td>Loan must be repaid to sponsor only if the project is successful.</td>
</tr>
</tbody>
</table>
Table 6B: List of Possible Financing Mechanisms Offered to Consumer

<table>
<thead>
<tr>
<th>Financing Mechanism</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash purchases</td>
<td>End-user pays for PV system in one lump-sum cash purchase.</td>
</tr>
<tr>
<td>Vendor financing</td>
<td>PV distributor directly finances the purchase of a system for 1-3 months at market rates.</td>
</tr>
<tr>
<td>Revolving funds</td>
<td>End-user pays a down payment and makes periodic payments at market rates with the system as collateral. The money goes into a revolving credit fund for future investments.</td>
</tr>
<tr>
<td>Leasing or hire-purchase arrangements</td>
<td>A monthly fee with no down payment paid to an intermediary. PV systems often bought through seed capital.</td>
</tr>
<tr>
<td>Energy Service Company (ESCO)</td>
<td>ESCO buys PV systems and end-user is billed for service.</td>
</tr>
</tbody>
</table>

Essentially, by offering these various financing mechanisms the World Bank Group is acting as an investor in the PV market and will serve as the first large investor in the private sector.
Rather than merely establishing demonstration projects and subsiding technologies, options are being offered to creditors along terms that are more favorable than traditional commercial terms. This strategy will help to eliminate or reduce several of the barriers facing the four actors. However, it will not remove all of them. The remainder of this section will analyze the degree to which these programs address the barriers facing each actor and outline some issues that may persist into the future. Table 3 is reproduced below and lists the barriers according to each actor.

Table 3: List of Barriers to PV Market Expansion

<table>
<thead>
<tr>
<th>Actor:</th>
<th>Barrier:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer:</td>
<td>Awareness of and satisfaction with technology.</td>
</tr>
<tr>
<td></td>
<td>Ability to pay (access to finance).</td>
</tr>
<tr>
<td>PV Retailer:</td>
<td>Lack of access to capital and infrastructure improvements.</td>
</tr>
<tr>
<td></td>
<td>Untrained personnel, technicians, management – poor operation &amp; maintenance.</td>
</tr>
<tr>
<td>Financial</td>
<td>Immature/undeveloped financial institutions.</td>
</tr>
<tr>
<td>Institution:</td>
<td>No profits or motivation for financial institutions to enter the private market, risk of PV market.</td>
</tr>
<tr>
<td>Government/</td>
<td>Subsidies for competing fuels.</td>
</tr>
<tr>
<td>Utility:</td>
<td>Import duties and high tariffs on PV modules and parts.</td>
</tr>
</tbody>
</table>

Section 5.2.1: Barriers Facing Financial Institutions:

Risk of Entering the Market:

One of the primary reasons why financial institutions have not been active in the PV market thus far is their inability to accurately assess the risk of investing and their ability to profit. Removing this barrier is a priority for all the programs because without active investors the private market will not sustain itself into the future. Mechanisms for addressing this barrier include
demonstrating through example the viability of the market, and furnishing guarantees such as cross-collateralization of loans and contingent finance. One issue that may discourage financial institutions from participating is the foreign exchange risk because the loans are issued to the banks in US dollars and must be repaid in dollars. Currently, there is fear of a world economic crisis. Should this materialize or even affect only a handful of countries the local banks will have a difficult time repaying loans. This is a challenge for many other industries as well and may not prove to be a deterrent to participation.

Both present and future investors and financial institutions will benefit from these programs because the World Bank will establish through example a successful track record. A successful track record will mean that they will have demand for their funds and liquidate portfolios, borrowers will retain adequate repayment records, and there will be demand for the service that the borrowers are providing. If this track record is realized it will motivate private investors and financial institutions in developing countries to offer credit services as well.

Another method used by these programs to reduce risk is guarantee mechanisms. These guarantee mechanisms include revolving credit facilities, cross-collateralization of loans within a portfolio of projects, prepayment meters in solar home systems, and contingent finance. With the last type of loan, contingent finance, the borrower is only required to pay back the lender if the project is successful. Revolving credit facilities and cross-collateralization of loans provide guarantees to the local banks because if one borrower is not able to repay the bank then they still have the other borrowers' collateral.
The programs that are under operation or in the process of selecting projects have been able to encourage financial institutions to participate. According to the PVMTI Project Document, in Kenya local banks make up four out of the eight potential loan recipients. The banks will use the funds to on-lend to small distributors, NGO’s, or large agro-industrial companies; or will use them to develop end-user finance schemes. In Indonesia, in the design phase of the project, four participating banks agreed to offer credit to dealers for up to five years. The banks are responsible for assessing the dealer’s performance and determining his credit worthiness. Under the SME program, most of the intermediaries selected are NGO’s or non-financial institutions. This is consistent with their program goals, which place a company’s environmental experience over their financial capacity. Thus far none of the SME intermediaries have displayed weakness in their financial capabilities. After the replenishment of funds, program managers intend to select financial intermediaries and train them in environmental matters.

The fact that investors are required to accept funds in US currency and must agree to pay back the loan in US currency is a risk that will persist into the future. As stated before, this is risky for many banks in developing countries because their economies are often unstable. The examples listed above do not outline any specific way to move forward with this issue. It may be necessary to find ways to deal with the foreign exchange risk.

Enersol Associates has developed an original way to improve consumer’s and dealer’s access to finance. Through Fondo Solar, Enersol Associates was able to resolve the foreign exchange risk as well as provide a guarantee mechanism to the local bank. In 1993, Enersol deposited a $85,000 grant from the Rockefeller Foundation into an U.S. interest-bearing account.
additional $30,000 was borrowed from the International Fund for Renewable Energy (IFREE). Enersol used the money as a guarantee to local banks that agreed to invest in renewable energy projects. The banks in turn lent to agencies that provided up to three-year loans to consumers. Under this system it is estimated that roughly 120,000 to 200,000 households could afford the system. The foreign exchange risk is reduced under this scenario as well as the risk that consumers will not repay the banks. If that happens Fondo Solar would pay the bank for their losses.

**Immature/Undeveloped in PV Market:**

Resolving the first barrier facing investors will encourage them to offer financial services. However these institutions still lack experience in the photovoltaic market and rural lending in general which may impair their ability to lend effectively. One method of addressing this barrier is to provide training on good lending practice before or during loan issuance. Another technique is to encourage banks to lend to NGOs or distributors themselves who can in turn offer credit to consumers. Challenges that will persist in the future include the high costs associated with appraising project viability in rural areas and the extent to which local banks, NGOs, and dealers can work effectively together. In other words, in practice it may be difficult to establish such networks. This barrier must be addressed if the programs expect local banks to participate in the market.

The Solar Development Corporation (SDC) is an example of a program that intends on providing education and information services to financial institutions to teach them about remote areas and the market. Under the SME program intermediaries have been selected that are NGOs, not
financial institutions. These NGOs are interested in entering the market and under this program they are able to receive guidance from the IFC. The GEF country projects also spend a great deal of time in the host country ensuring that the proper channels are developed prior to the operation of projects.

However, there are programs that are not directly addressing the fact that financial institutions are immature or unknowledgeable about the renewable energy market. According to the Project Document, the REEF program will only extend services to sponsors with relevant experience in the field. Since the project is still in its closing stage it is not possible to see whom they have established as sponsors. This is also the case with PVMTI in which it appears that a primary goal is to attract stable projects that will move ahead without significant guidance. US AID and US DOE are not included in this section because they do not directly lend funds to investors.

There are problems that will persist into the future if this barrier is not addressed by each of the Programs. First, local banks may be eligible to receive funds from one of the programs and then may not be able to effectively distribute the funds to qualified borrowers because of lack of experience. The likely result will be discouraged financial institutions that are not interested in being a part of the market. I do not anticipate that this mistake will be made by any of the programs. Instead those programs that are not addressing this barrier will lend to companies that do not need technical assistance.

This is the second issue that will determine whether or not this barrier is removed. If lending is only offered to financial institutions or companies that have relevant experience then the local
banks and other local institutions will remain inexperienced with this market. If local dealers and consumers use the local banks rather than the larger international finance companies then this barrier may adversely affect the expansion of the private market.

The third issue is how to link the banks, NGO’s, governments, and funders. It is the banks that will be key to the sustainability of the market since, once these programs are completed, they will be expected to continue providing financing. However, banks are typically in urban areas. This means that they must travel to rural areas to appraise the viability of projects or determine the credit-worthiness of consumers. They must also understand how rural areas function and how one differs from another. The dealers and suppliers are also expected to be able to work in rural areas. But, it is the NGOs in these communities that best understand the needs of people. Without a doubt these programs will be more successful if relationships are built between the banks, dealers, and NGOs. The NGO or a community leader could be the community representative and able to work with the dealers or banks. They can help as a local expert to do feasibility studies, surveys, training, and aid the banks with fee collection. In practice this is not always easy and there is little documented evidence of this alliance working. One reason for this is that each group has their own agenda and terms that they must adhere to which may not always agree with another group’s. Also, sometimes these groups have limited information and it is hard to bring them together. Lastly, it is administratively costly. It may be necessary that these programs include in their budget funds that can be used to teach banks about the local market or bring together parties that can provide this service.
Section 5.2.2: Barriers Facing Retailer/Dealer:

Lack of Access to Capital:

The unavailability of credit for retailers and dealers to purchase working capital and invest in expanding operations is being addressed by all of the World Bank Group projects. The primary method employed is issuing loans - at rates that are more favorable than commercial terms - directly to the retailer or to a local bank that will invest in retailers. The rates that loans are issued at after these programs are completed may be of some concern. Banks and other lending institutions will not be able to offer as favorable terms as the World Bank. If companies are still not making a large enough profit they may not be able to afford the loans or the bank may not deem them creditworthy.

As previously discussed, retailers require credit options so that they are able to purchase large quantities of systems and replacement parts. Once they have a large capital base they may be able to lease systems or offer short-term financing options to consumers. Each Bank program offers financing methods, which allow borrowers to choose the most viable option(s) for their purpose. Table 6A listed all of the different financing methods available. The most commonly used methods are concessional loans comprised of debt and equity that are issued at terms not available in the commercial market. However, grants are still available under certain circumstances. An example of a possible financing package is: an entrepreneur needing a combination of a long-term loan for capital purchases and a grant to lower the cost of the technology or cover administrative costs until his business is able to expand. If loans were the only financing option new companies may still perceive the market to be too risky and choose not to participate.
The grant portion is typically small. It usually comprises less than 10 percent of the total project cost. Subsidies are generally used to cover the incremental cost of the technology, for technical training, or towards the development of technology standards. In general, the incremental cost figure for the technology is equal to a $100 buy-down of the cost for the solar home system.\textsuperscript{73}

\textit{Untrained Personnel, Technicians, and Managers:}

Poor business practice due to untrained personnel, technicians, and managers is the second barrier facing PV retailers. This obstacle is also being addressed to some degree by all of the programs. Methods being used include aiding in the development of business plans and proposals, providing grants for technical training, and through the development of technical standards. The degree to which this barrier is removed depends in part on what types of retailers receive program funds.

The following are examples of how programs are addressing this barrier. The REEF program plans on addressing this barrier by establishing a "deal flow" or a network of organizations that will provide ad hoc advice to players in the market. PVMTI, SDC, GEF country projects, REAT, and RSVP will or are offering training through workshops, collaboration with utilities, or institutional development. The Renewable Energy Project Support Offices (REPSO) in India and Latin America have been active in technical assistance efforts. Both have sponsored or participated in seminars as well as more hands on capacity building exercises. In India, the REPSO is preparing a "PV Manual" that will be used to help educate NGOs and other parties using case studies and information on technology status, applications, and policies.\textsuperscript{74} In addition, they held a seminar with 21 NGOs that have experience in local areas and understand the needs
and capabilities of the local people. The purpose of the seminar was to encourage the NGOs to become involved in the market so that the obstacles between consumers and retailers can be resolved.\textsuperscript{75}

These approaches will disseminate information about the technology and the market to the appropriate actors. This will surely improve the relationship between the bank, retailer, and consumer. However, it is still difficult in practice to coordinate the needs of the retailers, banks, NGOs, and consumers. The REPSO in India may in fact be heeding successful results. But, it is too early to be able to determine what will be the magnitude of the effect or how easy it will be for the seminar attendees to take the knowledge they learned and apply it to their businesses.

The degree to which this barrier is resolved depends partly on which retailers are awarded loans. Currently, there are two types of retailers: those that are indigenous to a particular country's market and international companies that have grown mostly out of earlier non-profit efforts. The latter type is financially sound and has better technical capability and managerial skills. Two of the three companies that SME has issued loans to, as well as most of the companies that will receive the initial loans from PVMTI, fall into this category. The companies that are indigenous to developing countries tend to struggle with business plans and are not as technically trained. However, these companies understand their markets and may know how to work within them better than the international companies. The sustainable development view would encourage local firms to grow because it will offer employment opportunities and benefit the developing country. Plus, if they show a profit it is a local profit and is usually reinvested into the local economy. These programs can choose to fund one or the other or some combination of the two.
If the international companies receive most of the funds then it is unlikely that these programs will affect the business practice of local firms. It is critical that program managers consider this before loans are awarded.

Also, there may be contention from the government or potential retailers within the country that an outsider was offered funds. This may exacerbate the effect of existing barriers. This situation has been noted in Morocco regarding the use of PVMTI funds. Morocco currently has a small market and has been actively investing in solar photovoltaics prior to the creation of this program. Existing retailers and distributors are concerned that they are not able to access the funds because they are not able to meet the eligibility requirements. There may also be concerns that larger enterprises will enter the market and push them out.

Conversely, there are also risks in granting new or inexperienced companies access to funds. In the GEF Indonesia project, project managers chose eight new companies as their dealers. Currently, less than half of them are still in business. This may be partly due to the financial crisis, but it may also be due to a lack of experience. It was very difficult for them to figure out how to best serve customers and how to effectively operate their businesses.

Another issue with granting funds to new companies is the risk that they are not interested in establishing a market or business, but rather they intend to use World Bank funds to make a personal profit. Using funds to make a personal profit will most certainly fail in almost all countries due to the immaturity and complexity of the market. Establishing a business in rural areas of the developing world requires a great commitment. Often, companies are selling
systems to households that are dispersed in a region. This infers that selling systems, maintaining systems, collecting fees, and marketing services is not only capital intensive but time intensive as well. Dealers must be able to provide all of these services to remain in business.

**Section 5.2.3: Consumer Barriers:**

*Lack of Access to Credit:*

All of the World Bank Group programs discussed in this paper address consumer’s lack of access to financing by issuing loans to retail companies and local banks to establish credit schemes for customers. Possible credit schemes, which were outlined in Table 6B, include vendor financing, revolving funds, and leases. The only way to measure the success of the credit schemes will be to see how many companies and/or banks actually provide credit to rural customers without assistance from these programs.

The method used by SME and REEF to eliminate this barrier is to supply distributors with credit who in turn can offer it to their consumers. The examples from the SME project discussed earlier illustrate how this functions. SME provides EEAF with a loan that in turn offers ENSO a larger loan that in turn offers its consumers longer-term financing for the purchase of an SHS. Based on the anticipated deal flow for PVMTI, a significant number of potential borrowers will use their funds to establish end-user credit schemes. SDC is expected to also offer various financing modalities to end-users. In most cases though, the dealer can use the financing offered with their own discretion and are not required to extend credit to their customers.
These programs can demonstrate through surveys and past examples that customers are willing and able to pay for the service. At the end of the programs, local banks will have three to five years experience with lending in this field. In practice, it may still be difficult for lenders to determine the creditworthiness of the applicants. It will take further development of credit institutions in many developing countries for this barrier to be fully removed. An example of a lender that has identified an alternate method for determining creditworthiness is Grameen Shakti. In order to ensure repayment they require that the applicant have four other individuals agree to be responsible for the payments. This way if one person fails to make a payment it is up to the remaining four individuals to do so.\textsuperscript{76} Program design should consider whether they need to develop creative schemes, specific to the country, in the early phase of the Program to ensure that this barrier is addressed.

\textit{Awareness of Technology:}

The second barrier facing consumers is the lack of awareness and satisfaction with the technology. This barrier is not being directly addressed by all of the programs. The programs that are concentrating on eliminating this barrier are REAT, SDC and the GEF country projects. The RSVP and PVMTI Programs are pursuing indirect or less intense efforts. REAT and SDC are addressing it directly either through generic marketing and advertising or by collaborating with local communities to inform them of the benefits of solar energy. A challenge that has been noted in several of the program documents is the lack of motivation for retailers to invest in marketing to increase the number of households that are aware of SHS as an energy option.
Under the REAT program, the REPSO’s are attempting to work more intimately with communities by educating them as to what options exist for electrification. The REPSO’s are also trying to build more cohesion in communities to resolve issues such as lack of ownership that have plagued past projects. This is aided also by their efforts to build alliances between investors and NGO’s through activities such as the workshops they hold. A different technique that they also employ is to set up a revolving fund within a community only after the idea has been discussed by community members and the option is understood and accepted. The SDC Program has set aside a portion of its funds to be used for generic marketing and advertising efforts. Since the Program is not in operation yet the effectiveness of this approach is unknown. The GEF Programs are trying to remove this barrier before the projects get under way. They do this by teaching dealers about the benefits and risks of PV’s who in turn are supposed to share this information with their customers.

The RSVP program will indirectly improve customer satisfaction with PV technology through the use of their computer models and Internet database. The computer models are designed to determine the “best” technology for the region while the database is an information clearinghouse that can be used by project developers to help them design the most effective policy. PVMTI documents have also referenced the need for increased marketing efforts in the host country. However, the documents have not designated a certain amount of money that will be used for this purpose.

Several of the program documents have noted that dealers are not pursuing marketing and that perhaps funds should be used for this. It is believed that the reason why dealers are not investing
in marketing is because they perceive marketing to be a public good in that any marketing they invest in will benefit other companies as well. However, this is a challenge that retailers in all markets face and yet extensive marketing still occurs. Perhaps this is where true entrepreneurial spirit and drive to succeed in this market comes into play. It is quite possible to create a marketing strategy that will encourage customers to buy a specific product rather than a competitor's. Examples may include offering a lower cost for certain components, discounting the cost of using the local battery charging station, selling another product in conjunction with the solar home system, or establishing a good reputation for service. I believe that by the time these programs are completed that a large majority of potential rural customers will be aware of solar energy as a viable energy source. Thus, additional funds for marketing may not be a priority.

Section 5.2.4: Barriers Imposed by Institutions/Governments:

Subsidies for Competing Fuels:

A barrier imposed by government policy or institutions that often reduces the attractiveness of PV is subsidies for competing fuels. This barrier is not being addressed by all of the programs because it is time-intensive and beyond the capability of the programs. The programs that are addressing it are generally employing one of three tactics. The first is to only fund projects in countries that have attractive markets and governments or utility companies that welcome the program. The second technique, which is only used by the GEF country projects, is to require the host country to develop an action plan outlining how the program will sustain itself after the GEF pulls out. In most cases, this ensures that institutional barriers are addressed. Last, the SDC and REPSO's are lobbying for these barriers to be removed. For example, in Brazil a
consensus building process within the REPSO helped to eliminate an eighteen percent Value
Added Tax on PVs. The SDC has agreed to identify and report countries with institutional
barriers to World Bank officials who in turn will try and work through communication and
diplomatic processes to have them removed. It has been shown in the past that it is hard to
remove subsidies.

Import Taxes and High Electricity Tariffs:
The second barrier is the high import taxes on PV modules and balance of system components
and high electricity tariffs. Again, this barrier is not being addressed by all of the programs since
it is time-intensive and very difficult to alter government policy. The same techniques are being
used including encouraging the government to lower the taxes and tariffs or refusing to
implement projects within the country.

Government Policy:
Institutional barriers such as taxes and duties for equipment or subsidies for competing fuels will
have significant bearing on whether or not projects are sustainable. Governments may affect
program success in other ways as well. A possible scenario is that the government maintains a
subsidized rural energy development plan. It is quite common for the government to set up
subsidized energy projects as part of its social service programs. If this is the case then it will be
difficult for a retailer to go to a village to try and sell systems if the households believe that they
are next in line for a free system. This exact scenario has been played out in India and had
detrimental impacts on the photovoltaic market. It is essential that favorable relationships with
pertinent institutions are developed before efforts are made to establish a private market.
The individual GEF country programs spend a significant amount of time in the host country working on establishing a market that can respond to private sector activity. This effort has been time intensive and is part of the reason why it takes so long for their projects to become operational. However, the result is a country that has all of the key players in place and is prepared to implement a successful private market scheme. PVMTI has also learned through its development that a more active role would have to be taken in each of the three countries than originally anticipated. Releasing funds to dealers and banks was not sufficient to remove the barriers. It will be interesting to see how SDC, which is designed to be a fund for all developing countries, is able to cope with this issue. They will certainly not have the resources to alter existing institutional barriers.

If the institutional environment is unfavorable to the market it is unlikely that the market will be able to significantly expand. This will especially be the case once the World Bank Group projects are completed. This is because it is more likely that the host country will remove barriers to please the Bank than on their own accord in the future. In addition, if the host country and the programs are able to establish electrification goals together it is more likely that projects will reap greater success. This is because the government or utility often have rural development or rural electrification plans in place. Even if these plans are not successful, the government should be aware of what measures are being taken outside of their control. With this knowledge they have an opportunity to alter existing policies or to develop new policies that are in line with the current efforts. In practice, this is not simple because host countries prefer to have programs function as they like. This was the case with PVMTI in India. The government became so involved and wanted to alter the program nearly forcing the program to discontinue activities in
India. Regardless of how difficult it may be, in the long run it will benefit the market more if the government is in accordance and is implementing policies that complement the market.

Section 5.3: Market Size and Cost Reduction

The goal of these programs is to help create a sustainable market for PV technology. An underlying implication of these programs and a necessity for growth is that costs for systems will be lowered as the market expands. This will allow more consumers to be able to afford the service and thus attract more retailers and investors. This section looks first at the impact that these programs will have on the size of the market. Then ways in which cost reductions may occur is provided. Last, an analysis of what mechanisms are being employed by these programs that may cause reductions in the cost of solar photovoltaics is laid out.

Section 5.3.1: Programs Impact on Market Size

Appendix B provides a quantitative analysis of the World Bank programs. The first section of columns lists the funds committed and projected from both public and private parties, the number of solar home systems they propose to install, the total kW’s installed, the cost of the system in dollars per watt, and what the costs per watt are projected to be in the future.

The present manufacturing price for a single module is four dollars per Watt peak and installed prices are roughly ten to fifteen dollars per Watt peak. This price includes the manufacturing price and roughly four to six dollars per Watt for balance of system costs with the remainder being typically made up of taxes and duties or markups. Currently, there are roughly 500,000
systems installed in developing countries with 80,000 installed annually. If these programs are successful they will install between two and a half and five million new systems by the year 2005. This figure indicates that roughly 700,000 systems will be installed annually. This figure is nearly ten times larger than the amount currently installed per year. However, it should be noted that the vast majority of the new systems are slated to come from the Solar Development Corporation, which is not yet operational.

Section 5.3.2: Sources of Cost Reductions

There are several different ways in which cost reductions can occur. Sources of cost reductions can be broken down into four areas: the retailer, the government, improving manufacturing, and lowering transaction costs. If the programs discussed are successful in meeting their objectives it is likely that the cost for solar home systems will be lowered. This section describes the four sources of cost reductions and discusses which programs will influence reductions in cost.

Retailers can lower the cost of solar home systems by improving operation and maintenance techniques. Another way in which costs can be lowered is by purchasing modules and components in bulk. For example, in Indonesia when large orders of modules are purchased the cost is only four dollars per peak Watt whereas in the Dominican Republic small orders can be as high as eight dollars per peak Watt. The last way in which retailers can affect the price is by increased competition in the market. As the market matures and more retailers enter the market the cost will be driven down.
All of the World Bank Group programs are addressing one or more of the ways that retailers can lower costs. For instance, PVMTI is offering training that will improve operation and maintenance techniques. It is estimated that the PVMTI program will increase the size of the market by thirty-three percent in Morocco, fifty-five percent in India, and sixty-six percent in Kenya. This implies that there will be significant increases in competition as new companies enter the market. It is also possible that companies will grow and with the loans provided by the program they will purchase systems in bulk. Therefore, it is likely that PVMTI will lower the costs associated with the retailer in all three of the methods discussed. This is also the case with the Solar Development Corporation (SDC) and the GEF country projects.

The SDC proposes to bring about an order of magnitude increase in solar home system sales for rural areas over 1996 levels. They plan to complement the efforts of the other Bank programs, but it is suggested that this figure is independent of the other program’s installment goals. SDC assumes that their goals for installed systems would cause the price to drop as well. They will also offer training and other services that will improve the efficiency of the retailers business. The GEF projects address the three areas for cost reductions in the same manner. As discussed previously, the GEF concentrates on a single country and works with the market until it is capable to sustain itself. The GEF projects buy down the cost of the technology by roughly $100 per system to make it more affordable the customer. It is anticipated that by the end of the project, when the private market takes over, the system price will continue to fall even farther below the subsidized price. This is because more retailers will enter the market since it will be possible for more customers to purchase systems at the subsidized price. This will increase
competition and encourage more bulk purchases. Of the GEF projects discussed in this paper, a total of roughly 26,000 kW's will be installed.

It is difficult to determine whether or not SME and/or REEF will be able to affect these types of cost reductions. This is because they concentrate on other types of renewable energy sources and are not dedicating as much money to PV’s as the other programs. It is also not likely that RSVP or REAT will be able to witness significant reductions in these areas since they do not offer loans for capital improvements.

The government can also affect the price of solar home systems. The primary way in which they affect the price is through import duties and taxes on modules and components. Implementing these policies raises the price of solar home systems. The government can aid in the development of a private market by lowering or removing duties and taxes.

Programs that have or will likely influence government policies that adversely affect the price of solar home systems are REAT, the GEF country projects, and SDC. Under REAT, some of the REPSO’s have been successful in lobbying for the government to reduce taxes. For instance in Brazil, the REPSO helped to remove an eighteen percent value added tax on PV’s. The GEF also encourages governments to reduce adverse policies when they are developing the program. They also require that the government develop an action plan that outlines how the market will continue into the future. This plan should address such policies. Last, the SDC will use diplomatic processes and dialogue to try and remove policies that are affecting market growth in particular countries. REEF and PVMTI are only funding projects in countries with attractive
markets. This tactic will not reduce the cost in the country, however, since duties and/or taxes will not be removed.

One of the most promising areas for cost reductions is in the manufacturing of solar home systems. One way to lower the cost is through reductions in production costs. As demand for systems increases the cost of manufacturing will fall. Increased demand can also lead to increases in the size of manufacturing plants. For example, a factory producing 2MW per year would cost $12.5 million to build, but if the factory produced 80 MW per year the costs would only increase by 6 times as much or a total cost of $80 million. The second way in which costs can be lowered is by establishing in-country manufacturing and/or assembly. This is due to three reasons. First, many of the necessary inputs are lower in developing countries. Second, costs would be saved since the systems would not have to be shipped all over the world. Last, import duties could be avoided. One way to encourage in-country manufacturing and assembly is by establishing joint ventures in developing countries. For example, integrating system assembly and distribution could save costs. The last way in which costs could be lowered is by technological breakthroughs primarily realized through research and development efforts.

None of the programs are directly addressing manufacturing as a means for cost reductions. However, it is possible that the programs that intend on installing a significant amount of systems in a region may indirectly encourage manufacturing improvements. Also, as demand increases for systems plants may reach full capacity, which would help lower the cost. Programs that are installing a large amount of systems and may be able to influence manufacturing scale-ups include PVMTI, SDC, and the GEF. Under the SME program, SELCO Vietnam currently
uses balance of system components that are manufactured in-country. This is one way to reduce
the cost of SHS’s that may be possible for others to emulate. The US DOE is spending a
significant amount of money in the US on research and development that aims to make
technological breakthroughs that would cause reductions in the cost for PV’s.

The last source of cost reductions can be realized by lowering transaction costs. Again, as
demand increases the fixed costs of sales and servicing will be lowered because the costs will be
spread over a larger customer base. Also, reducing the number of reseller steps, or the number of
intermediaries in the process, will reduce costs. This is because a profit is made at each step so
reducing the number of steps will make the cost to the consumer lower. The degree to which
these programs can affect transaction costs can only be determined once the programs have been
operational for several years or are completed. It is probable that the GEF country projects and
PVMTI will be able to reduce these costs because they are working extensively within each
country and plan on greatly improving the efficiency within each market.

Chapter 6: Conclusion

The new generation of programs developed by the World Bank Group, the US Agency for
International Development, and the US Department of Energy are designed in a manner to
overcome the barriers facing the market for solar photovoltaics. The goal of these programs is to
reduce the barriers and to establish a private market for solar photovoltaics. These organizations
are trying to establish this market because there are several benefits that PVs provide. A private
market for solar PV’s will benefit the consumer by providing them with a reliable form of
electricity. Currently, target households are without electricity and it is not anticipated that grid extension will occur in the next few years. A private market will also stimulate economic growth and provide jobs for local people. Another benefit is that solar PVs are an environmentally sustainable technology. This benefit is the primary reason why multi- and bi-lateral organizations are investing in these programs. The degree to which these programs are successful depends on their effectiveness in removing the barriers to market development.

Currently, barriers affecting consumers, retailers, and financial institutions are deterring development of a private market. Barriers facing consumers include unawareness of the technology and a lack of access to credit that would allow them to finance the system over an extended period of time. Retailers also face a lack of access to credit that would enable them to make capital improvements. Untrained personnel, technicians, and managers also disable retailers from running an efficient business. Last, financial institutions perceive the market as risky and are not knowledgeable about how to lend to rural customers that are not able to display credit worthiness. These two barriers discourage them from lending to retailers and consumers. In addition, national governments can implement policies that increase the cost of PVs. Import duties and taxes on modules and components can significantly raise the cost to the consumer. Also, subsidies on competing fuels, such as kerosene, make PVs appear unattractive.

These programs are employing several innovative tactics that will address the barriers outlined above. The World Bank Group programs are trying to establish a private market by offering loans at rates below commercial terms to retailers or financial institutions that are interested in investing in PV projects. This will allow retailers the opportunity to purchase capital and offer
credit to customers. This tactic will also allow the bank to prove to financial institutions, through example, that this market offers sound investment possibilities. In addition to issuing loans to banks, that will enable them to offer loans to retailers and consumers, many of the programs are offering guarantee mechanisms to financial institutions. Guarantee mechanisms will hedge risks, such as borrowers not repaying loans, that banks may incur. Also, training on how to lend to rural customers and how to appraise the viability of projects is being offered. Many of the programs are also trying to influence government policy and encourage them to remove those that influence the costs of PVs.

Regardless of the extent to which the barriers are addressed, there may be particular challenges that will persist into the future and may affect the pace at which the market develops. The national government and/or national utility company may prove to be an on-going concern. Utility companies in developing countries are often very powerful. They may perceive a private market for electricity as an adversary because it would detract from their potential profits. Even though most utilities are not able to meet current energy demand by providing service to all customers it is unlikely that they would like to the market. A solution is to engage the utility company in the market in some fashion.

Another issue that may prove to be a problem in the long term is battery replacement. The ideal battery for a solar home system is a lead-acid deep-cycle battery, which if used correctly can last up to five years. These batteries are costly, so most customers use lead-acid automotive batteries. Old batteries can cause environmental contamination or harm users if not disposed of properly. Ideally, batteries should be recycled. None of the program documents mention how
they will address this issue or discuss establishing a recycling program while designing projects.

Perhaps, this is one area where these programs could engage the utility companies by having them replace batteries, as well as recycling them. This issue may prove to be an issue in the future and may affect PV’s reputation as an environmentally sustainable technology.

These programs are lending at rates below what is available under traditional commercial terms. One question that deserves further research is whether or not the market will be to continue after the life of these programs at commercial terms. The goal of these programs is to stimulate a private market, not sustain it with low-interest loans. It has been stated in the research materials that retailers only need the initial low-interest loans in order to make capital improvements. If this is true then why are companies that have been established for years, such as Soluz, Inc., still applying for the loans? Perhaps, it is very difficult for retailers to make a profit and these loans allow them to stay in business. If this is the case, and only further research and time can tell, then the sustainability of this market may be in jeopardy.

As discussed in this paper, several barriers are currently deterring development of a private market for solar photovoltaics. The programs developed by the World Bank Group, US Agency for International Development, and US Department of Energy aim to reduce the intensity of these barriers by employing many innovative tactics. However successful these programs are in meeting their goals, there are still challenges and concerns that will persist into the future and may jeopardize market development. Since most of these programs will become operational in 1999, the next five to ten years will shed light on these programs ability to overcome the barriers and stimulate a self-sustaining private market.
Endnotes:


4 Ibid.


8 Ibid.


11 Ibid.


14 Cabraal. 1995. Note 12

15 Ibid.


18 Cabraal. 1995. Note 12


20 Ibid.


Ibid.


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World Bank. 1996. Note 7

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50 *Clean Energy Finance*. Note 33.


52 Ibid.


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55 Pumfrey, Ross. Personal Communication, April 1998

56 Ibid.


59 Ibid.


61 Ibid.


65 Ibid.


70 Ibid.


72 Ibid.


75 Ibid.

76 Wimmer. 1998. Note 68.


79 Ibid.
Appendix A: Matrix of Projects against Barriers:

<table>
<thead>
<tr>
<th>Barriers \ Projects</th>
<th>SME</th>
<th>REEF</th>
<th>PVMTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness of and satisfaction with technology</td>
<td>Intermediaries select SME’s with local experience.</td>
<td>Not addressed.</td>
<td>Funds may be requested for marketing efforts.</td>
</tr>
<tr>
<td>Ability to pay (access to finance)</td>
<td>Providing credit and leasing schemes.</td>
<td>Financing options to extend payment terms.</td>
<td>Financing options.</td>
</tr>
<tr>
<td>Immature/undeveloped Financial Institutions</td>
<td>Building capacity in non-FI’s to broaden the number of firms in the market.</td>
<td>Sponsors will have relevant experience, but will work closely to structure and implement projects.</td>
<td>Joint ventures between companies, must remain at least 51% private.</td>
</tr>
<tr>
<td>Risks of entering market (ability to profit)</td>
<td>Cross-collateralization of funds, percent of funds retained by Intermediary.</td>
<td>Loan, guarantee, and equity financing mechanisms. GEF co-financing to hedge risk.</td>
<td>Guarantee mechanisms, joint ventures.</td>
</tr>
<tr>
<td>Lack of access to capital</td>
<td>Funds dispersed for capital improvements.</td>
<td>Loans, equity, and grants.</td>
<td>Concessional financing. Encourages JV’s to purchase large quantities of systems.</td>
</tr>
<tr>
<td>Untrained personnel, technicians, managers</td>
<td>Training may be provided through Intermediary, but it is not required.</td>
<td>“Deal flow” – a network of organizations to provide ad hoc advice to players in the market.</td>
<td>Service, training, and institutional development.</td>
</tr>
<tr>
<td>Subsidies for competing fuels</td>
<td>Not addressed.</td>
<td>Funds can not be used to compensate for market distortions, must be made in attractive markets.</td>
<td>Chosen countries have some established market and the governments endorse the project.</td>
</tr>
<tr>
<td>Taxes, duties, and trade tariffs</td>
<td>Not addressed.</td>
<td>Funds can not be used to compensate for market distortions, must be made in attractive markets.</td>
<td>Chosen countries have some established market and the governments endorse the project.</td>
</tr>
<tr>
<td><strong>Barriers \ Projects</strong></td>
<td><strong>SDC</strong></td>
<td><strong>GEF projects</strong></td>
<td><strong>REAT</strong></td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Awareness of and satisfaction with technology</td>
<td>Generic advertising, marketing, and promotion.</td>
<td>Customer protection and awareness of risks and benefits through links between dealers and end-users.</td>
<td>Coordination with local community needs, teaching communities about options.</td>
</tr>
<tr>
<td>Ability to pay (access to finance)</td>
<td>Financing options may be available through dealers, not SDC directly.</td>
<td>First cost buy-down by GEF and payment of system to dealers in 3-4 years with down payment.</td>
<td>Credit, revolving funds, and leasing options available.</td>
</tr>
<tr>
<td>Immature/undeveloped Financial Institutions</td>
<td>Encourage FI’s to be more responsive to the market. Education and information dissemination.</td>
<td>Collaboration between GEF, banks, and dealers to write applications and business plans.</td>
<td>Trade missions, conferences, and Internet services. Pre-investment studies and project research.</td>
</tr>
<tr>
<td>Risks of entering market (ability to profit)</td>
<td>Create a “code of conduct” among donors that will help the private market. Illustrate success</td>
<td>Banks were chosen in advance and were able to review dealer info and credit needs.</td>
<td>Funded org.’s that invested in projects that were successful thus demonstrating level of risk.</td>
</tr>
<tr>
<td>Lack of access to capital</td>
<td>Financing to businesses for capital improvements, equity investments.</td>
<td>Banks make loans to dealers based on cash flow.</td>
<td>Not addressed.</td>
</tr>
<tr>
<td>Untrained personnel, technicians, managers</td>
<td>Aid in the development of business plans. Technical training.</td>
<td>Limited training through workshops, conferences, and study tours.</td>
<td>Collaboration with utilities, conferences, etc.</td>
</tr>
<tr>
<td>Subsidies for competing fuels</td>
<td>Identify countries with policies that act as disincentives and then the World Bank will try through dialogue to remove the barriers.</td>
<td>As part of the grant the country, must develop an action plan as to how efforts will continue into the future.</td>
<td>Not addressed.</td>
</tr>
<tr>
<td>Taxes, duties, and trade tariffs</td>
<td>Identify countries with policies that act as disincentives and then the World Bank will try through dialogue to remove the barriers.</td>
<td>As part of the grant the country, must develop an action plan as to how efforts will continue into the future.</td>
<td>Consensus building process in Brazil by REPSO to remove 18% VAT, now only 10% import tax on PV’s.</td>
</tr>
<tr>
<td>Barriers \ Projects</td>
<td>RSVP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Awareness of and satisfaction with technology</td>
<td>Computer models to determine the best technology option.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to pay (access to finance)</td>
<td>Not addressed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immature/undeveloped FI's</td>
<td>Conferences among actors to spur the interest of FI's.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks of entering market (ability to profit)</td>
<td>Not addressed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of access to capital</td>
<td>Not addressed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untrained personnel, technicians, managers</td>
<td>Provides technical assistance to resolve administrative and regulatory barriers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsidies for competing fuels</td>
<td>Offers assistance to officials as to how projects can be more successful.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxes, duties, and trade tariffs</td>
<td>Offers assistance to officials as to how projects can be more successful.</td>
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</table>
### Appendix B: Quantitative Analysis of World Bank Group Programs

<table>
<thead>
<tr>
<th>Program Name</th>
<th>Life of Project (yrs)</th>
<th>Public ($M)</th>
<th>Private ($M)</th>
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<tbody>
<tr>
<td></td>
<td>Committed</td>
<td>Projected</td>
<td>Total</td>
</tr>
<tr>
<td><strong>GEF Projects</strong></td>
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</tr>
<tr>
<td>Sri Lanka</td>
<td>5</td>
<td>7.9</td>
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</tr>
<tr>
<td>Indonesia</td>
<td>4.5</td>
<td>45.8</td>
<td>0</td>
</tr>
<tr>
<td>Argentina</td>
<td>not yet approved</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>China</td>
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<td><strong>Total GEF Projects</strong></td>
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<td></td>
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<td>55</td>
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<td>30</td>
<td>0</td>
</tr>
<tr>
<td><strong>SDC</strong></td>
<td>3(guided then</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>stand alone)</td>
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<tr>
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<td>3</td>
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<td><strong>REEF</strong></td>
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<td>5-21</td>
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<td>(10-13 for liquidation)</td>
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<td>95-111</td>
<td>196-213</td>
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*Est. 1/4 of total project costs for PV's

---

*EEAF Mexico

An estimated 10% of total funds for off-grid uses.
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<th>Program Name</th>
<th># of PV Systems</th>
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<th>W/SHS</th>
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<th>Total $/W</th>
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<td>Projected</td>
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<tr>
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<td>200,000</td>
<td>550-800</td>
<td>50+</td>
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<tr>
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<td>200-450 w/GEF</td>
<td>200-450 w/oGEF</td>
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</table>